IN AMERICA AND CONNECTICUT, ENERGY WASTE IS THEIR MOST IMPORTANT AND PROLIFIC PRODUCT.

March 7, 2013

SENT VIA E-MAIL TO: ET.TESTIMONY@CGA.CT.GOV

P.O. Box 71
Windsor, CT 06095-2205

Co-chairmen and Members
Co-Chairmen and Members
Energy and Technology Committee
Connecticut Legislature
Room 3900, Legislative Office Building
Hartford, CT 06106

Re: **H.B. 6360, An Act Concerning Implementation of Connecticut's Comprehensive Energy Strategy**.

Dear Co-Chairs and Members:

INTRODUCTION

Essentially, Public Act ("P.A.") 11-80, section 51 (a) requires the Connecticut Department of Energy and Environmental Protection ("DEEP") to develop an energy plan every three years. The Draft Comprehensive Energy Strategy Plan ("Draft") prepared by DEEP analyzes the state's energy use and identifies how to improve efficiency in heating, air conditioning and other building systems and appliances. Executive Summary ("ES"), pages 1-2. It also calls for economic incentives such as subsidies and power purchase agreements to reduce the cost of renewable electricity and promotes housing and retail construction near mass transit to reduce automobile use and encourages bikeways and walking paths. *Id*. The Draft, also, considers financing to promote gas heat at residences and businesses. *Id.* Also, the Draft offers . . . "a set of recommendations designed to advance the **Governor's agenda** of moving Connecticut toward a cheaper, cleaner, and more reliable energy future." (Emphasis added.)" ES, p. 1, paragraph 1.

The Draft is incontrovertibly **NOT COMPREHENSIVE and NOT STRATEGIC** because it is neither designed as claimed by DEEP to "Conserve, improve and protect our natural resources and environment nor to ensure a clean, affordable, reliable, and sustainable energy supply" nor consistent with the requirements of Section 51(a) for a Comprehensive Energy Plan, nor the declared policies of section 16a-35k of the Connecticut General Statutes ("G.S.").

The Strategy offers recommendations in the following five major priority areas:

A. Energy Efficiency
B. Electricity Supply Including Renewable Power
C. Industrial Energy Needs
D. Transportation
E. Natural Gas

Executive Summary ("E. S."), p. 1, par. 2.

COMMENTS

I. General

A. *Everyone's got a plan until they get punched in the mouth*. Former Heavyweight Champ, Mike Tyson

B. The Draft is best described by the title of James Howard Kunstler's latest book entitled, *Too Much Magic; Wishful Thinking, Technology, and The Fate Of The Nation*.

C. The statement that the Draft advances the Governor's agenda constitutes the crass **politicization of energy planning**. Public Act 11-80 and section 16a-35k do not establish any requirement for providing recommendations, which advance the Governor's agenda. **This phrasing should be removed from the Draft**.

D. The use of the amorphous term "clean energy" is deceptive and disingenuous. Clean energy is dirty energy when examined over the life cycle of the apparatus used to capture and transform solar radiation, wind and water into electricity. The operation of the transformative devices are cleaner but the processes to extract the raw materials, process them into the apparatus and transport them to specific destinations all use fossil fuels, which pollute.

E. It perpetuates the energy crisis in its implication of a perpetual supply of fossil fuels, i.e., natural gas.

F. The bill essentially describes plans, which fall within the purview of **Energy Assurance**

G. The Strategy displays a brand of shocking ignorance by the Governor and DEEP to the global energy conditions – worldwide net energy is in depletion mode.

G. Fossil fuel depletion trumps technology.

I. Peak fossil fuels equals peak economy.

J. There is no provision for energy analysis anywhere in the bill to support the energy planning process.

II. Energy Assurance

Energy Assurance is a management program designed to ensure the secure and available (i.e., reliable and maintainable) flow of energy that meets mission goals and objectives, which are achieved through implementation of specifications, standards and regulations. Its purpose is to protect critical energy infrastructure and ensure its resilience. Operational Availability (“A_o”) is defined as reliability divided by reliability plus maintainability. Mathematically A_o = Mean Time Between Failures / Mean Time Between Failures + Mean Time To Repair.

Energy Assurance should be the primary management program for securing the delivery of all energy systems and DEEP has ignored this overarching management principle. The agency does not address data collection, analysis and consequence assessment for both reliability and maintainability.

III. Priority Areas and Energy Waste

Section 51(a) requires an “assessment of current . . . demand and costs, identification and evaluation of the factors likely to affect future . . . demand and costs, a statement of energy policies and long-range energy planning objectives and strategies appropriate to achieve, among other things . . . measures that reduce demand for energy, giving due regard to such factors as . . . security . . . conservation of energy and energy resources.”

Further, section 16a-35k declared that it is the policy of the state to “assist citizens and businesses in implementing measures to reduce energy consumption. . . . “

Missing from consideration in the Strategy are measures to minimize the demand for energy in solid waste, food, manufacturing, information, healthcare, education, home heating oil, energy storage, and nuclear power. Additionally, security, and entropy are ignored.

Section 16a-35k of the G.S. declared that state policy is to “giv[e] due regard to such factors as . . . conservation of energy and energy resources.” Meaning, the state is obligated to avoid unnecessary and wasteful consumption. Absolute minimization of energy waste is essential to implement this policy. Yet, DEEP has not provided a Comprehensive Strategy for Energy Conservation across the full spectrum of Connecticut's economy. For example, there was no consideration for the energy embodied in solid waste, healthcare products and services, automobiles, land use, architecture, etc. Even though, section 22a-1b(c)(7) of the G.S. requires consideration of the "the effect of the proposed action on the use and conservation of energy resources," no Environmental Impact Evaluation that I have reviewed – I have reviewed many - which were prepared by federal and state agencies has ever analyzed and assessed such effects. Moreover, energy efficiency is only a small part of conservation.

The "reduce, recycle, reuse" theme of DEEP's Solid Waste (Mis)management Plan is ineffective in reducing energy consumption and waste attributed to nonessential products and services. The Strategy should propose to significantly minimize solid waste and include as a first element of management the theme of "**refuse**," which is contrary to mindless growth of excessive wealth and prosperity.

This state does not need more energy generation or new fuel supplies; it needs to cut the energy waste. Every day, Connecticut wastes more generated energy during the off peak hours of demand than the state ever uses during the peak hours. Our country wastes enough energy everyday to power the entire country of Japan. It is actually a lot worse than that; it is more like multiple Japan's.

IV. Energy Storage

Society has already paid the pollution price and this electrical energy is just going to waste, storing the "off-peak" is as clean as energy can be. Off-peak energy has already been paid for so it should be free. The only thing left is to pay the utilities for delivery.

It takes about a month to shut down and then ramp up a base load power plant. When ratepayers turn off their lights, pretty much the same amount of fuel is burned to produce the same amount of electric energy to the grid. Ratepayers pay for it in the overall rate structure, and it is all just going to waste.

See Appendix B for a perspective on energy waste. *Also see*, Appendix F, infra, on energy storage.

V. Duration of the Plan

The Strategy is predicated on economic and population growth until the planning year of 2050. ES, p. 1, par. 1. However section 51 (a) of P.A. 11-80, also, requires an updated Plan every three years. In a world of finite natural resource, perpetual or unlimited economic and population growth is unrealistic, unachievable and unsustainable in light of the incontrovertible developing scarcities in extractible fossil fuels and raw materials such as rare earth elements derived from minerals, the increasing energy costs for the net gain in the quantity and quality of such fuels, declining global net energy. Not only does the state plan to grow but it uses neoclassical economics for its model, which is a proven failure because unlike the new field of Biophysical Economics, it discredits the limits of the resources in the physical world. In other words, peak resources equals peak economy. Planning to the year 2050 is not a statutory requirement and should be abandoned. The Governor and Legislature cannot even plan the budget for the next year never mind energy supplies and demand to the year 2050. **Peak oil equals peak economy.**

VI. Quality of Life and Living

Section 16a-35k reads in pertinent part as follows;

> it is the continuing responsibility of the state to use all means consistent with other essential considerations of state policy . . . to achieve a balance between population and resource use which will permit the maintenance of adequate living standards and a sharing of life's amenities among all citizens. . . .

This policy declaration requires the creation of a “Quality of Life” and “Quality of Living” standards for planning purposes only. The European Union has adopted such planning criteria. Otherwise, there is simply no foundation as a benchmark for planning. Is the Governor’s political agenda the ground floor? As a result, current state planning including the Strategy is haphazard, arbitrary and capricious without such reference point. What is the ultimate purpose, goal and wishful achievement expected from economic growth until 2050? Connecticut needs to realistically embrace and plan for economic contraction, which is a more likely scenario. Also see, Appendix B for a historical perspective on living standards.

VII. Economic Growth

Section 51 (a) requires the Plan to “giv[e] due regard to such factors as . . . the ability of the state to compete economically”; this is an euphemism for economic growth, which is nothing more than attaching collateral for past debts.

The tools of the past no longer fit the economy of the future? Economic growth, as we have known it, is being constrained by an unprecedented slowing of growth in world oil supply. Connecticut’s path to future prosperity needs to recognize and confront this new energy reality, and adapt our economy to run on a lot less oil.

VIII. EROEI or EROI

"In integrating energy, environmental, and economic goals, the Strategy breaks new ground and advances a broad and robust structure for thinking through energy options." ES, page 1, par. 3. "It moves away from subsidizing favored technologies or companies toward a flexible "finance" model that encourages entrepreneurship and private sector leadership in scaling up clean energy projects." *Id.* "Emphasis is placed not on picking `winners' but on using limited government resources to leverage private capital and increase the flow of funds into energy efficiency, renewable power, natural gas availability, and a 21st century transportation infrastructure that promotes mobility options, transportation-oriented development, and market-based opportunities for clean fuels and clean vehicles." *Id.*

"This Strategy builds on the fundamental premise that the public's interest in and ongoing commitment to clean energy depends on the emergence of new technologies that out-compete fossil fuel alternatives." ES, page 1, par. 3. "It therefore proposes an array of economic incentives designed to drive down the cost of new energy technologies." *Id.* "By harnessing market forces and competitive pressures, this policy framework promises to spur innovation while offering support for a portfolio of renewable power generation alternatives." *Id.*

How much energy must be invested to achieve all the goals in the Strategy? For sure, Merlin the Magician will not suddenly appear, go "poof" and all the energy will magically become available to attain the state's objectives.

The Abstract of reference [3] reads as follows (The full paper appears in Part II of my comments as separate correspondence.)

> Economic production and, more generally, most global societies, are overwhelmingly dependent upon depleting supplies of fossil fuels. There is considerable concern amongst resource scientists, if not most economists, as to whether market signals or cost benefit analysis based on today's prices are sufficient to guide our decisions about our energy future. These suspicions and concerns were escalated during the oil price increase from 2005 – 2008 and the subsequent but probably related market collapse of 2008. We believe that Energy Return On Investment (EROI) analysis provides a useful approach for examining disadvantages and advantages of different fuels and also offers the possibility to look into the future in ways that markets seem unable to do. The goal of this paper is to review the application of EROI theory to both natural and economic realms, and to assess preliminarily the minimum EROI that a society must attain from its energy exploitation to support continued economic activity and social

function. In doing so we calculate herein a basic first attempt at the minimum EROI for current society and some of the consequences when that minimum is approached. The theory of the *minimum EROI* discussed here, which describes the somewhat obvious but nonetheless important idea that for any being or system to survive or grow it must gain substantially more energy than it uses in obtaining that energy, may be especially important. Thus any particular being or system must abide by a “Law of Minimum EROI”, which we calculate for both oil and corn-based ethanol as about 3:1 at the mine-mouth/farm-gate. Since most biofuels have EROI’s of less than 3:1 they must be subsidized by fossil fuels to be useful.

