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How a low-tech renewable solid fuel is an important component of the pathway to a more decarbonized future:

Wood Pellets as a Substitute for Coal in Power Generation

By William Strauss, PhD, President, FutureMetrics

September 16, 2017

Most developed nations and many developing nations have strategies and policies aimed at addressing climate change. Most notably, reducing the emissions intensity of their energy sectors and transitioning to a more decarbonized future. The transportation, heating, and power sectors are all large users of fossil fuel and thus large emitters of CO₂.

Mitigating CO₂ emissions from the energy sectors is critical to the future stability of our environment and the well-being of future generations. But carbon mitigation strategies should also minimize disrupting national economic systems and the well-being of current generations.

This short paper discusses a renewable biomass-based strategy for the power sector that is good for the environment and offers a low-cost method of reducing CO₂ emissions while providing essential baseload power to the grid¹. The strategy is not based on complex chemistry to produce liquid fuel from biomass. The strategy is based on a proven process for upgrading wood into a densified and durable solid fuel that is suitable for use in large utility power boilers that are based on pulverized coal fuel systems.

In many countries around the world, substituting densified sustainably produced wood pellets for coal is already part of pragmatic strategies for moving toward a more decarbonize future.

Why Worry about CO₂ in Three Charts

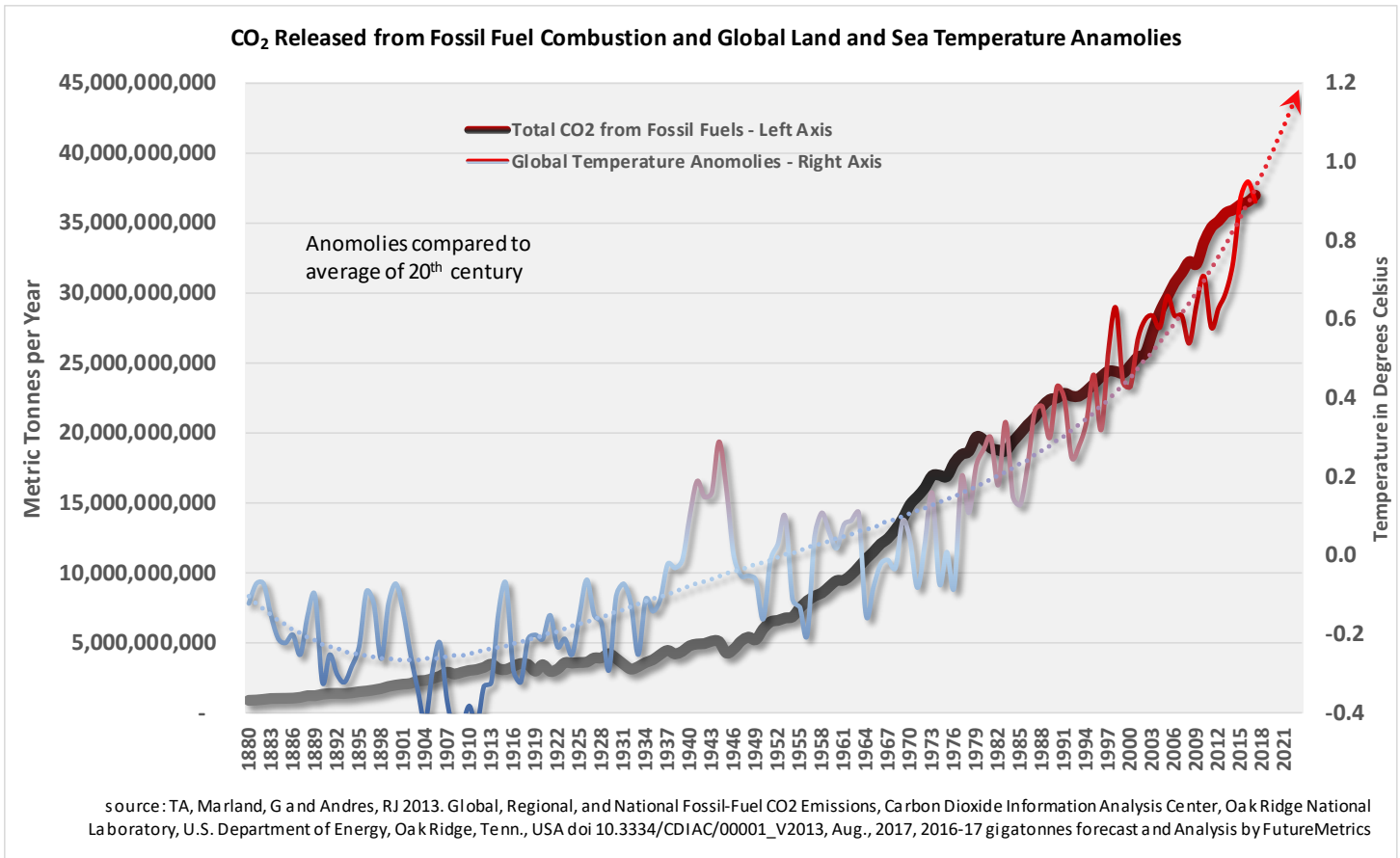
The criticality of acting decisively to control CO₂ emissions is illustrated in the first chart below. The chart shows the relationship between the tonnes per year of CO₂ released globally and the global combined land and sea temperature variations around the average from 1901-2000.

