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THE GODS OF EPF

In which we watch cultural and legislative barriers put systemic evolution in reverse, and decide we need a template to distinguish between changes destined to survive and those destined to fail.

"Whales and Whisky Barrels" emphasized *technical* barriers and attractors.[1] Now let's pay attention to culture and legislation. Since barriers are usually stronger than attractors, and legislation is always the child of culture, I'll pluck the next story from our rich history of legislative barriers.

In 1954, the United States Supreme Court ordered price regulation of natural gas transported across state lines. Prices were fixed below their market value, artificially encouraging consumption and discouraging the hunt for new supplies. It was a formula for trouble. Yet the trouble was postponed for almost two decades by a massive surplus of natural gas, delaying the collision between increasing demand and declining supply, and giving time to build the violence of the ultimate confrontation.[2]

High in their mythical mountain tops, mists swirling about them, frolicked the gods of Energy Planning Foolishness. Like the gods of love and war who are the stuff of Greek and Nordic legend, the gods of EPF get much of their fun from meddling in the affairs of mortals—stirring up mischief with a little tweak here and a little push there. So the gods were delighted at the prospect of the coming collision, and set about to nudge mortal events towards the best time for EPF knavery. Why not, the gods asked themselves, arrange the collision to coincide with a time already disrupted by other energy troubles, like oil embargoes and exceptionally cold winters in eastern North America? The gods chortled at their wrinkle about the cold winters in the East, because they knew natural gas was delivered from the West through dated, undersized pipelines—so their prank would *also* stir up East–West conflict. Not the East–West conflict of traditional geopolitics, but rather home-grown conflict in the "good old U.S. of A."

It was all arranged for the mid-1970s. Eastern and Mid-Western schools and factories closed down for weeks. "Freezing in the dark" entered our lingo and the cultural response was swift. Everyone decided we were running out of natural gas. What was worse, many people saw the big guys protected from shortages while ordinary folks suffered. "Why," they asked, "should large industries and electric utilities be allowed to gulp natural gas when the news showed school children shivering?"

Legislators scurried about for answers, lusting to appear decisive. This gave the gods of Energy Planning Foolishness another sweet opportunity, because they knew the supply snag had nothing to do with fundamental shortages of oil or natural gas in the ground. The gods of EPF knew the supply snag had been caused by an earlier generation of law makers, the 1950s generation, who took actions that slowed exploration for new supplies, and delayed the repair of old (and the construction of new) infrastructures to deliver natural gas. But the gods also guessed these realities would not change the cultural response. They were right. The 1970s legislators passed a "Fuels Use Act" that made it illegal to use natural gas for electricity generation.[3] Carried forward by the unquestioned belief that we were running out of natural gas, laws were written to send utility executives to jail if they insisted on burning the stuff. Other laws exhorted and cheered the users of coal. All for the good of society.

To legislate a preference for coal over natural gas was to blow against the breeze of historical pattern. For more than a century, the energy system had been evolving towards lower-carbon fuels like natural gas, and away from higher-carbon fuels like coal. Low-carbon fuels had long been capturing an increasing market share among energy sources. Trains ran better, further and cleaner on diesel than on coal. Home heating was better and cleaner with natural gas than oil. We talked about this trend towards lower carbon fuels in "Liberty".

Modern natural gas-fired generating stations produce electricity much more efficiently and cleanly than coal-fired stations (coal-fired stations run at about 43% efficiency, combined-cycle natural gas-fired stations run at about 63% or more) which, retrospectively, makes blocking natural gas from electricity generation even more preposterous. Yet none of these realities stopped legislation that encouraged coal and forbade natural gas. To imbed these ideas as conventional wisdom within our collective thinking, billboards and full-page magazine advertisements repeatedly told us that coal was "the fuel of the future." Sometimes they still do.