One potentially useful alternative to conventional economic analysis is net energy analysis, which is the examination of how much energy is left over after correcting for how much of that energy (or its equivalent from some other source) is required to generate (extract, grow or whatever) a unit of the energy in question. Net energy analysis is sometimes called the assessment of energy surplus, energy balance, or, as we prefer, energy return on investment (EROI or sometimes EROEI) (The reference is attached as a separate correspondence for my comments.). The EROI is calculated from the following simple equation, although the devil is in the details:

$$\text{EROI} = \frac{\text{Energy returned to society}}{\text{Energy required to get that energy}}$$

Since the numerator and denominator are usually assessed in the same units (an exception we treat later is when quality corrections are made) the ratio so derived is dimensionless, e.g. 30:1 which can be expressed as “30 to one”. This implies that a particular process yields 30 Joules on an investment of 1 Joule (or Kcal per Kcal or barrels per barrel). EROI is usually applied at the mine-mouth, wellhead, farm gate, etc. The EROI is not to be confused with *conversion efficiency*, i.e. going from one form of energy to another such as upgrading petroleum in a refinery or converting diesel to electricity. It is only loosely related, at least in the short term, to the concept of energy return on monetary investment.

Net energy analysis offers the possibility of a very useful approach for looking at the advantages and disadvantages of a given fuel and offers the possibility of looking into the future in a way that markets seem unable to do. Its advocates also believe that in time market prices must approximately reflect comprehensive EROIs, at least if appropriate corrections for quality are made and subsidies removed. Nevertheless we hasten to add that we do not believe that EROI by itself is necessarily a sufficient criteria by which judgments may be made, although it is the one we favor the most, especially when it indicates that one fuel has a much higher or lower EROI than others. In addition it is important to consider the present and future potential magnitude of the fuel, and how EROI might change if a fuel is expanded.

I recommend all staff and stakeholders watch the following three (3) videos concerning Dr. Charles Hall's[1] lectures on Biophysical Economics:

1. http://www.youtube.com/watch?v=HZOAovp0S6s&feature=player_embedded;
2. http://www.youtube.com/watch?v=Bk7Ux4gCXjE&list=UUegQs-U_vRxxhe_4tuXJICQ&index=2&feature=plcp;
3. http://www.youtube.com/watch?v=YwdwUStzxww&list=UUegQs-U_vRxxhe_4tuXJICQ&index=3&feature=plcp; and
4. http://www.youtube.com/watch?v=SIcSeJE8-1E&list=UUegQs-U_vRxxhe_4tuXJICQ&index=4&feature=plcp

Also, all should read Dr. Hall's latest book *Energy and the Wealth of Nations*[2]. In the book, Hall and his co-author explore the relation between energy and the wealth

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[1] Dr. Charles A.S. Hall is Environmental Science and Forestry Foundation Distinguished Professor at State University of New York in the College of Environmental Science & Forestry. Hall describes himself primarily as a systems ecologist in the field of Systems ecology with strong interests in biophysical economics, and the relation of energy to society. Dr. Hall was trained as a systems ecologist by Howard Odum at the University of North Carolina. Since then he has had a diverse career at Brookhaven Laboratory, The Ecosystems Center at the Marine Biological Laboratory, Woods Hole, Cornell University, University of Montana and, for the last 20 years, at the State University of New York College of Environmental Science and Forestry (SUNY ESF). His work has involved streams, estuaries and tropical forests but it has focused increasingly on human-dominated ecosystems in the US and Latin America. His research reflects his interest in understanding and developing analyses and computer simulation models of the complex systems of nature and humans and their interactions. Halls focus has been on energy as it relates to economics and environment. His focus is studying material and energy flows referred to as Industrial ecology, and applying this perspective, to attempting to understand human economies from a biophysical rather than just social perspective. Dr. Hall teaches a freshman course called The Global Environment and the Evolution of Human Culture and graduate level courses in Systems Ecology, Ecosystems, Energy systems, Tropical Development and Biophysical Economics.

[2] The Table of Contents for the book is as follows:

Part I. Energy and the Origins of Wealth
Chapter 1. Poverty, Wealth, and Human Ambition
Chapter 2. Energy and Wealth Production: An historical perspective
Chapter 3. The Petroleum Revolution I: The first half of the age of oil
Part II. Energy, Economics and the Structure of Society
Chapter 4. Explaining Economics from an Energy Perspective
Chapter 5. The Limits of Conventional Economics
Chapter 6. The Petroleum Revolution II: Concentrated Power and Concentrated Industries
Chapter 7. The Postwar Economic Order, Growth and the Hydrocarbon Economy
Chapter 8. Globalization and Efficiency
Chapter 9. Are there Limits to Growth? Examining the Evidence
Part III. Energy and Economics—the Basics
Chapter 10. What is Energy and How is it Related to Wealth Production?

explosion of the 20th century, the failure of markets to recognize or efficiently allocate diminishing resources, the economic consequences of peak oil, the EROI for finding and exploiting new oil fields, and whether alternative energy technologies such as wind and solar power meet the minimum EROI requirements needed to run our society as we know it.

IX. Clean Energy Strategy

The Strategy builds on the fundamental premise that the public's interest in and ongoing commitment to clean energy depends on the emergence of new technologies that out-compete fossil fuel alternatives." ES, p.1, par. 4.

There are neither known nor projected future technologies that can out-compete fossil fuels. The Energy Return on Energy Invested aka energy profit ratio for fossil fuels far exceeds that for any apparatus harnessing renewable energy sources. See Appendix C for chart and table of EROEIs.

The Strategy, also, ignored the energy required for maintenance and repair of renewable energy facilities into the foreseeable future. When the global and national fossil fuel supplies are significantly depleted within the next 10 years (my estimation), maintaining and repairing equipment as well as the rest of the technological advances will face a rendezvous with entropy. Technology requires two essential entities: raw materials and a fuel supply for processing, which are both dwindling [1][2]. See Appendix D for article on looming shortage of rare metals.

X. Energy Efficiency Strategy

"Energy conservation offers a mechanism for reducing utility bills for every family and business in Connecticut while creating thousands of new jobs. The Strategy calls for an expanded commitment to `all cost-effective' energy efficiency through programs that will. . . ." ES, page 2, par. 3.

Chapter 11. The Basic Science Needed to Understand the Relation of Energy to Economics
Chapter 12. The Required Quantitative Skills
Chapter 13. Economics as Science: Social or Biophysical?
Part IV. The Science Behind How Economies Work
Chapter 14. Energy Return on Investment
Chapter 15. Peak Oil, EROI, Investments and Our Financial Future
Chapter 16. The Role of Economic Models for Good and Evil
Chapter 17. How to do Biophysical Economics
Part V. Understanding How Real World Economies Work
Chapter 18. Peak Oil, the Great Recession and the Quest for Sustainability
Chapter 19. Environmental Considerations: Beyond Externalities
Chapter 20. Living the Good Life in a Lower EROI World

The Strategy should analytically determine the quantity of energy necessarily invested to achieve the anticipated efficiencies. In other words, what is the **net energy saved**?

Also, the Strategy has not dealt with "Jevons paradox." In 1865, the English economist William Stanley Jevons observed that technological improvements that increased the efficiency of coal use led to increased consumption of coal in a wide range of industries. He argued that, contrary to common intuition, technological improvements could not be relied upon to reduce fuel consumption.

The issue has been re-examined by modern economists studying consumption rebound effects from improved energy efficiency. In addition to reducing the amount needed for a given use, improved efficiency lowers the relative cost of using a resource, which tends to increase the quantity of the resource demanded, potentially counteracting any savings from increased efficiency. Additionally, increased efficiency accelerates economic growth, further increasing the demand for resources. The Jevons paradox occurs when the effect from increased demand predominates, causing resource use to increase.

The Jevons paradox has been used to argue that such energy conservation is futile, as increased efficiency may increase fuel use. Nevertheless, increased efficiency can improve material living standards. Further, fuel use declines if increased efficiency is coupled with a green tax or other conservation policies that keep the cost of use the same (or higher). As the Jevons paradox applies only to *technological improvements* that increase fuel efficiency, policies that impose conservation standards and increase costs do not display the paradox.

To be clear, the rebound effect is real. The theory behind it is sound: Lower the cost of anything and people will use more of it, including the cost of running energy consuming equipment. But as with many economic ideas that are sound theory (like the idea that you can raise government revenues by cutting tax rates), the trick is in knowing how far to take them in reality. (Cutting tax rates from 100% to 50% would certainly raise revenues. Cutting them from 50% to 0% would just as surely lower them.)

For example, Stan Cox, author of *Losing Our Cool*, noted that between 1993 and 2005, air conditioners in the U.S. increased in efficiency by 28%, but by 2005, homes with air conditioning increased their consumption of energy for their air conditioners by 37%. Real (inflation adjusted) per capita income increased by just over 30% over that time period. All else being equal, when people have more money, they buy more stuff, including cool air.

The average size of new homes increased from 2,095 to 2,438 square feet, over 16%. More square feet means more area to cool and more energy needed to cool it.

In 1993, of homes that had air conditioning, 38% only had room units while 62% had central air. By 2005, 75% of air conditioned homes had central units. Bigger units covering more rooms means more cool air and, you guessed it, more energy.

Real electricity prices were mostly flat over this time period, falling by just over 1%, contributing little, if anything, to the increase.)

Accounting only for the increased income over the timeframe, a few rough calculations point to an increase in energy use for air conditioning of about 30% from 1993 to 2005, despite the gains in efficiency.

It's one of the well-established frustrations of the energy efficiency world that people pay too much attention to the up-front cost of goods and not enough to the energy costs needed to use them. Again, what is the net energy savings.

XI. Renewable Power

See Appendix F for a dissertation, which appeared in Forbes Magazine on *Renewable Energy's Sixty years of Broken Dreams* and the November 21, 2011 research note by Michael Cembalest, the chief investment officer for JPMorgan Private Bank entitled *The quixotic search for energy solutions*.

XII. Crude Oil

World crude oil production has been on a century-long rising trend—from less than one million barrels per day (mbpd) in 1900 to nearly 75 mbpd today. There have been aberrations along the way, such as a large fall in production during the Great Depression, but the upward trend has persisted—until recently. Since 2005, global oil production has been essentially flat. There have been plateaus before, but what is different this time is that real oil prices — i.e. adjusted for inflation — have roughly tripled within the span of a decade, yet relatively little additional production has been brought forth.

For most of the 20th century, oil prices in 2009 dollars were less than $35 per barrel. During the 25-year economic boom following World War II, they stayed reliably below $20. Real prices shot up to the $50 mark in the early 1970's following the Arab oil embargo and reached $100 shortly thereafter with the Iranian hostage crisis. Excepting those oil shocks, average real prices remained remarkably low. But something appears to have fundamentally changed over the past decade. Since 2000, aside from a spike and crash in 2008 and 2009, U.S. oil prices have climbed steadily and are now holding in the $80-$100 per barrel range, approximately three times their historic average, despite a worldwide economic slowdown. The country has essentially been in a long, slow, but equally damaging oil shock for several years, only this one is not associated with any acute geopolitical event.

Various forces are contributing to rising oil prices, but an unavoidable key factor is the increasing cost and energy required to produce each new barrel of oil. From an energy and economic standpoint, the return on energy invested for new petroleum sources — such as tight oil in North Dakota, Canadian tar sands, or deepwater offshore oil is much lower than for conventional oilfields of the past, as research at the State University of New York at Syracuse has shown. Essentially, this means that oil is delivering substantially less energy “profit” or surplus wealth to society than it used to. Higher prices also mean more American dollars flowing to oil-exporting countries, less money for households and businesses to invest or spend on other goods and services, and rising prices for oil-dependent products (a long list). It all adds up to a major drag on economic growth.

There is another important new wrinkle in the story of the petroleum age. Before 2000, we didn’t care much about other countries. The United States essentially laid first claim to the world’s oil exports. This is no longer the case. Oil consumption in developing countries, especially China, has exploded over the past decade. At the same time, oil-exporting countries are using more oil domestically. The result: oil exports available on the global market have been declining by an estimated 0.7 percent per year since 2005, according to analysis by Texas geologist Jeffrey Brown, and competition for those declining oil exports has increased, pushing prices further upward.