¹ Hydro power is an exception to that statement. However, in most jurisdictions the low-cost hydro assets have already been exploited. Hydro is not an option in most jurisdictions for increasing the baseload generation from renewable energy.



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The first chart above illustrates the strong correlation² between the CO₂ being released from fossil fuel combustion and the rapid warming of the atmosphere and oceans.

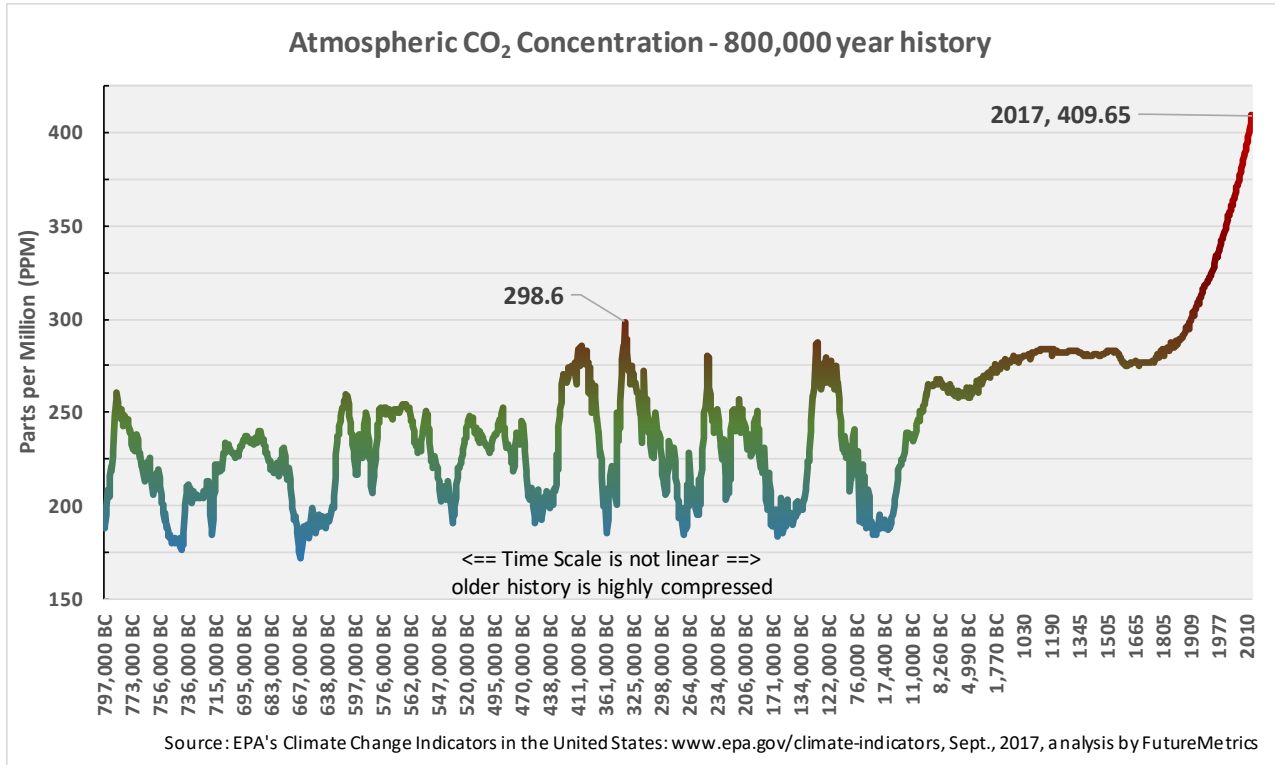
The second chart below plots the concentration of CO₂ in the atmosphere over the last 800,000 years.

² The Pearson correlation coefficient of the two time series is 0.92.

