Why Hydrogen? Can Anything Better Come Along?

Some introductory thoughts for the

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About the future, we never know everything but we always know something. And for some things we can often project the deep future better than tomorrow. These observations are especially relevant to our energy system when that "something" is energy *currencies*. Then, relatively predictable of currencies can be used to at least deduce patterns in a few other components of energy system infrastructures.

These ideas can help focus this symposium, because it's prudent to distinguish between those things which are impossible to project and those that are pretty damn certain (at least, if civilization survives).

Focusing on *energy currencies* leads to the logic that, a century from now, the staple energy currencies will be hydrogen and electricity. This robust tether of longer-view predictability can help us leap the tangles of today's vested mantras, ill-found hopes and conventional *wishdoms* – to better anticipate future infrastructures, a little about future sources, but much less about future service technologies.

To put this last in context, we need the idea of the energy system's architecture. After a brief discussion ot the architecture, we can go on to "Why Hydrogen?" and "Can Anything Better Come Along?"

Architecture of the Energy Systems

The unfortunate thing about the energy system is that few people think of it as a system. Instead most think about its bits-and-pieces—about electricity networks or oil cartels, about how the latest geopolitics will influence prices — but little about the integrated system. We need a concept of systemic architecture to see how the bits and pieces fit together, what they do themselves and do for each other.

At its simplest, the system may be represented by a five-link chain that starts with energy services, moves to technologies (that deliver the services), then to energy currencies (that feed the service technologies), then transformer technologies (that produce the currencies) and finally the sources that the transformer technologies harvest. This figure shows where things fit.

To appreciate how the system functions, it's *essential* to remember that people want energy *services*; they don't much care about energy itself. Energy is a means to ends. Services are the ends.

Why Hydrogen?

As we embark upon the 21st century, two specters threaten civilization. One is the prospect of economic disarray and incitement to war caused by the local depletion and global mal-distribution of high-quality fossil fuels, especially oil. The second is the prospect of almost unimaginable environmental, economic and cultural disruption caused by climate volatility and triggered, primarily, by our energy system's carbon dioxide (CO_2) emissions.

If we remain tethered to fossil fuels it is merely a question of when, not if, one or both specters become reality. Today we're seeing the precursors of both. From the viewpoint of Earth's physiology, climate

volatility is much the more critical. Yet at any moment flaring geopolitics could suddenly destroy international fossil-energy supply.

Happily, a straightforward pathway can steer us clear of both specters. First, we must rapidly adopt sustainable energy sources that don't emit CO_2. Such sources include solar, wind and next-generation nuclear power. Second – and perhaps more critical because it's so poorly understood – we must rapidly adopt the twin energy currencies, hydrogen and electricity. Alone among currencies, both can (a) be manufactured from any energy source, (b) neither emits carbon dioxide and, (c) together, they can provide the full menu of energy services, from flying airplanes to running computers.

Depletion rationale:

Today's transportation fuels are harvested exclusively from fossil energy sources. But because fossil sources are threatened by regional depletion and are a sure cause of international conflict, civilization must move to sustainable, regionally available, non-fossil sources. We must harvest sustainable sources to manufacture chemical fuels in general and transportation fuels in particular. Realistically, the only way sustainable sources can manufacture transportation fuels is via hydrogen. (How else, for example, can we use the energy from wind, solar or nuclear to fly an airplane?) Therefore, a significant move from fossil to sustainable sources can only begin with the increased use of hydrogen in transportation, and can only be completed with the supremacy of hydrogen among chemical fuels.

Climate disruption rationale:

Today our energy system's CO_2

Synergies:

The patterns in synergies are:

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