Not only is U.S. oil production unlikely to meet current consumption (ignore the hype, check the numbers for yourself), more domestic production will not address oil’s increasing burden on the economy. Canada, for example, produces much more oil than it consumes; however, adjusting for taxes, our northern neighbors pay about the same at the pump as we do.

No matter who is the President, in Congress or Connecticut’s governor, America and the state cannot drill its way out of our oil predicament, and more importantly, we cannot just “grow” our way to prosperity without addressing this new energy reality and charting a new course toward a low-oil economy. This conflicts with the wishful thinking and, techno-narcissism evidenced in theStrategy.

XIII. Natural Gas

“The Strategy further seeks to align Connecticut's energy future with the emerging opportunity provided by shale gas for a lower-cost, less-polluting, and domestically available (and thus more reliable) foundation for society's energy needs." ES, page 2, par. 1. "In identifying natural gas as a bridge to a truly sustainable energy future, it puts forward a seven-year game plan for expanding natural gas use across Connecticut with a goal of providing nearly 300,000 Connecticut homes, businesses, and other facilities with access to gas." This would be a 100% huge gift to the Utilities. On what planet is the staff, who prepared the Strategy operating?

> The current price situation in shale gas is different than shale oil. The drilling frenzy in shale gas produced a glut, which drove down prices from a $13 a unit (thousand cubic feet or mcf) to around $2 at its low point earlier this year. That's way below the price that is economically rational to drill and frack for it. The price collapse has played havoc among the companies engaged in shale gas, though it has been a boon to customers. A lot of the drilling equipment has moved to the North Dakota oil fields. There will be less shale gas in the period ahead and the price will go up. It has got to go above about $8 a unit or there will be no reason for any company to be in the shale gas business. But as is always the case in such a correction, the price will surely overshoot $8, at which point it will become unaffordable to its customers. The volatility alone will make the business of shale gas drilling impossible to maintain. Forget about the USA becoming a major gas exporter.

See Kunstler, James Howard, *Epic Disappointment*, November 19, 2012 on the Internet at kunstler.com. The full article is attached as Appendix E.

How much energy must be invested to achieve the goals? And, what will be the EROEI for the conversion to natural gas? What is the embodied energy for the existing oil-fired system, which would be wasted by the conversion? Please provide the analysis.

XIV. TRANSPORTATION

"Cars, trucks, buses, trains, and planes account for 32% of the energy consumed in Connecticut and an even higher percentage of the fossil fuels burned." ES, p.4, par. 1.

"Providing the State's citizens with mobility options is therefore a high priority of the Strategy, which calls for:

- Expanded commitment to transport-oriented development and a broader mobility focus that encourages bikeway, walking paths, and other quality of life investments;

- Secure funding for transportation infrastructure in support of reduced road congestion, improved air quality, and a strengthened pIatform for o growth and job creation;

- Investment in a clean fuels/vehicles initiative that will ensure that the basic infrastructure needed for vehicle choice will be in place including:

- Sufficient electric vehicle charging stations (about 100 statewide) so that no one in the state need suffer from range anxiety,

- Support for conversion of fleets (delivery vans, taxis, garbage trucks, public works vehicles, etc.) to natural gas in conjunction with private sector-funded construction of natural gas filling stations that will be publicly available,

- Establishment of a core set of Liquefied Natural Gas stations at truck stops in support of the growing number of long haul trucking fleets considering conversion to natural gas as their primary fuel,

- Expanded hydrogen filling stations as demand for fuel cell-powered vehicles grows,

- Support for better fuel economy in Connecticut vehicles and development of second-generation biofuels such as biodiesel from food waste."

ES, p.4, par. 1

How much energy is required to achieve each of the goals? As Admiral Hyman Rickover postulated, the problem is the EROI for the automobile over its expected life, which is far more significant than energy savings from increased mileage or Corporate Average fuel Economy (CAFÉ) standards.

XV. Project Analysis and Evaluations

When evaluating projects, the company should perform a net energy analysis for each proposal. Such analysis shall include calculations of all embodied energy requirements used in the materials for initial construction of the facility over its projected useful lifetime. The analysis shall be expressed in a dimensionless unit as an energy profit ratio of energy generated by the facility to the calculated net energy expended in plant construction, maintenance and total fuel cycle energy requirements over the projected useful lifetime of the facility. The boundary for both the net energy calculations of the fuel cycle and materials for the facility construction and maintenance shall both be at the point of primary material extraction and include the energy consumed through the entire supply chain to final, but not be limited to, such subsequent steps as transportation, refinement and energy for delivery to the end consumer. The results of said net energy analysis shall be included in the results forwarded to the client. For purposes of this paragraph, "facility net energy" means the heat energy delivered by the facility contained in a fuel minus the life cycle energy used to produce the facility. "Fuel net energy" means the heat energy contained in a fuel minus the energy used to extract the fuel from the environment, refine it to a socially useful state and deliver it to consumers, and "embodied energy" means the total energy used to build and maintain a process, expressed in calorie equivalents of one type of energy.

Such analysis are ignored by the state even though CGS, section 22a-1b(c)(7) requires them.

XVI. Conclusion

After a thorough review of theStrategy, I can only conclude that it was drafted by amateurs, is neither comprehensive nor strategic, and DEEP now stands for the Connecticut Department of Energy Waste and Environmental Politics.

Very truly yours,

Robert Fromer

REFERENCES (Available upon request)

[1] Diederen, *Metal minerals scarcity: A call for managed austerity and the elements of hope*, MSc.TNO Defence, Security and Safety, P.O. Box *45,* 2280 AA Rijswijk, The Netherlands, andre.diederen@tno.nl, March 10, 2009.

[2] Andersson, Bjorn A., *Material Constraints on Technology Evolution: The Case of Scarce Metals and Emerging Energy Technologies*, Doctor of Philosophy Thesis, Department of Physical Resource Theory Chalmers University of Technology and Goteborg University, Goteborg, Sweden 2001

[3] Hall, C.A.S.; Powers, R.; Schoenberg, W. *Peak Oil, EROI, Investments and the Economy in an Uncertain Future*. In Renewable Energy Systems: Environmental and Energetic Issues. Pimentel, D., Ed.; Elsevier: London, 2008; pp. 113-136.

APPENDIX A

KEY ELEMENTS OF PUBLIC ACT AND CONNECTICUT GENERAL STATUTE

Public Act 11-80

The primary requirements in Sec. 51 (a) for preparation of the Plan are as follows:

I. The Plan shall reflect the legislative findings and policy stated in **section 16a-35k** of the General Statutes, as amended by this Act, and shall incorporate:

(1) an assessment and plan for all energy needs in the state, including, but not limited to, electricity, heating, cooling, and transportation,
(2) the findings of the integrated resources plan,
(3) the findings of the plan for energy efficiency adopted pursuant to section 16-245m of the general statutes, as amended by this act, and
(4) the findings of the plan for renewable energy adopted pursuant to section 16-245n of the general statutes; and

II. The plan shall further include, but not be limited to:

(A) an assessment of current energy supplies, demand and costs,
(B) identification and evaluation of the factors likely to affect future energy supplies, demand and costs,
(C) a statement of progress made toward achieving the goals and milestones set in the preceding Comprehensive Energy Plan,
(D) a statement of energy policies and long-range energy planning objectives and strategies appropriate to achieve, among other things, a sound economy, the least-cost mix of energy supply sources and measures that reduce demand for energy, giving due regard to such factors as consumer price impacts, security and diversity of fuel supplies and energy generating methods, protection of public health and safety, environmental goals and standards, conservation of energy and energy resources and the ability of the state to compete economically,
(E) recommendations for administrative and legislative actions to implement such policies, objectives and strategies,
(F) an assessment of the potential costs savings and benefits to ratepayers, including, but not limited to, carbon dioxide emissions reductions or voluntary joint ventures to repower some or all of the state's coal-fired and oil-fired generation facilities built before 1990, and
(G) the benefits, costs, obstacles and solutions related to the expansion and use and availability of natural gas in Connecticut. If the

department finds that such expansion is in the public interest, it shall develop a plan to increase the use and availability of natural gas for transportation purposes.

Connecticut General Statutes, Section 16a-35k.

In section 16a-35k, the General Assembly found that:

(1) the state of Connecticut is severely disadvantaged by its lack of primary energy resources;
(2) primarily as a result of past policies and tendencies, the state has become dependent upon petroleum as an energy source;
(3) national energy policies do not preclude the recurrence of serious problems arising from this dependence during petroleum shortages;
(4) the increase in oil prices since the 1973 oil embargo has had a major impact on the state;
(5) the economy has suffered directly because of our dependence on petroleum and constraints upon the rate of conversion to alternatives;
(6) other conventional sources of energy are subject to constraints involving supply, transportation, cost and environmental, health and safety considerations;
(7) the state must address these problems by conserving energy, increasing the efficiency of energy utilization and developing renewable energy sources;
(8) energy use has a profound impact on the society, economy and environment of the state, particularly in its impact on low and moderate-income households and interrelationship with population growth, high density urbanization, industrial well-being, resource utilization, technological development and social advancement, and
(9) energy is critically important to the overall welfare and development of our society.

Also, in section 16a-35k, the General Assembly declared that it is the policy of the state of Connecticut to:

(1) conserve energy resources by avoiding unnecessary and wasteful consumption;
(2) consume energy resources in the most efficient manner feasible;
(3) develop and utilize renewable energy resources, such as solar and wind energy, to the maximum practicable extent;
(4) diversify the state's energy supply mix;
(5) where practicable, replace energy resources vulnerable to interruption due to circumstances beyond the state's control with those less vulnerable;
(6) assist citizens and businesses in implementing measures to reduce energy consumption and costs;

(7) ensure that low-income households can meet essential energy needs;
(8) maintain planning and preparedness capabilities necessary to deal effectively with future energy supply interruptions;
(9) when available energy alternatives are equivalent, give preference for capacity additions first to conservation and load management;
(10) it is the continuing responsibility of the state to use all means consistent with other essential considerations of state policy to improve and coordinate the plans, functions, programs and resources of the state to attain the objectives stated herein without harm to the environment, risk to health or safety or other undesirable or unintended consequences, to preserve wherever possible a society which supports a diversity and variety of individual choice, to achieve a balance between population and resource use which will permit the maintenance of adequate living standards and a sharing of life's amenities among all citizens, and to enhance the utilization of renewable resources so that the availability of nonrenewable resources can be extended to future generations; and
(11) the energy policy is essential to the preservation and enhancement of the health, safety and general welfare of the people of the state and that its implementation therefore constitutes a significant and valid public purpose for all state actions.

Further, section 16a-35k requires that the state seek:

(1) all possible ways to implement this policy through public education and cooperative efforts involving the federal government, regional organizations, municipal governments, other public and private organizations and concerned individuals;
(2) using all practical means and measures, including financial and technical assistance, in a manner calculated to promote the general welfare by creating and maintaining conditions under which energy can be utilized effectively and efficiently.

APPENDIX B

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"Energy resources and our future" - remarks by Admiral Hyman Rickover delivered in 1957
by Rear Admiral Hyman G. Rickover, U.S. Navy

FOR RELEASE AT 7:00 P.M. TUESDAY, MAY 14, 1957

Remarks Prepared by

Rear Admiral Hyman G. Rickover, USN
Chief, Naval Reactors Branch
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And
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For Delivery at a Banquet of the Annual Scientific Assembly of
the Minnesota State Medical Association
St. Paul, Minnesota

May 14, 1957

Energy Resources and Our Future

I am honored to be here tonight, though it is no easy thing, I assure you, for a layman to face up to an audience of physicians. A single one of you, sitting behind his desk, can be quite formidable.

