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Metatrend #16: Globally-Abundant, Cheap Renewable Energy

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Tue, Jan 31, 2023 at 11:09 AM

abundance 360

Today's blog is brought to you by Abundance360, my year-round leadership program designed for founders, executives, and investors who are ready to create meaningful impact and leave a legacy.

We are on the cusp of an energy revolution.

Continued advances in solar, wind, geothermal, hydroelectric, and fusion power, along with localized grids, and battery technologies will continue to drive humanity towards cheap, abundant, and ubiquitous renewable energy.

The price per kilowatt-hour will continue to drop at the same time that energy storage drops below 3-cents/kilowatt-hour. The result will be the continued displacement of fossil fuels globally.

The world's poorest countries are also the world's sunniest countries, accordingly driving humanity towards an age of energy abundance.

In today's blog, we'll look briefly at humanity's use of energy over time and discuss some of the most exciting recent developments that will lead us to a future of energy abundance.

Let's dive in!

(This blog is written by Peter H. Diamandis, MD and Cheo Rose-Washington)

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WHY ENERGY ACCESS IS SO IMPORTANT

Energy and prosperity go hand in hand.

The easier it is for a community, village, or nation to access energy, the more prosperous it is.

That's because energy is the driving force behind all economic activity—from enabling services such as education and healthcare, to powering industrial processes and meeting basic household needs.

For example, the International Energy Agency (IEA) estimates that every $1 spent on energy infrastructure can generate *up to $5* in overall economic activity.

The relationship between energy access and prosperity is even more obvious when we look at electricity. According to the World Bank, a 1% increase in electricity access results in up to 1.5% increase in GDP growth.

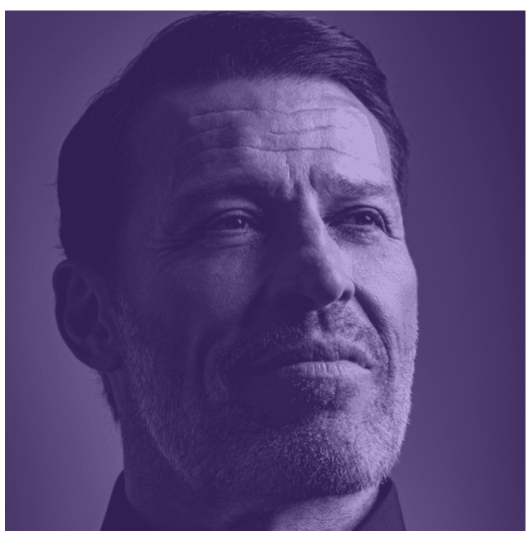
At the same time, the World Health Organization (WHO) has found that access to consistent electricity can lead to a 20-30% reduction in poverty.

2023 A360 SUMMIT SPEAKER SNAPSHOT

Here's a sneak peek of the A360 speaker lineup. This will be an exciting year!

***Note**: At the time of this email, we have 34 remaining spots to attend the Summit live in March.*

LEARN MORE ABOUT PETER'S MEMBER COMMUNITY & SUMMIT



Tony Robbins

#1 *New York Times* bestselling author and life & business strategist. He is a leading philanthropist and through his 1 Billion Meals Challenge, he has provided over 945 million meals in the last 8 years and is ahead of schedule to provide 1 billion meals by 2025.

Andrew Yang

2020 Democratic presidential candidate and 2021 New York City mayoral candidate. He is the Founder of Humanity Forward, and his *New York Times* bestselling book *The War on Normal People* helped introduce the idea of universal basic income (UBI) into the political mainstream.

Jacqueline Novogratz

Founder and CEO of Acumen, whose mission is to change the way the world tackles poverty. She is a *New York Times* bestselling author and was named by *Insider* as a top 30 global leader working on climate solutions.

Mark Hyman, MD

Family physician and internationally recognized thought leader in the field of functional medicine. He is a fourteen-time *New York Times* bestselling author, and Board President for Clinical Affairs of The Institute for Functional Medicine.

A BRIEF HISTORY OF HUMANITY'S ACCESS TO ENERGY

Now that we know why energy access is so important, let's take a brief look at how our sources and uses of energy have evolved over time.

Our bodies are the source of one of the earliest sources of energy—in the form of **human muscle**.

Era of Human Muscle: For ancient civilizations, human muscle was the primary energy source powering those societie, and we can still see evidence of this—from the Great Wall in China to the pyramids in Egypt.

