

**ROBERT FROMER**

*EJD, M.S.E.E., P.C., P.E., R.E.P.*

---

P.O. Box 71, Windsor, Connecticut 06095

E-mail: saintrobert@comcast.net

January 23, 2010

Chairman and Members  
Connecticut Energy Advisory Board  
C/o CERC  
805 Brook Street, Building 4  
Rocky Hill, CT 06067-3405

**Re: Comments on the 2010 Electric Distribution Companies Integrated Resource Plan (“IRP”) for Connecticut**

Dear Chairman and Members:

The Connecticut Energy Advisory Board (“CEAB”) invited interested persons to submit written comments that focus on the way in which the Electric Distribution Companies (“EDCs”) Integrated Resource Plan (“Plan”) meets the statutory requirements of Connecticut General Statutes Section 16a-3a (Section 51 of Public Act 07-242, An Act Concerning Electricity and Energy Efficiency), and/or the ways in which the EDCs Plan should be modified to better conform to the statutory requirements.

**EXECUTIVE SUMMARY**

Before creation of the Plan, the CEAB needs to establish the minimum and maximum acceptable Quality of Life and Quality of Living as the fundamental goal and objective in all energy planning for a sustainable standard of living over a determined number of years; otherwise, the effort constitutes capriciousness and arbitrariness. An example of such fundamental criteria for QoL’s by the European Union appears in Attachment 1.

The Primary Findings, Recommendations and supportive information in the Plan failed to adequately and fully address the individual requirements of Connecticut General Statutes, §§ 16a-3a(a) to 16a-3a(d) as more fully set forth below. The Plan’s narrative and information was not identified with a specific subsection of the statutes to demonstrate responsiveness to the legislative mandate.

Additionally, the projections for future availability of natural gas lack analysis of current production statistics for specific fields. See Attachment 2.

Additionally, nuclear power is not an economically viable source of electric power and provides a low Energy Return On Energy Investment (“EROEI”) because it requires fossil fuels for construction, operation, maintenance, and decommissioning and produces Greenhouse Gases from the use of such fuels. Furthermore, the Plan failed to address one of the most viable technologies as a demand side resource – electrical energy storage, and it failed to consider the future of the fuel supply for the energy sources given the realities of Peak Oil, Peak Natural Gas, and Peak Nuclear Fuel. Finally, the EROEI of renewables is low compared to fossil fuels and will not within 30 years come close to replacing power generation using fossil fuels assuming no population or energy growth.

Rather than the overly optimistic opinions of the EDC’s and members of the CEAB sans dealed analyses from know and available field statistics, Mr. Bill Powers’ article in the January 9, 2010 of the Association for the Study of Peak Oil (Attachment 2) of the major producing basins believes that the United States will suffer a net decline in natural gas supplies of approximately 8.5 bcf/d in 2011.

Predicting the timing of when United States gas supplies will go into severe deficit vies-a-vie demand and will cause a significant and sustained natural gas price spike to occur is very difficult. Timing is affected by a host of factors such as the vagaries of economic activity, the weather and uneconomic production. Its occurrence, however, is imminent. Mr. Powers’ envisions its scenario occurring by the middle of 2011; he believes 19 months should provide sufficient time for this past year’s collapse in natural gas directed drilling to have an impact on supply.

Short of the world going into a severe depression sometime during 2010, the coming drop in US natural gas supplies will put unrelenting upward pressure on natural gas prices when the market realizes the magnitude of supply deficit. When this will happen is unknowable. However, investors can position themselves ahead of time. Several of the companies in my Model Portfolio are gas weighted and are well positioned to take advantage of the upcoming change in the economics of natural gas.

Interestingly, the Plan offers no Master Plan of Energy Conservation to significantly reduce demand; neither, does the Plan consider the Green House Gases produced from the externalities developed from generation, transmission and distribution.

**I. INTRODUCTION: ADMIRAL RICKOVER, *ENERGY RESOURCES AND OUR FUTURE***

The consideration of plug-in electric vehicles and other electrical energy demands without holistic consideration of their life cycle energy consumption necessitates review of excerpts from his May 14, 1957 speech at a banquet of the Annual Scientific Assembly of St. Paul, Minnesota by Rear Admiral Hyman Rickover, father of the nuclear United States Navy, who proclaimed the following about the Nation's energy resources and its 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.**

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.

**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.

**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 expectancy 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.

**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.**

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.

(Emphasis added.)

By design and arrogance, the CEAB continues to ignore Admiral Rickover's message. The key point of the Admiral's dissertation is to analyze and audit all energy consumption relative to natural resources with the goal of extending the time for significant depletion of fossil fuels and raw materials, which would permit readjustment of the American economy to a different standard of living.

## **II. COMPREHENSIVE PLAN FOR ENERGY RESOURCE PROCUREMENT: STATUTORY REQUIREMENTS AND COMMENTS**

The Connecticut General Statutes, Section 16a-3a(a) provides that the electric distribution companies ("EDCs") consulting with the Connecticut Energy Advisory Board ("CEAB") shall review the state's energy and capacity resource assessment and develop a comprehensive plan for the procurement of energy resources, including, but not limited to, conventional and renewable generating facilities, energy efficiency, load management, demand response, combined heat and power facilities, distributed generation and other emerging energy technologies to meet the projected requirements of their customers in a manner that minimizes the cost of such resources to customers over time and maximizes consumer benefits consistent with the state's environmental goals and standards.

The creation of the report entailed a collaborative effort by The Connecticut Light and Power Company (CL&P) and The United Illuminating Company (UI"), and *The Brattle Group*, an independent economic consulting firm, with guidance from CEAB's IRP subcommittee. This 2009 report continues the effort started in the 2008 report, and consists of ten "whitepapers" addressing issues collaboratively identified by the Companies and the CEAB. It provides an assessment for the next three, five, and ten years, through 2019. The ten whitepapers constitute subsequent sections of the document and include discussion, analysis, and updates to previous work on the following topics: *Resource Adequacy; Demand-Side Management (DSM); Renewable Energy; Transmission; Nuclear*

*Power Fact Finding; Combined Heat and Power (CHP); Environmental Regulatory Evolution; Energy Security; Resource Finance; and Emerging Technologies.*

**A. Requirements**

Section 16a-3a(b) requires that the companies annually submit to the CEAB an assessment of:

- (1) Energy and capacity requirements of customers for the next three, five and ten years;
- (2) Manner of how best to eliminate growth in electric demand;
- (3) How best to level electric demand in the state by reducing peak demand and shifting demand to off-peak periods;
- (4) Impact of current and projected environmental standards, including, but not limited to, those related to greenhouse gas emissions and the federal Clean Air Act goals and how different resources could help achieve those standards and goals;
- (5) Energy security and economic risks associated with potential energy resources; and
- (6) Estimated lifetime cost and availability of potential energy resources.