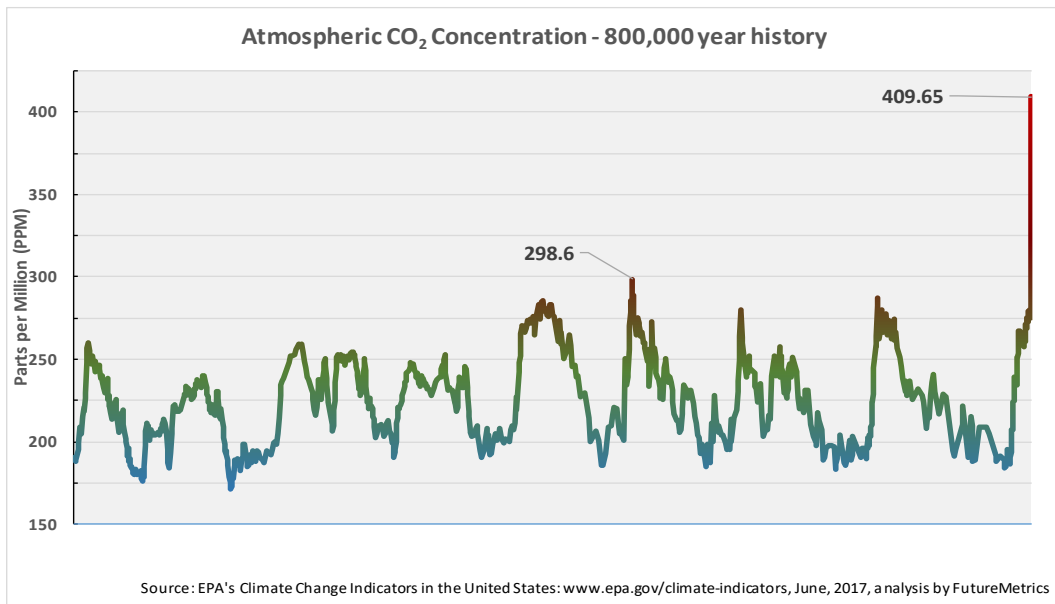


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The time scale on the X-axis in the chart above is not linear. The intervals between the dates vary, and the interval gets much smaller over the last 2000 years. As the chart shows, the level of CO₂ concentration in 2017 is clearly unprecedented over the time series. The rate of increase, which is even more dramatic, is shown more clearly in the third chart below in which the horizontal X-axis is scaled normally.



The rapid increased in CO₂ levels in the atmosphere over the last 200 or so years is caused by our use of fossil fuels. Combined with the fact that the concentration of CO₂ in the atmosphere is directly related to



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how much heat is trapped on the planet³, the three charts illustrate a major indicator of the beginning of the Anthropocene epoch⁴. How this epoch of human influence on the earth's dynamic systems plays out depends on how we change the way we create and consume useful energy.

A Non-Disruptive and Proven Solution for the Power Generation Sector

If there is to be action to change the carbon intensity of our energy consumption, then all three of the major fossil fuel consuming sectors, transportation, heating, and power, will have to evolve. But the transition from today's intensive dependence on fossil fuels to a more decarbonized future must be well planned and, to the greatest degree possible, be non-disruptive to our economic well-being. Most national economies are heavily dependent on the benefits of fossil fuel energy. Strategies that provide a gradual but meaningful transition allow markets to adjust.

The remainder of this white paper focuses on the power sector and a strategy that produces reliable on-demand baseload generation; something that the other major renewable power sources, wind and solar, cannot provide. The strategy is a perfect component of a managed non-disruptive reliable transition toward a low carbon future.

The strategy is, as the title of this paper makes clear, to substitute sustainably produced biomass-derived solid fuel for coal.

Wood pellets produced from sustainably managed forestry operations, when used to produce power, do not increase the net stock of CO₂ in the atmosphere⁵. Wood pellets are an easy substitute for coal in existing coal power plants. Pellets do not require complex biochemical refineries or unproven and challenging technology/business models. The pellet production process is well-proven and the supply chain for moving pellet fuel is mature and robust.

As the chart below shows, in 2017 about 30 million metric tonnes of wood pellets will be produced globally. More than half that amount (about 17 million metric tonnes in 2017) is being used in large utility power plants as a renewable low carbon emitting substitute for coal.

³ See Wikipedia article https://en.wikipedia.org/wiki/Greenhouse_gas

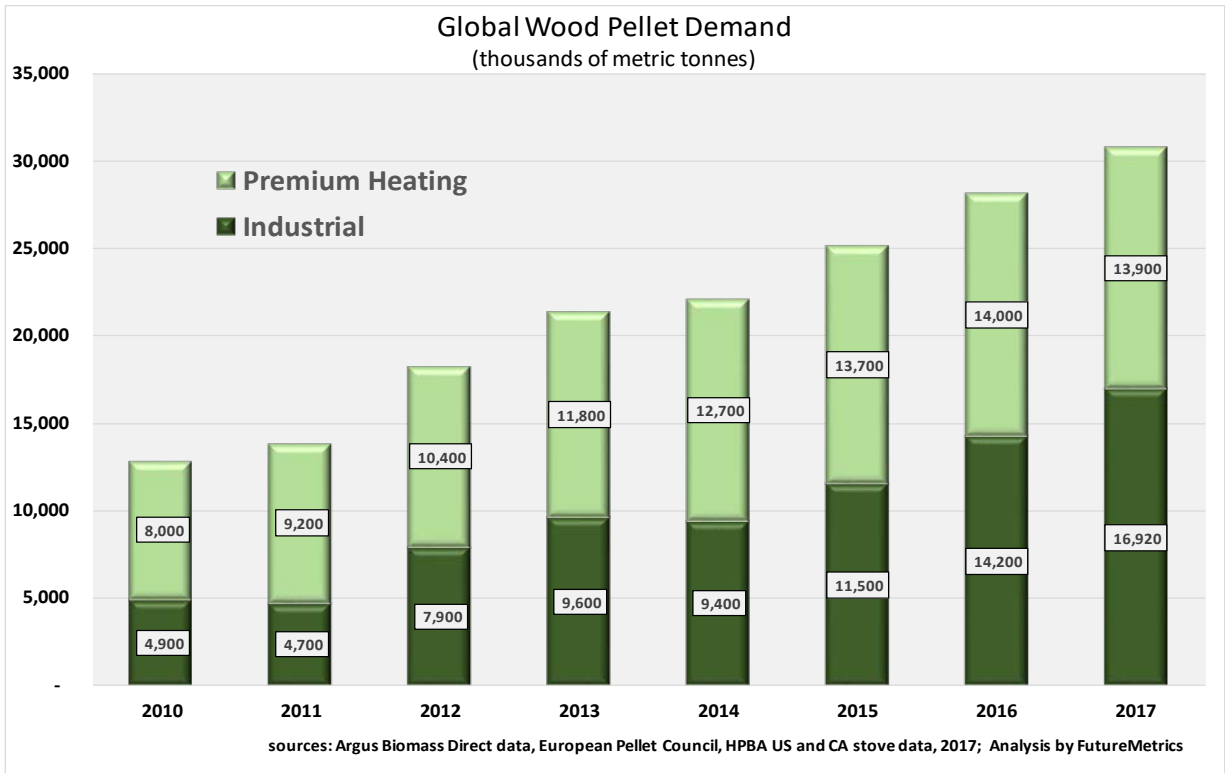
⁴ "The Anthropocene is a proposed epoch dating from the commencement of significant human impact on the Earth's geology and ecosystems, including, but not limited to, anthropogenic climate change." From Wikipedia.