Era of Domesticated Animals: The earliest uses of animal energy were the use of horses and oxen to pull carts and plows. These and other tasks were critical to the development of agricultural societies.

Age of Water Wheels: Ancient Greece and Rome used power mills and grind wheat and other grains. But it was in the Middle Ages when water wheels became more sophisticated and were used for industrial purposes.

The Steam Age: This energy source dates back to James Watt's invention of the steam engine in the 18th century. This also marked the beginning of the Industrial Revolution. Steam revolutionized everything from transportation to manufacturing: steam-powered ships made travel across the oceans faster and more efficient, while factories powered by steam led to the growth of a range of industries, including heavy machinery, steel, and textiles.

The Fossil Fuel Era: While coal was used for cooking and heating in ancient China and Rome, it was the Industrial Revolution that really kicked off the use of fossil fuels, especially coal, which powered the steam engine. But as demand for energy around the word grew, the use of natural gas also increased, revolutionizing transportation and other industries. Today, fossil fuels continue to be the dominant source of energy, accounting for over 80% of global warming nervy consumption.

The Nuclear Age: Beginning in late 19th century when scientists discovered they could split the atom to harness energy, this led to the first commercial nuclear power plants in Russia and the US in the 1950s. Today, there are over 400 nuclear power plants in operation, providing roughly 10% of the world's electricity.

The Era of Renewable Energy: While renewable energy sources also have a long history of use with ancient civilizations using the sun, water, and wind to meet their energy needs. The recent upsurge of solar and wind has been impressive, with wind power capacity increasing over 400% in the last 20 years, and solar power capacity increasing by more than 1,500% over the same period. And estimates suggest we're still at the early end of that growth curve. The IEA estimates that renewables could potentially meet over 80% of global power demand by 2050.

THE CASE FOR RENEWABLES

We are in the midst of a renewable energy revolution. Four statistics are compelling and tell a powerful story:

1. Green energy sources will overtake coal and become the largest global source of electricity by early 2025 (according to a December 2022 report by the International Energy Agency).

2. Between 2022 and 2027, global renewable energy capacity is expected to grow by 2,400 gigawatts—that's equal to the ***entire power generating capacity of China today***.

3. McKinsey estimates that **global demand for fossil fuels will peak sometime between this year and 2025**. Based on this same analysis, by 2050 fossil fuels will make up just 43% of global energy demand.

4. Investment in clean energy technologies (including renewables, EVs, energy storage, etc.) **reached *$1.1 trillion* in 2022**—matching investment in fossil-fuel power generation for the first time (based on research from BloombergNEF).

Let’s now look at a few of the technologies powering this renewables revolution, starting with solar…

SOLAR ENERGY

Every five days, the Sun provides the Earth with as much energy as all proven supplies of oil, coal, and natural gas.

If we could capture just *one part* in 6,000 of available solar energy, we would be able to meet 100% of our global energy needs.

Our progress towards a solar economy has been impressive and is expected to continue unabated. Here are just a few key examples:

1. The IEA (International Energy Agency) expects **cumulative solar PV capacity to nearly triple in the next 4 years**, growing by roughly 1,500 gigawatts and ***surpassing natural gas by 2026 and coal by 2027***.

2. In the US alone, according to the IEA there were about **74 gigawatts of installed solar PV capacity at the end of 2022**, 3X the solar capacity in 2017.

3. Looking ahead, the IEA projects that the ***US will add another 63 gigawatts of solar by the end of 2024, an 84% increase.*** With those capacity additions, solar’s share of overall power generation in the US will ***double from 3% today to 6%*** by the end of next year.

4. The key drivers behind the explosive growth of solar energy (globally and in the US), is dramatically falling costs. As the IEA puts it: ***"Solar PV is becoming the lowest-cost option for new electricity generation in most of the world."***

5. 10X drop in cost: According to the US Department of Energy, the average cost of utility-scale solar PV in the US in 2010 was a whopping *28 cents per kWh*. But by 2021, that cost had fallen to just 2.8 - 3 cents per kWh.

However, one thing that these average costs mask is the influence of location. In the sunniest parts of the world, the cost of solar power is even cheaper. Here are a few of the major price milestones achieved by utility-scale solar power plants over the past few years:

- **Saudi Arabia Cost**: 1.04 cents per kWh -- 600 MW solar plant in Saudi
- **Portugal Cost**: 1.32 cents per kWh: 10 MW solar plant in Portugal
- **New Mexico, USA Cost**: 1.50 cents per kWh: 100 MW solar plant in New Mexico

But cost isn't the only factor driving the dramatic adoption of solar around the world—materials matter too.