My speech has no medical connotations. This may be a relief to you after the solid professional fare you have been absorbing. I should like to discuss a matter, which will, I hope, be of interest to you as responsible citizens: the significance of energy resources in the shaping of our future.

We live in what historians may some day call the Fossil Fuel Age. Today coal, oil, and natural gas supply 93% of the world's energy; waterpower accounts for only 1%; and the labor of men and domestic animals the remaining 6%. This is a startling reversal of corresponding figures for 1850 - only a century ago. Then fossil fuels supplied 5% of the world's energy, and men and animals 94%. **Five sixths of all the coal, oil, and gas consumed since the beginning of the Fossil Fuel Age has been burned up in the last 55 years.**

These fuels have been known to man for more than 3,000 years. In parts of China, coal was used for domestic heating and cooking, and natural gas for lighting as early as 1000 B.C. The Babylonians burned asphalt a thousand years earlier. But these early uses were sporadic and of no economic significance. Fossil fuels did not become a major source of energy until machines running on coal, gas, or oil were invented. Wood, for example, was the most important fuel until 1880 when it was replaced by coal; coal, in turn, has only recently been surpassed by oil in this country.

Once in full swing, fossil fuel consumption has accelerated at phenomenal rates. All the fossil fuels used before 1900 would not last five years at today's rates of consumption.

Nowhere are these rates higher and growing faster than in the United States. Our country, with only 6% of the world's population, uses one third of the world's total energy input; this proportion would be even greater except that we use energy more efficiently than other countries. Each American has at his disposal, each year, energy equivalent to that obtainable from eight tons of coal. This is six times the world's per capita energy consumption. Though not quite so spectacular, corresponding figures for other highly industrialized countries also show above average consumption figures. The United Kingdom, for example, uses more than three times as much energy as the world average.

With high energy consumption goes a high standard of living. Thus the enormous fossil energy which we in this country control feeds machines which make each of us master of an army of mechanical slaves. **Man's muscle power is rated at 35 watts continuously, or one-twentieth horsepower.** Machines therefore furnish every American industrial worker with energy equivalent to that of 244 men, while at least 2,000 men push his automobile along the road, and his family is supplied with 33 faithful household helpers. Each locomotive engineer controls energy equivalent to that of 100,000 men; each jet pilot of 700,000 men. Truly, the humblest American enjoys the services of more slaves than were once owned by the richest nobles, and lives better than most ancient kings. In retrospect, and despite wars, revolutions, and disasters, the hundred years just gone by may well seem like a Golden Age.

Whether this Golden Age will continue depends entirely upon our ability to keep energy supplies in balance with the needs of our growing population. Before I go into this question, let me review briefly the role of energy resources in the rise and fall of civilizations.

Possession of surplus energy is, of course, a requisite for any kind of civilization, for if man possesses merely the energy of his own muscles, he must expend all his strength - mental and physical - to obtain the bare necessities of life.

Surplus energy provides the material foundation for civilized living - a comfortable and tasteful home instead of a bare shelter; attractive clothing instead of mere covering to keep warm; appetizing food instead of anything that suffices to appease hunger. It provides the freedom from toil without which there can be no art, music, literature, or learning. There is no need to belabor the point. What lifted man - one of the weaker mammals - above the animal world was that he could devise, with his brain, ways to increase the energy at his disposal, and use the leisure so gained to cultivate his mind and spirit. Where man must rely solely on the energy of his own body, he can sustain only the most meager existence.

Man's first step on the ladder of civilization dates from his discovery of fire and his domestication of animals. With these energy resources he was able to build a pastoral culture. To move upward to an agricultural civilization he needed more energy. In the past this was found in the labor of dependent members of large patriarchal families, augmented by slaves obtained through purchase or as war booty. There are some backward communities, which to this day depend on this type of energy.

Slave labor was necessary for the city-states and the empires of antiquity; they frequently had slave populations larger than their free citizenry. As long as slaves were abundant and no moral censure attached to their ownership, incentives to search for alternative sources of energy were lacking; this may well have been the single most important reason why engineering advanced very little in ancient times.

A reduction of per capita energy consumption has always in the past led to a decline in civilization and a reversion to a more primitive way of life. For example, exhaustion of wood fuel is believed to have been the primary reason for the fall of the Mayan Civilization on this continent and of the decline of once flourishing civilizations in Asia. India and China once had large forests, as did much of the Middle East. Deforestation not only lessened the energy base but had a further disastrous effect: lacking plant cover, soil washed away, and with soil erosion the nutritional base was reduced as well.

Another cause of declining civilization comes with pressure of population on available land. A point is reached where the land can no longer support both the people and their domestic animals. Horses and mules disappear first. Finally even the versatile water buffalo is displaced by man who is two and one half times as efficient an energy converter as are draft animals. It must always be remembered that while domestic animals and agricultural machines increase productivity per man, maximum productivity per acre is achieved only by intensive manual cultivation.

It is a sobering thought that the impoverished people of Asia, who today seldom go to sleep with their hunger completely satisfied, were once far more civilized and lived much better than the people of the West. And, not so very long ago, either. It was the stories brought back by Marco Polo of the marvelous civilization in China, which turned Europe's eyes to the riches of the East, and induced adventurous sailors to brave the high seas in their small vessels searching for a direct route to the fabulous Orient. The "wealth of the Indies" is a phrase still used, but whatever wealth may be there it certainly is not evident in the life of the people today.

Asia failed to keep technological pace with the needs of her growing populations and sank into such poverty that in many places man has become again the primary source of energy, since other energy converters have become too expensive. This must be obvious to the most casual observer. What this means is quite simply a reversion to a more primitive stage of civilization with all that it implies for human dignity and happiness.

Anyone who has watched a sweating Chinese farm worker strain at his heavily laden wheelbarrow, creaking along a cobblestone road, or who has flinched as he drives past an endless procession of human beasts of burden moving to market in Java - the slender women bent under mountainous loads heaped on their heads - anyone who has seen statistics translated into flesh and bone, realizes the degradation of man's stature when his muscle power becomes the only energy source he can afford. Civilization must wither when human beings are so degraded.

Where slavery represented a major source of energy, its abolition had the immediate effect of reducing energy consumption. Thus when this time-honored institution came under moral censure by Christianity, civilization declined until other sources of energy could be found. Slavery is incompatible with Christian belief in the worth of the humblest individual as a child of God. As Christianity spread through the Roman Empire and masters freed their slaves - in obedience to the teaching of the Church - the energy base of Roman civilization crumbled. This, some historians believe, may have been a major factor in the decline of Rome and the temporary reversion to a more primitive way of life during the Dark Ages. Slavery gradually disappeared throughout the Western world, except in its milder form of serfdom. That it was revived a thousand years later merely shows **man’s ability to stifle his conscience - at least for a while - when his economic needs are great.** Eventually, even the needs of overseas plantation economies did not suffice to keep alive a practice so deeply repugnant to Western man's deepest convictions.

It may well be that it was unwillingness to depend on slave labor for their energy needs which turned the minds of medieval Europeans to search for alternate sources of energy, thus sparking the **Power Revolution of the Middle Ages** which, in turn, paved the way for the Industrial Revolution of the 19th Century. When slavery disappeared in the West, engineering advanced. Men began to harness the power of nature by utilizing water and wind as energy sources. The sailing ship, in particular, which replaced the slave-driven galley of antiquity, was vastly improved by medieval shipbuilders and became the first machine enabling man to control large amounts of inanimate energy.

The next important high-energy converter used by Europeans was gunpowder - an energy source far superior to the muscular strength of the strongest bowman or lancer. With ships that could navigate the high seas and arms that could out fire any hand weapon, Europe was now powerful enough to preempt for herself the vast empty areas of the Western Hemisphere into which she poured her surplus populations to build new nations of European stock. With these ships and arms she also gained political control over populous areas in Africa and Asia from which she drew the raw materials needed to speed her industrialization, thus complementing her naval and military dominance with economic and commercial supremacy.

When a low-energy society comes in contact with a high-energy society, the advantage always lies with the latter. The Europeans not only achieved standards of living vastly higher than those of the rest of the world, but they did this while their population was growing at rates far surpassing those of other peoples. In fact, they doubled their share of total world population in the short span of three centuries. From one sixth in 1650, the people of European stock increased to almost one third of total world population by 1950.

Meanwhile much of the rest of the world did not even keep energy sources in balance with population growth. Per capita energy consumption actually diminished in large areas. It is this difference in energy consumption, which has resulted in an ever-widening gap between the one-third minority who live in high-energy countries and the two-thirds majority who live in low-energy areas.

These so-called underdeveloped countries are now finding it far more difficult to catch up with the fortunate minority than it was for Europe to initiate transition from low-energy to high-energy consumption. For one thing, their ratio of land to people is much less favorable; for another, they have no outlet for surplus populations to ease the transition since all the empty spaces have already been taken over by people of European stock.

Almost all of today's low-energy countries have a population density so great that it perpetuates dependence on intensive manual agriculture, which alone can yield barely enough food for their people. They do not have enough acreage, per capita, to justify using domestic animals or farm machinery, although better seeds, better soil management, and better hand tools could bring some improvement. A very large part of their working population must nevertheless remain on the land, and this limits the amount of surplus energy that can be produced. Most of these countries must choose between using this small energy surplus to raise their very low standard of living or postpone present rewards for the sake of future gain by investing the surplus in new industries. The choice is difficult because there is no guarantee that today's denial may not prove to have been in vain. This is so because of the rapidity with which public health measures have reduced mortality rates, resulting in population growth as high or even higher than that of the high-energy nations. Theirs is a bitter choice; it accounts for much of their anti-Western feeling and may well portend a prolonged period of world instability.

How closely energy consumption is related to standards of living may be illustrated by the example of India. Despite intelligent and sustained efforts made since independence, India's per capita income is still only 20 cents daily; her infant mortality is four times ours; and the life expectance of her people is less than one half that of the industrialized countries of the West. These are ultimate consequences of India's very low energy consumption: one-fourteenth of world average, one-eightieth of ours.

Ominous, too, is the fact that while world food production increased 9% in the six years from 1945-51, world population increased by 12%. Not only is world population increasing faster than world food production but unfortunately, increases in food production tend to occur in the already well-fed, high-energy countries rather than in the undernourished, low-energy countries where food is most lacking.

I think no further elaboration is needed to demonstrate the significance of energy resources for our own future. **Our civilization rests upon a technological base, which requires enormous quantities of fossil fuels.** What assurance do we then have that our energy needs will continue to be supplied by fossil fuels: The answer is - in the long run - none.

The earth is finite. Fossil fuels are not renewable. In this respect, our energy base differs from that of all earlier civilizations. They could have maintained their energy supply by careful cultivation. We cannot. Fuel that has been burned is gone forever. Fuel is even more evanescent than metals. Metals, too, are non-renewable resources threatened with ultimate extinction, but something can be salvaged from scrap. Fuel leaves no scrap and there is nothing man can do to rebuild exhausted fossil fuel reserves. They were created by solar energy 500 million years ago and took eons to grow to their present volume.

In the face of the basic fact that fossil fuel reserves are finite, the exact length of time these reserves will last is important in only one respect: the longer they last, the more time do we have, to invent ways of living off renewable or substitute energy sources and to adjust our economy to the vast changes which we can expect from such a shift.

Fossil fuels resemble capital in the bank. A prudent and responsible parent will use his capital sparingly in order to pass on to his children as much as possible of his inheritance. A selfish and irresponsible parent will squander it in riotous living and care not one whit how his offspring will fare.

Engineers whose work familiarizes them with energy statistics; far-seeing industrialists who know that energy is the principal factor which must enter into all planning for the future; responsible governments who realize that the well-being of their citizens and the political power of their countries depend on adequate energy supplies - all these have begun to be concerned about energy resources. In this country, especially, many studies have been made in the last few years, seeking to discover accurate information on fossil-fuel reserves and foreseeable fuel needs.

