Another Thought: Brace for the Impact of "The Washington Solution to Fix Climate Change" and How It Impacts Our Industries

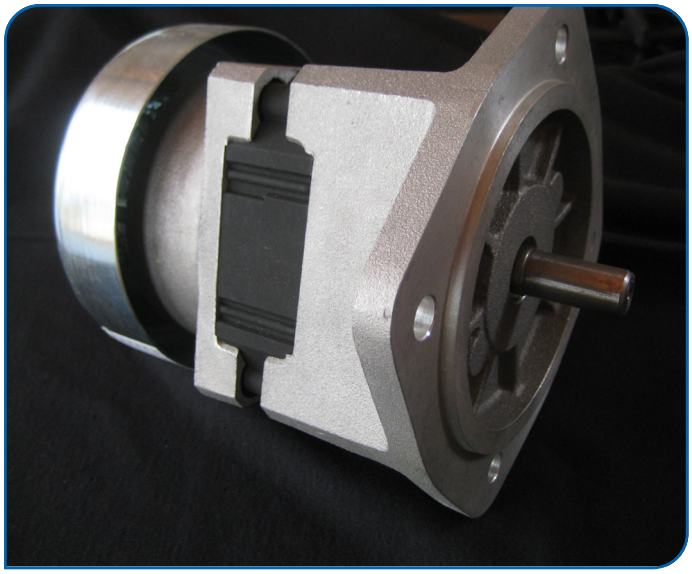
George Holling

Hardly a day passes where the Washington Mafia does not offer another proposed fix to our climate change problems. Yes, the climate appears to be changing and we must look at viable solutions, if they can be found. The magic formula in Washington appears to be: "eliminate all fossil fuels, switch everything to electric, and promote green energies."

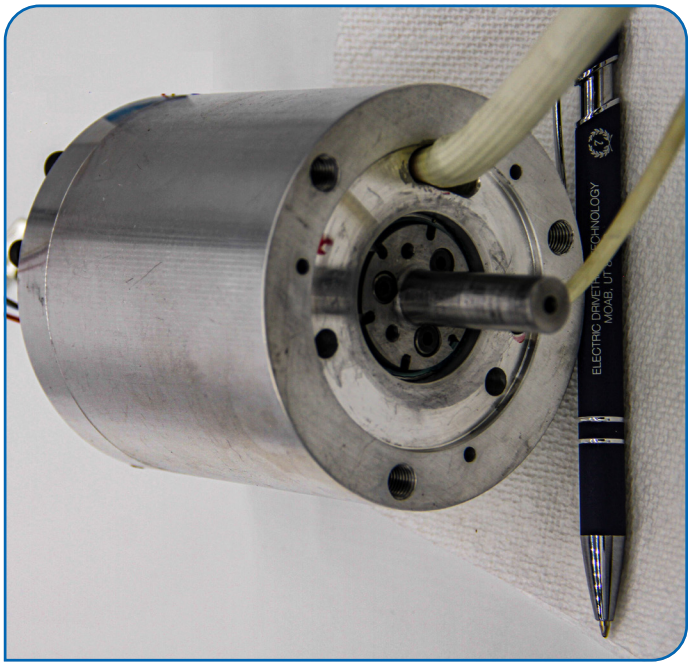
I could dwell on the fact that the majority of our electricity is still generated from fossil fuel sources—maybe more efficient than the automobile, but still dirty. It is also a well known fact that the construction of solar panels and batteries is not exactly clean and many of these emotional and politically motivated proposals have no hard facts and they offer trade-off studies to validate that the "green energies" which are being promoted will, in fact, result in a beneficial net reduction in green house gases and pollution.

Instead, I want to focus on the technical feasibility and the impact on the electric motor industry.

For many years the industry has been working diligently to improve the efficiency of electric motors and it is continuing to do so. After all, electric motors account for over 65% of the industrial electric energy consumption in the US; if it could be achieved, a 5% across-the-board efficiency increase can reduce the industrial power consumption 3.25%. Yet, we are still left with a huge amount of power that the industry consumes. In addition, we now start to add the power used by electric vehicles (EV), which will become significant as the use of EVs increases.