**A. Comments**

(1) My review and comments focused on whether the Plan complied with the requirements of Section 16a-3a, which only governs electrical energy resources. Unfortunately, the report did not follow the individual requirements established in each of subsections (b) through (d) but, rather, created the above order from elements of each subsection. Although Section 16a-3a did not require any specific order for presenting the Plan, the arrangement made tracking information to requirements quite difficult. For example, the white paper on Resource Adequacy projected available resources to meet future needs to satisfy: Demand, Connecticut and Independent Service Operator (“ISO”) - Wide Reliability Requirements, Generation Resources, Demand-Side Resources, Net Imports and Tie-Line Benefits, Resource Gap, and Scenarios. The approach is similar to ordering food off of a Chinese restaurant menu - one from column A and one from column B.

- (2) The Plan avoided—addressing the issues raised in §§ 16a-3a(b)(2) to (6).

**B. Requirements**

Section 16a-3a(c) requires that resource needs first be met through all available energy efficiency and demand reduction resources that are cost-effective, reliable and feasible. The projected customer cost impact of any demand-side resources considered pursuant to this

subsection shall be reviewed on an equitable bases with nondemand-side resources. The procurement plan shall specify:

- (1) The total amount of energy and capacity resources needed to meet the requirements of all customers;
- (2) The extent to which demand-side measures, including efficiency, conservation, demand response and load management can cost-effectively meet these needs;
- (3) Needs for generating capacity and transmission and distribution improvements;
- (4) How the development of such resources will reduce and stabilize the costs of electricity to consumers; and
- (5) The manner in which each of the proposed resources should be procured, including the optimal contract periods for various resources.

#### **B. Comments**

(1) The Plan was unresponsive to the detailed requirements in § 16a-3a(c) that “resource needs first be met through all available energy efficiency and demand reduction resources that are cost-effective, reliable and feasible.”

(2) The Plan neglected to consider off-peak demand fixed and mobile storage technologies for residential and commercial and vehicular applications as an essential resource component.

#### **C. Requirements**

Section 16a-3a (d) requires that the procurement plan consider:

- (1) Approaches to maximizing the impact of demand-side measures;
- (2) The extent to which generation needs can be met by renewable and combined heat and power facilities;
- (3) The optimization of the use of generation sites and generation portfolio existing within the state;
- (4) Fuel types, diversity, availability, firmness of supply and security and environmental impacts thereof, including impacts on meeting the state's greenhouse gas emission goals;
- (5) Reliability, peak load an' energy forecasts, system contingencies and existing resource availabilities;
- (6) Import limitations and the appropriate reliance on such imports; and (7) the impact of the procurement plan on the costs of electric customers.

### **C. Comments**

(1) The Plan failed to realistically consider the future of the fuel supply for the energy sources given the realities of Peak Oil, Peak Natural Gas, and Peak Nuclear Fuel. Finally, the EROEI of renewables as shown in Attachment (3), Dr. Charles Hall's Balloon Graph and interpretation), is low compared to fossil fuels and will not within 30 years come within range of replacing power generation using fossil fuels assuming no population or energy growth.

(2) Section 5A of the Plan presents its "Summary and Key Findings." The Plan claimed that:

Although the analysis of market impacts of a new nuclear plant in Connecticut has limitations, the results suggest the potential to realize both economic and environmental benefits. New nuclear capacity in Connecticut would displace generation from fossil-fired plants, substantially reducing emissions of CO<sub>2</sub> as well as NO<sub>x</sub> and SO<sub>2</sub>. The relative cost of a nuclear resource option depends on the ultimate nuclear construction cost, a figure that is subject to significant uncertainty and possible upside risk. Once built, however, a nuclear plant's operating costs are not subject to fluctuations in the price of natural gas or CO<sub>2</sub> emissions. If the cost recovery of a nuclear plant is based on cost-of-service principles, a new nuclear plant could reduce customers' exposure to the potentially volatile costs of natural gas and CO<sub>2</sub> emissions. While the economic benefits and costs of a new nuclear facility in Connecticut are uncertain, the potential environmental benefits are much clearer.

The opinion provided in Attachment (4) best addresses the economic fallacies of nuclear power. Additionally, the Energy Profit Ratio or Energy Return On Energy Investment ("EROEI)" for construction, operation, maintenance, and decommissioning would be low over the 30+ year life of a plant because of the need for fossil fuels, which would, also, produce Greenhouse Gases.

(3) Solar and other renewables are not viable substitutes for fossil fuels because of their: 1) insufficient energy density; 2) untransportability; 3) relatively high environmental impact per net unit of energy delivered to society; and 4) relatively low EROI. See attached Balloon Graph of Dr. Charles Hall to support these claims.

(4) No where does the Plan even suggest creation of a Master Conservation Plan and Program to significantly reduce demand.

Cordially,



---

Robert Fromer  
Environmental and Public Interest Consultant

Attachment: (1) European Union, Quality of Life and Quality of Living  
(2) ASPO, Natural Gas Field Analyses  
(3) Dr. Charles Hall's Balloon Graph  
] (4) Lester Brown, The Flawed Economics of Nuclear Power

## **Consumption, Everyday Life & Sustainability**

funded by the European Science Foundation's

TERM (Tackling Environmental Resource Management) Programme

(<http://www.comp.lancs.ac.uk/sociology/esf/index.htm>)

### **The Quality of Life**

*Michael Jacobs, General Secretary of the Fabian Society, London*

#### **Introduction**

The term Quality of Life (QoL) has been widely used in a number of disciplines to express the idea of personal well-being in a framework which goes beyond the simple economic equation of well-being with income. (There is one important variant on this which I shall not discuss here, namely its use in the health policy literature to refer to the nature - as opposed to the length - of elderly or sick people's lives.) Quality of life is generally used as the overarching concept, which encompasses income (and therefore consumption) but also includes other factors which contribute to well-being. In this short paper I shall discuss the meanings that have been attached to QoL in the literature, some issues concerned with its measurement, and the component factors, which are generally held to contribute to it. I shall then offer a very sketchy observation on the relationship between QoL and consumption.

#### **The Quality of Life: Individual and Social**

The first point to make is that the literature on quality of life generally fails to distinguish between the quality of individual lives and the quality of the collective life of a society (or a place) as a whole.

The starting place for most QoL studies has been the subjective experience of well-being of the individual. However the attempt to measure this has involved an inexorable slide towards a non-individual perspective. People's subjective perceptions of their well-being are so clearly non-comparable, and affected by expectation and social comparison, that attention quickly turned to the identification of objective conditions which influence subjective experience: people's objective state of health, for example, rather than their feelings of well-ness. But many of these objective conditions are not (or cannot be measured as) peculiar to the individual at all. The quality of air, the level of education or indeed the level of employment, all require collective or aggregate measurement. So the quality of life gradually became, for many researchers, a description of the collectively experienced conditions of a society or place, with only an indirect and contingent relationship to the subjective experience of well-being of individuals.