⁵ See several white papers by FutureMetrics on this topic at www.FutureMetrics.com. In general, if the forest growth rate equals or exceeds the harvest rate, the net stock of carbon held in the forest is constant or growing. Thus the CO₂ released in combustion is contemporaneously absorbed by the new growth and no net new CO₂ is added to the atmosphere.



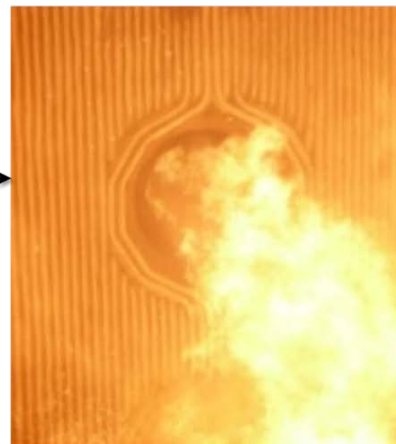
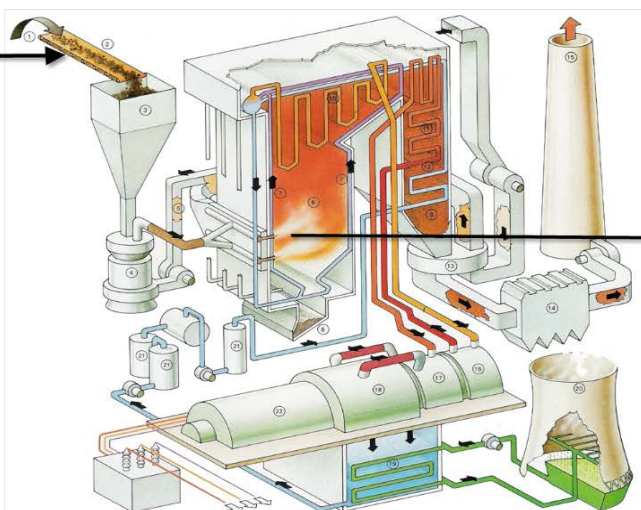
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Large utility coal fueled power plants pulverize the coal prior to combustion. The finely ground coal is conveyed pneumatically to burners that burn the injected powdered coal almost like a liquid fuel. Pellets also pulverize and, with relatively minor modifications to the power plant, can be used as a substitute for coal.

Wood pellets are used in large power boilers that rely on pulverized coal. Wood pellets pulverize and can substitute for coal. If properly modified, there is no loss of power output or reliability.



FutureMetrics - Intelligent Analysis, Operations Expertise, and Strategic Leadership for the Pellet Sector



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Pellet Fueled Power is Baseload Power

To illustrate the value of renewably generated baseload power, we will look at the power grid in Great Britain. The UK is the home of Drax Power. The Drax station consumes more pellet fuel per year than any other power station in the world. The Drax power station consists of six 645 megawatt (MW) turbine-generators. Not very many years ago all six power boilers at the Drax station were fueled with coal. Today, three of the six units run on 100% wood pellets.

The charts on the next two pages⁶ show how the low carbon⁷ baseload power generated by pellets (called “biomass” in the charts on the next pages) forms part of the power grid’s foundation.

The first chart shows one year of data. The second chart shows one week of data.

The pellet generated power is shown by the orange line that is second from the bottom on the chart. The red line near the top of the chart shows the carbon intensity of the UK’s generation mix.

