

# One Belt, **One Road**:

Ushering in a Green Internet Plus  
Third Industrial Revolution in China, the  
European Union and across Eurasia



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## INTRODUCTION

The global economy is slowing, productivity is waning in every region of the world, and unemployment remains stubbornly high in every country. At the same time, economic inequality between the rich and the poor is at the highest point in human history. In 2010 the combined wealth of the 388 richest people in the world equaled the combined wealth of the poorest half of the human race. By 2014 the wealth of the 80 richest individuals in the world equaled the combined wealth of the poorest half of the human race.

This dire economic reality is now compounded by the rapid acceleration of climate change brought on by the increasing emissions of industrial induced global warming gases. Climate scientists report that the global atmospheric concentration of carbon, which ranged from a 180 to 300 parts per million (ppm) for the past 650,000 years, has risen from 280 ppm just before the outset of the industrial era to 400 ppm in 2013. The atmospheric concentrations of methane and nitrous oxide, the other two powerful global warming gases, are showing similar steep trajectories.

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At the Copenhagen global climate summit in December 2009, the European Union proposed that the nations of the world not exceed carbon dioxide emissions of 450 ppm by 2050, with the hope that if we were able to do so, we might limit the rise in Earth's temperature to 3.5°F (2°C). Even a 3.5°F rise, however, would take us back to the temperature on Earth several million years ago, in the Pliocene epoch, with devastating consequences to ecosystems and human life.

The EU proposal went ignored. Now, six years later, the sharp rise in the use of carbon-based fuels has pushed up the atmospheric levels of carbon dioxide (CO<sub>2</sub>) far more quickly than earlier models had projected,

making it likely that the temperature on Earth will rush past the 3.5° target and could top off at 8.1°F (4.5°C) or more by 2100—temperatures not seen on Earth for millions of years. (Remember, anatomically modern human beings—the youngest species—have only inhabited the planet for 175,000 years or so.)

What makes these dramatic spikes in the Earth's temperature so terrifying is that the increase in heat radically shifts the planet's hydrological cycle. We are a watery planet. The Earth's diverse ecosystems have evolved over geological time in direct relationship to precipitation patterns. Each rise in temperature of 1°C results in a 7 percent increase in the moisture-holding capacity of the atmosphere. This causes a radical change in the way water is distributed, with more intense precipitation but a reduction in duration and frequency. The consequences are already being felt in eco-systems around the world. We are experiencing more bitter winter snows, more dramatic spring storms and floods, more prolonged summer droughts, more wildfires, more intense hurricanes (category 3, 4, and 5), a melting of the ice caps on the great mountain ranges, and a rise in sea levels.

The Earth's ecosystems cannot readjust to a disruptive change in the planet's water cycle in such a brief moment in time and are under increasing stress, with some on the verge of collapse. The destabilization of ecosystem dynamics around the world has now pushed the biosphere into the sixth extinction event of the past 450 million years of life on Earth. In each of the five previous extinctions, Earth's climate reached a critical tipping point, throwing the ecosystems into a positive feedback loop, leading to a quick wipe-out of the planet's biodiversity. On average, it took upward of 10 million years to recover the lost biodiversity. Biologists tell us that we could see the extinction of half the Earth's species by the end of the current century, resulting in a barren new era that could last for millions of years. James Hansen, former head of the NASA Goddard Institute for Space Studies and the chief climatologist for the U.S. government, forecasts a 6°C rise in the Earth's temperature between now and the turn of the century—and with it, the end of human civilization as we've come to know it. The only hope, according to Hansen, is to reduce the current concentration of carbon in the atmosphere from 385 ppm to 350 ppm or less—something no government is currently proposing.

Now, a new economic paradigm is emerging that is

going to dramatically change the way we organize economic life on the planet. The European Union and China are embarking on a bold new course to create a high-tech 21st Century smart green digital economy, making each potentially the most productive commercial spaces in the world and the most ecologically sustainable societies on Earth. The plans are called Digital Europe and China Internet Plus. The EU and China vision of a green digital economy is now being embraced by other nations around the world.

China and the European Union's plans to establish an Internet Plus platform for a smart green economy opens up the prospect of joint collaboration in the creation of a digitalized integrated economic space across the Eurasian landmass to foster the transition into a Third Industrial Revolution and an ecological civilization. In recent months, President Xi and Premier Li of China have called for a new high-tech Eurasian Silk Road - One Belt, One Road - to connect the Eurasian land mass in a seamless integrated market from Shanghai to the Irish Sea (the EU is China's largest trading partner, and China is the EU's second largest trading partner). The build-out of a digitalized Internet of Things infrastructure across Eurasia could lead to a new age of deep collaboration between the EU and China, and emerging nations, bringing much of the human family together for the first time in history.

The digitalization of Europe and China involves much more than providing universal broadband, free Wi-Fi, and a flow of Big Data. The digital economy will revolutionize every commercial sector, disrupt the workings of virtually every industry, bring with it unprecedented new economic opportunities, put millions of people back to work, democratize economic life, and create a more sustainable low-carbon society to mitigate climate change. Equally important, the new economic narrative is being accompanied by a new biosphere consciousness, as the human race begins to perceive the Earth as its indivisible community. We are each beginning to take on our responsibilities as stewards of the planetary ecosystems which sustain all of life.

