

ENERGY TRANSITIONS: WHAT WE HAVE LEARNED FROM THE PAST TO CREATE A BRIGHT FUTURE

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Introduction

An energy transition is a process and a time period during which one dominant energy regime is being replaced by another. We have observed various energy transitions in the past, with certain features being shared among all of them at least to some extent. Although the current, or pending, energy transition towards truly dominating renewable energy shares appears to be fundamentally different, clues from past transitions will allow us to set up a framework that will facilitate such transition.

Energy Eras of the Past

In order to study energy transitions we first need to identify and define the energy eras or ages that have preceded and succeeded past energy transitions [1].

The Foraging Age

From the human standpoint the energy baseline is defined by the Foraging Age, during which bands of humans were hunting and gathering, and eventually widened their energy spectrum by commanding open fire. This era was characterized by low, or lack of, professional specialization, lack of excess energy, and low or negligible population growth resulting from high birth rates combined with high death rates.

The Agricultural Age

The Agricultural Age was a long and complex era, defined by the ability of humans to direct sunlight towards the growth of nutritional energy rather than looking for food in wide landscapes the way nature happens to provide it. The resulting excess nutritional energy allowed for professional specialization and led to stratified societies. For millennia, slaves represented the lowest end of such societies. They often made up for large shares of society, and the principal pair of fuel and prime mover in this era remained grain and human workers, though beasts of burden were variously introduced and provided for increased power output. At the higher end of society more hands were freed from physical work, and knowledge accumulated at ever faster rates, especially when declining death rates led to strong population growth and more humans being around to think. In the energy arena, the positive feedback cycles led to tools and equipment augmenting muscle power and, eventually, to the introduction of wind and water power as well as the use of biomass for industrial purposes. However, these applications of non-nutritional renewable energy remained niche applications of sorts and did not lead straight into a new Energy Age. Wind power became critical for mobility at sea only and, just like water power, limited to specific regions when it came to stationary productive applications. Meanwhile, industrial biomass remained subjected to natural growth rates, with charcoal use for ironmaking often resulting in critical deforestation. When the use of peat, arguably not a renewable resource, gained prominence in regions that happened to be endowed with it, productivity and wealth increased in these regions, while peat did not extend a military advantage as its flame was not hot enough for ironmaking.

The Coal Age

The Coal Age is defined by the utilization of large amounts of coal, a resource of stored energy that is quite widely distributed over the globe, and quite easily accessible. The principal prime mover to utilize coal was the steam engine, which was initially used for stationary work, but soon also revolutionized mobility both on land (steam trains) and the sea (steam ships). The use of coal released human energy consumption from the limitations imposed by the given intensity of incoming solar radiation and thus the rate of biomass growth, the hydro cycle and the heating of the atmosphere for wind generation. What is more, coal products could be used to make hard metal in large quantities and to mass produce

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pharmaceuticals, dyes, and other useful chemicals. The Coal Age eventually featured the introduction of two new prime movers, the water turbine, which was an improvement over the water wheel, and the steam turbine, which was sort of a crossover between the steam engine and the water turbine. Both provided high rotary power and were used for electricity generation, while steam turbines were also used to build the fastest boats. The Coal Age witnessed an acceleration of the effects observed in the Agricultural Age in terms of increased life expectancy, population growth and knowledge generation, but coal did not work well for individual land transport and for work on the fields. The horse populations thus peaked in various countries towards the end of the Coal Age and claimed a share of the agricultural output.

The Oil Age

The Oil Age took full advantage of the availability of liquid fuels derived from crude oil. Comparatively light internal combustion engines allowed for the construction of cars, tractors and airplanes, but trains and ships soon employed them, too. Oil thus became the most critical fuel in terms of mobility, and it transformed the physical world by serving as the raw material for plastics, next to pharmaceuticals and a range of new synthetic chemicals. Agricultural output, the human population, and knowledge accumulation soared to unprecedented levels. Gas turbines featuring continuous combustion entered the scene providing for jet propulsion and efficient power generation, where natural gas was introduced, while coal remained important. Oil was used for electricity generation, too, besides serving for domestic and industrial heating purposes. Oil thus reached the highest share among all available fuels.

What Do We Know About Past Energy Transitions?

Various aspects of past energy transitions can be observed. One is that they are notoriously slow, as new technology emerges rather than being the result of strokes of genius. Foraging societies in a very long process began protecting and manipulating their target species in nature before turning into farmers, and inefficient steam engines did nothing but pumping water at mines for nearly a century before turning into a universally useful prime mover. Also, transitions create winners and losers, with those losing out in the transitions fighting it as long as possible. Foraging societies were expelled or enslaved by expanding farming societies, landowners lost out against industrialists, resisting farm and cottage workers eventually turned into factory workers, and the British Red Flag Act requiring a man with a red flag to walk at least 60 yards ahead of each self-propelled vehicle was eventually abolished. Notably, the transitions of the past always involved a major technological advance over the previous energy era, with the new energy technology serving various purposes and sectors.

Is a New Transition on Its Way?

The current energy transition towards renewable energy is fundamentally different, as it is driven by environmental and security of supply concerns. As a matter of fact, it is questionable to speak about an energy transition just yet, as renewable energy shares remain low on a global scale, and as the larger shares remain restricted to electricity generation only. Critically, the introduction of intermittent renewables regimes as such can hardly be considered an advance over conventional on-demand regimes from the technological standpoint. It can thus not be expected that a top-down, externally imposed energy transition will develop the same dynamics as the previous, self-motivated transitions. Policies such as incentivizing renewable energy use through guaranteed feed-in tariffs have distorted markets to require further interventions, which will only be fruitful in triggering a real transition if they lead towards technology that is at least as advanced as previous technology, while being environmentally more sound. Meanwhile, this planned transition will create losers just like the previous transitions, with resistance from the coal districts being well on its way. On the other hand, the grassroots climate action movement will provide support, and introducing the right policies and setting up the right frameworks might transform the current attempts into a true, self-propelled energy transition.

References

- [1] M. Weissenbacher, Sources of Power- How Energy Forges Human History. Volume 1: Before Oil: the Ages of Foraging, Agriculture, and Coal. Volume 2: The Oil Age and Beyond. Santa Barbara/Denver/Oxford: Praeger, 2009.