In the hands of Greens, this process has been taken further. Concerned to argue that the social costs of economic growth have increased to the point where they now outweigh the benefits of

higher income, green writers have included factors such as loss of natural habitats, global warming and increasing inequality to their concept of quality of life. Yet these factors are not elements of personal well-being at all. They are components of the quality or health or sustainability of society as a whole. Their value is not derived from the aggregate well-being of individuals, but independently, from a conception of what constitutes a good society.

There are thus two related but separate concepts operating here: individual QoL and social QoL. This is particularly important in relation to environmental goods. Some environmental goods and costs directly affect individual QoL - air quality, for example, or traffic congestion. But many do not. Natural habitats do not make me better off personally, nor does reducing the risk of global warming to future generations. These contribute rather to the health or quality of society. The same is true of many social or shared goods, including cultural goods which many people do not use themselves, such as universities and public service broadcasting.

Of course social QoL contributes to individual QoL: (some) individuals feel better off when they live in a better society. But this is not the justification for pursuing social QoL. They are logically separate. (Conversely, individual QoL should contribute to social QoL: a society would not be very good or healthy if its natural habitats were preserved and inequality eradicated but its people were all stressed at work and going through divorce). If people feel that social QoL contributes to their own personal QoL this indicates a self-identification with, or feeling of membership of, society. Politically this would appear to be an important prerequisite for defending social goods whose contribution is to social QoL.

The rest of this paper will focus on individual QoL.

### **Individual Quality of Life: Definition**

The simplest definition of individual QoL is the *subjective feeling that one's life overall is going well*. (Note that this differentiates QoL from 'happiness', which tends to connote too transitory and emotional a condition). 'Overall' is intended to define QoL as the overarching judgment of how all the different elements of one's life combine together.

There are three problems with this definition, however. The first is that it can only be measured subjectively, by asking people about their own QoL. This raises all the familiar problems of subjective measurement, its reliability and comparability. The second is that QoL in this definition relies heavily on the character and dispositions of the individual. A person may be rich, successful in their job, healthy and happily married and *still* not feel their life is going well, perhaps because they have unfulfilled personal goals or simply because they have a depressive personality. If we say such a person does not have a good QoL, as we will have to on this definition, the concept becomes more or less meaningless in terms of public policy and research.

The third problem is the converse of this. Subjective satisfaction with one's life is strongly related to one's expectations of it. Expectations in turn are related to social position: people compare themselves to others in their self-perceived social position. Low expectations achieved lead to higher subjective reporting of QoL than high achievement that fails to meet expectations. This

leads to the apparent conclusion that one way to increase QoL is to reduce people's expectations. Yet this fails to account for the desirability of personal growth and development, of the accomplishment of challenging individual life goals. As J S Mill said, it is better to be Socrates dissatisfied than the pig satisfied.

These problems suggest a definition of QoL not in terms of overall subjective experience, but as *a set of conditions relating to an individual's life that would appear to indicate, from outside, that it is going well*. This definition accepts that it may not, in fact, capture the subjective perception of overall well-being, but makes a generalized claim that - if these conditions obtain - in most cases it will.

The crucial distinction between the two definitions is not between subjective and objective measurement. Many of the factors, which contribute to QoL on the second definition require at least a partial element of subjective measurement. It is between QoL as an 'overall' judgment and QoL as a set of separate conditions or factors which contribute to this judgment. Whereas the 'overall' judgement can only be made by the individual, the separate factors can be observed and presented by the social researcher. There is no need, in fact, to combine them into a single 'overall' measure of QoL. To do so requires procedures for commensuration and weighting which will inevitably involve disputable value judgments.

### **The Components of Individual Quality of Life**

Many years of both conceptual and empirical research (the latter on what people report contributes to their QoL) have resulted in a generally accepted list of factors which together comprise or determine QoL. (There are generally small differences of content and presentation.) The same factors can contribute to a good or a bad QoL, though not always symmetrically. Ill health, for example, can make QoL worse more or less without limit, but good health contributes to a good QoL only up to a point. The following is my own presentation / categorisation:

- (1) Income and consumption
- (2) Health:
  - (a) Physical
  - (b) Mental (stress, depression, happiness)
- (3) Relationships:
  - (a) Family
  - (b) Friends
- (4) Satisfaction with:
  - (a) Job
  - (b) Leisure

- (5) Personal autonomy:
  - (a) 'Free' time (in which activities can be 'chosen')
  - (b) Life opportunities and choices
  
- (6) Security, of:
  - (a) Person
  - (b) Income, employment, housing etc
  - (c) Lifeworld, including environment (NB. Different people need or want different levels of security.)
  
- (7) Personal development: accomplishment, personal growth
  
- (8) Social goods contributing to individual well-being:
  - (a) Environmental (air quality, townscape, etc)
  - (b) Social (low crime, social order)
  - (c) Public services (education, health, parks, etc)
  
- (9) Social goods contributing to a good society:
  - (a) Environmental (natural habitats, risks)
  - (b) Cultural (museums, art galleries, etc - if not used)
  - (c) Ethical (equality, reduction in poverty, etc)
  - (d) Government (democracy, etc)

Discussion of QoL generally assumes that the relationship between income and QoL is unproblematic. Higher incomes allow higher consumption levels, and people are assumed to buy goods and services because they contribute to their QoL. In fact the relationship between consumption and QoL is not quite so simple; we shall discuss this below.

All the other factors are only partially related to individual income, or not related to it at all. (This is of course the reason for the QoL concept in the first place.) The quality of personal relationships are not affected by income. In some cases there are society-wide relationships with income which do not apply to all individuals: this applies to physical health, job satisfaction, personal development. Many affluent people do not experience high quality in these aspects of their lives; many poorer people do. In the case of social goods, these are not bought individually but provided through collective regulation or public spending. Higher individual income may enable a person to move to an area with (say) better environmental or crime conditions but it may not.

## Quality of Life and Public Policy

The public policy relevance of the concept of QoL as defined in this way should be fairly clear. If the objective of government is to improve QoL (because this is the overarching concept of well-being), raising household incomes, which is normally taken to be the principal objective of economy policy, may not be the most appropriate method. Depending on the trade-offs people make (or society judges) between gains in income and gains in the other factors, it may be more important to concentrate on improving the latter.

Indeed if the very economic processes which generate higher incomes themselves contribute to a reduction in the other factors, then raising incomes may be positively counter-productive. Present patterns of economic growth clearly contribute to environmental degradation, and arguably to poor job satisfaction, low job and income security, high levels of stress, certain health problems, possibly even to high crime. This is the familiar environmentalist argument about 'the social costs of growth'; the claim is that to improve QoL society should either stop income growth altogether (the older version of the argument) or change its patterns (the more modern version). (There is no guarantee of course that changing the patterns of economic activity to improve environmental impacts would also lead to improvements in the other aspects of quality of life, though this is often implicitly assumed by environmentalists.)