To grasp the enormity of the economic change taking place, we need to understand the technological forces that have given rise to new economic systems throughout history. Every great economic paradigm requires three elements, each of which interacts with the other to enable the system to operate as a whole: new communication technologies to more efficiently

manage economic activity; new sources of energy to more efficiently power economic activity; and new modes of transportation to more efficiently move economic activity.

In the 19th century, steam-powered printing and the telegraph, abundant coal, and locomotives on national rail systems gave rise to the First Industrial Revolution. In the 20th Century, centralized electricity, the telephone, radio and television, cheap oil, and internal combustion vehicles on national road systems converged to create an infrastructure for the Second Industrial Revolution.

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### **THE THIRD INDUSTRIAL REVOLUTION**

Today, the European Union and China are laying the ground work for the Third Industrial Revolution. Jean-Claude Juncker, President of the European Commission, has introduced a new long-term economic vision and development plan called “Digital Europe,” while President Xi and Premier Li of China have introduced a similar vision called “China Internet Plus.” In both the EU and China, the digitalized communication Internet is converging with a digitalized renewable Energy Internet, and a digitalized automated Transportation and Logistics Internet, to

create a super-Internet of Things (IoT) infrastructure. In the Internet of Things era, sensors will be embedded into every device and appliance, allowing them to communicate with each other and Internet users, providing up to the moment data on the managing, powering, and moving of economic activity in a smart digital society. Currently, 14 billion sensors are attached to resource flows, warehouses, road systems, factory production lines, the electricity transmission grid, offices, homes, stores, and vehicles, continually monitoring their status and performance and feeding big data back to the Communication Internet, Energy Internet, and Transportation and Logistics Internet. By 2030, it is estimated there will be more than 100 trillion sensors connecting the human and natural environment in a global distributed intelligent network. For the first time in history, the entire human race can collaborate directly with one another, democratizing economic life.

In this expanded digital economy, private enterprises connected to the Internet of Things can use Big Data and analytics to develop algorithms that speed efficiency, increase productivity, and dramatically lower the marginal cost of producing and distributing goods and services, making European and Chinese businesses more competitive in an emerging post-carbon global marketplace. (Marginal cost is the cost of producing an additional unit of a good or service, after fixed costs have been absorbed.)

The marginal cost of some goods and services in a Digital Europe / Internet Plus China will even approach zero, allowing millions of prosumers connected to the Internet of Things to produce and exchange things with one another, for nearly free, in the growing Sharing Economy. Already, a digital generation is producing and sharing music, videos, news blogs, social media, free e-books, massive open online college courses, and other virtual goods at near zero marginal cost. The near zero marginal cost phenomenon brought the music industry to its knees, shook the television industry, forced newspapers and magazines out of business, and crippled the book publishing market.

While many traditional industries suffered, the zero marginal cost phenomenon also gave rise to a spate of new entrepreneurial enterprises including Google, Alibaba, Facebook, Tencent, Twitter, and YouTube, and thousands of other Internet companies, who reaped profits by creating new applications and

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establishing the networks that allow the Sharing Economy to flourish.

Economists acknowledge the powerful impact the near zero marginal cost has had on the information goods industries but, until recently, have argued that the productivity advances of the digital economy would not pass across the firewall from the virtual world to the brick-and-mortar economy of energy, and physical goods and services. That firewall has now been breached. The evolving Internet of Things will allow conventional businesses enterprises, as well as millions of prosumers, to make and distribute their own renewable energy, use driverless electric and fuel cell vehicles in automated car sharing services, and manufacture an increasing array of 3D-printed physical products and other goods at very low marginal cost in the market exchange economy, or at near zero marginal cost in the Sharing Economy, just as they now do with information goods.

### **THE RENEWABLE ENERGY INTERNET**

The bulk of the energy we use to heat our homes and run our appliances, power our businesses, drive our vehicles, and operate every part of the global economy will be generated at near zero marginal cost and be nearly free in the coming decades. That's already the case for several million early adopters in the EU who have transformed their homes and businesses into micro-power plants to harvest renewable energy on-site. Currently, twenty-seven percent of the electricity powering Germany comes from solar and wind renewable energies. By 2020, thirty-five percent of the electricity powering Germany will be generated by solar and wind energies; it will be 45% by 2025, 50% by 2030, and 65% by 2035.

The quickening pace of renewable energy deployment



is due, in large part, to the plunging cost of solar and wind energy harvesting technologies. The fixed costs of solar and wind harvesting technologies have been on exponential curves for more than 20 years, not unlike the exponential curve in computing. In 1977, the cost of generating a single watt of solar electricity was \$76. By the last quarter of 2012, the cost of generating a watt had fallen to \$0.50, and by 2017 the cost is projected to fall to \$0.36 per watt. After the fixed costs for the installation of solar and wind are paid back—often as little as 2 to 8 years—the marginal cost of the harvested energy is nearly free. Unlike fossil fuels and uranium for nuclear power, in which the commodity itself always costs something, the sun collected on rooftops and the wind traveling up the side of buildings are free. In some regions of Europe and America, solar and wind energy is already as cheap, or cheaper, than fossil fuel or nuclear generated energy.