SR165 => A 4.5 HP Switched Reluctance Motor.



4 Nm VSR => A 75 mm diameter Switched Reluctance Motor that will deliver 8 Nm peak torque.

The transition from fossil powered cars and the increases in electric motor efficiency have implications that many politicians do not understand and even those in the industry that are familiar with motors and power can easily overlook: the limited supply of crucial raw materials.

20 years ago most industrial motors were AC induction motors, as were EV motors 10 years ago. To improve motor efficiency and to make motors smaller and lighter, permanent magnet (PM) based motors are steadily replacing the AC induction motors. This means our demand for high energy magnets, specifically Neodymium-based with current technology, is ever increasing. As we transition larger motors from AC induction to PM based ones, we need increasing amounts of rare-earth magnets, most of which are made in China.

It was not that long ago when China flexed its muscle and Neodymium prices shot up, which paralyzed the motor industry and led to inflation in the motor costs. Even worse, I suspect that all the rare-earth mines currently in production would not provide sufficient output to provide all the magnets required for a U.S. or worldwide transition from gasoline power to electric cars, leading to shortages and sky high prices for magnets, motors, cars and a wide variety of industrial and consumer products.

I will concede that more rare-earth mines could be placed in operation, and even some in the U.S., but that creates another slew of contamination-related issues beyond the scope of this discussion.

It also gives foreign governments undue power to influence and blackmail the U.S. into submission, which undermines the rhetoric of fighting unfair competition and bringing industrial production back to the U.S. Maybe in order to buy the magnets we now have to purchase the complete EV from China.

Similar considerations hold true for lithium in the use of batteries, which is increasingly in short supply, but which is, once again, not the topic of this discussion. However, this issue remains for the availability of other raw materials such as copper, etc. where we also experience rapid price increases and shortages.

My personal opinion: rather than having a lot of ideologists in Washington, we may need some knowledgeable folks there who can really work through the technical aspects and feasibility and assess all the related implications. Wishful thinking can and will not remedy the climate issues.

Now let us move on: What are the implications? I remember back after the last recession when the availability of rare-earth magnets was restricted and prices shot up 1,000% and higher — manufacturers were hurting. One reason was the cost of their products increased, but more importantly, sometimes the magnets simply were not available. That was bad for the motor manufacturers, but it really helped consultants and small design companies that could offer alternatives.

One of these alternatives was the proliferation of internal permanent magnet (IPM) motors which had a high reluctance component, also referred to as PM-assisted reluctance motor. One of the designs I was involved with was a 60 KW traction motor that achieved wide operating range efficiency between 97.5% to over 98%, with only a small amount of rare-earth magnet materials. This efficiency had been validated by multiple dyno tests at different test locations and measured by independent consultants.

Similar results can be achieved if the rare-earth magnets are replaced with AC-8 ferrite magnets. There is at least one U.S. manufacturer left, but the U.S. has plenty of raw materials (mines) that can be ramped up quickly to provide U.S.-based magnets for such traction and industrial motors at a very beneficial cost infrastructure. Yet, little research is spent on advancing such motor designs, which opens up a potential magnet trap in the future. Ferrite magnet-based IPM motors can be one of the solutions to solve the pending magnet crisis, but it will require foresight and proactive R&D investments.

SYR pump => A 80 mm diameter high efficiency 1.5 KW pump motor.

The (variable) switched reluctance (VSR) motor has also been investigated as a potential solution to the magnet crisis, and we have seen many more VSR designs enter the marketplace. Unfortunately, the VSR motor requires very specialized controllers along with some operating noise, which offsets some of the potential cost savings that they offer. Yet, we can build VSR motors in the 1 KW range that operate at > 95% efficiency, which compares favorably with similar PM motors. Thus, in the correct application, the VSR motor can be an attractive motor alternative to a PM design.

Lastly, we also have the synchronous reluctance motor (SYR), which I have talked about before. The SYR has low torque ripple, low operating noise, high efficiency and it runs with standard brushless PM motor controller hardware. We are currently designing a highly fault-tolerant 1 KW SYR motor for the Army that will operate at > 95% efficiency with low noise and which can be powered by a standard brushless motor controller. In fact, we are designing a similar SYR motor for a commercial client that plans to use it in production along with a standard brushless motor controller which they are currently already using in production.

