Economic Development and Energy

What role do energy, energy efficiency, and new energy sources play in the economy?

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The subject of this talk is the connection between energy and economic development. Specifically: what policies are likely to help us get the most economic development from the energy we use?

Economic development means change that improves people's overall quality of life. The term has an anthropocentric focus, but includes improvements beyond of the narrow realms of finance, production, and consumption. In particular, it includes community, culture, and the environment.[3]

- The relative importance of efficiency of energy use and availability of new energy (independent of carrier),
- The nature of transitions from one carrier to another, and
- The role of adaptation in the long run.

Point 1: Efficiency is More Important Availability

I first want to explore the relative importance of energy efficiency and energy availability. We can get economic development either by using more energy or by making more effective use of the energy we have. What has been the mix of these two strategies over time?

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[2] http://www.aceee.org/conf/08ag/agenda.htm.

[3] The term "economic development" is used in two senses by economists and lay persons: (a) Benefits to a particular place or group from change in economic activity (e.g., new jobs, new investment, more efficient production, cleaner environment, etc.) and (b) Net total benefits from such a change.

The difference is one of focus. Economists are more likely to focus on the second sense and therefore to ask what the offsetting changes are and whether they outweigh the gains or not. Lay persons are more likely to focus on the first sense and therefore to consider the gains alone. If the offsetting losses occur "somewhere else," and if we feel justified in not caring about that group or place, then we feel justified ignoring those offsets. Yet, there are many cases where the offsets occur to the group or place that we do care about.

The main point about economic development is this: there are lots of changes that yield significant net gains, even when they create significant local losses. In general, "economic development" occurs because those changes occur.

1. a. Economic growth is more influenced by energy efficiency than by energy availability.

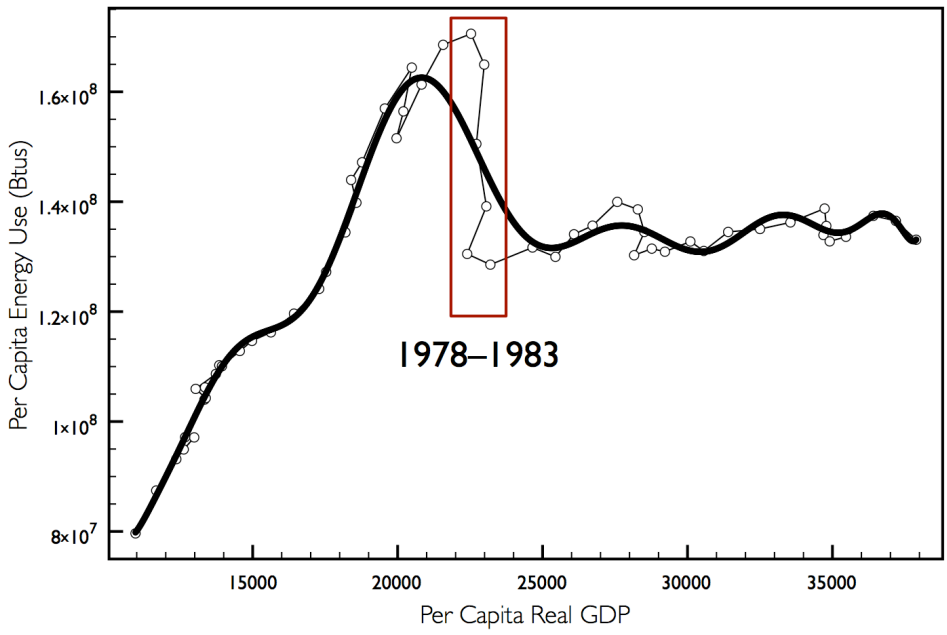
Clearly, we use more energy total than we did 50 years ago. Also clearly, we use more energy per capita than we did 50 years ago. Part of our economic growth can be attributed to this increased energy use. However, contrary to popular belief, a lot of our economic growth does not come from increased energy use alone. There is something else going on in the economy, and that thing is greater efficiency (i.e., economic productivity).

Between 1949 and 2006, U.S. per capita energy use increased by 1.6 times while per capita GDP increased by 3.1 times. We are getting considerable growth by using energy more efficiently.

1.b. Efficiency has become increasingly important to growth.