The EU and China are each accelerating the transition into renewable energies. While the EU led the way into the new green energies, China has quickly caught up in recent years and is now the leading manufacturer of solar and wind harvesting technologies in the world. In 2013, China installed more renewable energy capacity than all of Europe and the entire Asia-Pacific region.

The impact on society of near zero marginal cost solar and wind energy is all the more pronounced when we consider the enormous potential of these energy sources. The sun beams 470 exajoules of energy to Earth every 88 minutes—equaling the amount of

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energy human beings use in a year. If we could grab hold of one-tenth of 1 percent of the sun's energy that reaches Earth, it would give us six times the energy we now use across the global economy. Like solar radiation, wind is ubiquitous and blows everywhere in the world—although its strength and frequency varies. A Stanford University study on global wind capacity concluded that if 20 percent of the world's available wind was harvested, it would generate seven times more electricity than we currently use to run the entire global economy (China has the largest renewable energy potential of any country in the world, accounting for 20% of total global potential). The Internet of Things will enable businesses and prosumers to monitor their electricity usage in their buildings, optimize their energy efficiency, and share surplus green electricity generated on-site with others across nations and continents.

The Energy Internet is comprised of five foundational pillars, all of which have to be phased-in simultaneously for the system to operate efficiently. First, buildings and other infrastructure will need to be refurbished and retrofitted to make them more energy efficient so that renewable energy technologies—solar, wind, etc.—can be installed to generate power for immediate use or for delivery back to the electricity grid for compensation. Second, ambitious targets must be set to replace fossil fuels and nuclear power with renewable energy sources. To achieve this goal, feed-in tariffs need to be introduced to encourage early adopters to transform buildings and property sites into micro-power generation facilities. The feed-in tariffs guarantee a premium price above market value for renewable energies generated locally and sent back to the electricity grid. Third, storage technologies including hydrogen fuel cells, batteries, water pumping, etc., will need to be embedded at local generation sites and across the electricity grid to manage both the flow of intermittent green electricity and the stabilization of peak and base loads. Fourth, advanced meters and other digital technology will need to be installed in every building to transform the electricity grid from servo mechanical to digital connectivity in order to manage multiple sources of energy flowing to the grid from local generators. The distributed smart electricity infrastructure will enable passive consumers of electricity to become active producers of their own green electricity, which they can then use off-grid to manage their facilities or sell back to the Energy Internet. Fifth, every parking space will need to be equipped with a charging station to

allow electric and fuel cell vehicles to secure power from the Energy Internet, as well as sell power back to the electricity grid. Millions of electric and fuel cell vehicles connected to the Energy Internet also provide a massive backup storage system that can send electricity to the grid during peak demand, when the price of electricity has spiked, allowing vehicle owners to be appropriately compensated for contributing their electricity to the network.

The phase-in and the integration of the above five pillars transforms the electricity grid from a centralized to a distributed electricity system, and from fossil fuel and nuclear generation to renewable energy. In the new system, every business, neighborhood, and homeowner becomes the producers of electricity, sharing their surplus with others on a smart Energy Internet that is beginning to stretch across national and continental land masses.

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The democratization of energy is forcing electricity companies to rethink their business practices. A decade ago, four giant vertically integrated electricity generating companies—E.ON, RWE, EnBW, and Vattenfall—produced much of the electricity powering Germany. Today, these companies are no longer the exclusive arbiters of power generation. In recent years, farmers, urban dwellers, and small and medium sized enterprises (SMEs) established electricity cooperatives across Germany. Virtually all of the electricity cooperatives were successful in securing low interest loans from banks to install solar, wind, and other renewable energies on-site. The banks were more than happy to provide the loans, assured that the funds would be paid back by the premium price the cooperatives would receive—via feed-in-tariffs—from selling the new green electricity back to the grid. Today,

the majority of the green electricity powering Germany is being generated by small players in electricity cooperatives. The big four electricity generating companies are producing less than 7 percent of the new green electricity that’s taking Germany into a Third Industrial Revolution.

While these traditional vertically integrated power companies proved quite successful in generating relatively cheap electricity from traditional fossil fuels and nuclear power, they have not been able to effectively compete with local electricity cooperatives whose laterally scaled operations are better adept at managing energy harnessed by thousands of small players in broad collaborative networks. Peter Terium, CEO of RWE, the German-based energy company, acknowledges the massive shift taking place in Germany from centralized to distributed power, and says that the bigger power and utility companies “have to adjust to the fact that, in the longer term, earning capacity in conventional electricity generation will be markedly below what we’ve seen in recent years.”

A growing number of electricity generating companies are coming to grips with the new reality of distributed energy and are changing their business model to accommodate the new Energy Internet. In the future, their income will increasingly rely on erecting and operating the Energy Internet and managing their customers’ energy use. The electricity companies will mine Big Data across each of their clients’ value chains and use analytics to create algorithms and applications to increase their aggregate energy efficiency and productivity, and reduce their marginal cost. Their clients, in turn, will share the efficiency and productivity gains back with the electricity companies in what are called “Performance Contracts.” In short, power companies will profit more from managing energy use more efficiently, and selling less rather than more electricity.