This argument of course ignores the equally plausible claim that recent patterns of economic growth have increased QoL, not just by raising incomes but by increasing personal autonomy, improving health, education and other public services, even improving family relationships through the liberation of women (and so on). It is by no means clear, contrary to what environmentalists frequently argue, that individual QoL has fallen in (say) the last twenty years. (In fact many environmentalists actually want to argue that social QoL has fallen - society has got worse - a much more plausible claim. But they have failed to distinguish between the individual and social concepts.)

In fact, the relationship between national income and QoL is not obvious. Many of the components of QoL would appear to be only partially related to economic factors. They would seem to be primarily culturally or personally determined. Economic policy may simply not be the relevant field of public policy, either negatively or positively. In other cases the issue would appear to be, less the growth of national income as simply its allocation. It may well be that a reallocation of resources into education, preventive health care and environmental protection would improve the quality of life more than either a reduction or growth of current spending patterns. (Of course, higher national income might allow even more spending in these fields.)

Indeed it is not clear that any aspect of public policy can affect some of the aspects of QoL. There are surely strict limits to how far governments can improve personal relationships, satisfaction with leisure activities or personal development.

Where improving the non-income components of QoL will involve a reduction in national income and therefore in personal income (or just in personal income, for example through a reduction in working hours) the trade-off between income and the other components of QoL is crucial. People

may be willing to substitute some of their income for an improvement in other aspects of QoL, but they may not. (Experience of the demand for reduced working hours suggests caution here, as does the unpopularity of taxes.)

There may be a particular problem in an increasingly competitive global economy. Some policies to improve QoL, such as in increased job satisfaction and reduced working hours (and stricter environmental regulation) may raise costs in such a way as to seriously undermine competitiveness. The trade-off may then become, not just a marginal income loss but a substantial income and employment loss, of a kind which would clearly reduce QoL. There may actually be little scope for marginal trade-offs: they will perforce become large trade-offs, and then unacceptable.

Whatever people's *actual* trade-offs, of course, it will always be possible for the social critic to challenge these. Many Greens want to argue that people would in fact have a higher QoL if they traded off income for time or environmental goods or personal development, even though they do not realize this now. This is a perfectly legitimate position.

### **Consumption and the Quality of Life**

The missing question in all this is how consumption is related to QoL. It is generally assumed in the QoL literature that consumption improves people's QoL, otherwise they wouldn't do it. But is this so? How much consumption actually *adds* to QoL? It is arguable that much consumption in industrial societies simply maintains the social position of households, fitting them out with the basic prerequisites of participation in a society in which everyone else is also buying more. If the social pressures to consume as the basis of social participation were reduced, people wouldn't need to buy some of what they currently do.

If we can in this way distinguish between genuinely QoL-enhancing consumption and participation-maintaining consumption, and reduce the requirements of the latter, we may find that the contribution of income to QoL is not as important as generally thought. This, however, cannot be done by individuals. The question is, what are the social and institutional processes by which it might occur?

**From the Reader distributed for the *Consumption, Everyday Life and Sustainability* Summer School 1999, Lancaster University.**



# Peak Oil News

A Compilation of New Developments, Analysis,  
and Web Postings

Saturday, January 09, 2010

## 23. THE GAS CRISIS OF 2011

Bill Powers  
Jan 08, 2010

One of the favorite phrases of fellow Chicago financial analyst Don Coxe is along the lines of “the most money is not made from investing in front page stories but rather investing in page 16 stories that are on their way to the front page.” After writing about America’s coming gas deliverability problem in a previous issue, I discovered that if domestic production continues to decline in conventional natural gas producing basins, imports from Canada continue to dwindle and LNG imports remain at the subdued levels, production from unconventional gas producing basins will not be sufficient to keep US supplies even close to current levels. Production declines from both Canada and conventional basins in the US as well as several unconventional basins are being masked by a weak economy, a glut of gas in storage from last year’s drilling orgy and gas from a few shale plays whose economics are extremely poor at today’s prices.

Predicting the timing of when US gas supplies will go into severe deficit vis-a-vis demand and cause a significant and sustained natural gas price spike to occur is very difficult. Timing is affected by a host of factors such as the vagaries of economic activity, the weather and uneconomic production. Its occurrence, however, is imminent. I see this scenario happening by the middle of 2011. I believe 19 months should provide sufficient time for this past year’s collapse in natural gas directed drilling to have an impact on supply.

I came to the conclusion that we are headed for a severe supply deficit after I examined the production profiles of the major conventional and unconventional fields in the US and Canada. By June of 2011, only 19 months from now, we are on pace to suffer a reduction in US gas supply of approximately 8.5 billion cubic feet per day (bcf/d) – approximately 13% of US supply. In this article I will discuss the changes in major producing areas in the US and examine the impact a continued fall in Canadian natural gas production will have on US supplies. Additionally, I will also address the insignificant impact current LNG imports are having on US supply and their likely future impact on supply.

While oil focused producers are the darlings of the investment community today, I believe gas weighted producers will also have their day in the sun. Investors with a longer-time horizon should consider keeping gas weighted companies on their radar screens. One of my Model Portfolio members, which has a huge inventory of economic drilling locations, is an excellent

example of a firm I believe will build large amounts of shareholder value as they develop their drilling locations into a higher gas price environment.

#### Areas of Production Growth

##### Fayetteville Shale

The Fayetteville shale is one of the four large shale plays that have shown explosive growth over the last five years. While the growth of natural gas production in the Fayetteville has been nothing short of phenomenal over the last five years, we are already seeing a slowdown in growth.

Despite Southwestern Energy's efforts to drive down well costs through continuous improvements in drilling and fracturing and its commitment to participating in 575 wells this year, the law of large numbers is catching up with the Fayetteville Shale [note: SWN is the most active driller and largest land holder in the Fayetteville Shale]. With over 1,000 wells drilled into the play already and the high decline nature of horizontal wells, the rate of production growth will slow over the next several years before the play reaches an ultimate peak of 3 bcf/d in 2012/2013. Based on the drilling of approximately 900 wells by Southwestern and other operators in the play over the next 19 months, I expect the Fayetteville to contribute 2.25 bcf/d to US gas supply in June of 2011.

##### Haynesville Shale

Estimating current production from the Haynesville Shale is far more difficult since the State of Louisiana does not break down production statistics on a field-by-field basis, rather by onshore and offshore production. Therefore, to come up with an estimate of current Haynesville production, I examined the Q3 2009 earnings releases of the largest operators in the play.

While the Haynesville will be the main focus area for several large independent operators such as Chesapeake Energy and PetroHawk Energy, these companies as well as their smaller peers are likely to cut back spending plans in the Haynesville due to balance sheet constraints.