PEROVSKITE: A REVOLUTIONARY MATERIAL

A materials science breakthrough called Perovskite is driving down the cost of commercial solar. Perovskite is a light-sensitive crystal (mineral) with the unique optical and electronic property of efficiently converting sunlight into electricity.

Historically, most commercial solar panels have conversion efficiencies of 15% to 22%, meaning they capture 15% to 22% of the energy to which they are exposed.

But perovskite promises much higher efficiencies.

In the last several years, perovskite's conversion efficiency has increased from just 3% to 30%, making it the fastest-developing technology in the history of photovoltaics.

The theoretical upper limit of perovskite's efficiency is roughly 66%, compared to a theoretical upper limit of 32% for silicon.

Even better, **perovskite's ingredients are widely available and inexpensive** to combine, which promises to further lower solar costs.

Regular thin-film (silicon) photovoltaics cost roughly $0.40 to $0.69 per watt, compared to just $0.16 per watt for perovskite, which is expected to plunge to $0.10 per watt in the near future.

Ultimately we could see a doubling of efficiency, along side a 4x reduction in price, yielding an 8X overall improvement over todays options.

These technical and economic achievements are combining to power growth for the perovskite market, which is expected to grow from roughly $600 million in 2021 to over $6 billion by 2030.

GEOTHERMAL ENERGY

Another untapped source of energy is geothermal.

If we could capture just 0.1% (1 part in 1000) of the heat content of the Earth, we could supply humanity's total energy needs for 2 million years, according to the US Department of Energy.

That's the promise of geothermal energy: the technology that harnesses the heat beneath the Earth's crust.

Yet geothermal currently accounts for only 0.4% of total utility-scale power generation in the US—nearly half of which came online in the 1980s!

But that's about to change.

Google has partnered clean energy startup Fervo to develop a geothermal power project, and Microsoft is building one of the largest geothermal plants in North America, the 3-million-square foot Thermal Energy Center outside of Seattle.

At the same time, government policies around the world are spurring investment and incentivizing breakthroughs.

The US federal government, why he set a goal of 50% carbon-free energy by 2030, has issued an “Energy Earthshot” to reduce the cost of geothermal by 90% by 2035. And the Indonesian government is underwriting the exploration of people of w fields, while the Philippines is now allowing large-scale geothermal projects to be owned by foreign developers.

One of the most exciting recent developments in geothermal is the use of enhanced geothermal systems (EGS).

Whereas traditional geothermal power plants rely on naturally occurring reservoirs of hot water and steam, EGS technology allows for the creation of artificial reservoirs by injecting water into hot, dry rock.

EGS technologies are going deeper to reach superhot rocks, making the high heat needed to generate electricity available in more locations—not just geologic fault lines. A key benefit of these superhot rock systems is that if the heat of the well increases by just 42%, the system can produce 10X more energy.

One of startups looking for new ways to drill deeper is Quaise Energy, an MIT spinout that refashioning millimeter-wave drilling techniques used for nuclear fusion experiments to reach the hot rock 2 to 12 miles beneath the Earth’s surface.

As Quaise Co-founder and CEO Carlos Araque points out, geothermal could become the workhorse of the clean energy transition with **a goal of increasing geothermal energy from 0.4% (today) to a target of 30% or more by 2050.**

NUCLEAR FUSION

Fusion has long been the dream for limitless, clean, and renewable energy at near zero cost.

To put fusion into context: If we could replicate the power-generating process of the Sun while eradicating the issues of nuclear waste, it would be the solution to replace all other solutions.

Fusion energy reactors replicate the process performed 24/7 by the Sun, fusing two heavy isotopes of hydrogen atoms (tritium and deuterium) together at immense pressures and temperatures to create helium. In the process, a small amount of "excess" mass is converted into energy according to Einstein's formula E=mc^2.

The first attempts to create controlled fusion date back to 1958, 65 years ago. That is why the December 2022 announcement that scientists California's National Ignition Facility at the Lawrence Livermore National Laboratory had achieved a net energy gain in a fusion reactor for the first time is such a big deal.

For the first time ever, scientists got more energy out of the fusion process than they had to put in (resulting in a net energy gain of 1.5 megajoules).

While this particular form of fusion will require much more work to reach commercial utility, it shows us what's possible in the future.

It also reflects growing interest and investment into the field.