### **THE AUTOMATED GPS-GUIDED TRANSPORTATION AND LOGISTICS INTERNET**

The meshing of the Communication Internet and the Energy Internet makes possible the build-out and scale-up of the automated Transportation and Logistics Internet. The convergence of these three Internets comprise the kernel of the Internet of Things platform for managing, powering, and transporting goods in a Third Industrial Revolution economy. The automated Transportation and Logistics Internet is made up

of four foundational pillars, which, like the Energy Internet, have to be phased-in simultaneously for the system to operate efficiently. First, as mentioned previously, charging stations will need to be installed ubiquitously across land masses, allowing cars, buses, trucks, and trains to power up or send back electricity to the grid. China leads the world in the sale of electric vehicles. More than 300,000 mini electric vehicles were sold in China in 2014. The number of electric vehicles is expected to climb dramatically in the Thirteenth Five-Year Plan between 2016 and 2020, with generous government subsidies and incentives to the industry and car buyers, positioning China as the frontrunner in the shift from internal combustion to electric transport. Second, sensors need to be embedded in devices across logistics networks to allow factories, warehouses, wholesalers, retailers, and end users to have up-to-the-moment data on logistical flows that affect their value chain. Third, the storage and transit of all physical goods will need to be standardized so that they can be efficiently passed off to any node and sent along any passageway, operating across the logistics system in the same way that information flows effortlessly and efficiently across the World Wide Web. Fourth, all of the operators along the logistics corridors need to aggregate into collaborative networks to bring all of their assets into a shared logistical space to optimize the shipment of goods, taking advantage of lateral economies of scale. For example, thousands of warehouses and distribution centers might establish cooperatives to share unused spaces, allowing carriers to drop off and pick up shipments using the most efficient path on route to their destination.

The Internet of Things platform will provide real-time logistical data on pick-up and delivery schedules, weather conditions, traffic flows, and up-to-the-moment information on warehouse storage capacities on route. Automated dispatching will use Big Data and analytics to create algorithms and applications to ensure the optimization of aggregate efficiencies along the logistical routes and, by so doing, dramatically increase productivity while reducing the marginal cost of every shipment.

By 2025, at least some of the shipments on roads, railways, and water will likely be carried out by driverless electric and fuel cell transport, powered by near zero marginal cost renewable energies, and operated by increasingly sophisticated analytics and algorithms. Driverless transport will accelerate

productivity and reduce the marginal labor cost of shipping goods toward near zero on a smart automated Transportation and Logistics Internet.

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The erection of the automated Transportation and Logistics Internet also transforms the very way we view mobility. Today's youth are using mobile communication technology and GPS guidance on an incipient automated Transportation and Logistics Internet to connect with willing drivers in car sharing services. Young people prefer “access to mobility” over ownership of vehicles. Future generations will likely never own vehicles again in a smart automated mobility era. For every vehicle shared, however, 15 vehicles are eliminated from production. Larry Burns, the former Executive Vice President of General Motors, and now a professor at the University of Michigan, did a study of mobility patterns in Ann Harbor, a mid-sized American city, and found that car sharing services can eliminate 80% of the vehicles currently on the road, and provide the same, or better, mobility at a lesser cost.

There are currently a billion cars, buses, and trucks crawling along in traffic in dense urban areas around the world. Gasoline-powered internal combustion vehicles were the centerpiece of the Second Industrial Revolution. The mass production of these vehicles devoured vast amounts of the Earth's natural resources. Cars, buses, and trucks also burn massive amounts of oil and are the third major contributor to global warming gas emissions, after buildings and

beef production and related agricultural production practices. Burns' study suggest that 80% of the vehicles currently on the road are likely to be eliminated with widespread adoption of car sharing services over the course of the next generation. The remaining 200 million vehicles will be electric and fuel cell transport, powered by near zero marginal cost renewable energy. Those shared vehicles, in turn, will be driverless and running on automated smart road systems.

The long-term transition from ownership of vehicles to access to mobility in driverless vehicles on smart road systems will fundamentally alter the business model for the transportation industry. While the big auto manufacturers around the world will produce fewer vehicles over the course of the next 30 years, they will likely increasingly reposition themselves as aggregators of the global automated Transportation and Logistics Internet, managing mobility services and logistics.

The convergence of the Communication Internet, renewable Energy Internet, and automated Transportation and Logistics Internet in an operating kernel becomes the global brain for an Internet of Things cognitive infrastructure. This new digital platform fundamentally changes the way we manage, power, and move economic activity across the numerous value chains and networks that make up the global economy. The digitalized Internet of Things platform is the core of the Third Industrial Revolution.

### **DISTRIBUTED MANUFACTURING**

Virtually every industry will be transformed by the Internet of Things platform and the ushering-in of a Third Industrial Revolution. For example, a new generation of micro manufacturers are beginning to plug in to the incipient IoT, and dramatically increasing their productivity while reducing their marginal costs, enabling them to outcompete the formerly invincible global manufacturing firms, organized around vertically integrated economies of scale. It's called 3D printing and it is the manufacturing model that accompanies an IoT economy.

In 3D printing, software directs molten feedstock inside a printer to build up a physical product layer by layer, creating a fully formed object, even with movable parts, which then pops out of the printer. Like the replicator in the Star Trek television series, the printer can be programmed to produce an infinite variety of

products. Printers are already producing products from jewelry and airplane parts to human prostheses, and even parts of cars and buildings. And cheap printers are being purchased by hobbyists interested in printing out their own parts and products. The consumer is beginning to give way to the prosumer as increasing numbers of people become both the producer and consumer of their own products.