The flush production and steep decline of the typical Haynesville well makes the price received during the first year of production extremely important in determining the lifetime economics of the well. At today's gas prices and a relatively flat strip price, it would take nearly eight years for a Haynesville well to pay out. Putting high-rate, very high decline, \$8 million Haynesville wells into production when spot gas prices are less than \$3.50 per thousand cubic feet (mcf) is essentially financial suicide. Given that most Haynesville operators have reduced hedges in place for 2010 and limited balance sheet flexibility, I expect to see a slowdown in the rate of growth of activity in the play.

Despite these obstacles, the desire of Haynesville operators to show growth at any cost to Wall Street analysts will keep production flowing at an unsustainably high rate for now. I believe that the Haynesville Shale will be producing approximately 2 bcf/d by June 2011.

##### Marcellus Shale

Similar to the State of Louisiana, the Commonwealth of Pennsylvania does not break gas production down by field. Therefore, I relied on Q3 2009 financial statements to get a tally of where Marcellus Shale production currently stands.

The Marcellus Shale is the best example of an emerging shale play that has massive potential reserves but equally large developmental obstacles. As discussed in the October 1, 2009 issue of the Powers Energy Investor, initial estimates of the reserves contained in the Marcellus range from 50 and 300 trillion cubic feet, possibly more if some of the more optimistic estimates are to be believed. However, the difficult topography of western Pennsylvania, water rights issues as well as lack of gathering systems will restrain the growth of the Marcellus.

1. As an aside, in December 2007, I was at an industry conference in a very snowy Pittsburgh where I listened to a representative of Range Resources discuss how his company was fully committed to the Marcellus and was putting the full resources of the company into its development. Given all of the company's efforts and money put into the Marcellus and their continuous promotion of the play, I find it very odd that Range Resources has not been able to achieve more than 80 million cubic feet per day (mmcf/d) of production two years later. Therefore, based on the slow ramp up of production from the Marcellus, I expect the play to be producing approximately 500 mmcf/d in June 2011.

#### The Woodford Shale

The Woodford shale came to the forefront as a prospective shale play approximately five years ago when Barnett Shale pioneer Devon Energy and Newfield Exploration applied many of the techniques used to unlock the Barnett Shale to this 500,000 acre prospective area in south central Oklahoma. With the understanding that every shale play is different, the two companies, along with a host of smaller operators, set out to determine the optimal methods for drilling and completing Woodford shale wells while continuously driving down total costs. While operators in the play have been able to drive down wells costs, raise initial production (IP) rates and expected ultimate recoveries, they have not been able to achieve the economics enjoyed by operators in other shale plays such as the Haynesville and the Barnett. Given that the estimated break even costs of the Woodford are \$7.00 per mcf, this has caused an exodus of operators such as Devon Energy from the play.

Due to the high decline rates of the Woodford and the decline in drilling activity in the play, I expect production to grow to approximately 550 mmcf/d by June 2011.

#### Eagleford Shale

The Eagleford is the most recent shale play to go into commercial development. The play is located in south Texas and contains approximately 500,000 acres. Due to its very modest break-even costs, the play is quickly gaining industry attention. Because of the early stage nature of the play, I expect the Eagleford to grow quickly over the next couple of years.

While listening to the conference calls of both Anadarko and El Paso, it became apparent that the management teams of both companies believe that the early results from Eagleford are encouraging; however it is still in its early days. I take this to mean that operators in the play are still defining the sweet spot and expect wide variation in drilling results. Despite the potential for significant disparities in drilling results, I expect gas production from the Eagleford shale to reach approximately 200 mmcf/d by June 2011.

#### Cana Woodford

The Cana Woodford is a very new shale play in western Oklahoma that is being pioneered by Devon Energy. According to the company's Q3 2009 conference call, the company has acquired 109,000 net acres and has applied nearly the same techniques in its original Woodford play to achieved 53 mmcf/d. Devon Energy mentioned on its conference call that it is moving one rig from its Barnett Shale project and one from its original Woodford play to ramp up activity in the Cana Woodford. The only other operator that I have found to be active in the Cana Woodford play at this time is Questar Energy. Questar has a one rig program beginning in 2010. I believe production will increase to approximately 150 mmcf/d by June 2011 given the favorable economics of the Cana Woodford.

#### Granite Wash

The Granite Wash play of the Texas Panhandle and western Oklahoma is a tight sand gas reservoir that occurs in thick, stacked sequences of sands, siltstones and shales up to 3,500 feet thick (Source: Oil and Gas Investor, August 14, 2009). The Granite Wash sequence occurs at approximately 11,000 to 12,000 feet. Operators in the area have used both vertical and horizontal wells, which are multi-stage fractured and cost approximately \$7 million each to drill and complete. While the Granite Wash is still in the early stages of development, operators in the play have been met with a significant amount of success. For example, Newfield Exploration's first seven wells in the area have averaged 22 million cubic feet equivalent per day (mmcfe/d) according to a news release dated July 22, 2009. It should be noted that a significant portion of Granite Wash production can be comprised of natural gas liquids or oil.

The early success of the Granite Wash has attracted the largest unconventional gas operators to the play and seems to be attracting new entrants on a daily basis.

Given the high liquids content of Granite Wash production, I am probably overstating current natural gas production from the play. However, for the purpose of this exercise, I am trying to be generous but realistic in my estimates of current production. Since the economics of the play are so robust given today's high liquids prices, production from the play should increase significantly over the coming years. I expect production from the Granite Wash to be approximately 500 mmcf/d in June 2011.

#### The Pinedale Anticline

The final area of growing production over the next 19 months is the Pinedale Anticline of southwest Wyoming. The Pinedale Anticline is approximately 90 square miles into which approximately 1,000 wells have been drilled over the past decade. (Source: Ultra Petroleum) Most production from the field comes from the Lance formation, which is interspersed throughout several different intervals. Similar to other tight sand plays, the Pinedale's economics were unlocked once operators discovered the technique to fracture several distinct pay intervals simultaneously. According to a recent presentation by Ultra, the Pinedale currently produces approximately 1.2 bcf/d.

Based on the increasing pipeline capacity that is coming onstream in the Rockies over the next two years and the very low cost nature of Pinedale wells, I expect the area to grow production to approximately 1.8 bcf/d by June 2011.

#### Areas of Production Stagnation

After researching every major producing basin for this article, I uncovered four unconventional gas plays, areas that were previously the focus of heavy industry activity where production has reached a plateau or has begun a gradual decline.

While there are many other natural gas plays that have plateaued or are in gradual decline due to the maturity of the play or lack of drilling at today's low prices, the main four were once thought to be part of an unconventional gas revolution that would supply abundant gas for decades. However, no matter how revolutionary the technology, the laws of physics catch up with every field. Production declines eventually set in and the consequences can be severe.

