

The Third Industrial Revolution: How the Internet, Green Electricity, and 3-D Printing are Ushering in a Sustainable Era of Distributed Capitalism

By Jeremy Rifkin



grow the German economy, the EU economy, or, for that matter, the global economy, in the last stages of a great energy era and an industrial revolution built on it?”

It is becoming increasingly clear that the Second Industrial Revolution is dying and that industrial induced CO₂ emissions are threatening the viability of life on Earth. What we need now is a bold new economic narrative that can take us into a sustainable post-carbon future. Finding that new vision requires an understanding of the technological forces that precipitate the profound transformations in society.

A New Economic Narrative

The great economic revolutions in history occur when new communication technologies converge with new energy systems. New energy revolutions make possible more expansive and integrated trade. Accompanying communication revolutions manage the new complex commercial activities made possible by the new energy flows. In the 19th century, cheap steam powered print technology and the introduction of public schools gave rise to a print-literate work force with the communication skills to manage the increased flow of commercial activity made possible by coal and steam power technology, ushering in the First Industrial Revolution. In the 20th century, centralized electricity

Our industrial civilization is at a crossroads. Oil and the other fossil fuel energies that make up the industrial way of life are sunseting, and the technologies made from and propelled by these energies are antiquated. The entire industrial infrastructure built off of fossil fuels is aging and in disrepair. The result is that unemployment is rising to dangerous levels all over the world. Governments, businesses and consumers are awash in debt and living standards are declining everywhere. A record one billion human beings — nearly one seventh of the human race—face hunger and starvation. Worse, climate change from fossil fuel-based industrial activity looms on the horizon, imperiling our own species’ very ability to survive.

Since the beginning of the Great Recession in the summer of 2008,

governments, the business community, and civil society have been embroiled in a fierce debate over how to restart the global economy. While austerity measures and fiscal, labor, and market reforms will all be necessary, they are not sufficient to re-grow the economy. Let me explain by way of an anecdote. Just months after arriving in office, the new Chancellor of Germany, Angela Merkel, asked me to come to Berlin to help her administration address the question of how to create new jobs and grow the German economy in the twenty-first century. I began my remarks by asking the chancellor, “How do you

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communication — the telephone, and later radio and television — became the communication medium to manage a more complex and dispersed oil, auto, and suburban era, and the mass consumer culture of the Second Industrial Revolution.

Today, Internet technology and renewable energies are beginning to merge to create a new infrastructure for a Third Industrial Revolution (TIR) that will change the way power is distributed in the 21st century. In the coming era, hundreds of millions of people will produce their own renewable energy in their homes, offices, and factories and share green electricity with each other in an “Energy Internet” just like we now generate and share information online.

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The establishment of a Third Industrial Revolution infrastructure will create thousands of new businesses and millions of jobs and lay the basis for a sustainable global economy in the 21st century. However, let me add a cautionary note. Like every other communication and energy infrastructure in history, the various pillars of a Third Industrial Revolution must be laid down simultaneously or the foundation will not hold. That’s because each pillar can only function in relationship to the others. The five pillars of the Third Industrial Revolution are (1) shifting to renewable energy; (2) transforming the building stock of every continent into micro-power plants to collect renewable energies on-site; (3) deploying hydrogen and other storage technologies in every building and throughout the infrastructure to store intermittent energies; (4) using Internet technology to transform the power grid of every continent into an energy internet that acts just like the Internet (when millions of buildings are generating a small amount of renewable energy locally, on-site, they can sell surplus green electricity back to the grid and share it with their continental neighbors); and (5) transitioning the transport fleet to electric plug-in and fuel cell vehicles that can buy and sell green electricity on a smart, continental, interactive power grid.

The creation of a renewable energy regime, loaded by buildings, partially stored in the form of hydrogen, distributed via a green electricity Internet, and connected to plug-in, zero-emission transport, opens the door to a Third Industrial Revolution. The entire system is interactive, integrated, and seamless. When these five pillars come together, they make up an indivisible technological platform—an emergent system whose properties and functions are qualitatively

different from the sum of its parts. In other words, the synergies between the pillars create a new economic paradigm that can transform the world.

The public/private financing of the Third Industrial Revolution infrastructure build-out across the world will be at the very top of the agenda for the international banking and financial community in the first half of the 21st century.