Statistics involving the human factor are, of course, never exact. The size of usable reserves depends on the ability of engineers to improve the efficiency of fuel extraction and use. It also depends on discovery of new methods to obtain energy from inferior resources at costs, which can be borne without unduly depressing the standard of living. Estimates of future needs, in turn, rely heavily on population figures, which must always allow for a large element of uncertainty, particularly as man reaches a point where he is more and more able to control his own way of life.

Current estimates of fossil fuel reserves vary to an astonishing degree. In part this is because the results differ greatly if cost of extraction is disregarded or if in calculating how long reserves will last, population growth is not taken into consideration; or, equally important, not enough weight is given to increased fuel consumption required to process inferior or substitute metals. We are rapidly approaching the time when exhaustion of better grade metals will force us to turn to poorer grades requiring in most cases greater expenditure of energy per unit of metal.

But the most significant distinction between optimistic and pessimistic fuel reserve statistics is that the optimists generally speak of the immediate future - the next twenty-five years or so - while the pessimists think in terms of a century from now. A century or even two is a short span in the history of a great people. It seems sensible to me to take a long view, even if this involves facing unpleasant facts.

For it is an unpleasant fact that according to our best estimates, total fossil fuel reserves recoverable at not over twice today's unit cost, are likely to run out at some time between the years 2000 and 2050, if present standards of living and population growth rates are taken into account. Oil and natural gas will disappear first, coal last. There will be coal left in the earth, of course. But it will be so difficult to mine that energy costs would rise to economically intolerable heights, so that it would then become necessary either to discover new energy sources or to lower standards of living drastically.

For more than one hundred years we have stoked ever growing numbers of machines with coal; for fifty years we have pumped gas and oil into our factories, cars, trucks, tractors, ships, planes, and homes without giving a thought to the future. Occasionally the voice of a Cassandra has been raised only to be quickly silenced when a lucky discovery revised estimates of our oil reserves upward, or a new coalfield was found in some remote spot. Fewer such lucky discoveries can be expected in the future, especially in industrialized countries where extensive mapping of resources has been done. Yet the popularizers of scientific news would have us believe that there is no cause for anxiety, that reserves will last thousands of years, and that before they run out science will have produced miracles. Our past history and security have given us the sentimental belief that the things we fear will never really happen - that everything turns out right in the end. But, prudent men will reject these tranquilizers and prefer to face the facts so that they can plan intelligently for the needs of their posterity.

Looking into the future, from the mid-20th Century, we cannot feel overly confident that present high standards of living will of a certainty continue through the next century and beyond. Fossil fuel costs will soon definitely begin to rise as the best and most accessible reserves are exhausted, and more effort will be required to obtain the same energy from remaining reserves. It is likely also that liquid fuel synthesized from coal will be more expensive. Can we feel certain that when economically recoverable fossil fuels are gone science will have learned how to maintain a high standard of living on renewable energy sources?

I believe it would be wise to assume that the principal renewable fuel sources which we can expect to tap before fossil reserves run out will supply only 7 to 15% of future energy needs. The five most important of these renewable sources are wood fuel, farm wastes, wind, water power, and solar heat.

Wood fuel and farm wastes are dubious as substitutes because of growing food requirements to be anticipated. Land is more likely to be used for food production than for tree crops; farm wastes may be more urgently needed to fertilize the soil than to fuel machines.

Wind and water power can furnish only a very small percentage of our energy needs. Moreover, as with solar energy, expensive structures would be required, making use of land and metals, which will also be in short supply. Nor would anything we know today justify putting too much reliance on solar energy though it will probably prove feasible for home heating in favorable localities and for cooking in hot countries, which lack wood, such as India.

More promising is the outlook for nuclear fuels. These are not, properly speaking, renewable energy sources, at least not in the present state of technology, but their capacity to "breed" and the very high energy output from small quantities of fissionable material, as well as the fact that such materials are relatively abundant, do seem to put nuclear fuels into a separate category from exhaustible fossil fuels. The disposal of radioactive wastes from nuclear power plants is, however, a problem which must be solved before there can be any widespread use of nuclear power.

Another limit in the use of nuclear power is that we do not know today how to employ it otherwise than in large units to produce electricity or to supply heating. Because of its inherent characteristics, nuclear fuel cannot be used directly in small machines, such as cars, trucks, or tractors. It is doubtful that it could in the foreseeable future furnish economical fuel for civilian airplanes or ships, except very large ones. Rather than nuclear locomotives, it might prove advantageous to move trains by electricity produced in nuclear central stations. We are only at the beginning of nuclear technology, so it is difficult to predict what we may expect.

Transportation - the lifeblood of all technically advanced civilizations - seems to be assured, once we have borne the initial high cost of electrifying railroads and replacing buses with streetcars or interurban electric trains. But, unless science can perform the miracle of synthesizing automobile fuel from some energy source as yet unknown or unless trolley wires power electric automobiles on all streets and highways, it will be wise to face up to the possibility of the ultimate disappearance of automobiles, trucks, buses, and tractors.

Before all the oil is gone and hydrogenation of coal for synthetic liquid fuels has come to an end, the cost of automotive fuel may have risen to a point where private cars will be too expensive to run and public transportation again becomes a profitable business.

Today the automobile is the most uneconomical user of energy. Its efficiency is 5% compared with 23% for the Diesel-electric railway. It is the most ravenous devourer of fossil fuels, accounting for over half of the total oil consumption in this country. **And the oil we use in the United States in one year took nature about 14 million years to create.** Curiously, the automobile, which is the greatest single cause of the rapid exhaustion of oil reserves, may eventually be the first fuel consumer to suffer. Reduction in automotive use would necessitate an extraordinarily costly reorganization of the pattern of living in industrialized nations, particularly in the United States. It would seem prudent to bear this in mind in future planning of cities and industrial locations.

Our present known reserves of fissionable materials are many times as large as our net economically recoverable reserves of coal. A point will be reached before this century is over when fossil fuel costs will have risen high enough to make nuclear fuels economically competitive. Before that time comes we shall have to make great efforts to raise our entire body of engineering and scientific knowledge to a higher plateau. We must also induce many more young Americans to become metallurgical and nuclear engineers. Else we shall not have the knowledge or the people to build and run the nuclear power plants, which ultimately may have to furnish the major part of our energy needs. If we start to plan now, we may be able to achieve the requisite level of scientific and engineering knowledge before our fossil fuel reserves give out, but the margin of safety is not large. This is also based on the assumption that atomic war can be avoided and that population growth will not exceed that now calculated by demographic experts.

War, of course, cancels all man's expectations. Even growing world tension just short of war could have far-reaching effects. In this country it might, on the one hand, lead to greater conservation of domestic fuels, to increased oil imports, and to acceleration in scientific research, which might turn up unexpected new energy sources. On the other hand, the resulting armaments race would deplete metal reserves more rapidly, hastening the day when inferior metals must be utilized with consequent greater expenditure of energy. Underdeveloped nations with fossil fuel deposits might be coerced into withholding them from the free world or they may decide to retain them for their own future use. The effect on Europe, which depends on coal and oil imports, would be disastrous and we would have to share our own supplies or lose our allies.

Barring atomic war or unexpected changes in the population curve, we can count on an increase in world population from two and one half billion today to four billion in the year 2000; six to eight billion by 2050. The United States is expected to quadruple its population during the 20th Century from 75 million in 1900 to 300 million in 2000 - and to reach at least 375 million in 2050. This would almost exactly equal India's present population, which she supports on just a little under half of our land area.

It is an awesome thing to contemplate a graph of world population growth from prehistoric times - tens of thousands of years ago - to the day after tomorrow - let us say the year 2000 A.D. If we visualize the population curve as a road, which starts at sea level and rises in proportion as world population increases, we should see it stretching endlessly, almost level, for 99% of the time that man has inhabited the earth. In 6000 B.C., when recorded history begins, the road is running at a height of about 70 feet above sea level, which corresponds to a population of 10 million. Seven thousand years later - in 1000 A.D. - the road has reached an elevation of 1,600 feet; the gradation now becomes steeper, and 600 years later the road is 2,900 feet high. During the short span of the next 400 years from 1600 to 2000 - it suddenly turns sharply upward at an almost perpendicular inclination and goes straight up to an elevation of 29,000 feet - the height of Mt. Everest, the world's tallest mountain.

In the 8,000 years from the beginning of history to the year 2000 A.D. world population will have grown from 10 million to 4 billion, with 90% of that growth taking place during the last 5% of that period, in 400 years. It took the first 3,000 years of recorded history to accomplish the first doubling of population, 100 years for the last doubling, but the next doubling will require only 50 years. Calculations give us the astonishing estimate that one out of every 20 human beings born into this world is alive today.

The rapidity of population growth has not given us enough time to readjust our thinking. Not much more than a century ago our country the very spot on which I now stand was a wilderness in which a pioneer could find complete freedom from men and from government. If things became too crowded - if he saw his neighbor's chimney smoke - he could, and often did, pack up and move west. We began life in 1776 as a nation of less than four million people - spread over a vast continent - with seemingly inexhaustible riches of nature all about**. We conserved what was scarce - human labor - and squandered what seemed abundant - natural resources - and we are still doing the same today.**

Much of the wilderness which nurtured what is most dynamic in the American character has now been buried under cities, factories and suburban developments where each picture window looks out on nothing more inspiring than the neighbor's back yard with the smoke of his fire in the wire basket clearly visible.

Life in crowded communities cannot be the same as life on the frontier. We are no longer free, as was the pioneer - to work for our own immediate needs regardless of the future. We are no longer as independent of men and of government as were Americans two or three generations ago. **An ever larger share of what we earn must go to solve problems caused by crowded living** - bigger governments; bigger city, state, and federal budgets to pay for more public services. Merely to supply us with enough water and to carry away our waste products becomes more difficult and expansive daily. More laws and law enforcement agencies are needed to regulate human relations in urban industrial communities and on crowded highways than in the America of Thomas Jefferson.

Certainly no one likes taxes, but we must become reconciled to larger taxes in the larger America of tomorrow.

I suggest that this is a good time to think soberly about our responsibilities to our descendents - those who will ring out the Fossil Fuel Age. Our greatest responsibility, as parents and as citizens, is to give America's youngsters the best possible education. We need the best teachers and enough of them to prepare our young people for a future immeasurably more complex than the present, and calling for ever larger numbers of competent and highly trained men and women. This means that we must not delay building more schools, colleges, and playgrounds. It means that we must reconcile ourselves to continuing higher taxes to build up and maintain at decent salaries a greatly enlarged corps of much better trained teachers, even at the cost of denying ourselves such momentary pleasures as buying a bigger new car, or a TV set, or household gadget. We should find - I believe - that these small self-denials would be far more than offset by the benefits they would buy for tomorrow's America. We might even - if we wanted - give a break to these youngsters by cutting fuel and metal consumption a little here and there so as to provide a safer margin for the necessary adjustments, which eventually must be made in a world without fossil fuels.