We are just completing the design of a 50 KW SYR traction motor with a 240 mm outer diameter (OD) that will deliver

similar performance compared to a 50 KW 230 mm OD IPM motor. The SYR will achieve over 97.2% operation efficiency compared to 97.9% for the IPM design.

While the Army's focus is on high-temperature operation, the commercial application is concerned about the continued reliable availability of cost-effective rare-earth magnets.

As a quick note, I will not discuss AC induction motors, as I am not aware of any AC motor design that can achieve similar operating efficiencies and power densities in the motor sizes that I discussed above.

What I do want to stress is that a small and growing number of manufacturers and OEMs perceives the disruptions in the continued availability of rare-earth as a significant threat to their business, and they are taking active steps to investigate other motor options that can be U.S.-made with all U.S.-sourced materials and which have the potential to support the required electric motor efficiency improvements, along with potential cost reductions to protect their competitive strengths.Such motors could also be the key to replacing fossil fuel power systems with electric-driven ones.

The motor manufacturers must explore such alternatives on their own to strengthen their technology base and prevent potential shutdowns if critical rare-earth magnets cannot be easily obtained at reasonable cost.

More research and investments will be needed. Washington tries to throw money away — here is a cause that will actually provide a broad range of benefits, as it is environmentally and climate-friendly and beneficial for the independence of the U.S. manufacturing base. **PTE**

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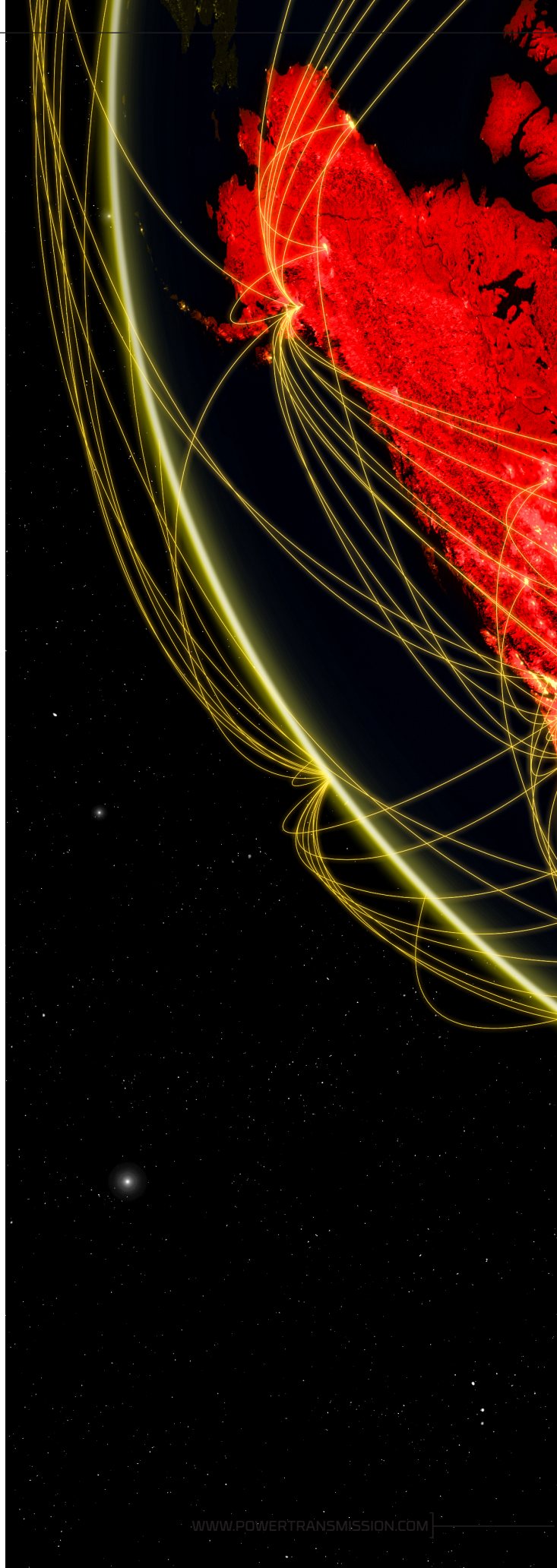