Thinking back to those times, I recall a trip to Norfolk, Virginia in the late 1970s. I couldn't resist a harbour tour. The tour boat took us past the decommissioned passenger liner *United States*, then passed an impressive fleet of commissioned and mothballed warships, and finally passed Jacques Cousteau's small, forlorn *Calypso*, bobbing against a particularly rickety jetty, a rusty fragment from her TV image. Still, what most sticks in my mind is not the ships, the tugboats, or even the shockingly small *Calypso*. What sticks in my mind is trying to keep ahead of the coal dust landing on my clothes, getting inside my shirt, itching under my belt—coal dust carried out to our tour boat by a fresh offshore breeze. I got an especially painful micro-lump stuck in my eye, just as the tour boat

announcer, bubbling with tour boat announcer exuberance, pointed out the large piles of coal on the docks and told us how "this was only the beginning," how Norfolk was about to play a major role shipping "the fuel of the future" around the globe to an energy-hungry world. As we floated within the cloud of coal dust coming across the water, he *really did* use those words. With tears pouring down my check from a small bit of the future lodged in my left eye, I had my doubts.

"Whales and Whisky Barrels" showed technical, economic or supply barriers stopping, for a while, the orderly evolution of the energy system towards a brighter future. Now we see that legislative barriers can slam systemic evolution into reverse.

The gods of EPF always have their best chance for chicanery when they exploit our conventional wisdom—better yet, our conventional wishdom. For as Karen Blixen says in her beautiful line from *Out of Africa*, "When the gods want to punish you, they answer your prayers." So can we find any principles, any overarching guidelines, to test the legitimacy of emerging mainstream thinking before it has us serving up sacrifices to the gods of Energy Planning Foolishness?

A good way to find these principles is to return to our barrier–attractor imagery, because we need to know *what it is that the system is evolving towards.* We need a concept of the future, or at least of the patterns of the future. We need to have a sense of where the system is going and how it is getting there. Otherwise, how can we know which are barriers and which attractors? Knowing which are which requires knowing the direction towards the future.

The best way to determine direction may be by observing that energy system evolution always takes a path, however meandering, that improves:

- the *quality* of the service;
- the *convenience* of the service;
- the *economic efficiency* of the system chain delivering the service;
- the *energy efficiency* of the system chain delivering the service;
- the *environmental gentility* of the system chain delivering the service.

We might collapse these five characteristics into two: *improved quality* and *lowered costs.* But I prefer five. Five begins to give texture, to give shape to events too easily lost within the more simplistic notions of quality and cost.

When I was developing these ideas, talking with friends and colleagues about nuances, I first put in, then took out, then put back in, *energy efficiency.* Systemic evolution is driven by quality, convenience, economic efficiency and environmental gentility. My dithering was caused by realizing that energy efficiency is usually either a *means* or a *result* but not a driver. Finally, I included energy efficiency, because my objective is to identify how we can characterize energy system evolution, not to judge what drives what. We want to develop templates we can use to test whether a proposed innovation is likely to be a winner or or a loser, whether it will become embedded within the system or be cast aside—and whether proposed legislation will help or hinder.

One more point before we move on. To some people, environmental gentility may seem a soft idea—a well-meaning but fuzzy pair of words signifying little. But to me it is a sharp idea. Sharp, because environmental gentility means reduced environmental intrusion: the amount by which any action—the action of people building a city, or of beavers damming a stream—intrudes upon nature's flows and upon nature's equilibria. Environmental intrusion can always be judged qualitatively, and often quantitatively, and was the subject of "Tidal Flats and Airports".[5]

"Whales and Whisky Barrels"[1] talked about how the five barrier and attractor categories are linked: for example, how supply barriers (like the shortage of illuminants) can induce economic barriers (like the high cost of illuminants). Not surprisingly, the five *characteristics* of systemic evolution are also linked. When technological advances are introduced, they normally bring improved *quality* of service hand-in-hand with improved *convenience* of service. When change delivers *economic efficiency* it is often carried in by improved *energy efficiency.* Improved *energy efficiency* almost always improves *environmental gentility.*

So there is little point debating which characteristic is more important. We have five descriptors that make up our template—any one of which can be used as a starting point to determine if an embryonic or contemplated change is consistent with the direction to the future. Innovations most likely to succeed will probably satisfy all five. Some will satisfy most, but not all—although in time, sustained changes usually satisfy all.

The "trigger" characteristic is more a function of perception, of who is thinking about the change, rather than of what is fundamentally the most important. Worldly "left-brainers" may decide economics drives it all. "Right-brainers" will have a hard time being definitive. Dedicated environmentalists may argue that environmental gentility is the only thing that matters, and so their circle of linkages will spread out from an environmental apex with diminished weight on the others.