Three-dimensional printing differs from conventional centralized manufacturing in several important ways. To begin with, there is little human involvement aside from creating the software. The software does all the work, which is why it's more appropriate to think of the process as "info-factory" rather than "manufacture."

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The early practitioners of 3D printing have made strides to ensure that the software used to program and print physical products remains open source, allowing prosumers to share new ideas with one another in do-it-yourself (DIY) hobbyist networks. The open design concept conceives of the production of goods as a dynamic process in which thousands—even millions—of players learn from one another by making things together. The elimination of intellectual-property protection also significantly reduces the cost of printing products, giving the 3D printing enterprise an edge over traditional manufacturing enterprises, which must factor in the cost of myriad patents. The open-source production model has encouraged exponential growth.

The 3D printing production process is organized completely differently than the manufacturing process of the First and Second Industrial Revolutions. Traditional factory manufacturing is a subtractive process. Raw materials are cut down and winnowed



and then assembled to manufacture the final product. In the process, a significant amount of the material is wasted and never finds its way into the end product. Three-dimensional printing, by contrast, is additive info-facturing. The software is directing the molten material to add layer upon layer, creating the product as a whole piece. Additive info-facturing uses one-tenth of the material of subtractive manufacturing, giving the 3D printer a dramatic leg up in efficiency and productivity. 3D printing is projected to grow at a blistering compound annual rate of 106% between 2012 and 2018.

3D printers can print their own spare parts without having to invest in expensive retooling and the time delays that go with it. With 3D printers, products can also be customized to create a single product or small batches designed to order, at minimum cost. Centralized factories, with their capital-intensive economies of scale and expensive fixed-production

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lines designed for mass production, lack the agility to compete with a 3D production process that can create a single customized product at virtually the same unit cost as producing 100,000 copies of the same item.

Making 3D printing a truly local, self-sufficient process requires that the feedstock used to create the filament is abundant and locally available. Staples—the office supply company—has introduced a 3D printer, manufactured by Mcor Technologies in its store in Almere, the Netherlands, that uses cheap paper as feedstock. The process, called selective

deposition lamination (SDL), prints out hard 3D objects in full color with the consistency of wood. The 3D printers are used to info-facture craft products, architectural designs, and even surgical models for facial reconstruction. The paper feedstock costs a mere 5 percent of previous feedstocks. Other 3D printers are using recycled plastic, paper, and metal objects as feedstock at near zero marginal cost.

A local 3D printer can also power his or her fabrication lab with green electricity harvested from renewable energy onsite or generated by local producer cooperatives. Small- and medium-sized enterprises in Europe, China, and elsewhere are already beginning to collaborate in regional green-electricity cooperatives to take advantage of lateral scaling. With the cost of centralized fossil fuels and nuclear power constantly increasing, the advantage skews to small- and medium-sized enterprises that can power their factories with renewable energies whose marginal cost is nearly free.

Marketing costs also plummet in an IoT economy. The high cost of centralized communications in both the First and Second Industrial Revolutions—in the form of magazines, newspapers, radio, and television—meant that only the bigger manufacturing firms with integrated national operations could afford advertising across national and global markets, greatly limiting the market reach of smaller manufacturing enterprises. In the Third Industrial Revolution, a small 3D printing operation anywhere in the world can advertise info-factured products on the growing number of global Internet marketing sites at nearly zero marginal cost.

Plugging into an IoT infrastructure at the local level gives the small info-facturers one final, critical advantage over the vertically integrated, centralized enterprises of the nineteenth and twentieth centuries: they can power their vehicles with renewable energy whose marginal cost is nearly free, significantly reducing their logistics costs along the supply chain and in the delivery of their finished products to users.

The new 3D printing revolution is an example of “extreme productivity.” The distributed nature of manufacturing means that anyone and eventually everyone can access the means of production, making the question of who should own and control the means of production increasingly irrelevant for a growing number of goods.

China, like the EU, is setting the pace in the

development of 3D printing. Beihang University is using 3D printing to manufacture sophisticated parts used in rockets and satellites. WinSun, another Chinese company, built ten small houses in less than 24 hours in 2014, using cheap recycled materials. The construction of the houses required very little human labor, and cost less than \$5000 a piece to construct, making possible the production of millions of cheap homes at low or near zero marginal cost in China and other developing countries. Tiertime, China's largest producer of desktop 3D printers for use in small businesses and households, unveiled its newest model UP! in 2014. The company is competing head to head with America's leading producers of 3D printers, in the hopes of capturing much of the global market in the years ahead.

Many of Europe's and China's global manufacturing enterprises will continue to flourish, but will be fundamentally transformed by the diffusion of manufacturing, which favors a high-tech renaissance for small and medium sized enterprises. Europe and China's manufacturing giants will increasingly partner with a new generation of 3D-printing small and medium sized enterprises in collaborative networks. While much of the manufacturing will be done by SME's that can take advantage of the increased efficiencies and productivity gains of lateral economies of scale, the giant enterprises will increasingly find value in aggregating, integrating, and managing the marketing and distributing of products.