One final thought I should like to leave with you. High-energy consumption has always been a prerequisite of political power. The tendency is for political power to be concentrated in an ever-smaller number of countries. Ultimately, the nation, which control - the largest energy resources will become dominant. If we give thought to the problem of energy resources, if we act wisely and in time to conserve what we have and prepare well for necessary future changes, we shall insure this dominant position for our own country.

~~~~~~~~~~~~~~~ Editorial Notes ~~~~~~~~~~~~~~~~~~~

Contributor Rick Lakin writes:

> *Admiral Rickover was considered the Father of the Nuclear Submarine. As an employee of the US Atomic Energy Commission, later Department of Energy, he had great influence on the development of our country's civilian Nuclear Power Generation Industry.*
>
> *This speech, given almost 50 years ago, sheds an important light on our current discussion about the future of energy in our country. In the 1970s, Admiral Rickover worked closely with President Jimmy Carter on energy issues. I served on Navy Nuclear Submarines as a Nuclear Reactor Operator for 8 years.*
>
> *I would like to give special thanks to Theodore Rockwell, author of* ***The Rickover Effect: How One Man Made a Difference*** *for searching his files and sending me a copy of this speech so that I could convert it for digital publication. Mr. Rockwell has a more recent book,* ***Creating the New World:***

***Stories & Images from the Dawn of the Atomic Age**. Both are available on amazon.com.*

Biography of Hyman G. Rickover from Wikipedia:en.wikipedia.org/wiki/Hyman_G._Rickover

Many thanks to Rick Lakin and Theodore Rockwell who have made this historic document available. Rickover's speech was covered in an excellent 1957 article in the Christian Science Monitor that EB just posted: Admiral Rickover: The future of fossil fuels.

This document is also posted at http://www.hilltoplancers.org/photos/rickover0557.pdf.

UPDATE (July 1, 2007) Admiral Rickover's speech has just been reposted on The Oil Drum by Gail Tverberg.

APPENDIX C

Energy Returned On Energy Invested - EROEI

By Cleveland, Costanza, Hall & Kauffman (1984)

Process	**Energy Profit Ratio**		
Non Renewable			
Oil & Gas (domestic wellhead)	Production		Discovery
1940's			**>100**
1970's	**23**		**8**
Coal (mine mouth)	**< Lo**		**Hi >**
1950's		**80**	
1970's		**30**	
Oil Shale	**0.7**		**13.3**
Coal Liquefaction	**0.5**		**8.2**
Geo-pressured gas	**1**		**5**
Renewable			
Ethanol (sugarcane)	**0.8**		**1.7**
Ethanol (corn)			
Ethanol (corn residues)	**0.7**		**1.8**
Methanol (wood)		**2.6**	
Solar space heat (fossil backup)			
Flat Plate Collector		**1.9**	
Concentrating Collector		**1.6**	
Electricity Production			
Coal			
US Average		**9**	
Western Surface Coal			
No Scrubbers		**6**	
Scrubbers		**2.5**	

David Pimentel Study: Cornell Univ.

ETHANOL EROEI	Gallons
1 Acre yield:	328
Agricultural Costs:	-140
Distilling Costs	??
	<u>BTU</u>
Make 1 Gallon	133,000
Energy in 1 Gallon	77,000
REAL YIELD	0.59

That is a 41% LOSS of ENERGY

NUCLEAR FUSION is great, but …

<u>Hurdles to Nuclear Fusion include:</u>
* Reactor Temperatures in the range of 360 MILLION degrees Fahrenheit
* Billions spent - but NO reactor has yet produced more than it has spent.
* AND the PROMOTERS agree it's 50 years away at best.

Will we have an industrial base to SUPPORT that effort over 50 years?

Hydropower	11.2		Hydro Looks **GOOD**, huh?
Nuclear (light-water)	4		
Solar			
Power Satellite	2		
Power Tower	4.2		
Photovoltaics	1.7	10	

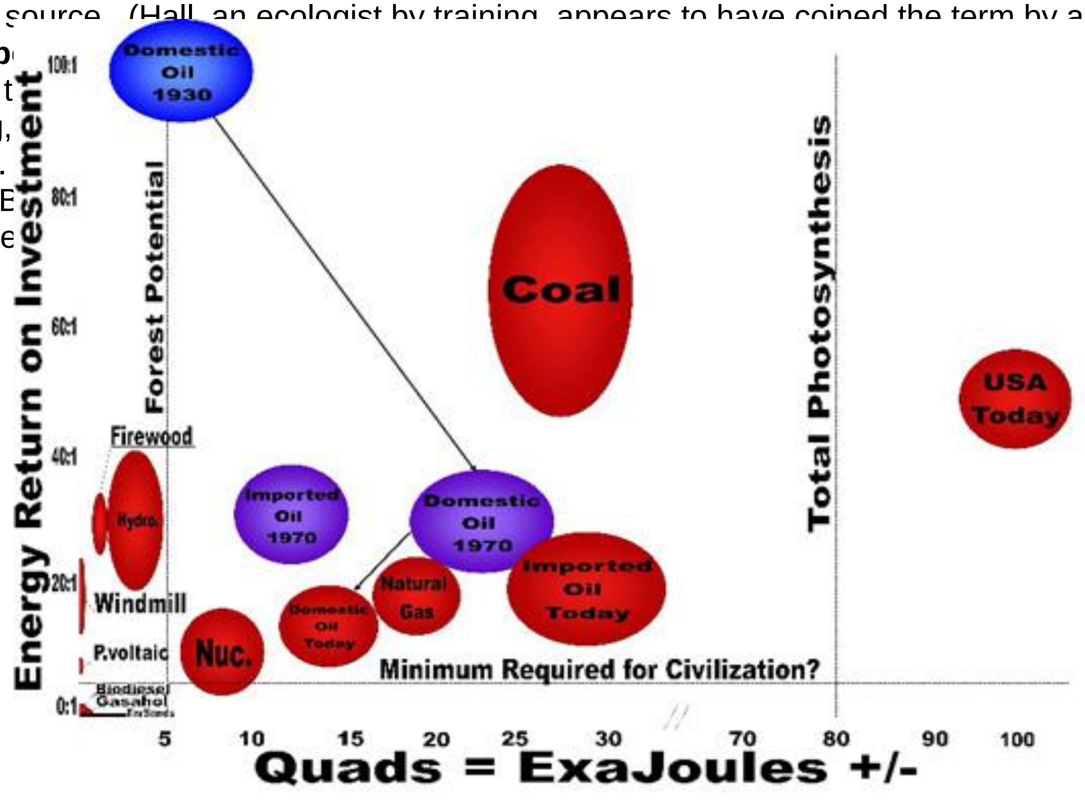
NOTHING Lasts forever
That's back to the issue of our base …
Are we going to build these by **HAND**?

Energy researcher Charlie Hall's balloon graph challenges the notion that alternative energy sources will provide a smooth transition to a post-fossil fuel society. Scale and energy return remain huge obstacles.

Charlie Hall, professor, State University of New York College of Environmental Science and Forestry, Syracuse, New York 13210, is one the best-known energy researchers you've never heard of. That's because he puts his effort into understanding whole energy systems such as human civilization rather than perfecting headline-grabbing energy panaceas such as corn ethanol. From the early 1980s onward Hall and his colleagues--some of them former students--have been warning that a society hooked on fossil fuels would find itself up against limits not easily breached--probably sooner rather than later.

With the current boom in biofuels, wind, and solar, and even a revival in nuclear power, many people believe that a smooth transition to a post-fossil fuel economy is already a foregone conclusion. But a careful look at Charlie Hall's balloon graph tells a different and much more disconcerting story (1). (To view a larger version of the graph, click here or on the graph itself.)

First, let's look at the components of the chart. On the vertical axis we have energy return on investment (EROI) expressed as the ratio of energy output versus energy input for each energy source. (Hall, an ecologist by training, appears to have coined the term by adapting
"**yield p** ...
people t ... ting,
refining, ... of
society. ... n
BTUs (E ... he
principle



The various colors put focus on the annual production totals and energy return of oil at different times. The sizes for all the balloons represent a very rough guide to the uncertainties in calculating EROI ranges. (As we shall see, even with these uncertainties there is a very large discernible gap between what we currently get from fossil fuels and what we can expect to get from alternatives.)

Oil, which makes up the largest percentage of U.S. energy consumption today (40%), has shown a substantial increase in its total output even as its EROI has fallen. To see this on the graph look at the blue balloon labeled "Domestic Oil 1930," the purple balloons labeled "Imported Oil 1970" and "Domestic Oil 1970" and the red balloons labeled "Domestic Oil Today" and "Imported Oil Today." That same move to a lower EROI is also being seen for natural gas and coal though the balloon graph does not depict these trends.

Everyone knows that at some point fossil fuel supplies, which are finite, will begin to decline. To replace them we currently have biofuels such as biodiesel; other renewables such as wind, photovoltaic, and hydroelectric; and nuclear power. Oil from tar sands is also shown in the lower left-hand corner, but you have to look hard. And, that's just the point. You have to look pretty hard to see these alternatives on the graph. There are two reasons for this. First, some of these new sources are not very far along in their deployment. As they are more widely deployed, they will supply more total power and move to the right on the graph. Second, the EROI for biofuels such as biodiesel and for unconventional oil such as that extracted from tar sands is extremely low. Given current technology, these alternatives are not likely to move upward very much on the graph anytime soon.

Hall believes we have two problems illustrated by his balloon chart. First, in order for these alternative sources to move rightward on the graph--that is, produce much larger quantities of energy for society--they will have to be deployed on a vast scale which few people contemplate or understand. Two examples come to mind. The worldwide installed capacity of solar photovoltaic cells is 10.9 gigawatts. With the total worldwide installed electrical generating base at 3,872 gigawatts<http://www.eia.doe.gov/pub/international/iealf/table64.xls>, it would take more than 2,000 years at the current rate of installation (1.74 gigawatts/year) <http://www.solarbuzz.com/Marketbuzz2007-intro.htm>to reach today's capacity. And that's without even considering future growth in electricity demand. If we include the installed base of wind (74.3 gigawatts) and the current rate of wind installations (14.9 gigawatts/year) <www.awea.org>, we can bring the figure all the way down to about 230 years, again without considering growth in demand. Of course, the rates of installation will grow, and there are other renewable and nonrenewable energy sources available. But the challenge of scale remains huge.

When it comes to biofuels, the scale problem gets no better. Biofuels researcher Tad Patzek uses corn ethanol as an example. To fuel the American vehicle fleet using corn ethanol:

> [o]ne would have to grow corn on 1.8 billion acres, year-after-year, for decades. There are about 400 million acres of arable land now in cultivation in the U.S. Therefore, one would have to use the land area equal to 4.5 times the current arable land area....

If we want to continue living in the kind of energy-drenched civilization we now enjoy, we will have to move simultaneously rightward *and* upward on the balloon graph. Hall estimates that if society were to average less than a 5 to 1 ratio of EROI, anything resembling our modern civilization would probably not function. The balloon graph suggests a minimum EROI for the United States of around 40 to 1 for 100 quads of energy generated. Therefore, without major breakthroughs in the efficiency of alternative energy sources, no combination of those sources has the prospect of giving us both the high energy returns and the large total production we are accustomed to from our current energy sources.

(It's important to note that nearly all the good sites for hydro power in the world have already been taken. And, turning to firewood for fuel would simply result in the leveling of the world's remaining forests, leaving us with nothing for the future and destroying the habitability of the planet in the bargain. The upshot: Neither of these alternatives is going to move much to the right on the graph.)

Many are saying peak world oil production will soon be upon us with peak natural gas and coal following close behind. To live anything like we now live, we are going to have to see some astounding technical breakthroughs in alternative energy sources soon. And those breakthroughs will have to be followed by dramatic and costly efforts to deploy alternatives rapidly and ubiquitously. For now we appear to be on a course that will require drastic changes in the way we live.

Perhaps we will somehow muddle through. But when you look at Charlie Hall's balloon graph, it's easy to conclude that even muddling through might end up being a very unpleasant affair.

Notes:

(1) Hall, C.A.S., R. Powers and W. Schoenberg. (in press). Peak oil, EROI, investments and the economy in an uncertain future. Pp. xxx-xxx in Pimentel, David. (ed). *Renewable Energy Systems: Environmental and Energetic Issues*.

APPENDIX D

As hybrid cars gobble rare metals, shortage looms
By Steve Gorman Posted Mon Aug 31, 2009 1:03am PDT

A piece of bastnasite ore, which contains rare earth elements, is shown by Brock O'Kelly from Molycorp Minerals Mountain pass Mine in Mountain Pass, Califonia August 19, 2009. REUTERS/David Becker

LOS ANGELES (Reuters) - The Prius hybrid automobile is popular for its fuel efficiency, but its electric motor and battery guzzle rare earth metals, a little-known class of elements found in a wide range of gadgets and consumer goods.

That makes Toyota's market-leading gasoline-electric hybrid car and other similar vehicles vulnerable to a supply crunch predicted by experts as China, the world's dominant rare earths producer, limits exports while global demand swells.

Worldwide demand for rare earths, covering 15 entries on the periodic table of elements, is expected to exceed supply by some 40,000 tons annually in several years unless major new production sources are developed. One promising U.S. source is a rare earths mine slated to reopen in California by 2012.

Among the rare earths that would be most affected in a shortage is neodymium, the key component of an alloy used to make the high-power, lightweight magnets for electric motors of hybrid cars, such as the Prius, Honda Insight and Ford Focus, as well as in generators for wind turbines.

Close cousins terbium and dysprosium are added in smaller amounts to the alloy to preserve neodymium's magnetic properties at high temperatures. Yet another rare earth metal, lanthanum, is a major ingredient for hybrid car batteries.