In the first chart, note how the carbon intensity over the year declines significantly as coal and natural gas become a smaller part of the mix as baseload non-carbon emitting renewable pellet generated fuel and nuclear carry an increasing proportion of the load.

The second chart clearly shows the intermittency and variability of wind and solar. Solar never generates at night and the wind blows at varying speeds. The second chart also show how the carbon intensity varies as natural gas plants follow the day and night demand peaks and valleys. Natural gas emits less CO₂ per kWh generated than coal but it is not the lowest carbon emitting source of power⁸.

Baseload power forms the stable constant reliable foundation upon which other renewables and natural gas sit. Baseload power is a critical part of any national power grid.

⁶ Source: Electric Insights http://electricinsights.co.uk/#/homepage?&_k=9d4yww

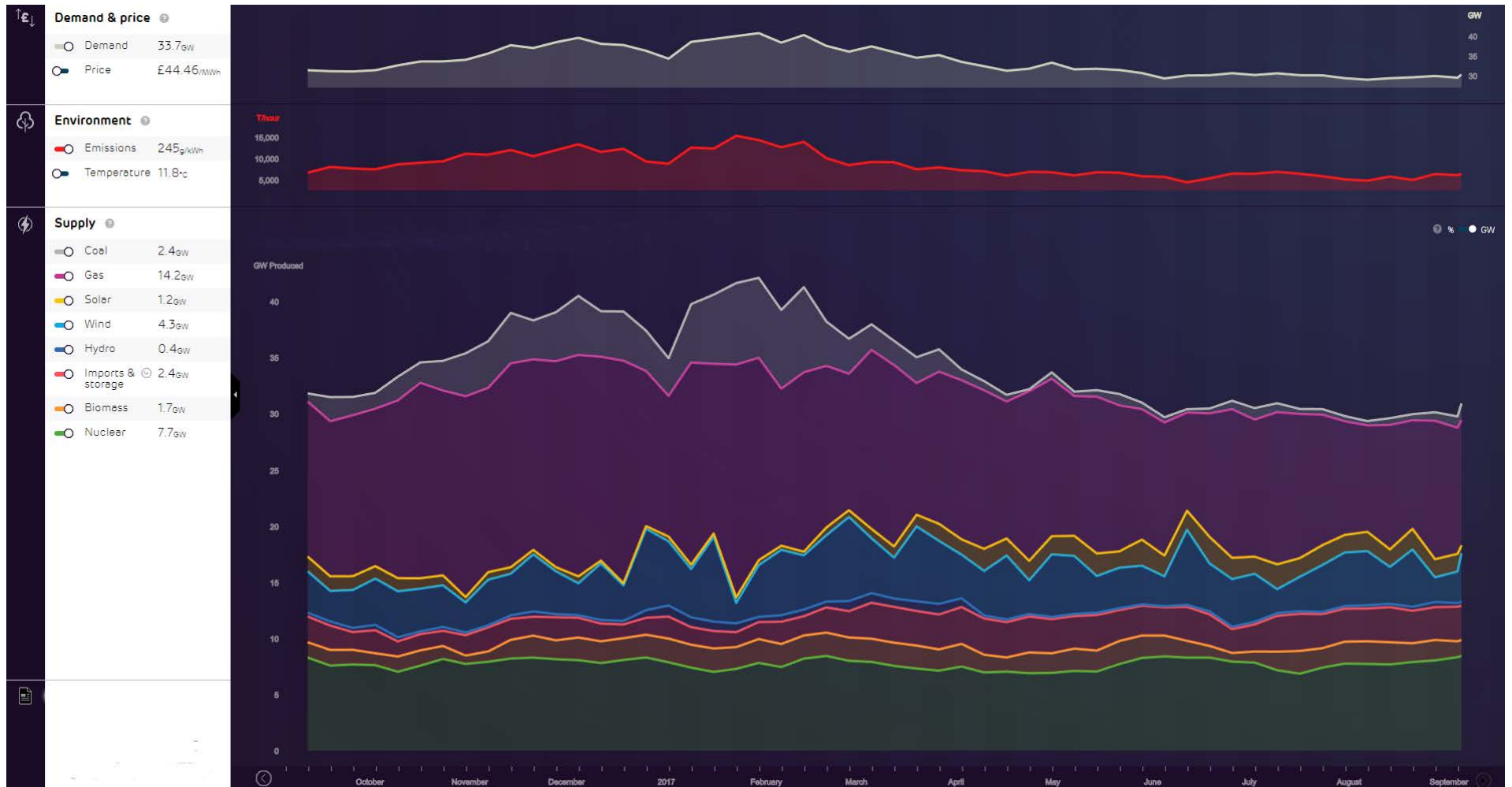
⁷ Referred to as “low carbon” because as with any fuel that has to be extracted, upgraded, and transported, some fossil fuel is used in the supply chain. Because pellets are net zero carbon emitting in combustion, the reduction in the net CO₂ added to the atmosphere for pellets versus coal is between 85% and 93% (depending on the length of the supply chain). On September 13, 2017, the EU Parliament confirmed the long-standing position that biomass energy carbon emissions will continue to be counted as zero at the point of combustion. The pellet fuel has to be certified by third party auditing to prove that the net stock of carbon held by the managed working forests is not being depleted.