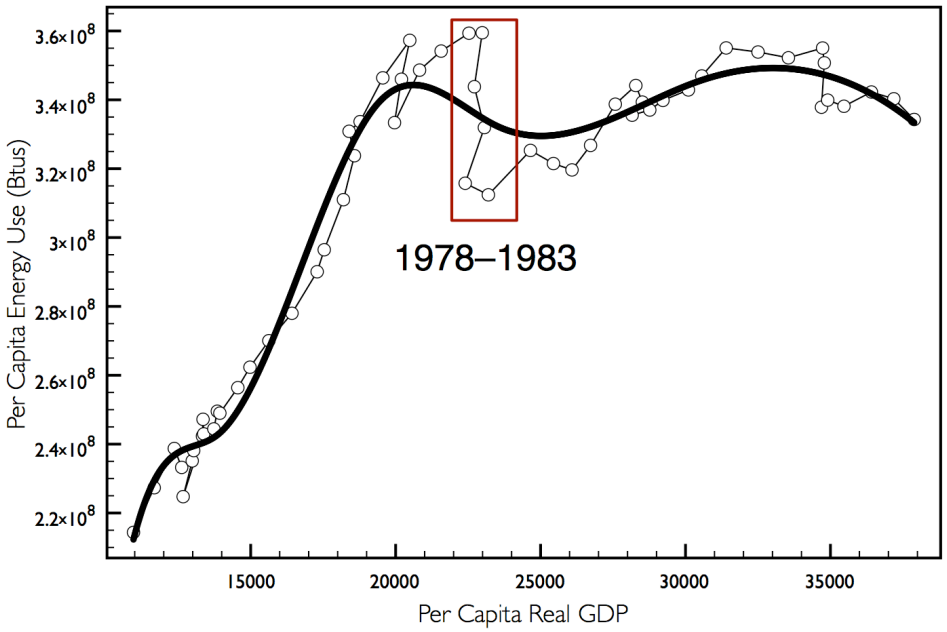
Looking at the 1949–2006 as a whole masks a second point about energy efficiency vs. energy availability: the contribution of efficiency to growth has increased (alternatively, the dependence on energy for growth has weakened in the last 30 years).

As this figure shows, the connection between U.S. per capita GDP and *oil* use has changed since 1983.[4]



The same point is true to a lesser extent for overall energy use:

[4] Sources: U.S. Energy Information Administration and U.S. Bureau of Economic Analysis.



1.c. GDP is a crude measure of growth and understates the importance of efficiency.

GDP is a crude measure of long-run growth. It measures the total economic activity in a country, but "activity" misses critical aspects of growth. In particular, efficiency gains have dramatically improved quality of life in ways that are never reflected in economic activity figures.

We can, to some extent, substitute two things for energy: ideas and organization. In other words, the connection between a unit of energy and what we get from it is not fixed, though there is a limit. Take the example of producing light, illustrated in the following table. The cost of light has fallen much more rapidly than the cost of energy.

Compare the amount of energy and person-hours required to generate light for the following technologies. When we replaced kerosene lamps with electric bulbs, the total sales from "light producing companies" probably did not change dramatically and therefore was not reflected in dramatic GDP growth. However, the quality of life from electric light is markedly better than that from kerosene lamps.

A fluorescent bulb gives us more light per unit energy than an incandescent and the difference is in both ideas—someone smart figured out how—and organization—people modified their companies, stores, laws, etc. to produce more fluorescents and get more of them in fixtures.

			Efficiency[5]	
Year	**Method**	**Fuel**	**Physical**	**Economic**
-500,000	Fire	Wood	0.002	70.0
-30,000	Lamp	Fat	0.015	15.0
-1,800	Lamp	Vegetable Oil	0.06	4.0
1800	Candle	Tallow	0.01	0.7
1870	Lamp	Gas	0.25	0.03
1890	Bulb	Electricity	2.6	0.08
1990	Bulb	Electricity	14.2	0.00006
2000	Low E Bulb	Electricity	70.0	0.00001

Point 2: Transitions are What Matter

The most important aspect of energy and economic development is found in the transitions from one energy carrier (more accurately, mix of carriers) to another.[6]