#### Areas of Declining Production

In my efforts to quantify the declines in natural gas production for the largest sources of US supply, I was able to find very good data sources at the state and federal level. To provide some background on my predictions for production in June 2011, I will provide several months of production history to show the production decline trend that is accelerating in nearly every case.

#### Piceance Basin

Similar to many unconventional gas plays, this tight sand gas play was the subject of intense development until the beginning of 2009. The Piceance Basin, centered in Garfield County, Colorado, was home to one of the most intense drilling booms North America has ever seen. The ramp up in gas production from the county was truly spectacular. However, the production decline from the area has been equally breathtaking. Drilling in Garfield County has virtually come to a standstill due to today's lower gas prices and tougher environmental regulations for the Colorado's exploration and production (E&P) industry. This situation, combined with the very high decline rate of Piceance Basin gas wells, will likely drop Piceance Basin production by 800 mmcf/d between now and by June 2011. [For readers who are historians of the Canadian natural gas industry, the production ramp up and dramatic fall in gas production from the Piceance Basin

reminds me of what occurred at the Ladyfern field in British Columbia. I will discuss the “Ladyferning” of US shale basins in a future issue of my publication.]

#### District Four of Texas

The Texas Railroad Commission, the keeper of all oil and gas data for the State of Texas, has divided the state in 10 districts. District Four encompasses several counties along the Gulf Coast in the far southern reaches of the state. It is here where dozens of E&P companies have successfully exploited the gas rich Frio, Vicksburg and Wilcox in addition to other formations. These three main formations, on which primarily vertical wells were used, all contain excellent permeability and high pressures. This combination allows gas to flow to a wellbore at very rapid initial rates. However, the conventional gas formations of the Frio, Vicksburg and Wilcox all have extremely high decline rates. Additionally, due to the maturity of District Four, the remaining targets have become progressively smaller over the years. This has greatly reduced drilling activity in the District since the beginning of the year, despite a large drop in drilling costs.

With the migration of rigs away from higher-cost traditional natural gas plays such as those found in District Four, I expect drilling in the area to continue to decline. Therefore, I expect production to fall approximately 1 bcf/d by June 2011.

#### District Six of Texas

Texas District Six is one of the most densely drilled areas of the world given that the area is home to the massive east Texas oil discoveries of the early 20th century and in more recent decades, drilling has focused on several tight sand intervals such as the Cotton Valley and Bossier. During the past two years, there have been efforts by several operators to determine the prospective nature of the area for Haynesville Shale production. To date, the Haynesville has proven very difficult for operators and most have chosen to focus their attention on the better defined portion of the play in northeastern Louisiana. With over 30,000 natural gas wells drilled in District Six over the last six years, there has been a significant spike in gas production.

The aftermath of the Cotton Valley drilling boom in District Six is already having a major impact on production. With a significant drop off in drilling activity, the production decline of the last year is only going to get worse. Similar to District 4, I expect production in District 6 to decline by 1 bcf/d by June 2011.

#### Barnett Shale

The Barnett Shale is the largest onshore natural gas field in the US and has been the focal point for the development of the shale gas industry in the US. Many of the techniques that were first developed to exploit the Barnett have been applied to other shale gas basins with varying degrees of success. Many of the operators in the Barnett Shale aggressively drilled up their positions over the past few years and are now left with lesser quality acreage that will only provide economic returns at significantly higher natural gas prices. Today’s low gas prices have caused operators such as Devon Energy and Carrizo Oil and Gas to delay completing Barnett Shale wells which has

further depressed production. After the exodus of nearly 150 drilling rigs from the Barnett over the past year, there is little doubt that the granddaddy of all shale plays is headed for a steep fall in production. The sharp ramp up in production from the Barnett over the last six years will lead to a continued slide in production over the next several years.

Given the steep decline curve of recent vintage Barnett Shale wells and the large exodus of drilling rigs from the area, I expect gas production from the area to drop 2 bcf/d by June 2011.

#### Gulf of Mexico

Gulf of Mexico (GOM) natural gas production has been in a freefall during the last seven years. A nearly 20 year low in the GOM rig count ensures that declines will continue. At today's gas prices, there is very little drilling for natural gas in the GOM and operators are having difficulty justifying the building of infrastructure to bring recent discoveries ashore. Despite the record gas prices over the last ten years, production in US federal waters has dropped by nearly half.

The only reason for the slight uptick in 2009 was flush production being put through newly repaired pipelines that were damaged during the 2008 hurricane season. Offshore wells, especially gas wells, are high pressure, high decline wells. Constant development of new wells is required to keep offshore production from heading into a violent downward spiral. The low gas price environment of the past year has put offshore production on exactly this trajectory. I expect GOM production to fall by 3 bcf/d by June 2011.

#### Powder River Basin CBM

The Powder River Basin (PRB) coal bed methane (CBM) play is the second largest CBM play in the country behind the massive San Juan field. However, unlike the San Juan, wells in the PRB are far less productive, each averages approximately 300 mmcf/d and produce significantly more water. The cost of water disposal is the issue that will force the shut-in of many marginally productive wells in the basin. According to the Wyoming Oil and Gas Commission there are 11,783 shut-in PRB wells as of April 1, 2009, up from 8,700 in August 2008. Given the low natural gas prices in the Rockies, I am confident that the number of shut-in PRB CBM wells now exceeds 13,000. This situation will only get worse until operators in the PRB are confident in a sustained rally in natural gas prices since it can take several months to pump the water off a shut-in well before it will return to its previous level of production.

Due to the time-delayed nature of CBM production, wells typically initially produce significant amounts of water and small amounts of natural gas and the water/gas ratio eventually reverses, production in the PRB has been resilient thus far. However, once last year's drilling boom fades and the impact of well shut-ins set in, production will trend downwards.

Based on a near shut down of CBM drilling in the PRB and an increasing amount of shut-in wells, I expect CBM production in the basin to decline approximately 200 mmcf/d by June 2011.

#### Canadian Imports

A recent research report by FirstEnergy analyst Martin King dated November 12, 2009 discussed the reasons natural gas production in the Western Canadian Sedimentary Basin (WCSB), which includes Saskatchewan, Alberta and British Columbia, is now moving towards blow down mode. Mr. King describes the situation in the WCSB as follows:

“Given the very slow pace of drilling, we see gas production in the basin slowly trending toward a ‘blow down mode’ in which production trends to the underlying declining rate near 20%.”

This winter’s drilling season, which began in late November when the ground froze and will extend until spring break-up in March, is likely to be a complete washout for natural gas drilling. With most Canadian operators solely focused on drilling on potential oil wells this winter, we are certain to see WCSB natural gas production decline at an increasingly rapid rate.