⁸ Power generated from a highly efficient natural gas fueled combined cycle power plant results in about a 59% lower CO₂ per MWh generated versus coal: 1.02 lbs./kWh for coal versus 0.42 lbs./kWh for natural gas used in a combined cycle unit. Source: US EIA, September, 2017.



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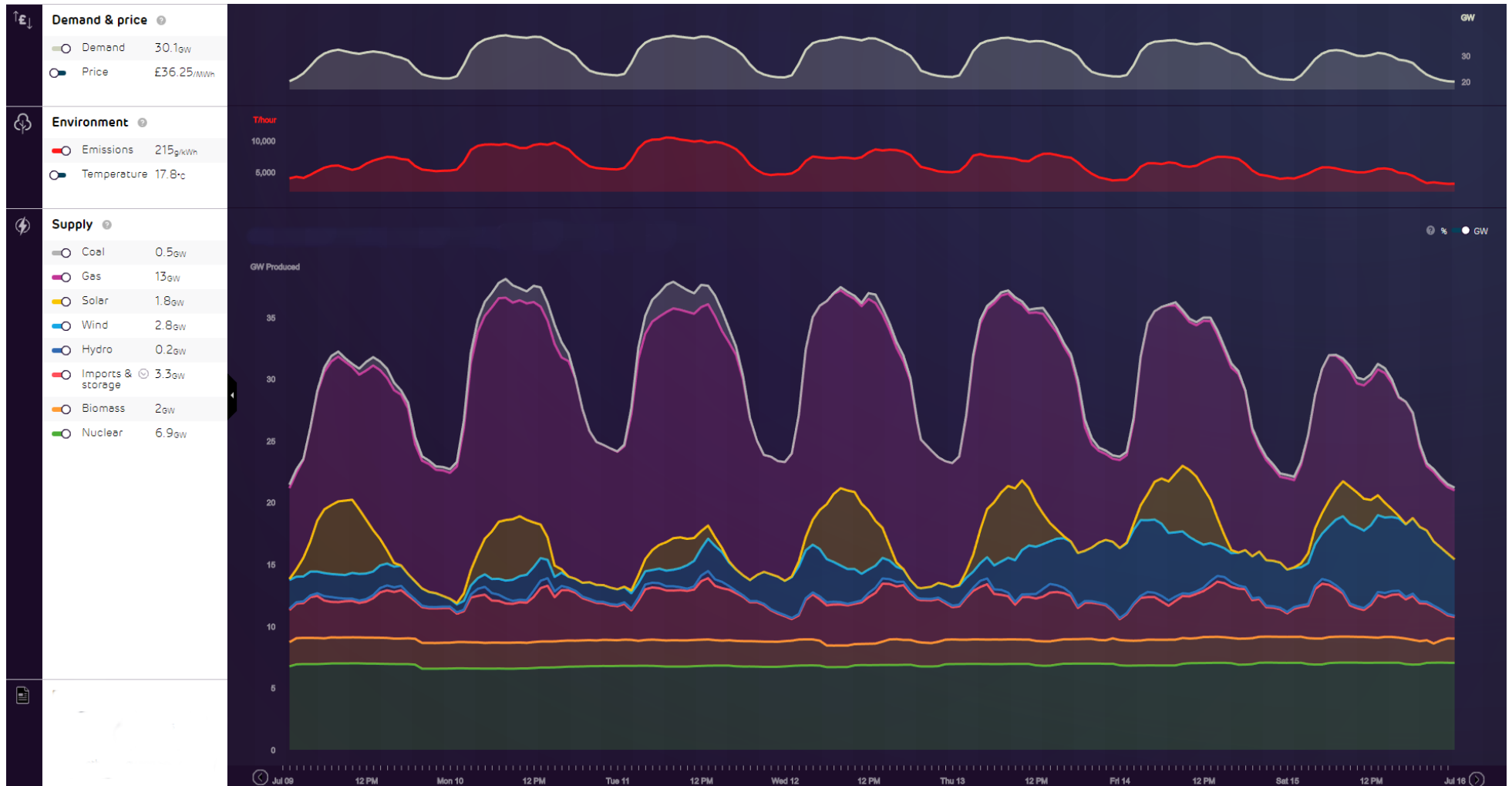


One Year data – September 2016 to September 2017



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One week data – Mid-July , 2017