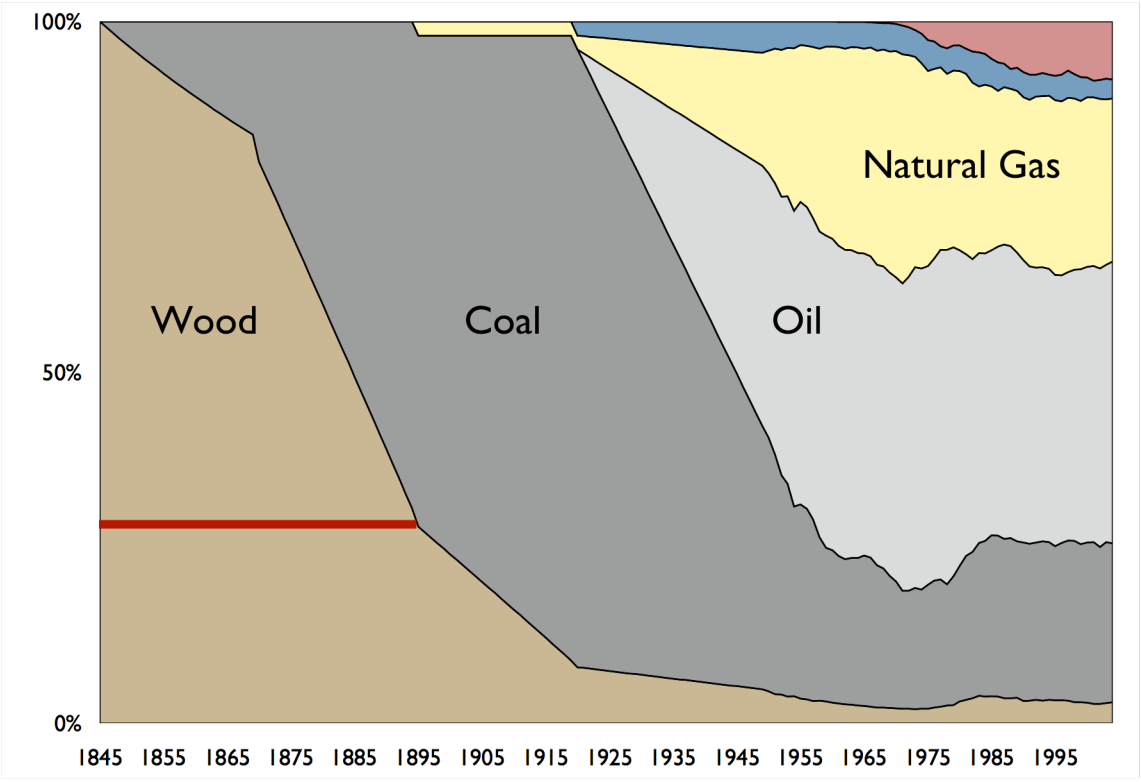
2.a. Energy transitions take a long time.

Transitioning from one energy carrier to another takes a long time, on the order of 25-100 years for complete transition. You can see this in a graph of the past energy transitions experienced in the U.S. The following chart shows the percentage of U.S. energy provided by various sources over time.[7]

[5] Table source: *Culture and Prosperity*, John Kay, Harper Collins (2004). Physical efficiency: Lumens per watt. Economic efficiency: person-hours required to generate light equivalent of a 100 watt incandescent bulb lit for one hour.

[6] We can distinguish energy carriers, such as electricity, wood, coal, oil, natural gas, wind, rivers, tides, etc. from the ultimate energy sources from which carriers derive their energy (the sun, other nuclear reactions, geothermal energy, and the gravity of the moon's orbit).

[7] Source: U.S. Energy Information Administration.



Note that, for example, coal adoption was slow even though the fuel and its technology for its use were much better than wood.

2.b. A lot has to change in a transition.

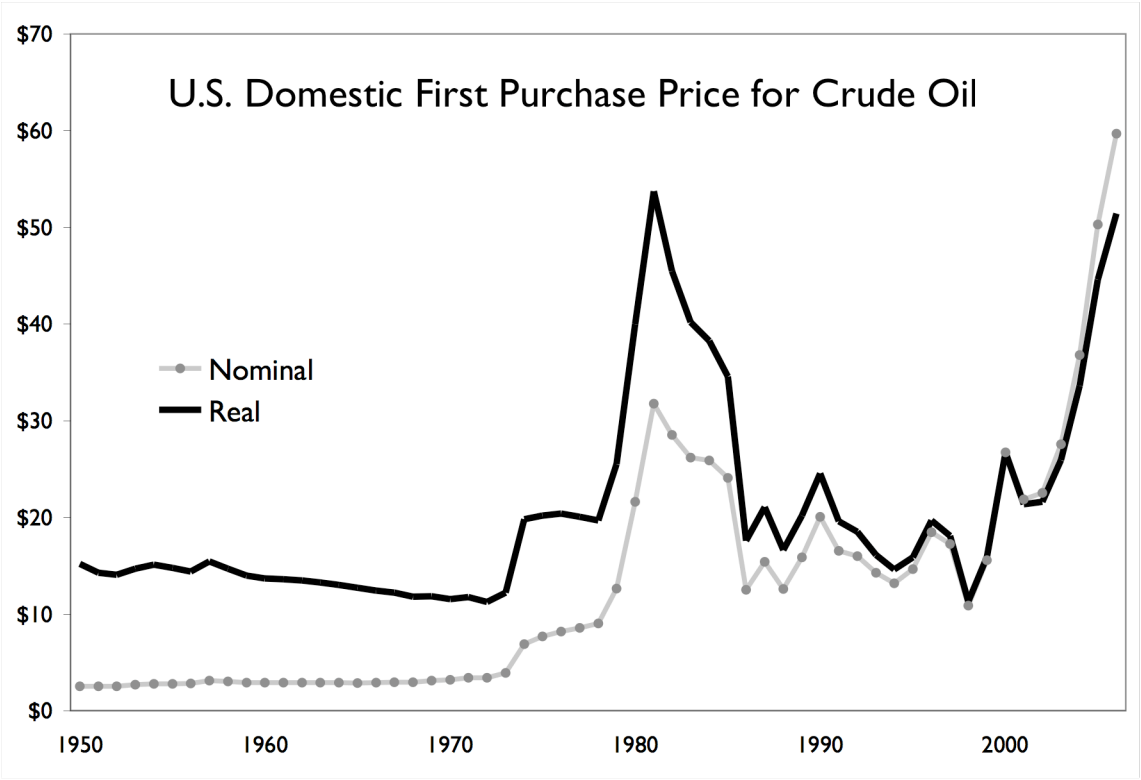
Energy transitions involve technological, infrastructure, and social changes. The infrastructure and social ones are why transitions are so slow. There are countless examples of this. For instance, to change from wood heat to coal heat involved changes in mining, handling, storage, financing, furnace technology, house design, living patterns, and personal preference. Existing wood heat systems had to reach obsolescence, which can take decades. New building stock had to outweigh existing stock.