In 2022, private investment into commercial fusion companies had topped $1 billion, supporting the work 40 privately-funded fusion companies. Among the best funded and most notable are the following three players:

- **Commonwealth Fusion Systems**, which has raised $2 billion and counts Bill Gates and Google among its investors and is building a prototype that is set to demonstrate net energy gain by 2025.
- **TAE Technologies**, which has raised $1.2 billion from investors including Goldman Sachs and Charles Schwab and is planning to unveil a fusion reactor by the early 2030s.
- **Tokamak Energy**, which has raised $250 million and in 2022 broke a longstanding record by generating 59 MJ of energy, the highest sustained energy pulse ever.

Bloomberg estimates that the nuclear fusion market could eventually be worth $40 trillion.

ENERGY STORAGE TECHNOLOGIES

To make use of solar and wind requires energy storage. Lots of storage.

Here too, exponential advances are being made.

According to the IEA, the total installed capacity of energy storage globally stood at about 160 GW in 2021.

BloombergNEF estimates that 387 GW of new energy storage capacity will be added globally from 2022 to 2030—more than Japan's entire power generation capacity in 2020.

Of the currently installed capacity, pumped-water-storage (hydropower) is the most widely deployed storage technology (one in which water is pumped up hill, and the energy stored as potential energy, recouped when it flows back downhill thru a turbine).

In the realm of batteries, Lithium-ion are the most common type of battery used for storage. A key reason for their popularity is the dramatic reductions in cost over the last decade.

According to BloombergNEF, the average price of a lithium-ion battery pack plummeted 5-fold from $732 per kWh in 2013 to just $151 per kWh in 2022.

But at least 2 other promising battery technologies are under development:

Flow batteries

Flow batteries use a liquid electrolyte to store energy. Compared to lithium-ion batteries, they have a longer lifespan, showing no performance degradation even after 25 to 30 years. Additionally, they can be sized according to energy storage needs with limited investment. The world's largest flow battery (made of vanadium redox) was commissioned in China in July 2022, with a capacity of 100 MW and a storage volume of 400 MWh.

Iron-air batteries

Each iron-air battery is as big as a washing machine and holds 50 iron-air cells, which are surrounded with a water-based electrolyte.

Iron-air batteries boast 2 advantages over lithium-ion:

- **Cost**: because iron is cheaper and easier to procure than lithium, cobalt, and nickel, iron-air batteries are less than half the cost of lithium-ion batteries.
- **Duration**: iron-air batteries can store power for up to 150 hours, which is critical for storing energy from intermittent renewable energy sources such as wind and solar.

So, given all these developments in energy storage what's needed to meet our renewable energy goals?

According to the National Renewable Energy Laboratory (NREL), if we're going to meet its Zero Carbon scenario by 2050, where 94% of electricity in the US comes from renewable sources, then we're going to need a lot more storage.

About 930 GW of energy storage and 6.5 hours of capacity would cover the US's entire electricity demand.

That represents a massive challenge and also an equally sized opportunity for entrepreneurs and investors, who are further incentivized by the Biden Administration's recent commitment to more than $80 billion in new investments for the battery supply chain as part of the US Inflation Reduction Act.

FINAL THOUGHTS: A VISION OF ENERGY ABUNDANCE

An age of abundant energy would mean a society with access to a wide variety of affordable, clean, and reliable energy sources such as solar, wind, fusion, and advanced energy storage technologies.

Energy abundance would also involve the widespread adoption of energy-efficient technologies and practices in homes, business, and across the transportation system. Additionally, it would entail a shift away from fossil fuels to reduce greenhouse gas emissions and mitigate the impacts of climate change.

The result would be more economic growth, improved quality of life, and better energy security—for everyone, everywhere.

So, how possible is energy abundance?

Solar energy alone could provide us a squanderable abundance of energy.

Every 88 minutes, 470 exajoules of solar energy hit our planet, which is as much as humanity consumes in a year. In 112 hours—or just less than five days—we get 36 zettajoules of energy, or what's contained in all proven oil, coal, and natural gas reserves on Earth.

When it comes to energy, ***it's not about scarcity, it's about accessibility***—which is the exact kind of problem that exponential technologies have a history of solving.

Welcome to a future driven by electrons generated from renewable sources of energy.

What are the implications to your business? Your industry? What will the impacts be on global geopolitics, our families, and our environment?

In our next blog in this Metatrend series (#17 of 20), we'll look at the **Increased Focus on Sustainability & Carbon**.

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