But business planners who dismiss *environmental gentility* from the template they use to test business plans are likely to lose a lot of money. And environmentalists who neglect *quality, convenience or economic efficiency* may feel good about what they are doing but are unlikely to bring sustained changes towards a better world.

I slipped these five characteristics into the last article without comment, used them presumptively, something like the way the phrase "we hold these truths to be self-evident" was used to save a lot of argument in the preamble to the American Declaration of Independence. Now we should try to make our five criteria a bit more "self-evident". To do this, let's return to the stories we already know, but now we'll look at them from our five-characteristic template.

"Liberty"[4] spoke of historical patterns that showed *material linkages* between energy currencies and energy sources becoming weaker with modern currencies. Often weaker material ties bring a parallel evolution that bequeaths the liberty to select from among sources. In "Liberty" we used the example of electric streetcars displacing horse-drawn streetcars.

Hay, which the horses used, could only be made by sunlight. Motors, using electricity, could tap *any* energy source. A free market among sources was created. People were free to select the best energy source they could find for streetcar pulling: best for cost, availability, convenience, or for the environment—and the preferred source could change from place to place. Hydraulic power could be used if it were available, coal or something else if it wasn't. Hay no longer had a monopoly. Streets had fewer horse buns.

If we think of the streetcar parable from our new perspective, we can see the harmony with our five-criteria template for sustainable change. *Quality* and *convenience* came from the ability to deliver higher speeds and more passengers. *Environmental gentility* came from fewer horse buns, tempered for a while by the visual pollution of overhead streetcar wiring—until many streetcars drove underground to become subways.

Some folks might say "I'd rather have a few horse buns than streets crowded with streetcars and traffic". But the imagery of a few horse buns is tied to equally few people using public transit. We need to remember that environmental intrusiveness must be measured in terms of the *service provided*—like the number of passengers transported and how far. Can you imagine the depth of horse buns if all the subways—now moving commuters through New York, Tokyo, London, Paris, Toronto, or Boston—were pulled by horses?

Switching from horses to electric motors also improved *economic efficiency*, although in some towns, in the early days, cost advantages were not immediately clear. Better service, encapsulated in "being up with the times," pushed city leaders into spending money to go electric.

Energy efficiency probably jumped the furthest ahead. We can think this through by comparing the service-to-source chain for horse drawn streetcars (Fig. 1), with the service-to-source chain for electric streetcars (Fig. 2)—and remembering the extraordinarily low energy efficiency of agriculture (transformer technology link) and horses (service technology link). The electric streetcar chain ends in a funnel that can draw on many source options. While the coal and hydraulic source options were the most prevalent during the early 1900s, you can see other sources, faded in Fig. 2—ready to be called upon after people developed the technologies for harvesting these sources to make electricity. Yet although energy efficiency probably took the greatest leap ahead, I doubt most people cared. Which demonstrates, once again, that although energy efficiency may not drive things, it is always there, allowing things to happen, a means to the end.

From our new optic, the parable of streetcars folds in on itself like a Möbius strip, unavoidably and repeatedly bumping into the five characteristics that constitute our template for sustained systemic evolution.

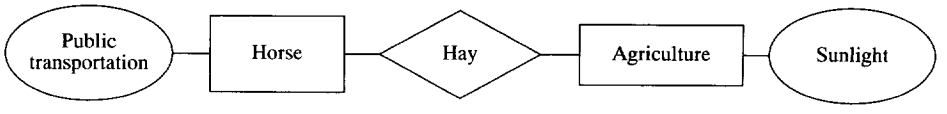

Fig. 1. System chain for horse-drawn streetcars.

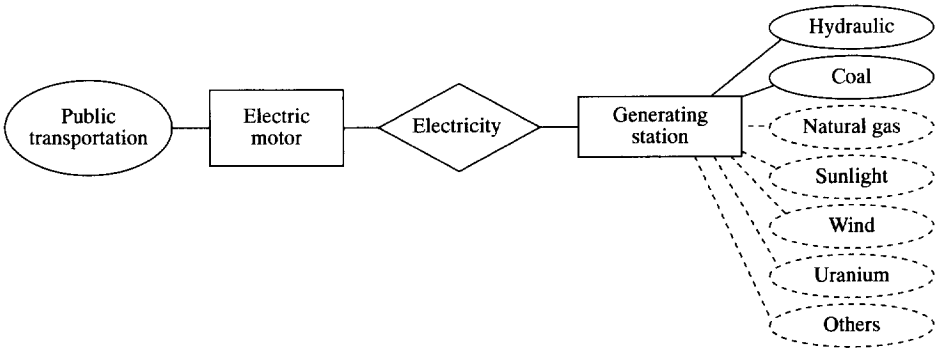

Fig. 2. System chain for electric streetcars.