The peer to peer nature of the Internet of Things platform allows millions of disparate players—small and medium sized businesses, social enterprises, and individuals—to come together and produce and exchange goods and services directly with one another, eliminating the remaining middle men that kept marginal costs high in the Second Industrial Revolution.

It is important to emphasize that the transition from the Second to the Third Industrial Revolution will not occur overnight, but, rather, take place of over thirty to forty years. Many of today's global corporations will successfully manage the transition by adopting the new distributed and collaborative business models of the Third Industrial Revolution while continuing their traditional Second Industrial Revolution business practices. In the coming years, capitalist enterprises will likely find more value in aggregating and managing laterally scaled networks than in selling discrete

products and services in vertically integrated markets.

## **DEVELOPING NATIONS LEAPFROGGING INTO THE THIRD INDUSTRIAL REVOLUTION**

The distributed features of the new economic paradigm also enable the least developed regions—that were largely excluded from the First and Second Industrial Revolutions—to “leapfrog” into a Third Industrial Revolution. Currently, more than 20 percent of the human race is without electricity, and an additional 20 percent has only marginal and unreliable access to electricity. These are the very countries where population is rising the fastest.

The lack of infrastructure is both a liability, and a potential asset. It is often cheaper and quicker to erect virgin infrastructure than to reconfigure existing infrastructure. We are already witnessing a surge of activity in some of the poorer region of the world with the introduction of solar, wind, geothermal, small-hydro, and biomass harvesting technologies and the installation of distributed renewable energy micro grids.

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Electricity is now coming to remote areas in Africa, which never before had access to a centralized power grid. Not surprisingly, the introduction of cell phones has helped precipitate the development of a nascent Third Industrial Revolution infrastructure. Virtually overnight, millions of Africa's rural households have scraped together enough money—from selling an animal or surplus crops—to purchase a cell phone. The phones are used as much for carrying on commercial activity as for personal communications. In rural areas, far removed from urban banking facilities, people are increasingly relying on cell phones to facilitate small money transfers. The problem is that without access to electricity, cell phone users often have to travel on foot to get to a town with electricity in order to recharge

their phones. Now a single solar panel affixed on the tin roof of a rural hut provides enough electricity to not only charge the cell phone but also power four overhead electric lights.

Although the statistics are still spotty, it appears that families across Africa are installing solar panels and analysts predict a quick scale-up as millions of others follow suit into the Third Industrial Revolution. What's going on in Africa heralds a historic transformation as households leapfrog from the pre-electricity era directly into the Third Industrial Revolution age.

Besides solar, other green micro-generation energy technologies are quickly coming online, including small biogas chambers that make electricity and fuel from cow manure, tiny power plants that make electricity from rice husks and small hydroelectric dams that generate power from local streams.

Lateral power is beginning to transform the developing world. This process represents the democratization of energy in the world's poorest communities. The electrification process is likely to accelerate in the future, giving rise to exponential curves and a qualitative "leap" into the Third Industrial Revolution era in previously underdeveloped regions.

For example, the electrification of the developing world makes possible the powering of 3D printers and a proliferation of distributed manufacturing. In poor urban outskirts, isolated towns, and rural locales—where infrastructure is scant, access to capital spotty, at best, and technical expertise, tools, and machinery virtually nonexistent—3D printing provides a desperately needed opportunity for building a Third Industrial Revolution infrastructure. Today, the emerging IoT infrastructure provides the means to lift hundreds of millions of human beings out of abject poverty and into a sustainable quality of life.

Bringing universal electricity to developing countries also fosters greater communication and connectivity between rural and urban communities. That connectivity is spawning the proliferation of shared Commons among farmers and consumers. A younger generation of farmers is sharing harvests on an agricultural scale with urban consumers. Community Supported Agriculture (CSA) began inauspiciously in Europe and Japan in the 1960s and accelerated rapidly in the United States and other countries in the 1990s

with the rise of the Internet. And now, as universal electricity and the Internet spread to developing nations, Community Supported Agriculture is beginning to transform the relationship between farmers and urban dwellers in these regions as well. Urban consumers pledge a fixed amount of money to local farmers in advance of the growing season to pay for the up-front cost of growing the crops. The consumers become, in effect, shareholders. In return, the consumers are provided with the bounty from the harvest delivered to their door or to nearby distribution centers throughout the growing season. If the farmers' crops are plentiful, the shareholders are awarded with the additional yield. Likewise, if yields are down because of adverse weather or other conditions, the shareholders share in the losses with the delivery of less produce.

The sharing of risk between consumers and farmers creates a bond of mutual trust and fosters social capital. Moreover, eliminating all the middlemen in the conventional, vertically integrated agribusiness operations dramatically reduces the costs of the produce for the end user.

“Lateral power is beginning to transform the developing world.”

Many CSA operations use ecological agricultural practices and organic farming techniques, eliminating the high costs and environmental damage caused by the use of petrochemical fertilizers and pesticides. Energy and environmental costs are further reduced by eliminating plastic packaging and the long-haul transport of produce.

