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The Carlyle Compass

By **James Gutman**
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*Welcome back to **The Carlyle Compass**, your weekly newsletter that brings together the latest research and market insights from our global team. This week's edition features guest author James Gutman, a Strategist of Energy Pathways, and highlights the evolution of how energy is produced, traded, and consumed.*

The Energy Transformation and the Energy Transition

Key Takeaways:

- Thanks to the infrastructure behind the grid and stationary storage, a range of fuel sources are increasingly able to compete in providing useful electrons to consumers, further enabling renewables and decarbonization.
- This evolution potentially means natural gas may at long last be supplanting oil as the marginal fuel that balances the market and may itself one day see hydrogen take this role in turn.
- The presence of such a storable and portable energy backstop provides the buffer to make the overall energy system more reliable as the share of renewables grows.

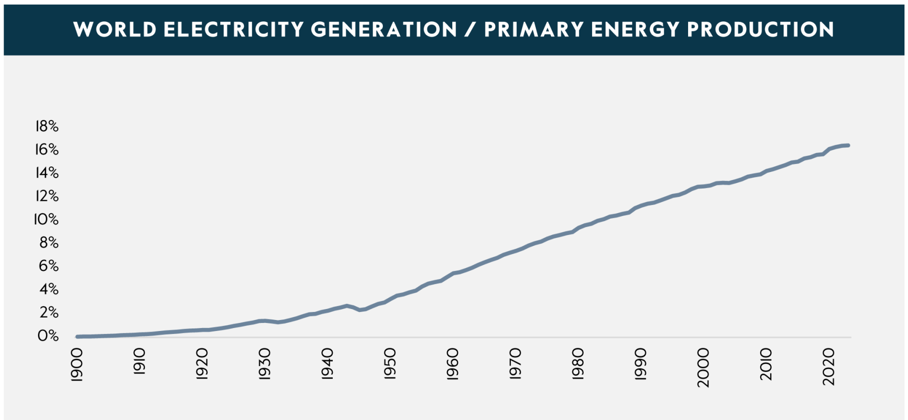
More than just a *transition*, we believe the energy ecosystem is going through a *transformation*. The transition is the decarbonization of our energy supply. The transformation is the change in the way energy is produced, traded, and consumed.

The energy transition couldn't happen without the energy transformation, but the converse is not true. The transformation is primarily about electrification, which opens up a range of new possibilities in the energy ecosystem. One of those possibilities is shifting our energy supply to zero carbon sources like wind, solar, nuclear, hydro, and geothermal.

The IEA has said the world is moving into an "age of electricity" as a necessary part of the energy transition, and we agree that the electricity transformation is a necessary condition for the decarbonization transition. However, there are two points where this can become confusing.

First, the "age of electricity" arguably began well over a century ago and has continued at a stable pace over the long-term, as shown in Figure 1. If anything, the pace has eased a bit over the past twenty years versus the twenty years prior, from a 1.4% CAGR to 1.1%. We expect the rate of electrification to accelerate, but we see this as a continuation of a long trend, not the ushering in of a new age.

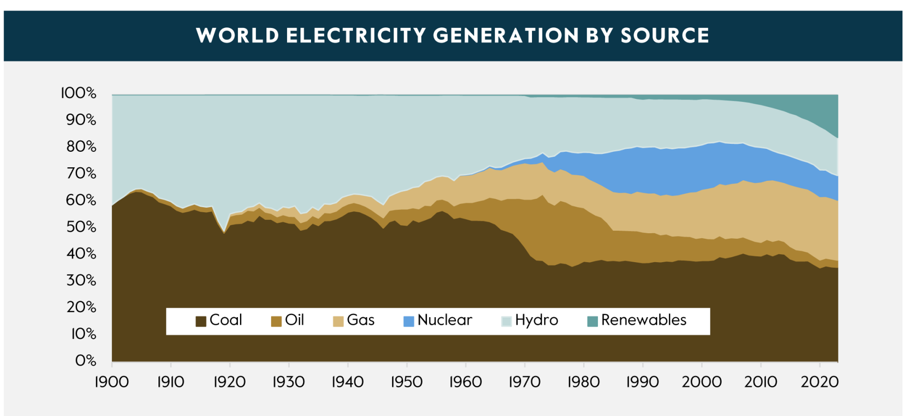
Figure 1: The "Age of Electricity" Began a Century Ago



Source: Carlyle Analysis; Ember, Our World in Data, Pinto el al (2022). There is no guarantee any trends will continue.