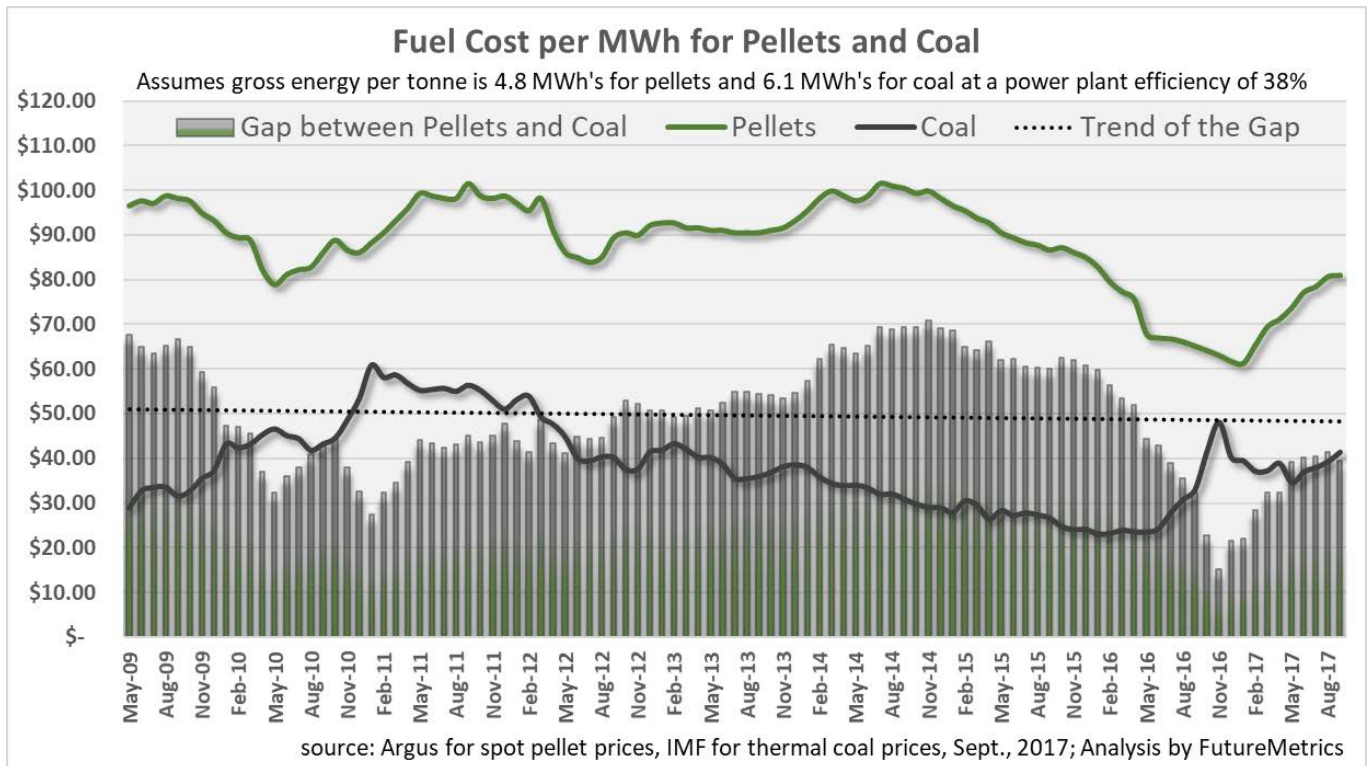


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But What about the Cost?

The fuel cost per megawatt-hour (MWh) generated is higher for pellets versus coal. The chart below shows the fuel cost per MWh for pellets and coal based on historical spot pellet and coal prices⁹. Pellet generated electricity is between \$30 and \$70 per MWh (\$0.03 to \$0.07 per kWh) more costly than coal generated power depending on the prices of each.



However, the cost of coal generation does not include the external costs associated with the carbon emissions that are causing the rapid changes to the earth's integrated systems¹⁰. The cost of CO₂ emissions is not a cost that is made visible and realized by the emitter (i.e., internalized) without policy and regulation.

If society considers the cost of carbon emissions and the resultant impacts to current and future generations, then policy should be crafted that influences the transition to a much less carbon intensive power sector.

New natural gas power plants are a step in the right direction and, given current low natural gas prices, do not need policy and regulation to support growth in that sector. However, natural gas is still a fossil fuel and, as a previous FutureMetrics paper and its accompanying dashboard¹¹ shows, if the decision metric used by policymakers is not the lowest cost per MWh but is the lowest cost per avoided tonne of CO₂ emitted,

⁹ Pellets are CIF delivered to ARA (Amsterdam, Rotterdam, Antwerp), coal is CIF delivered to northwest Europe.

¹⁰ The four "spheres": geosphere, atmosphere, hydrosphere, and biosphere.

¹¹ "The Lowest Cost Solution for Maximum Decarbonization of the Power Sector while Maintaining Grid Reliability" Published Oct. 20, 2016 and free to view on the FutureMetrics website www.FutureMetrics.com.