The Internet has been a great facilitator of CSA by making it easier for farmers and consumers to connect in peer-to-peer networks. Local CSA websites also allow farmers and customers to stay in constant contact, sharing up-to-date information on crop

performance and delivery schedules. CSAs replace sellers and buyers in the conventional market with providers and users exchanging produce on a social Commons. In a sense, consumers become prosumers by crowd-financing the means of production that deliver the end products they will consume. There are thousands of CSA enterprises scattered around the world, and their numbers are growing as a younger generation becomes increasingly comfortable with the idea of exercising more of its commercial options in a social economy on the Commons. Community Supported Agriculture is likely to grow even more quickly in developing regions of the world where farmers often lack sufficient capital to adequately finance the next year's crop. Electrification and the convergence of the Communication Internet with a digitalized renewable Energy Internet and a digitalized smart Transportation and Logistics Internet is likely to speed the development of Community Supported Agriculture in the poorest regions of the world.

The United Nations Industrial Development Organization (UNIDO) has made a commitment to help empower local populations to lay down a Third Industrial Revolution (TIR) infrastructure that can bring green electricity to 1.5 billion impoverished people. In 2011, I joined Dr. Kandeh Yumkella, director general of UNIDO and the head of U.N. Energy, at the organization's global conference in support of the TIR build-out in developing nations. Yumkella declared that "we believe we are at the beginning of a third industrial revolution and I wanted all member countries of UNIDO to hear the message and ask them the key question: How can we be part of this revolution?" The goal is to make electricity universally available by 2030. The electrification of every community on Earth will provide the impetus to lift the world's poor out of poverty and toward the zone of comfort that can sustain a decent quality of life for every human being.

“The goal is to make electricity universally available by 2030.”

## **RETHINKING ECONOMICS IN AN ECOLOGICAL ERA**

The transformation to an Internet of Thing infrastructure and a Third Industrial Revolution paradigm is forcing a wholesale rethinking of economic theory and practice. The unleashing of extreme productivity wrought by the digitalization of communication, energy, and transportation is leading to a reassessment of the very nature of productivity and a new understanding of ecological sustainability. Conventional economists fail to recognize that the laws of thermodynamics govern all economic activity. The first and second laws of thermodynamics state that "the total energy content of the universe is constant and the total entropy is continually increasing." The first law, the conservation law, posits that energy can neither be created nor destroyed—that the amount of energy in the universe has remained the same since the beginning of time and will be until the end of time. While the energy remains fixed, it is continually changing form, but only in one direction, from available to unavailable. This is where the second law of thermodynamics comes into play. According to the second law, energy always flows from hot to cold, concentrated to dispersed, ordered to disordered. For example, if a chunk of coal is burned, the sum total of the energy remains constant, but is dispersed into the atmosphere in the form of carbon dioxide, sulfur dioxide, and other gases. While no energy is lost, the dispersed energy is no longer capable of performing useful work. Physicists refer to the no-longer-useable energy as entropy.

All economic activity comes from harnessing available energy in nature—in material, liquid, or gaseous form—and converting it into goods and services. At every step in the production, storage, and distribution process, energy is used to transform nature's resources into finished goods and services. Whatever energy is embedded in the product or service is at the expense of energy used and lost—the entropic bill—in moving the economic activity along the value chain. Eventually, the goods we produce are consumed, discarded, and recycled back into nature, again, with an increase in entropy. Engineers and chemists point out that in regard to economic activity there is never a net energy gain but always a loss in available energy in the process of converting nature's resources into economic value. The only question is: when does the bill come due?



The entropic bill for the First and Second Industrial Revolutions has arrived. The accumulation in carbon dioxide emissions in the atmosphere from burning massive amounts of carbon energy has given rise to climate change and the wholesale destruction of the Earth's biosphere, throwing the existing economic model into question. The field of economics, by and large, has yet to confront the fact that economic activity is conditioned by the laws of thermodynamics.

Until very recently, economists were content to measure productivity by two factors: machine capital and labor performance. But when Robert Solow—who won the Nobel Prize in economics in 1987 for his growth theory—tracked the Industrial Age, he found that machine capital and labor performance only accounted for approximately 12.5 percent of all of the economic growth, raising the question of what was responsible for the other 87.5 percent. This mystery led economist Moses Abramovitz, former president of the American Economic Association, to admit what other economists were afraid to acknowledge—that the other 86 percent is a “measure of our ignorance.”

Over the past 25 years, a number of analysts, including physicist Reiner Kümmel of the University of Würzburg, Germany, and economist Robert Ayres at INSEAD business school in Fontainebleau, France, have gone back and retraced the economic growth of the industrial period using a three-factor analysis of machine capital, labor performance, and thermodynamic efficiency of energy use. They found that it is “the increasing thermodynamic efficiency with which energy and raw materials are converted into useful work” that accounts for most of the rest of the gains in productivity and growth in industrial economies. In other words, “energy” is the missing factor.

A deeper look into the First and Second Industrial Revolutions reveals that the leaps in productivity and growth were made possible by the communication/energy/transportation matrix and accompanying infrastructure that comprised the general-purpose technology platform that firms connected to. For example, Henry Ford could not have enjoyed the dramatic advances in efficiency and productivity brought on by electrical power tools on the factory floor without an electricity grid. Nor could businesses reap the efficiencies and productivity gains of large, vertically integrated operations without the telegraph and, later, the telephone providing them with instant

communication, both upstream to suppliers and downstream to distributors, as well as instant access to chains of command in their internal and external operations. Nor could businesses significantly reduce their logistics costs without a fully built-out road system across national markets. Likewise, the electricity grid, telecommunications networks, and cars and trucks running on a national road system were all powered by fossil fuel energy, which required a vertically integrated energy infrastructure to move the resource from the wellhead to the end users.

