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Hydrogen Buffer Storage For Wind and Solar Power

I would like to replace the similar comment I submitted earlier. This comment is a more complete clarification of my original document

Additional submitted attachment is included below.

HYDROGEN – KEY TO THE ALL-RENEWABLE ECONOMY

California is now committed to 100% renewable electricity by 2045. The only renewable resources sufficiently abundant to completely replace fossil fuel are wind and solar. Renewable power would have to meet peak demand – roughly double average demand. But, when wind and solar provide most of the renewable capacity, twice average demand might not be enough. What if the wind should be calm when demand peaks? Since wind-plus-solar variability can easily exceed two-to-one, even a further doubling might be insufficient. Accommodating the variability of wind and solar power with excess-capacity would waste most of the energy generated. Such waste of energy could be avoided by storing excess wind or solar energy, to use when needed.

But long-term energy storage has a serious issue: The excess energy that could accumulate over a season could overwhelm any ordinary storage medium. Sufficient buffer storage could be provided by a market medium: Something that could be generated by electricity, sold at market price, and repurchased when needed, to generate electricity. Hydrogen can be generated by electrolysis of water, store energy indefinitely, and be converted back to electricity by fuel cells. Hydrogen can provide the buffer storage for wind and solar power; but, first, it must become a widely available market commodity.

Hydrogen is the cleanest possible fuel: Its only tailpipe emission is water. Converted to electricity by fuel cells, hydrogen can power heavy-duty vehicles, for which batteries might be impractical. Fuel-cell electric buses are being evaluated commercially in five California cities, as well as in Boston and Cleveland. There also are about 5,000 hydrogen-powered Toyota, Hyundai, and Honda fuel-cell electric cars on the road in California. Their EPA-rated ranges are over 300 miles, and they can be refueled in five minutes. California now has 34 hydrogen fueling stations; the California Energy Commission is spending $20 million annually to reach 100 stations by 2020.

About eleven million tons of hydrogen are produced in the United States annually – mostly for refining petroleum and making fertilizer. Because almost all hydrogen is now produced from methane (natural gas), making hydrogen accounts for about thirty million tons of annual carbon dioxide emissions. Although producing hydrogen by electrolysis could eliminate these emissions, the retail cost of electricity makes electrolysis too costly to compete with methane for making hydrogen.

The California Independent System Operator (CAISO) now curtails wind or solar power when it exceeds grid demand. Current annual curtailment is substantial – over 400 million kilowatt hours. If this power could be used to replace methane hydrogen with electrolysis hydrogen, it would generate about 9,000 tons of hydrogen – reducing carbon-dioxide emissions by about 24,000 tons. This is definitely worth pursuing, if only to reduce greenhouse gas emissions; but using the excess power to make hydrogen would also accelerate the growth of wind and solar capacity; and could lead to developing hydrogen into a market commodity.

How could this be done? CAISO could locate one or more large hydrogen producers who would agree to make a portion of their hydrogen by electrolysis. The California Energy Commission would provide the on-site hydrolysis facilities. Whenever wholesale price declined to a chosen value, CAISO would divert enough power to hydrogen production to keep the price from going lower. If the minimum wholesale price were set at $.02/kWh, the hydrogen would cost about $1.00/kg – comparable to natural gas hydrogen. Preventing wholesale price from going below that value would materially reduce investment risk – promoting the growth of wind and solar capacity. Grid connection is already open to independent wind or solar suppliers. But, for this program, each new supplier would pay a connection charge – to cover the upgrade of transmission infrastructure required by the increased load – and an annual infrastructure maintenance fee. (The infrastructure charge is necessary because this program would create a large increase in grid load, very little of which would directly benefit electric utility customers.) As soon as wind-plus-solar capacity was sufficient, wholesale electricity would be made generally available for making hydrogen by electrolysis

What would be accomplished by these measures? Carbon-dioxide emissions would immediately decrease by about 24,000 tons; and the savings would grow directly with wind and solar capacity. Wind and solar capacity would grow in response to market forces, without the need for legislative mandate. The additional wind and solar power would displace fossil fuel for industry and transportation – sectors that had previously been resistant to greenhouse gas reduction efforts. (It is worth noting that very little of the additional wind and solar power would displace fossil fuel now used for generating electricity. This is because most of the existing fossil power is needed to buffer the shortfall of wind-plus-solar power until hydrogen buffering becomes available.) The increased use of electrolysis would help to promote on-site hydrogen production. And – most important – electricity cost would no longer be an obstacle to the production of hydrogen by electrolysis.

With on-site production, hydrogen would be cheaper than petroleum for the same energy. Cleaner as well as cheaper, hydrogen would be the fuel of choice for a wide range of vehicles. The tipping point would come when energy companies – realizing that hydrogen was destined to become the new petroleum – began investing seriously in wind and solar power, and in producing hydrogen on-site at gas stations and truck-stops. Another fifteen years might be needed for hydrogen to replace half the petroleum for transportation. But, by then, it would have become a commodity – available for buffering both the shortfall and the excess of wind and solar power. And California would be on the path, not just to 100% renewable electricity, but to an all-renewable economy.

Of course, California could not, alone, develop hydrogen into a national market commodity. But, if California takes the lead, others will soon follow. All balancing authorities face the issue of what to do about the growing waste of power as wind and solar capacity increases. California's action would also alert them to the need for hydrogen to buffer the variability of wind and solar power – motivating them to develop similar local programs.

In keeping with its essential role as buffer storage for wind and solar power, hydrogen is a versatile store of energy. Not only can it power fuel-cell electric drive vehicles, but it can be used as chemical feedstock for making any renewable hydrocarbon fuel that might be needed. To fully appreciate the central importance of hydrogen, it is helpful to picture the vast scope of the all-renewable economy. Renewable electricity – mostly wind and solar – with the aid of hydrogen energy, would have replaced virtually all present uses of fossil energy. This implies that today's large, vertically-integrated, petroleum-based energy companies would very likely be replaced by large, vertically-integrated, hydrogen-based energy companies. Wind and solar capacity would increase by more than a factor of twenty. Much of this generating capacity would be owned by hydrogen-based energy companies. They would supply electricity, on demand, to grid-balancing authorities. Whenever excess wind or solar power was available, they would use it to make hydrogen – much of it on-site at fueling stations, and industrial plants. They would store hydrogen in large underground caverns, for distribution – by pipeline – to fuel-cell electricity generation plants. When wind and solar power were insufficient, these plants would supply the additional power to meet grid demand. With hydrogen as buffer storage, the wholesale price of electricity would not go lower than its value for making hydrogen, or higher than the cost of generating electricity with hydrogen.

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