Secondly, much of the discussion around electricity implicitly conflates "electricity" with "green energy." Most of the energy used to produce electricity has been and remains brown, not green, as shown in Figure 2. The reason why this distinction occasionally gets overlooked is because green energy *must* become electricity to be broadly useful, even though electricity need not come from green energy sources.

Figure 2: Fossil Fuels Still Provide Most of Our Power, but the Mix Changes



Source: Carlyle Analysis; Ember, Our World in Data, Pinto et al (2022). There is no guarantee any trends will continue.

The Electron Is the Ultimate Commodity

The grid is in essence a vast clearinghouse for mediating homogenized energy. Instead of moving energy in the form of molecules (which come in vast array of chemistries and states) directly to the point of consumption, the energy is instead collected in the form of electrons (which is the quintessence of fungibility) and then distributed to the consumer.

Consider the energy ecosystem before electricity. The first source of energy was food, which allowed muscles to do the work of pulling a plow or turning a wheel. To replace this muscle power, we learned how to move stored energy in the form of wood, coal, oil, and gas to where we wanted to use it to power a machine.

The introduction of electricity meant these primary fuels could be used at a point far removed from where the final energy would be consumed. The molecules could be turned into heat far away, which would drive a turbine and generate an electrical current that could be dispatched through wires to a home, a factory, or an office. Coal no longer needed to be trundled through the streets and stored next to the boiler in the building, but instead could be kept by the power plant far from town. Machines could all be harmonized to use a standardized electric current, enabling mass production and allowing consumption wherever desired (as long as it was on the grid).

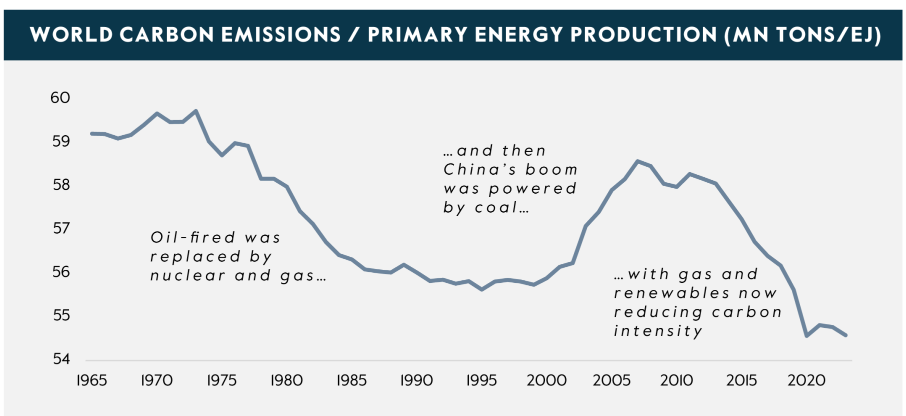
While useful, the new energy production possibilities it enabled were equally important. Hydropower simply doesn't work on a large scale without an electricity grid to move power from dam to city or factory. The same holds true for wind and solar, geothermal, and nuclear (although Small Modular Reactors may start to relax that constraint).