Similar to the shale gas plays in the US, British Columbia’s Horn River Basin shale play and the Montney shale play have received a great deal of industry attention as the industry’s greatest hope to reverse several years of declining production in the WCSB. However, according to Mr. King’s research, which is based on various pipeline postings, natural gas production in British Columbia has declined from 2.76 bcf/d in October 2008 to 2.46 bcf/d in October 2009. The decline in conventional BC natural gas production is more than offsetting production growth in BC’s emerging shale plays.’

Without the ability to keep domestic production stable, Canadian natural gas exports are nearly certain to collapse over the next 19 months. I expect Canada’s exports to drop to approximately 150 bcf a month by June 2011 or by approximately 4 bcf/d over the next 19 months.

#### LNG Imports

I find it interesting that many of the analysts who are now touting ever increasing production from shale gas, previously predicted that we would by now, be flooded by LNG arriving on the shores of the US. With over 10 bcf of re-gasification capacity now available and less than 1 bcf/d of LNG imports due to mostly low gas prices in the US compared to elsewhere in the world, facility operators find themselves in a very difficult position. With additional liquefaction capacity coming online over the next 18 months, there is a small window for US operators to lock in contracts if they are of the opinion gas will make a strong rebound in the near future. Despite the growth in the liquefaction capacity, re-gasification capacity is growing even faster. Increased demand from new LNG importers such as China, India, the UK, Argentina, Uruguay, Brazil to name only a few, will ensure that US imports stay at nominal levels for years to come.

#### Conclusion

Now that we have looked at all of the major sources of US natural supply, let’s examine where total supply is likely headed over the next 19 months.

Areas of Supply Growth: Production change:

Fayetteville Shale: +1.1 bcf/d  
Haynesville Shale: +1.08 bcf/d  
Marcellus Shale: +220 mmcf/d  
Woodford Shale: +108 mmcf/d  
Cana Woodford: +97 mmcf/d  
Eagleford Shale: +134 mmcf/d  
Granite Wash: +155 mmcf/d  
Pinedale Anticline: +600 mmcf/d  
Total: +3.494 bcf/d

Considering that the above seven natural gas plays employ close to 70% of the approximately 750 natural gas directed rigs currently running, there is unlikely to be other areas of significant production growth in the US.

Areas of Supply Declines; Change in Production:

Piceance Basin: -800 mmcf/d  
District Four of Tx.: -1 bcf/d  
District Six of Tx.: -1 bcf/d  
Barnett Shale: -2 bcf/d  
Gulf of Mexico: -3 bcf/d  
PRB CBM: -200 mmcf/d  
Canadian Imports: -4 bcf/d  
Total: -12 bcf/d

Based on my analysis of the major producing basins which I have highlighted above, I believe we will see a net decline of US natural gas supplies of approximately 8.5 bcf/d.

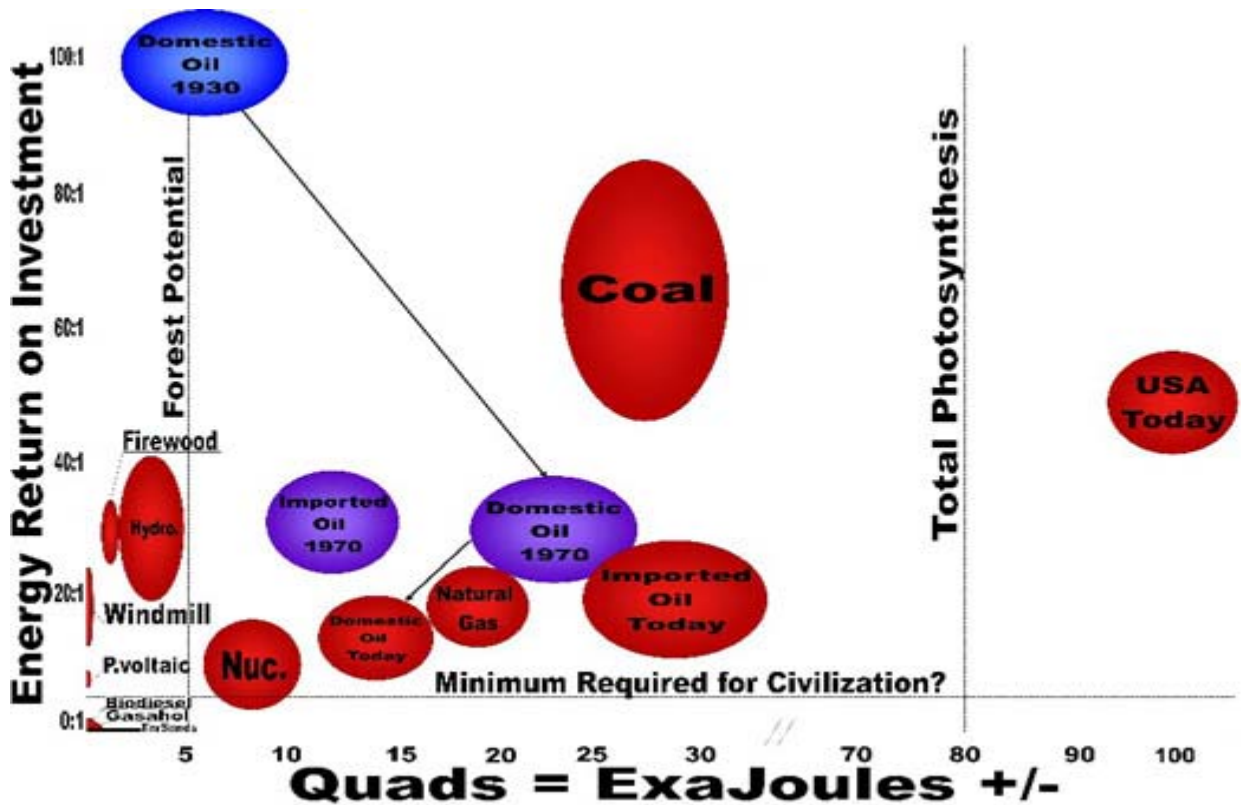
Short of the world going into a severe depression sometime during 2010, the coming drop in US natural gas supplies will put unrelenting upward pressure on natural gas prices when the market realizes the magnitude of supply deficit. When this will happen is unknowable. However, investors can position themselves ahead of time. Several of the companies in my Model Portfolio are gas weighted and are well positioned to take advantage of the upcoming change in the economics of natural gas.

**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 per effort" concepts from fisheries.) It is not always obvious to modern industrial people that it takes energy to get energy. The more energy we spend on finding, extracting, refining, and transporting energy resources, the less we have for all the other activities of society. The horizontal axis of the graph represents quads or more precisely, quadrillion [BTUs \(British Thermal Units\)](#). The graph depicts energy use in the United States. But the principles it demonstrates apply to the world as a whole.