The Shift To Lateral Power

The Third Industrial Revolution is the last of the great Industrial Revolutions and will lay the foundational infrastructure for an emerging collaborative age. Its completion will signal the end of a two-hundred-year commercial saga characterized by industrious thinking, entrepreneurial markets, and mass labor workforces and the beginning of a new era marked by collaborative behavior, social networks and professional and technical workforces. In the coming half century, the conventional, centralized business operations of the First and Second Industrial Revolutions will increasingly be subsumed by the distributed business practices of the Third Industrial Revolution; and the traditional, hierarchical organization of economic and political power will give way to lateral power organized nodally across society.

Lateral power is a new force in the world. Steve Jobs and the other innovators of his generation took us from expensive centralized main-frame computers, owned and controlled by a handful of global companies, to cheap desktop computers and cell phones, allowing billions of people to connect up with one another in peer-to-peer networks in the social spaces of the internet. The democratization of communications has enabled nearly one third of the human population on earth to share music, knowledge, news and social life on an open playing field, marking one of the great evolutionary advances in the history of our species.

But as impressive as this accomplishment is, it is only half of the story. The new, green energy industries are improving performance and reducing costs at an ever accelerating rate. And just as the generation and distribution of information is becoming nearly free, renewable energies will also. The sun, wind, biomass, geothermal heat and hydropower are available to everyone and, like information, are never used up.

When Internet communications manage green energy, every human being on earth becomes his or her own source of power, both literally and figuratively. Billions of human beings sharing their renewable energy laterally on a continental green electricity internet creates the foundation for the democratization of the global economy and a more just society.

Distributed Capitalism

Energy regimes shape the nature of civilizations—how they are organized, how the fruits of commerce and trade are distributed, how political power is exercised, and how social relations are conducted. To understand how the new Third Industrial Revolution infrastructure is likely to dramatically



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change the distribution of economic power in the twenty-first century, it is helpful to step back and examine how the fossil fuel-based First and Second Industrial Revolutions reordered power relations over the course of the nineteenth and twentieth centuries.

Fossil fuels—coal, oil, and natural gas—are elite energies for the simple reason that they are found only in select places. They require a significant military investment to secure their access and continual geopolitical management to assure their availability. They also require top down command and control systems and massive concentrations of capital to move them from underground to the end users. The ability to centralize production and distribution—the essence of modern capitalism—is critical to the effective performance of the system as a whole. The centralized energy infrastructure, in turn, sets the conditions for the rest of the economy, encouraging similar business models across every sector.

Virtually all of the other critical industries that emerged from the oil culture—modern finance, telecommunications, automotive, power and utilities, and commercial construction—and that feed off of the fossil fuel spigot were similarly predisposed to bigness in order to achieve their own economies of scale. And, like the oil industry, they require huge sums of capital to operate and are organized in a centralized fashion.

Three of the four largest companies in the world today are oil companies—Royal Dutch Shell, Exxon Mobil, and BP. Underneath these giant energy companies are some five hundred global companies representing every sector and industry—with a combined revenue of \$22.5 trillion, which is the equivalent of one-third of the world's \$62 trillion GDP—that are inseparably connected to and dependent on fossil fuels for their very survival.

The emerging Third Industrial Revolution, by contrast, is organized around distributed renewable energies that are found everywhere and are, for the most part, free—sun, wind, hydro, geothermal heat, biomass, and ocean waves and tides. These dispersed energies will be collected at millions of local sites and then bundled and shared with others over a continental green electricity internet to achieve optimum energy levels and maintain a high-performing, sustainable economy. The distributed nature of renewable energies necessitates collaborative rather than hierarchical command and control mechanisms.

This new lateral energy regime establishes the organizational model for the countless economic activities that multiply from it. A more distributed and collaborative industrial revolution, in turn, invariably leads to a more distributed sharing of the wealth generated.

The extraordinary capital costs of owning and operating giant centralized telephone, radio, and television communications technology and fossil fuel and nuclear power plants in markets is giving way to the new “distributed capitalism,” in which the low entry costs in lateral networks make it possible for virtually everyone to become a potential entrepreneur and collaborator, creating and sharing information and energy in open commons. Witness twenty something young men creating Google, Facebook, and other global information networks, literally in their college dorm rooms and thousands of small businesses converting their buildings to green micro power plants and connecting with one another in regional electricity networks.

What I am describing is a fundamental change in the way capitalism functions that is now unfolding across the economy and reshaping how companies conduct business. The shrinking of transaction costs in the music business

and publishing field with the emergence of file sharing of music, eBooks, and news blogs, is wreaking havoc on these traditional industries. We can expect similar disruptive impacts as the diminishing transaction costs of green energy allow manufacturers, service industries, and retailers to produce and share goods and services in vast economic networks with very little outlay of financial capital.