Production of both hybrids cars and wind turbines is expected to climb sharply amid the clamor for cleaner transportation and energy alternatives that reduce dependence on fossil fuels blamed for global climate change.

Toyota has 70 percent of the U.S. market for vehicles powered by a combination of an internal-combustion engine and electric motor. The Prius is its No. 1 hybrid seller.

Jack Lifton, an independent commodities consultant and strategic metals expert, calls the Prius "the biggest user of rare earths of any object in the world."

Each electric Prius motor requires 1 kilogram (2.2 lb) of neodymium, and each battery uses 10 to 15 kg (22-33 lb) of lanthanum. That number will nearly double under Toyota's plans to boost the car's fuel economy, he said.

Toyota plans to sell 100,000 Prius cars in the United States alone for 2009, and 180,000 next year. The company forecasts sales of 1 million units per year starting in 2010.

As China's industries begin to consume most of its own rare earth production, Toyota and other companies are seeking to secure reliable reserves for themselves.

Reuters reported last year that Japanese firms are showing strong interest in a Canadian rare earth site under development at Thor Lake in the Northwest Territories.

A Toyota spokeswoman in Los Angeles said the automaker would not comment on its resource development plans. But media accounts and industry blogs have reported recently that Toyota has looked at rare earth possibilities in Canada and Vietnam.

(Editing by Alan Elsner and Mary Milliken)

APPENDIX E

Epic Disappointment
By James Howard Kunstler
on November 19, 2012 9:01 AM

Those inhabiting the economic wish-space got a case of the vapors last week when the Paris-based International Energy Agency (IEA) published an annual report stating that the USA would overtake Saudi Arabia as the world's leading oil producer and reach the long-touted nirvana of "energy independence." The news was greeted in this country with jubilation. Thus, peak credulity meets peak bullshit.

It's been clear for a while that authorities in many realms of endeavor - politics, economics, business, media - are very eager to sustain the illusion that we can keep our way of life chugging along. But under the management of these elites, the divorce between truth and reality is nearly complete. The financial system now runs entirely on accounting fraud. Government runs on the fumes of statistical fraud. The business of oil and gas runs on public relations fraud. And the media runs on the understandable wish of the masses to believe that all the foregoing illusions still work to maintain the familiar comforts of modern life (minus Hostess Ho-Hos and Twinkies, alas).

And so the story has developed that the shale oil plays of North Dakota and Texas, which started ramping up around 2005 - the same year the world hit the wall of peak conventional oil - and the shale gas plays in Texas, Louisiana, Pennsylvania, New York, and Ohio would enable American "consumers" to drive to WalMart effectively forever.

Now, it happens that the particulars of oil and gas production are so abstruse that the editors of *The New York Times*, The Bloomberg News Service, CNN, and a score of other mass media giants swallowed the IEA report whole, with fanfares and fireworks, and a nation afflicted with doubt about its future swooned into the first week of the holidays in celebration mode - we're soon to be number 1 again, and the future is secure! Have a nice Thanksgiving and Christmas and prepare to sober up in 2013. When the truth finally emerges from this morass of dissimulation, the disappointment will be epic.

Here's why the shale oil story is not the "game changer" that the wishful claim it is: the price required to get it out of the ground (between $80-90 a barrel) will crush the US economy. Since prices are already in that range, the economy is already being crushed. The result is an economy in more-or-less permanent contraction. As demand for oil falls with declining economic activity the price of oil falls - below the level that makes it worthwhile to conduct expensive shale oil drilling and fracking operations.

Meanwhile, in the background, as economies contract and economic "growth" of the type our system requires no longer happens, the problems in finance and banking get a lot worse. This is largely because interest on borrowed money can no longer be paid back. Loans are defaulted on. As this happens, banks become insolvent. Governments play games with public money - including "money" they "create" out of thin air - to prop up the banks. None of it alters the sad fact that there is not enough real money in the system. The result of all these desperate monkeyshines is the impairment if capital formation. That is, the failure to accumulate new wealth along with declining prospects for the repayment of loans, leads to a shortage of credit, especially to businesses that require large supplies of it to keep gigantic complex operations like shale oil and gas going.

Shale oil (and shale gas) share some problematical properties. The cost of drilling each well is a big number, $6-8 million. The wells deplete very rapidly, over 40 percent after one year in the Bakken formation of North Dakota. The oil is not distributed equally over the whole play but exists in "sweet spots." The sweetest sweet spots were drilled the earliest and the quality of the remaining potential drill sites is already in decline. The current trend shows declining first-year productivity in new wells drilled since 2010 running at 25 percent.

There are over 4,300 wells for shale oil in the Bakken formation of North Dakota producing about 610,000 barrels a day. In order to keep production up, the number of wells will have to continue increasing at a faster rate than previously. This is referred to as "the Red Queen syndrome" which alludes to the character in *Alice in Wonderland* who famously declared that she had to run faster and faster just to stay where she is. The catch to all this is that the impairments of capital formation are working insidiously in the background to guarantee that the money will not be there to set up the necessary wells to keep production at current levels. In other words, shale oil (and shale gas) are Ponzi schemes. The story in the Eagle Ford play in Texas is very similar.

I haven't even mentioned the concerns about fracking and its effect on ground water, and won't go into it here, except to acknowledge that it presents an additional range of concerns.

The current price situation in shale gas is different than shale oil. The drilling frenzy in shale gas produced a glut, which drove down prices from a $13 a unit (thousand cubic feet or mcf) to around $2 at its low point earlier this year. That's way below the price that is economically rational to drill and frack for it. The price collapse has played havoc among the companies engaged in shale gas, though it has been a boon to customers. A lot of the drilling equipment has moved to the North Dakota oil fields. There will be less shale gas in the period ahead and the price will go up. It has got to go above about $8 a unit or there will be no reason for any company to be in the shale gas business. But as is always the case in such a correction, the price will surely overshoot $8, at which point it will become unaffordable to its customers. The volatility alone will make the business of shale gas drilling impossible to maintain. Forget about the USA becoming a major gas exporter.

You probably get the point by now, so I will only add a couple of out-of-the-box considerations vis-à-vis the prospect of the USA becoming energy independent.

-- Production is getting so low in the Prudhoe Bay fields of Alaska that the famous pipeline may not be able to operate. If the flow of oil reaches a certain low volume, it takes longer to make the long journey. The oil cools down and gets sludgy and some of the water that travels with it will freeze. This could destroy the pipeline. The capital is not there to retrofit the pipeline for a depleting oil field in a region that is difficult and expensive to work in.

-- Exporting countries (the ones that send us oil) are depleting their reserves and using more of their own oil, resulting in annually declining export rates. China, India, and other still-modernizing nations compete for a growing share of that declining export flow.

-- I have barely hinted at the geopolitical forces roiling behind the sheer business dynamics. But here's an interesting one: the time will come when the US will invoke the Monroe Doctrine to prevent Canada from sending its oil and tar-sand byproducts to nations other than ourselves. Just wait.

Finally, I have one flat-out prediction. One I have made before but deserves repeating: Japan will be the first society to consciously opt out of being an advanced industrial economy. They have no other apparent choice really, having next-to-zero oil, gas, or coal reserves of their own, and having lost faith in nuclear power. They will be the first country to enter a world made by hand. They were very good at it before about 1850 and had a pre-industrial culture of high artistry and grace - though, granted, all the defects of human psychology.

I don't think the U.S. can make that transition in an orderly way. We're too stricken with techno-narcissism and grandiosity. What troubles me is how we will greet the epic disappointment that waits for us when we discover that the journey to WalMart is over. My guess is that being predisposed to superstition and religious fanaticism, the American public will violently reject science and rationality and retreat into a world of shadows. We're already well on our way. The IEA report will just accelerate things.

APPENDIX F

Renewable Energy's Sixty Years Of Broken Dreams, But Keep Those Ideas Coming

By Bruce Upbin
Forbes magazine Staff
11/22/2011 @ 11:15AM

This is an excerpt from a Nov. 21, 2011 research note by Michael Cembalest, the chief investment officer for JPMorgan Private Bank. You can read the entire note here, and you should, especially if you care about redressing misperceptions that lead to flawed energy policies. His conclusion is that our quest for fossil-fuel replacements has led us to ignore economic (and thermodynamic) realities. Energy policy too often disregards the art of the possible for a future that may never arrive. The note concludes with one potentially game-changing idea but, like all the ideas before it, should come with the assumption that it, too, will fail.

This year, a look at something just as worrying in the long run as the fiscal problems of the West: **the search for energy solutions**. This journey has been fraught with similarly quixotic dead ends, fairy tales and blunders ignoring economic (and thermodynamic) realities. This is important to us, since energy cost and availability is central to how we think about growth, profits, stability and our portfolio investments. As part of this effort, I made a pilgrimage to Manitoba to spend a day with Vaclav Smil. Vaclav is one of the world's foremost experts on energy, and has written over 30 books and 300 papers on the subject (he's #49 on Foreign Policy's list of the 100 most influential thinkers). Vaclav's book "Energy Myths and Realities" should be required reading for politicians or regulators impacting energy policy. We start with an unflinching look at these realities before turning to solutions, and some potentially encouraging developments, which have less to do with how electricity is generated, and more to do with how it might be stored.

Over the last 50 years, a lot of proposed [energy] solutions have not panned out as expected. While the process of discovery and invention always includes large doses of failure, energy policy is different than say, cell phones or VCRs, since more public money, time and effort are spent on them. Hopes are raised, and as a result, less flashy but more reliable solutions are sometimes postponed or avoided altogether. Here are a few memorable predictions of our energy future:

- 1945. Oak Ridge National Laboratory nuclear physicists Weinberg and Soodak predict that nuclear breeders will be man's ultimate energy source; a decade later, the chairman of the US Atomic Energy Commission predict it would be "too cheap to meter"
- 1973. "Let this be our national goal: At the end of this decade, in the year 1980, the United States will not be dependent on any other country for the energy we need to provide our jobs, to heat our homes, and to keep our transportation moving." — Richard Nixon