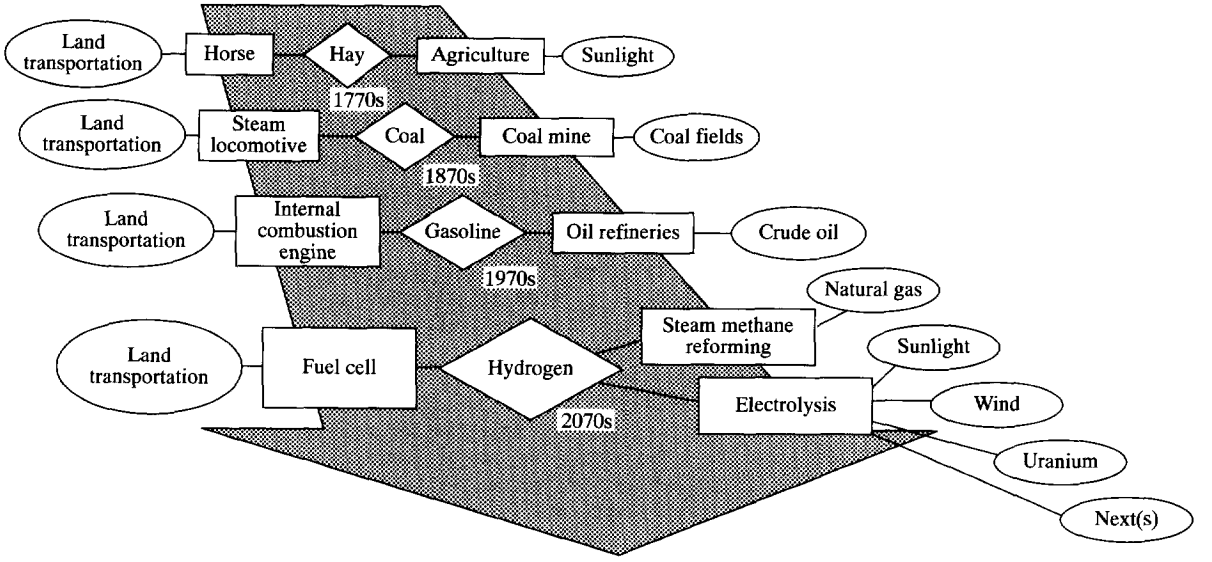

Fig. 3. Evolving system chain for land transportation.

"From Lamps to Lightbulbs"[6] reminded us that there are always two ways to clean the place up—add collectors to catch pollutants, or change the process to stop making pollutants. In that article, I looked back on my life thinking about how we heated our homes. My trip started with coal-fired convection heating, moved to coal-fired forced-air, to oil-fired forced-air, to natural gas-fired forced-air and, finally, to a heat pump that provides both heating and air conditioning. It's not surprising that the *overall* evolution in my personal home-heating (from coal to heat pumps) satisfies all five criteria. But what is remarkable is that *each* time our home heating changed, all five criteria were satisfied. "From Lamps to Lightbulbs" showed this phenomena for criteria like cleanliness, convenience and quality of service. Now let's zoom to efficiency. Our first coal furnace operated at about 40% efficiency, our second at about 50%, our oil furnace at about 60%, gas at about 80%, and the heat pump at between 200% and 300%. Heat pump efficiencies several times 100% may seem screwy, but that is the way they work. We'll be able to explain the magic of heat pumps after a later article has talked about entropy, exergy, and the second law of thermodynamics.

"The Energy System"[7] gave several examples showing how change works. One looked at the evolution of ground transportation through time and used Fig. 3. It's fun to look at Fig. 3 again, observing how each new stage in the evolution improved: quality, convenience, economic efficiency, energy efficiency and environmental gentility.

Anecdotes from earlier articles help reinforce our template for sustained systemic evolution, help make it more "self evident." But knowing what is self evident is different than governing our affairs by what we've agreed is self evident—as experience implementing the American constitution will attest. So our future will be splattered with foolish innovations, investments, legislation—most of which could have been avoided by applying our five-characteristic template as a go, no-go test before proceeding.