Democratizing Manufacturing

For example, consider manufacturing. Nothing is more suggestive of the industrial way of life than highly capitalized, giant, centralized factories equipped with heavy machines and attended by blue-collar workforces, churning out mass-produced products on assembly lines. But what if millions of people could manufacture batches or even single manufactured items in their own homes or businesses, cheaper, quicker, and with the same quality control as the most advanced state-of-the-art factories on earth?

While the TIR economy allows millions of people to produce their own virtual information and energy, a new digital manufacturing revolution now opens up the possibility of following suit in the production of durable goods. In the new era, everyone can potentially be their own manufacturer as well as their own internet site and power company. The process is called 3-D printing; and although it sounds like science fiction, it is already coming online, and promises to change the entire way we think of industrial production. Think about pushing the print button on your computer and sending a digital file to an inkjet printer, except, with 3-D printing, the machine runs off a three-dimensional product. Using computer aided design, software directs the 3-D printer to build successive layers of the product using powder, molten plastic, or

metals to create the material scaffolding. The 3-D printer can produce multiple copies just like a photocopy machine. All sorts of goods, from jewelry to mobile phones, auto and aircraft parts, medical implants, and batteries are being “printed out” in what is being termed “additive manufacturing,” distinguishing it from the “subtractive manufacturing,” which involves cutting down and pairing off materials and then attaching them together.

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3-D entrepreneurs are particularly bullish about additive manufacturing, because the process requires as little as 10 percent of the raw material expended in traditional manufacturing and uses less energy than conventional factory production, thus greatly reducing the cost.

In the same way that the Internet radically reduced entry costs in generating and disseminating information, giving rise to new businesses like Google and Facebook, additive manufacturing has the potential to greatly reduce the cost of producing hard goods, making entry costs sufficiently lower to encourage hundreds of thousands of mini manufacturers—small and medium size enterprises (SMEs)—to challenge and potentially outcompete the giant manufacturing companies that were at the center of the First and Second Industrial Revolution economies.

Already, a spate of new start-up companies are entering the 3-D printing market with names like Within Technologies, Digital Forming, Shape Ways, Rapid Quality Manufacturing, Stratasys, Bespoke Innovations, 3D Systems, MakerBot Industries, Freedom of Creation, LGM, and Contour Crafting and are determined to reinvent the very idea of manufacturing in the Third Industrial era.

The energy saved at every step of the digital manufacturing process, from reduction in materials used, to less energy expended in making the product, when applied across the global economy, adds up to a qualitative increase in energy efficiency beyond anything imaginable in the First and Second Industrial Revolutions. When the energy used to power the production process is renewable and also generated on site, the full impact of a lateral Third Industrial Revolution becomes strikingly apparent. Since approximately 84 percent of the productivity gains in the manufacturing and service industries are attributable to increases in thermodynamic efficiencies—only 14 percent of productivity gains are the result of capital invested per worker—we begin to grasp the significance of the enormous surge in productivity that will accompany the Third Industrial Revolution and what it will mean for society.

Near Zero Cost Marketing and Logistics

The democratization of manufacturing is being accompanied by the tumbling costs of marketing. Because of the centralized nature of the communication technologies of the first and second industrial revolutions—newspapers, magazines, radio, and television—marketing costs were high and favored giant firms who could afford to devote substantial funds to market their products and services. The internet has transformed marketing from a significant expense to a negligible cost, allowing start ups and small and medium size enterprises to market their goods and services on internet sites that stretch over virtual space, enabling them to compete and even out compete many of the giant business enterprises of the 21st century.

Consider Etsy, a brash, web start-up company that has taken off in the past seven years. Etsy was founded by a young New York University graduate, Rob Kalin, who made furniture in his apartment. Frustrated that he had no way to connect with potential buyers interested in hand-crafted furniture, Kalin teamed up with a few friends and put up a website designed to bring individual craftsmen of all kinds, from around the world, together with prospective buyers. The site has become a global virtual showroom, where millions of buyers and thousands of sellers from more than fifty countries are connecting, breathing new life into craft production—an art that had largely disappeared with the advent of modern industrial capitalism.

Connecting multitudes of sellers and buyers in virtual space is almost free. By replacing all of the middlemen—from wholesalers to retailers—with a distributed virtual network of sellers and buyers and eliminating the transaction costs that are marked up at every stage in the marketing process, Etsy has created a new global craft bazaar that scales laterally rather than hierarchically, and markets goods collaboratively rather than top-down.