- 1978. “Through modeling of supply and demand for over 200 US utilities it was projected that, by the year 2000, almost 60% of U.S. cars could be electrified, and that only 17% of the recharging power would come from petroleum”
- 1979. An influential Harvard Business School study projects that by 2000, the US could satisfy 20% of its energy needs through solar
- 1980. Physicist Bent Sorenson predicts that 49% of America’s energy could come from renewable sources by the year 2005
- 1994. Hypercar Center established, whose lightweight material and design would yield 200 mpg cars with a 95% decline in pollution
- 1994. InterTechnology Corporation predicts that solar energy would supply 36% of America’s industrial process heat by 2000
- 1995. Energy consultant and physicist Alfred Cavallo projects that wind could have a capacity factor of 60%, which when combined with compressed air storage, would rise to 70 – 95%
- 1999. US Department of Energy hopes to sequester 1 billion tonnes of carbon per year by 2025
- 2000. Fuel cell companies announce 250-kilowatt production plants that can fit into a conference room and produce energy at 10 cents per kilowatt hour, with the goal of 6 cents by 2003
- 2008. “Today I challenge our nation to commit to producing 100% of our electricity from renewable energy and truly clean carbon-free sources within 10 years. This goal is achievable, affordable and transformative.” Al Gore
- 2009. Gene scientist Craig Venter announces plans to develop next-generation biofuels from algae in a partnership with Exxon Mobil

How have things turned out? There are no commercial nuclear breeders on anyone’s horizon; global nuclear capacity is only 20% of the Atomic Energy Agency’s 1970 forecast; the Hypercar is nowhere to be seen; solar and wind make up a miniscule portion of U.S. electricity generation; wind capacity factors range from 20%-30%; the U.S. is reliant for 50% of its oil from foreign sources; 70% of U.S. electricity generation comes from coal and natural gas; fuel cells haven’t worked as expected; hybrids are 2% of US car sales; “clean coal” is mostly a blueprint; and Venter announced that his team failed to find naturally occurring algae that can be converted into commercial-scale biofuel (they will now work with synthetic strains instead).

Energy Information Agency	Installed base 2010 MW	Electricity gen in 2010 mm MWh	% of total gen.	Implied capacity factor	EIA Levelized cost 2016 per MWh	**<---Levelized cost incorporates upfront and ongoing capital costs, cost of capital, fuel and other operating costs, capacity factor and related power transmission investments (in 2009 dollars) for new construction**
Coal	316,800	1,847	45.4%	67%	$95 - $110	Abundant and cheap, but with a substantial range of environmental problems
Natural gas	407,028	988	24.3%	28%	$60 - $70	Capacity factors understate potential utilization
Nuclear	101,167	807	19.8%	91%	$114	Efficient once built; very expensive to build (costs rising sharply in recent decades)
Hydro	78,825	260	6.4%	38%	$86	Most viable sites already in use after incentives in the 1960s-1980s
Wind	39,135	95	2.3%	28%	$97	Low capacity factor, maturing technology; cost more than doubles offshore
Biomass/wood	11,406	56	1.4%	56%	$112	Expensive to aggregate and collect; high capital costs relative to energy density
Geothermal	2,405	18	0.4%	85%	$102	Very expensive, except near areas with active geothermal reservoirs
Solar PV/CSP	941	1	0.0%	15%	$210 - $312	Expensive, low capacity factors; this segment is commercial (non-res) installations

Click to enlarge chart. Capacity factors for each energy source, taking into account intermittency. Capacity factor = actual generation relative to potential maximum generation.

Unfounded expectations lead to suboptimal policy choices

One example: the Keystone Pipeline extension, which the President has opted not to consider until after 2012. The U.S. imports more oil from Canada than from any other country. With the extension, the Keystone system would account for 13% of US petroleum imports. The pipeline has been opposed on environmental grounds, but the extension itself would only add 1% to the entire network of crude oil and refined product pipelines already criss-crossing the U.S. Moving petroleum products by rail or truck instead is more expensive and riskier. If the US does not provide a market for the Alberta tar sands oil, it could end up on tankers to China; and the US will end up importing more of its energy needs from the Persian Gulf and Venezuela. Could misperceptions about wind, solar and biofuel feasibility explain why some people are opposed to this extension? Unclear.

Now let's take a (desperately needed) look at some good news. Over the last 3 decades, the oil intensity of the developed world has been falling, followed by non-OECD countries. **This is not meant to suggest that declining availability of cheap crude oil isn't a problem, since it is.** There are lots of studies showing rapid declines in the production rate of existing crude oil fields, and that the discovery of new fields is (a) not keeping up, and (b) are located where marginal costs of extraction are considerably higher. No need to repeat them here. But oil's importance to economic growth has been declining over time, and there is no reason to believe that these improvements have completely run their course. There is also room for reduced fuel consumption, although here's another case where energy fairy tales might have postponed smart policy choices. While waiting for a holy grail, the US left fuel efficiency standards unchanged from 1983 (light trucks) and 1987 (cars) until 2010. Chrysler head Lee Iacocca said this in 1986 when Ford/GM lobbied the Reagan Administration to lower ("CAFE") fuel efficiency standards: "**We are about to put up a tombstone that says, 'Here lies America's energy policy'. CAFE protects American jobs. If CAFE**

is weakened now, come the next energy crunch, American car makers will not be able to meet demand for fuel-efficient cars." Well, the rest of the world kept on truckin' as he suggested, and have more efficient fleets (see chart). If the US fleet were 30% more efficient, US gasoline consumption could fall by 40 billion gallons per year (~1 billion barrels). For context, the US imports 0.36 billion barrels of crude per year from Venezuela, and 0.62 billion from the Persian Gulf. The US just increased fuel efficiency standards, but it will take time to make an impact.

Other possible good news includes ongoing research by Daimler Engine Research Labs on improving gasoline engines, something the world should not give up on just yet. Prototypes with fewer cylinders and smaller displacement may yield a car with both lower fuel consumption and lower emissions, eventually at fuel efficiencies greater than hybrids like the Prius. The US Recovery Act included $100 million for Advanced Combustion Engine Research and Development; it could be money well spent. One example the DoE is working on: semiconductors, powered by the heat exiting the car in its exhaust pipe, used to create electricity and power the car's accessories, which are usually powered by belts driven by the car's engine.

A potential game-changer: electricity storage that works, in commercial scale

What would potentially change the energy equation is **storage**. The world has been generating commercially available electricity for over a hundred years, but as things stand now, the world has almost no electricity storage. The benefits of electricity storage, if it could be implemented, are self-evident:

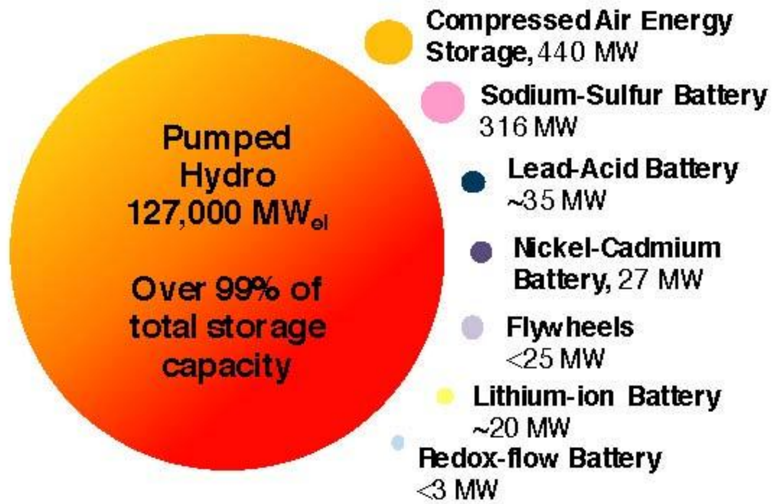
- increased cost-effectiveness of intermittent solar and wind power, and lower electricity costs, since electricity produced by wind at night could be stored and sold during the day; and electricity produced during sunny days could be stored and sold during cloudy spells. There are obvious tie-ins to the feasibility and cost of electric cars

- lower required **peak** production capacities of large urban power systems, by drawing on stored electricity reserves

- deferral or avoidance of costly upgrades to the transmission grid. As per the North American Electricity Reliability Corporation, only 27% of grid upgrades relate to integrating renewable energy. Almost half are designed to improve overall reliability, due to fluctuating loads (since the grid has to accommodate peak loads, and not just average ones)

- reduced consumption of fossil fuels which power most stand-by generators

Unfortunately, battery storage has moved along at a snail's pace. Moore's Law on doubling semiconductor capacity is something of a distraction; technology improvements over 15-18 months are hard to find anywhere EXCEPT semiconductors. Solar photovoltaic cell efficiency has doubled over 15-18 years; and battery storage has progressed even more slowly as it relates to commercial-scale applications9 (rather than lithium ion applications for cell phone and laptops). As a reminder, electricity is simply defined as the movement of electrons, which can only be "stored" as potential energy, for example via large height or chemical gradients (e.g., batteries).



Source: Fraunhofer Institute, EPRI, Electricity Storage Technology Options, 2010.

The accompanying chart shows the existing state of commercial-scale electricity storage; it's all about pumped hydro10, a process that uses cheaper electricity at night to pump water uphill into a reservoir basin, and then releases the water during the day to power a hydro-electric generator. The other technologies are an afterthought, at least right now. Note that more energy is expended in pumping the energy uphill than is generated by releasing it downhill; the economic value derives from much higher electricity prices during the day. Around 10%-20% of the potential pumped hydro energy is lost over time through evaporation and conversion losses.

There's no room to go through the complexities of the storage technologies shown below. Here are a couple of generalizations:

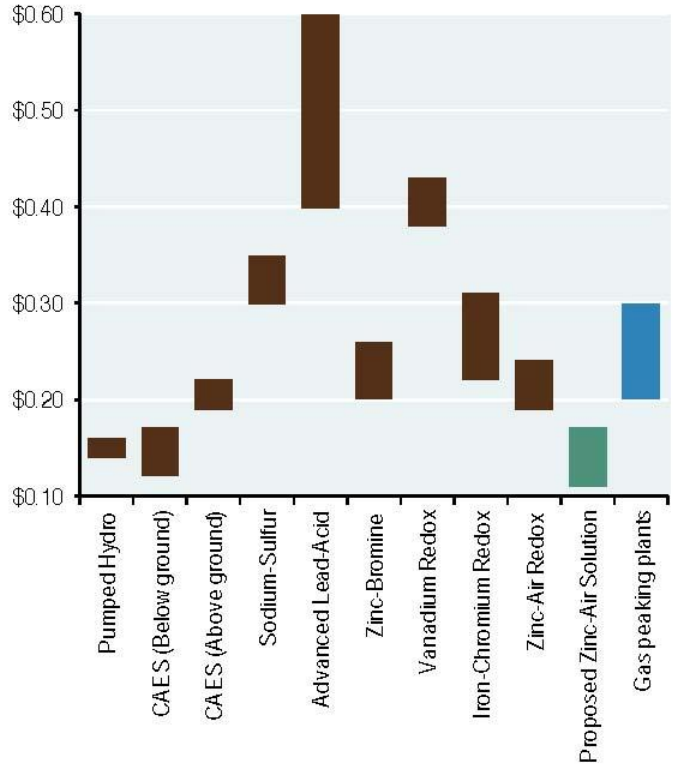
- Less expensive options like pumped hydro and compressed air storage require favorable sites with the right geology, which are rare in nature and expensive to build from scratch (and often not located near electricity demand centers), and in the case of compressed air, require co-located gas turbines for compression

- Many battery-based technologies suffer from high upfront capital or operating costs; low energy storage volumes; delayed response times; safety issues (such as zinc bromine); or short lives (limited number of recharge cycles)

I had a meeting a few weeks ago which was notable for its optimism and enthusiasm. I met with the managers of Eos Energy Storage, which is working on a zinc air battery solution which aims to conquer all of the obstacles outlined in the second bullet point above. If the Eos projections bear out, they will offer battery storage at a capital cost of ~$160 per kWh, in the form of a 1 MW battery that is the size of a 40 foot shipping container (for 6 MWh of storage). The concept of "levelized cost" synthesizes upfront costs, financing costs, useful life, fuel costs and ongoing maintenance expenses. Rather than looking projections of capital costs per kWh, levelized cost comparisons are more useful.

As shown, Eos aims to be the cheapest option that can be scaled, and flexibly and safely located where needed. Note as well that they expect to be cheaper than natural gas peaking plants. This is a relevant benchmark, since most utilities rely on natural gas peaking plants to meet daily peak load requirements and to compensate for intermittent renewable generation of wind and solar. If storage works, the need for lots of peaking facilities could disappear. Eos has a prototype of its zinc-air technology that has run around 2,000 cycles so far; we should all pray either for their success, or for the success of similar efforts undertaken by their competitors. Based on the outcome of energy dreams, we should always be skeptical of breakthrough claims, given the complexity of the challenge.

The cost of electricity storage options
Range of levelized costs, $ per kWh



Source: EPRI, Electricity Energy Storage Technology Options, 2010, Eos.
CAES: Compressed Air Energy Storage.