2.c. If energy availability changes too fast, we get economic disruption.

Although in the long run, a great deal can change in technology, infrastructure, and society, in the short run, change can be very difficult if energy availability changes too fast.

The energy transition between 1979 and 1983 was successful in the long run, but involved dramatic price rises and associated economic slow downs in the short run, as illustrated by the following graph of the nominal and real prices of U.S. crude oil domestic first purchase price.[8]

[8] Source: U.S. Energy Information Administration.



Point 3: Adaptation Should be the Main Policy Goal

Point two was that what really seems to matter for economic development is our ability to transition from one energy carrier to another, not the total availability of energy itself. Point three is that what really matters for energy transitions is the adaptability of the economy as a whole.

Note that this is a different focus than typical energy recommendations. The focus is on the *system*, not on energy carriers, technology, etc., as is typically done. This is not to imply that work is not needed on energy carriers, technology, etc. Rather, the point is that in addition to work on those topics, we need work on the system as a whole.

Fortunately, a lot is know about what makes economic systems adaptable. There are many ways in which adaptable economies differ from inflexible ones. In some ways, that is a larger topic than energy and the economy is. So we can only touch on a few of the important ways to support adaptability with regard to energy.

Note: the U.S. has a very adaptable economy in general, but we could make major improvements! Moreover, energy is obviously a global issue and the U.S. will be harmed by the lack of adaptability of other economies, particularly rapidly industrializing economies in Asia. This is a critical public policy issue.

3.a. Flexible economies encourage experimentation.

The best solutions are unknown *ex ante*. To get around this problem, flexible systems of all kind encourage lots of experimentation. Ant colonies, for instance, send out thousands of individual foragers. Once one is successful, others follow along, but foraging continues elsewhere. The only way to have lots of experimentation is to accept lots of failure. Yet public policy tries to insulate people from failure, notably by subsidizing businesses. Instead, public policy should make experimentation easy and allow failure to happen.

Policy implications:

- Fund startups, not established businesses
- Fund wide range of technologies, etc.
- Establish welfare and health care policies to reduce the personal costs of business failure

3.b. Flexible economies are open.

The most flexible economies are also the most open. They have competitive elections, stable institutions with political checks and balances, open corporate governance, a free press, and related institutions. These institutions may be the most important determinant of economic growth in the long run, more important than energy. Coincidentally, open economies also have the best environmental performance.[9]

Policy implications:

- Dispersed and constrained power (lots of competition!)
- Open corporate governance
- Secure property rights (e.g., no "windfall" taxes)

3.c. Flexible economies use technological and market standards and low cost signaling mechanisms (such as prices).

Complex systems, like economies, face an enormous signaling problem. Billions of individuals and firms need to coordinate their behavior in the face of uncertainty. To do so, they need signals that are clear, unbiased, and cheap to use. Prices are the leading such signal. Adaptable economies find ways to use prices to signal information. There are even ways to use prices to signal normally unpriced information such as pollution.

Policy implications:

- Use pollution charges or tradable permits
- Use policy to reduce transaction costs
- Develop settled standards to allow interchangeable parts

[9] See the Environmental Sustainability Index at http://sedac.ciesin.columbia.edu/es/esi/downloads.html.