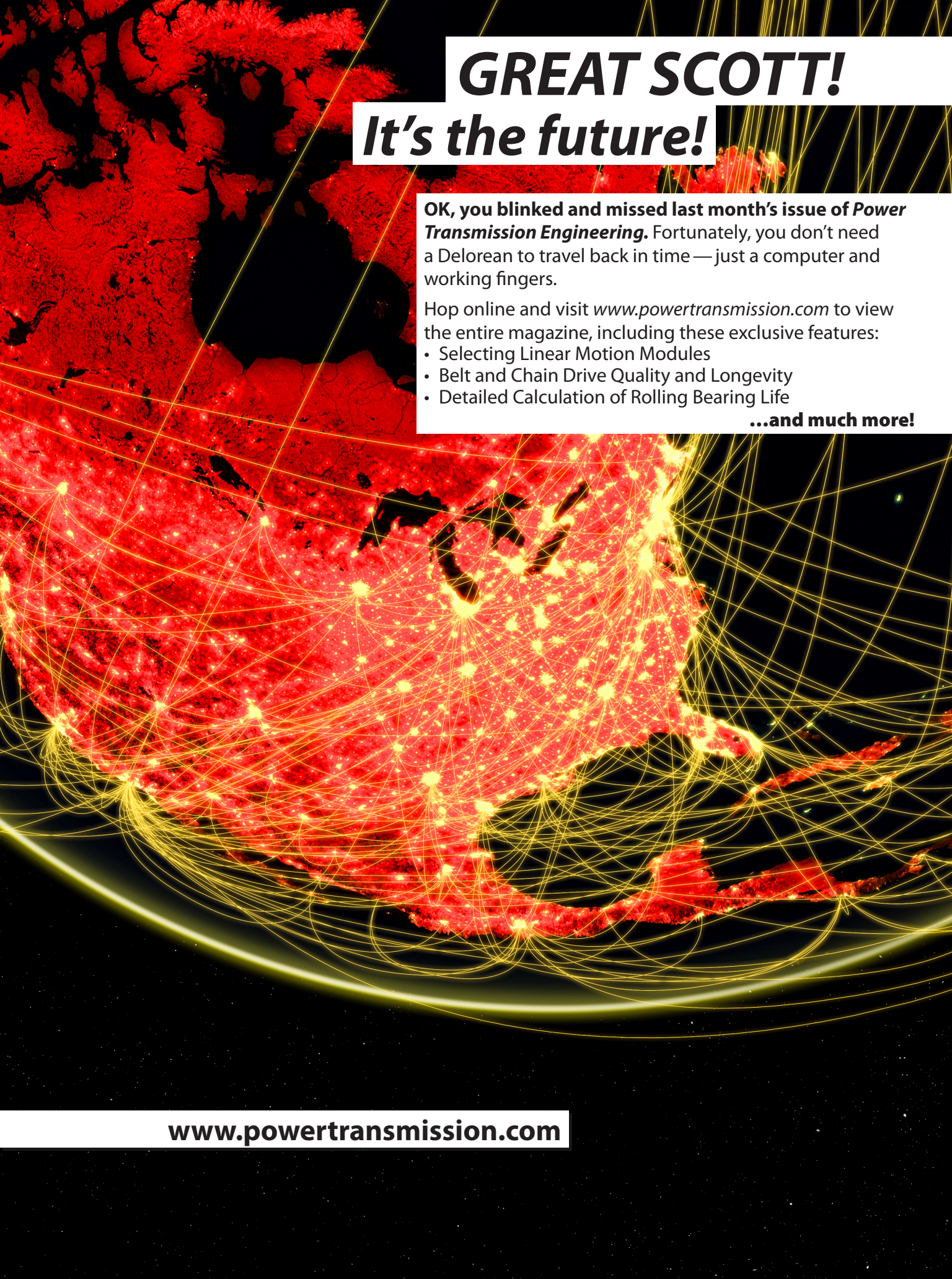
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