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Etsy brings another dimension to the market—the personalization of relationships between seller and buyer. The website hosts chat rooms, coordinates online craft shows, and conducts seminars, allowing sellers and buyers to interact, exchange ideas, customize products, and create social bonds that can last a lifetime. Giant, global companies mass-producing standardized products on assembly lines operated by anonymous workforces can’t compete with the kind of intimate one-to-one relationship between artisan and patron.

Although still in its infancy, Etsy is a quickly growing enterprise. In 2011, Etsy’s sales topped nearly \$500 million. In



a recent conversation, Kalin told me that his mission is to help foster “empathic consciousness” in the global economic arena and lay the foundation for a more inclusive society. His vision of connecting up “millions of local living economies that will create a sense of community in the economy again” is the essence of the Third Industrial Revolution model. Etsy is only one of hundreds of global Internet companies that are bringing together producers and consumers in virtual marketing spaces and, in the process, democratizing marketing costs across the global economy.

As the new 3-D technology becomes more widespread, on site, just in time customized manufacturing of products will also reduce logistics costs with the possibility of huge energy savings. The cost of transporting products will plummet in the coming decades because an increasing array of goods will be produced locally in thousands of micro-manufacturing plants and transported regionally by trucks powered by green electricity and hydrogen generated on site.

The lateral scaling of the Third Industrial Revolution allows small and medium size enterprises to flourish. Still, global companies will not disappear. Rather, they will increasingly metamorphose from primary producers and distributors to aggregators. In the new economic era, their role will be to coordinate and manage the multiple networks that move commerce and trade across the value chain.

New Business Models and Jobs in the 21st Century

Germany is leading the way into the new economic era. The Federal Government has teamed up with six regions across Germany to test the introduction of an energy internet that will allow tens of thousands of German businesses and millions of home owners to collect renewable energies on site, store them in the form of hydrogen, and share green electricity across Germany in a smart energy internet. Entire communities are transforming their commercial and residential buildings into green

micro-power plants. To date, more than 1 million buildings in Germany have been converted into partial green micro power plants. Companies like Siemens, Bosch and Daimler are creating sophisticated new IT software, hardware, appliances and vehicles, that will merge distributed Internet communication with distributed energy, to create smart buildings, infrastructure, and green mobility for the cities of the future.

including distributed and collaborative research and development strategies, open source and networked commerce, performance contracting, shared savings agreements, and sustainable low-carbon logistics and supply chain management. The skill levels and managerial styles of the Third Industrial Revolution workforce will be qualitatively different from those of the workforce of the Second Industrial Revolution.

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The transition to the Third Industrial Revolution will require a wholesale reconfiguration of the entire economic infrastructure of each country, creating millions of jobs and countless new goods and services. Nations will need to invest in renewable energy technology on a massive scale; convert millions of buildings into green micro power plants; embed hydrogen and other storage technology throughout the national infrastructure; lay down a green energy internet; and transform the automobile from the internal combustion engine to electric plug-in and fuel cell cars.

The remaking of each nation’s infrastructure and the retooling of industries is going to require a massive retraining of workers on a scale matching the professional and vocational training at the onset of the First and Second Industrial Revolutions. The new high tech workforce of the Third Industrial Revolution will need to be skilled in renewable energy technologies, green construction, IT and embedded computing, nanotechnology, sustainable chemistry, fuel-cell development, digital power grid management, hybrid electric and hydrogen-powered transport and hundreds of other technical fields.

Entrepreneurs and managers will need to be educated to take advantage of cutting edge business models,

The lateral scaling of the Third Industrial Revolution shifts the fulcrum of power from centralized global companies to distributed small and medium size enterprise networks. The rapid decline in transaction costs brought on by The Third Industrial Revolution are leading to the democratization of information, energy, manufacturing, marketing, and logistics, and the ushering in of a new era of distributed capitalism that is likely to change the very way we think of commercial life. The Third Industrial Revolution offers the hope that we can arrive at a sustainable post-carbon era by mid-century. We have the science, the technology, and the game plan to make it happen. Now it is a question of whether we will recognize the economic possibilities that lie ahead and muster the will to get there in time.

About the author

Jeremy Rifkin is the author of *The New York Times* best selling book, *The Third Industrial Revolution, How Lateral Power is Transforming Energy, the Economy, and the World*. Mr. Rifkin is an adviser to the European Union and to heads of state around the world. He is a senior lecturer at the Wharton School’s Executive Education Program at the University of Pennsylvania and the president of the Foundation on Economic Trends in Washington, D.C.