This expansion of production possibilities allows politics and economics to determine the energy mix in a sequence of small energy transitions. For example, a century ago, Figure 2 shows how electricity generation was dominated by hydropower (clean and cheap, but isolated and limited by the availability of suitable water resources) and coal (portable and storable, but dirty and expensive). Abundant cheap crude oil in the 1960s led to oil-fired plants providing nearly a quarter of the world's electricity by the mid-1970s, but the subsequent oil shocks meant that nuclear began to supplement oil for both security and economic reasons. From the mid-1990s onwards, it was natural gas that was rapidly expanding share thanks in large part to shale. Today, oil-fired power generation is rare, while renewables like wind and solar are plugging into the grid at a rapidly expanding pace.

The grid also enables new possibilities for energy consumption. Take automobiles as an example. A power plant—even coal fired—is far more efficient than an internal combustion engine at producing energy, which on its own is a good reason to shift to electric vehicles. However, for this to work, battery electric vehicles (BEVs) need to satisfy other consumer preferences relative to vehicles with internal combustion engines (ICEs). Both face range limitations (battery pack vs gasoline tank) and network dependence (charging stations vs gas stations), so it's not hard to envision a scenario where the utility advantage currently held by ICE (long range, convenient stations) fades relative to BEVs as batteries get better and infrastructure deepens. This could be how we further transform the energy system, shifting energy production for transportation from under the hood to over at the power plant, and thus advancing the energy transition.

These small transitions over the decades have directly affected carbon emissions, as seen in Figure 3. In the mid-1970s and 1980s, the carbon intensity of primary energy consumption declined as oil shrank as a share of the energy mix. Carbon intensity rebounded with the coal-fired China boom in the early 2000s but has since fallen back with the growth of renewables in the energy stack. As coal and oil are further crowded out by nuclear, renewables, and natural gas, we expect this carbon intensity will likely continue to decline.

Figure 3: Carbon Intensity Is Starting to Decline Again



Source: Carlyle Analysis; Energy Institute. There is no guarantee any trends will continue.

The Ongoing Energy Transformation Also Has Implications for How Prices Will Be Set

Ultimately, it is prices that drive our energy choices, and the overarching price of energy is determined by the fuel that clears the market in time, space, and form. Arbitrage relationships connect markets across time via storage, across space via transportation, and across form by processing. The energy source that becomes the price setter is the center of this web of arbitrages which balances the market by delivering the last joule demanded.

For more than fifty years, the price of crude oil has served in this role. Starting in the late 1960s, oil-fired plants became more common, which linked the power markets—with its various fuel sources—to the industrial and transportation markets. The global trade in oil also expanded substantially, linking different regions. Finally, oil storage expanded with the development of the oil futures market in the 1980s, linking the present to the future.

As a result, one narrow slice of the oil market—West Texas Intermediate (WTI)—and more recently Brent—became the de facto global price for energy. Through a chain of arbitrages, the price of energy in nearly every market would be impacted by this one price, which became the balancing term in the global energy equation. And not surprisingly, the price of WTI came to drive the business cycle and inflation. Indeed, even today the breakeven inflation embedded in the TIPS market is tightly linked to oil prices.

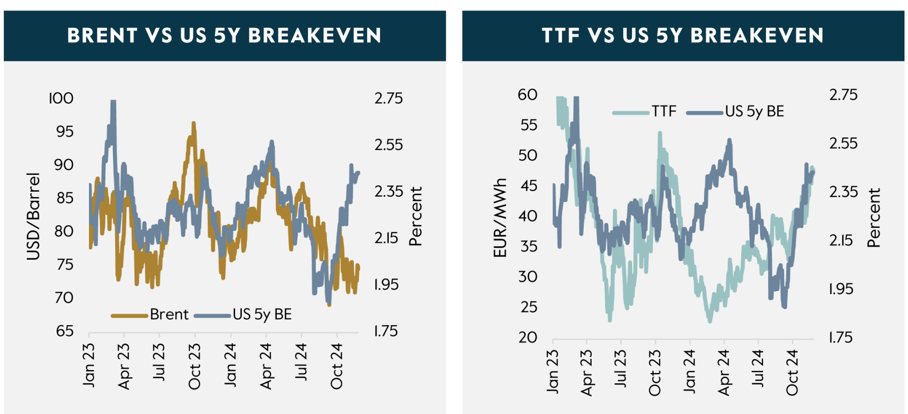
Oil hasn't been the price setter because it is the cheapest, or the most common, or the cleanest form of energy. In all cases, it is clearly not. What it has been is the most useful.