Yet if, for some people, our five characteristics are too simplistic or too obvious, there remains a single criterion that stands alone. It is something more profound, more abstract and less obvious. It is often rooted in the material decoupling of currencies from sources we introduced in "Liberty"—and it jumps out at us from Fig. 3. It is not always apparent in the short term. But for time horizons of half-centuries and longer, *the increasing selection of energy currencies that can be manufactured from any energy source* may be the best single criterion for anticipating energy system evolution. It leads us to the deep future. And it leads us to the twin currencies, hydrogen and electricity.

It is early morning, a few days past winter solstice. I'm waiting for the Sun to rise over the Straits of Juan de Fuca, waiting for pink to nip the glaciers atop the Olympic mountains in the State of Washington, enjoying reading the *Globe & Mail*, Canada's national newspaper, getting my daily fix of what-shall-I-wonder-about-today. The *Globe* has been running a series of articles on Saudi Arabia. Today, in part, the article is a series of vignettes about religious police. One vignette tells of a group of professional women being called whores and having their names read in mosques throughout the land, because they had banded together to protest a law that forbids Saudi women driving cars—an issue dismissed by a member of the religious police who said "they should (not) be outside the home at all, so whether they can drive or not is irrelevant."

The articles also discuss the conflict between the majority Sunni Muslims and the minority Shia who are concentrated in the kingdom's oil-rich eastern province. We are told of in-fighting between these two groups, and between them both and the Government. The Government is hard to distinguish from the Royal Family. Then we learn that the Saudi Royal Family, while protecting the privileges typical of entrenched ruling classes, is, paradoxically, trying to re-shape the Saudi culture so it offers more opportunities for all.

We Westerners may think Saudi treatment of women abhorrent—or think the absolute power of Kings to be a quaint anachronism. But for the implications these cultural phenomena may have upon the energy system, what we Westerners think is irrelevant. (Moreover, what we think—or worse, do—about other people's cultures has often not helped at all.) What matters, for the energy system, are the *magnitude* of cultural stresses within this one country, Saudi Arabia. When a country is shot through with such cultural tensions, too often they bring a national cataclysm. And a national cataclysm for the Saudis, spreading throughout the Middle-East, will be an energy cataclysm for the world.

So what-I-am-wondering-about-today becomes: is this one place where the destiny of women and the destiny of energy systems merge? And, could this *Globe* article be equally-well placed in the newspaper's Report on Business—say, in a special series on energy futures?

We have watched the gods of EPF fool Western societies, send them off on blind paths, cost them a lot of money. Now I wonder about cultural barriers in the country that has the world's largest reserves of easily-accessible oil—a country where *real* divisions are driven by what different people believe to be God's *real* rules. If a country like Saudi Arabia explodes, tricks played by the gods of EPF with North American natural gas legislation will seem mere child's play.

Fortunately, most often, things don't turn out as bad as they might. Thank God!

The ninth in a series of articles by

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1. D. S. Scott, Whales and Whisky Barrels. *Int. J. Hydrogen Energy* **20** (12) (1995).
2. The root of the natural gas demand difficulties was a shortage of infrastructure in which to *deliver* the natural gas, like interstate and local pipelines. This caused a lot of gas to be "flared" at the well-head. This flared natural gas was "associated gas", so called because it is produced in "association" with pumping oil. It might have been better to introduce fiscal policies that would have encouraged investment in natural gas delivery infrastructures, rather than employ the blunt, imperfect, tool of price regulation at the well-head.
3. You can find this all set out in United States Statutes at Large, 1978, Vol. 92, Part 3. The relevant Statute, called "Powerplant and Industrial Fuels Use Act of 1978", follows immediately upon an act, taking up less than half a page, dealing with imported bobsleds and luges. In those days it seems to have been downhill all the way.
4. D. S. Scott, Liberty. *Int. J. Hydrogen Energy* **19** (4) (1994).
5. D. S. Scott, Tidal flats and airports. *Int. J. Hydrogen Energy* **19** (9) (1994).
6. D. S. Scott, From lamps to lightbulbs. *Int. J. Hydrogen Energy* **19** (4) (1994).
7. D. S. Scott, The energy system. *Int. J. Hydrogen Energy* **19** (6) (1994).