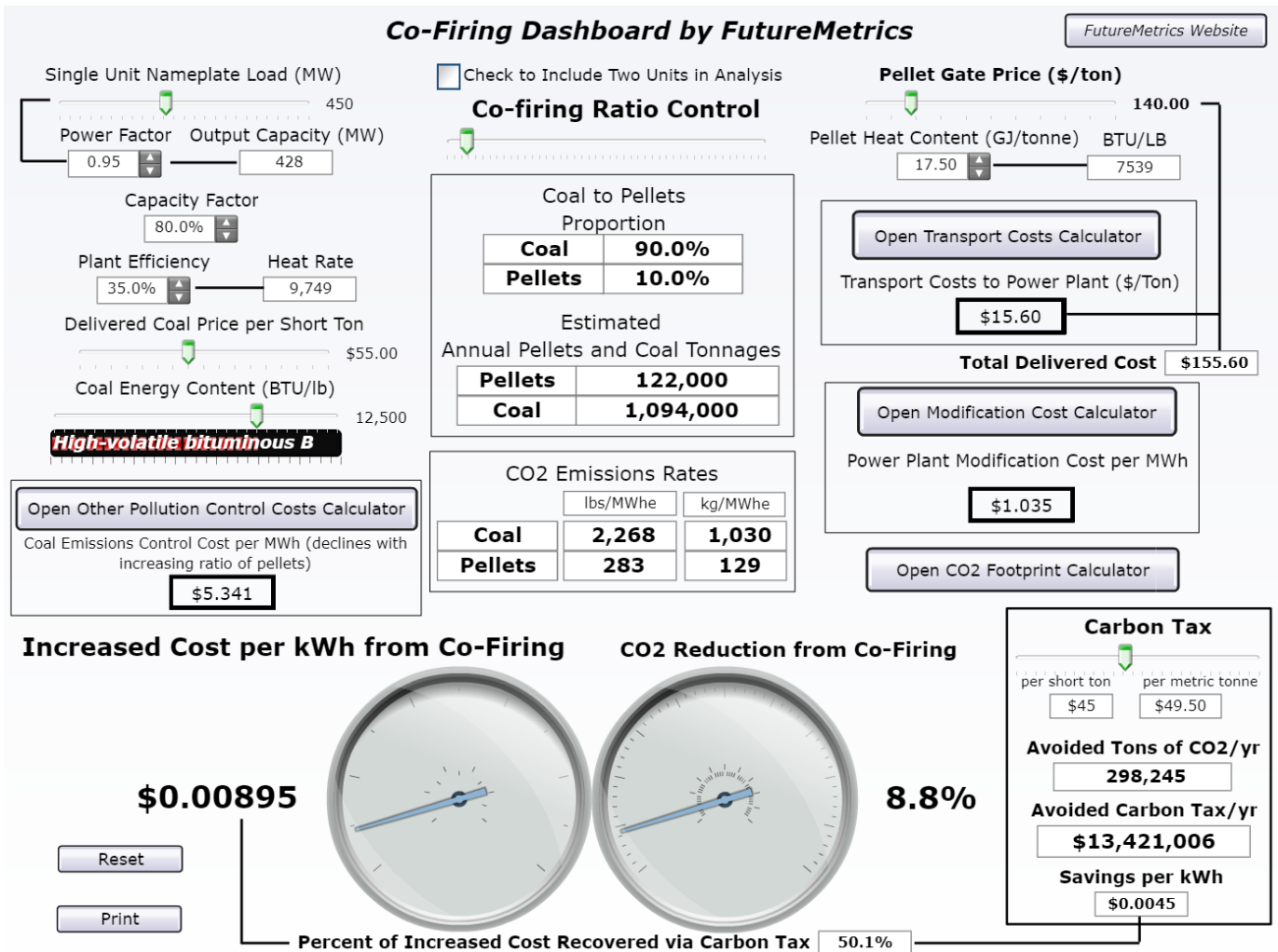


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then natural gas is not the optimal solution. The best solution is the one described above: leverage existing coal power stations and modify them into pellet fueled power stations.

Modified coal power plants do not need to use 100% pellets like the UK's Drax station. So-called co-firing allows some portion of the fuel to be wood pellets while the rest is coal. Co-firing at low ratios and ramping up the ratio over time allows a gradual transition. Co-firing lowers the gap between the fuel cost per MWh generated between pellets and coal that is shown on the chart on the preceding page. As the image from the FutureMetrics dashboard below shows, at a 10% co-firing rate, given the assumptions shown, the increased cost of generation is less and one penny per kWh.



The dashboard also shows that at \$50/tonne, a carbon tax removes about 1/2 of the gap in cost between coal and pellets. Internalizing the costs of the current and future impacts of adding net new carbon to the atmosphere means higher cost baseload generation versus business-as-usual. But with a gradual glide path from 100% coal to 100% pellets over a decade or more at selected critical baseload power plants, markets can adjust. Well-crafted policy can support the internalization of carbon emissions costs while minimizing the impact of those costs on economic well-being.



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Conclusion

The substitution of wood pellets for coal, either by co-firing or full conversions, is a practical and proven solution to moving toward a more decarbonized power sector.

Leveraging existing pulverized coal plants as part of the transition to a more decarbonized future should be part of the menu of solutions with the goal of minimizing the cost to power buyers, minimizing the risk to grid reliability, and to optimally lowering carbon intensity by transitioning from a high carbon fuel to a very low carbon fuel. No other solution provides the most reduction in CO₂ emissions for the lowest cost per avoided tonne while providing stable consistent baseload power from already built and operating power plants.

This strategy provides a proven, reliable, low-cost, and non-disruptive pathway to lowering carbon emissions.