FAHNESTOCK ASSET MANAGEMENT
of Oppenheimer & Co. Inc.

Craig W. Hutchison
Managing Director
Senior Portfolio Manager

Andrew A. Westhuis, CFA, CFP
Managing Director
Senior Portfolio Manager

382 Springfield Avenue, Suite 400
Summit, NJ 07901
Phone 908-273-2100
Fax 908-273-0788
Toll Free 800-522-785

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Most of the developed world can flip a switch and the lights turn on, access to energy is a modern miracle we take for granted. As the rest of the world aspires to our standard of living, global energy resources will be increasingly strained. **Fossil fuels power the world but are bad for the environment and eventually economic deposits will run out.** Reliance on fossil fuels is both a short-term and long-term problem, and while renewables are gaining traction, they are currently unable to meet global short-term energy needs. **Bridging the gap will require technological leaps in energy generation, transmission, storage and efficiency.**

Energy consumption per person is up 62% over the last 60 years and there are projected to be 1.8 billion more people on earth by 2050. The UN estimates that a shocking 15% of the global population lives in energy poverty which is *"a lack of adequate, reliable, and affordable energy for lighting, cooking, heating, and other daily activities necessary for welfare and economic development."* **More people, industrialization and our increasingly digital lifestyles require ever more volts to power our screens, cars, and the data centers on which it all runs.**

The below chart shows a breakdown of annual global energy use by source vs population growth. Interestingly, the world burns as much traditional biomass as it did 200 years ago and more fossil fuels than ever. **However, fossil fuel's share of the mix is actually falling by .4% annually as new technologies – nuclear, hydroelectric, wind, solar – become more prevalent.**

Primary energy sources need to be reliable, predictable, and scalable. They must provide "baseload power" that is always available. Gas/coal/nuclear/hydro plants are the main providers. Hydro is the only renewable source of baseload power and there are few viable unbuilt projects in the developed world. The developing world has significant untapped hydro capacity but projects are extremely expensive, especially for shakier economies. **Wind and solar are relatively cheap and clean but production is intermittent so, as it stands today, in most places they are only a supplemental source of energy.**

Wind and solar could hypothetically meet 100% of the world's energy needs but the wind doesn't always blow and the sun doesn't always shine and where it does consistently is usually far from major population centers (think deserts, plains and offshore). **Electricity weakens as it travels so generation needs to be close to where it is used.** High voltage lines are feasible up to 400 miles but take 15-20 years to build. Unlike pipelines, which are federally regulated, transmission lines are regulated at the state/local level, facing exponential red tape.

Pumped storage and chemical batteries are budding solutions to the intermittency problem but are not yet viable as a baseload solution. Pumped storage is a form of hydroelectric that uses excess electricity to drive water uphill into a reservoir to be released as needed. It is not very efficient: 25% of the energy is lost in the process, reservoirs have to be simultaneously close to large energy surpluses and urban areas, and they are extremely expensive to build and maintain. While battery costs have decreased by 85% in the last decade, they still only hold charges for 4-8 hours. **The ingredients – lithium, cobalt, nickel, rare earth minerals – come with ecological and ethical concerns.** The Democratic Republic of the Congo is the primary producer of cobalt, much of it from artisan mines

powered by child labor. Rare earth minerals are not rare, rather extracting them is so bad for the environment that only China is willing to do so at scale. Assuming battery technology were sufficiently advanced, demand for these metals would far outstrip the supply. The average mine takes 16 years to go from discovery to production and we would still be trading one finite resource for another.

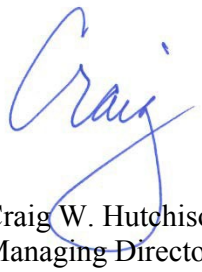
Things in our daily lives traditionally powered by fossil fuels are gradually becoming electrified. Electric vehicles are replacing internal combustion engines, heat pumps are replacing gas furnaces, and electric stoves are replacing gas stoves. Electric versions can be more efficient than their counterparts depending on the source of power. **Electric vehicles charged by rooftop solar and renewable grids are incredibly efficient, but the vast majority are still plugged into grids powered by fossil fuels.**

The transition is underway but will take decades due to chemistry, physics, cost, human behavior, and politics. It will not be a one size fits all solution, what works in sunny Arizona or windy Texas, may not in the Northeast. **Our current way of life is impossible without stable baseload power and a healthy economy is needed to fund TRILLIONS in research and development and new infrastructure.** Before we flip the switch on fossil fuels, especially cleaner natural gas as a bridge-fuel, there are major technical challenges to overcome in pursuit of clean, abundant, affordable energy for all.

There is no short-term solution to the world's long-term energy needs but human ingenuity should eventually prevail and as long term investors, we want to participate in the revolution. **Brookfield Renewable Corp** is one of the largest global generators of renewable power and decarbonization solutions. **Hannon Armstrong** invests in energy efficiency, renewable energy, and sustainable infrastructure. **Public Service** is a regulated grid operator and nuclear power producer that is upgrading their system to accommodate "electrified everything".

The leaves are beginning to turn and with the cooler weather we look forward to enjoying our biomass powered fireplaces. Happy Fall!

Sincerely,



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Executive Director
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