Electrification changes this. The grid obviously links markets across space, and electrons are in a universally fungible form, which makes the storability, portability, and convenience of oil molecules less important. The parallel development of the liquified natural gas (LNG) market, which increasingly connects regional markets, along with advancements in natural gas storage further erodes the advantage once held by crude.

We think natural gas is in the process of replacing oil as the marginal price of energy. It is not because natural gas is the most common primary fuel source, or the cheapest, or the cleanest. Natural gas is none of these things, but it is more useful than oil and solves a problem other forms of energy cannot—it can be easily stored, shipped, and used.

Figure 4 offers an early hint that this new relationship may be taking hold. Inflation breakevens, long tied to crude oil, most recently have been tracking TTF, or Title Transfer Facility—the European natural gas benchmark, instead of Brent.

Figure 4: Inflation Expectation May Be Starting to Track European Natural Gas Instead of Brent



Source: Carlyle Analysis, Bloomberg. There is no guarantee any trends will continue.

Natural Gas Replacing Oil and Enabling Renewables

Meanwhile, the links between natural gas markets are increasing. Imports of natural gas into Japan, which has been the largest importer in the past, used to be set as a function of the oil price—the "Japan Crude Cocktail." Now, there is an independent financial instrument (JKM) to price the LNG trade in Northeast Asia. LNG cargos to Europe have also dramatically expanded since the invasion of Ukraine, linking JKM with TTF. As liquefaction capacity comes online in the US Gulf Coast, Henry Hub will likely become linked more tightly to TTF. Thus, the three geographies—North America, Europe, and Asia—will have a physical and financial arbitrage to connect them.

Natural gas *competes* with renewables plus battery in the power market, but also *enables* renewables plus battery. The need for frequent charge/discharge cycles can make the economics of long-duration battery storage challenging, but chemical energy storage (in the form of natural gas) doesn't face this problem, as it is storable and relatively quick to become available when weather shifts. The reliability provided by natural gas peaking plants allows grid operators to comfortably depend on intermittent wind and solar in the power stack.

How I Learned to Stop Worrying About Dunkelflaute and Love Renewables

The recent German experience with *dunkelflaute*, when neither sun shines nor wind blows and thus wind and solar output is low, illustrates this evolution and adaptation of the energy ecosystem. As Germany relies heavily on renewables, their first recourse would be to either import power such as Spanish wind and solar or French nuclear, or to draw on storage. Neither the grid nor stationary storage are yet able to fully compensate for the shortfall, which leads to the second line of defense – drawing down natural gas inventories.

As a result of the sharp recent draw in inventories, TTF prices have spiked, and the forward prices for next summer have reversed the typical seasonality to trade at a premium to the following winter because of EU mandates requiring storage to be filled before the winter months in order to reduce geopolitical vulnerability to energy disruption.

This is exactly what the market is supposed to do. Prices and spreads spiked into order to motivate producers to balance the market with a portable and storable fuel in a relatively rare event. Indeed, the backstop of natural gas makes renewables like wind and solar a more reliable energy source. If natural gas can be called upon when the dunkelflaute arrives, then it is easier to rely on wind and solar. By balancing the market some of the time, natural gas enables renewables to satisfy the market the rest of the time.

As grid and storage infrastructure deepens, the occasions when chemical storage like natural gas is needed will likely become fewer in the years to come. And, if hydrogen can replace natural gas, then the carbon footprint of this balancing fuel can then be further eliminated. Thus, the infrastructure underpinning the energy transformation can enable the energy transition to a decarbonized world.

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