<http://img519.imageshack.us/img519/5209/balloonchartic8.jpg> 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](#), it would take more than 2,000 years at the [current rate of installation \(1.74 gigawatts/year\)](#) 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 \(14.9 gigawatts/year\)](#), 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*.

## **THE FLAWED ECONOMICS OF NUCLEAR POWER**

By Lester Brown  
Earth Policy Institute  
1350 Connecticut Ave. NW  
Suite 403  
Washington DC 20036

<http://www.earthpolicy.org/Updates/2008/Update78.htm>

Over the last few years the nuclear industry has used concerns about climate change to argue for a nuclear revival. Although industry representatives may have convinced some political leaders that this is a good idea, there is little evidence of private capital investing in nuclear plants in competitive electricity markets. The reason is simple: nuclear power is uneconomical.

In an excellent recent analysis, "The Nuclear Illusion," Amory B. Lovins and Imran Sheikh put the cost of electricity from a new nuclear power plant at 14¢ per kilowatt hour and that from a wind farm at 7¢ per kilowatt hour. This comparison includes the costs of fuel, capital, operations and maintenance, and transmission and distribution. It does not include the additional costs for nuclear of disposing of waste, insuring plants against an accident, and decommissioning the plants when they wear out. Given this huge gap, the so-called nuclear revival can succeed only by unloading these costs onto taxpayers. If all the costs of generating nuclear electricity are included in the price to consumers, nuclear power is dead in the water.

To get a sense of the costs of nuclear waste disposal, we need not look beyond the United States, which leads the world with 101,000 megawatts of nuclear-generating capacity (compared with 63,000 megawatts in second-ranked France). The United States proposes to store the radioactive waste from its 104 nuclear power reactors in the Yucca Mountain nuclear waste repository, roughly 90 miles northwest of Las Vegas, Nevada. The cost of this repository, originally estimated at \$58 billion in 2001, climbed to \$96 billion by 2008. This comes to a staggering \$923 million per reactor--almost \$1 billion each--assuming no further repository cost increases. (See data at [www.earthpolicy.org/Updates/2008/Update78\\_data.htm](http://www.earthpolicy.org/Updates/2008/Update78_data.htm)).

In addition to being over budget, the repository is 19 years behind schedule. Originally slated to start accepting waste in 1998, it is now set to do so in 2017, assuming it clears all remaining hurdles. This leaves nuclear waste in storage in 121 temporary facilities in 39 states--sites that are vulnerable both to leakage and to terrorist attacks.

One of the risks of nuclear power is a catastrophic accident like the one at Chernobyl in Russia. The Price-Anderson Act, first enacted by Congress in 1957, shelters U.S. utilities with nuclear power plants from the cost of such an accident. Under the act, utilities are required to maintain private accident insurance of \$300 million per reactor--the maximum the insurance industry will provide. In the event of a catastrophic accident, every nuclear utility would be required to contribute up to \$95.8 million for each licensed reactor to a pool to help cover the accident's cost.

The collective cap on nuclear operator liability is \$10.2 billion. This compares with an estimate by Sandia National Laboratory that a worst-case accident could cost \$700 billion, a sum equal to the recent U.S. financial bailout. So anything above \$10.2 billion would be covered by taxpayers.

Another huge cost of nuclear power involves decommissioning the plants when they wear out. A 2004 International Atomic Energy Agency report estimates the decommissioning cost per reactor at \$250-500 million, excluding the cost of removing and disposing of the spent nuclear fuel. But recent estimates for some reactors, such as the U.K. Magnox reactors that have high decommissioning waste volumes, decommissioning costs can reach \$1.8 billion per reactor.

In addition to the costs just cited, the industry must cope with rising construction and fuel expenses. Two years ago, building a 1,500-megawatt nuclear plant was estimated to cost \$2-4 billion. As of late 2008, that figure had climbed past \$7 billion, reflecting primarily the scarcity of essential engineering and construction skills in a fading industry.

Nuclear fuel costs have risen even more rapidly. At the beginning of this decade uranium cost roughly \$10 per pound. Today it costs more than \$60 per pound. The higher uranium price reflects the need to move to ever deeper mines, which increases the energy needed to extract the ore, and the shift to lower-grade ore. In the United States in the late 1950s, for example, uranium ore contained roughly 0.28 percent uranium oxide. By the 1990s, it had dropped to 0.09 percent. This means, of course, that the cost of mining larger quantities of ore, and that of getting it from deeper mines, ensures even higher future costs of nuclear fuel.

Few nuclear power plants are being built in countries with competitive electricity markets. The reason is simple. Nuclear cannot compete with other electricity sources. This explains why nuclear plant construction is now concentrated in countries like Russia and China where nuclear

development is state-controlled. The high cost of nuclear power also explains why so few plants are being built compared with a generation ago.

In an illuminating article in the Bulletin of the Atomic Scientists, nuclear consultant Mycle Schneider projects an imminent decline in world nuclear generating capacity. He notes there are currently 439 operating reactors worldwide. To date, 119 reactors have been closed, at an average age of 22 years. If we generously assume a much longer average lifespan of 40 years, then 93 reactors will close between 2008 and 2015. Another 192 will close between 2016 and 2025. And the remaining 154 will close after 2025.

But only 36 nuclear reactors are currently under construction worldwide--31 of them in Eastern Europe and Asia. Although there is much talk of building new nuclear plants in the United States, there are none under construction.

What these numbers indicate, Schneider points out, is that plant closings will soon exceed plant openings--and by a widening margin in the years ahead. The trend is clear. From 2000 to 2005, an average of 4,000 megawatts of nuclear generating capacity was added each year. Since 2005, this has dropped to only 1,000 megawatts of additional capacity per year.

Even if all reactors scheduled to come online by 2015 make it, the projected closing of 93 nuclear reactors by then will drop nuclear power generation roughly 10 percent below the current level. Unless governments start routinely granting operating permits for reactors more than 40 years old, a half-century of growth in world nuclear generating capacity is about to be replaced by a long-term decline.

Despite all the industry hype about a nuclear future, private investors are openly skeptical. In fact, while little private capital is going into nuclear power, investors are pouring tens of billions of dollars into wind farms each year. And while the world's nuclear generating capacity is estimated to expand by only 1,000 megawatts this year, wind generating capacity will likely grow by 30,000 megawatts. In addition, solar cell installations and the construction of solar thermal and geothermal power plants are all growing by leaps and bounds.

The reason for this extraordinary gap between the construction of nuclear power plants and wind farms is simple: wind is much more attractive economically. Wind yields more energy, more jobs, and more carbon reduction per dollar invested than nuclear. Though nuclear power

plants are still being built in some countries and governments are talking them up in others, the reality is that we are entering the age of wind, solar, and geothermal energy.

Lester R. Brown is president of Earth Policy Institute and author of Plan B 3.0: Mobilizing to Save Civilization, available at [www.earthpolicy.org](http://www.earthpolicy.org) for free downloading.