“The accumulation in carbon dioxide emissions in the atmosphere has given rise to climate change and the wholesale destruction of the Earth’s biosphere.”

The general-purpose technology infrastructure of the Second Industrial Revolution provided the productive potential for a dramatic increase in growth in the twentieth century. Between 1900 and 1929, the United States built out an incipient Second Industrial Revolution infrastructure—the electricity grid, telecommunications network, road system, oil and gas pipelines, water and sewer systems, and public school systems. The Depression and World War II slowed the effort, but after the war the laying down of the interstate highway system and the completion of a nationwide electricity grid and telecommunications network provided a mature, fully integrated infrastructure. The Second Industrial Revolution infrastructure advanced productivity across every industry, from automobile production to suburban commercial and residential building developments

along the interstate highway exits.

During the period from 1900 to 1980 in the United States, aggregate energy efficiency—the ratio of useful to potential physical work that can be extracted from materials—steadily rose along with the development of the nation's infrastructure, from 2.48 percent to 12.3 percent. The aggregate energy efficiency leveled off in the 1990s at around 13 percent with the completion of the Second Industrial Revolution infrastructure. Despite a significant increase in efficiency, which gave the United States extraordinary productivity and growth, nearly 87 percent of the energy we used in the Second Industrial Revolution was wasted during transmission.

Even if we were to upgrade the Second Industrial Revolution infrastructure, it's unlikely to have any measurable effect on efficiency, productivity, and growth. Fossil fuel energies have matured and are becoming more expensive to bring to market. And the technologies designed and engineered to run on these energies, like the internal-combustion engine and the centralized electricity grid, have exhausted their productivity, with little potential left to exploit.

Needless to say, 100 percent thermodynamic efficiency is impossible. New studies, however, including one conducted by my global consulting group, show that with the shift to a Third Industrial Revolution infrastructure, it is conceivable to increase aggregate energy efficiency to 40 percent or more in the next 40 years, amounting to a dramatic increase in productivity beyond what the economy experienced in the twentieth century.

Cisco systems forecasts that by 2022, the Internet of Things will generate \$14.4 trillion in cost savings and revenue. A General Electric study published in November 2012 concludes that the efficiency gains and productivity advances induced by a smart industrial Internet could resound across virtually every economic sector by 2025, impacting "approximately one half of the global economy."

### **THE RISE OF THE SHARING ECONOMY**

While the developing digital infrastructure is making the traditional capitalist market more productive and competitive, it is also spurring the meteoric growth of the Sharing Economy. In the Sharing Economy, social capital is as vital as finance capital, access is as

important as ownership, sustainability supersedes consumerism, cooperation is as crucial as competition, and "exchange value" in the capitalist marketplace is increasingly supplemented by "shareable value" on the Collaborative Commons. Millions of people are already transferring bits and pieces of their economic life to the Sharing Economy. Prosumers are not only producing and sharing their own information, news, knowledge, entertainment, green energy, transportation, and 3D-printed products in the Sharing Economy at near zero marginal cost. Forty percent of the US population is actively engaged in sharing homes, toys, tools, and countless other items. For example, millions of apartment dwellers and home owners are sharing their living quarters with millions of travelers, at near zero marginal cost, using online services like Airbnb and Couchsurfing. In New York City alone, Airbnb's 416,000 guests who stayed in houses and apartments between 2012 and 2013 cost the New York hotel industry 1 million lost room nights.

A younger generation of Chinese is already transforming itself from consumers to prosumers, producing and sharing music, videos, news, knowledge, cars, homes, tools, 3D-printed products—and soon renewable energy—at near zero marginal cost on a burgeoning Collaborative Commons.

“By 2022, the Internet of Things will generate \$14.4 trillion in cost savings and revenue.”

Carsharing in China is also taking off. Kandi technologies' EV Car Share takes carsharing to a new level of operations. In 2012 the company joined with the automaker Greely and signed an agreement with the city of Hangzhou to build 750 multi-story garages across the municipality and stock them with 100,000 Kandi electric vehicles. The garages are vending machine-like buildings, which provide easy instant access for anyone desiring to share a car. The carsharing service has proven wildly popular in Hangzhou, so much so that it's spreading to other cities

including Shanghai, Shandong, and Hainan.

Homesharing has also mushroomed in China in the past several years. Tujia Technology, a two year old Internet startup company, already lists 80,000 apartments and houses for short term rentals. Internet companies like Tujia are able to overtake the big global hotel chains because they can connect hundreds of thousands of apartment dwellers and homeowners with millions of prospective lodgers online at near zero marginal cost. Apartment dwellers and homeowners, in turn, are able to rent out their rooms far more cheaply than conventional hotels can price their rooms because their fixed costs have already been absorbed. Hotel chains, with their huge overhead and operating costs, simply can't compete with cheap short-term rentals, whose marginal cost of operations approach zero.

Even apparel is being shared en masse in China, facilitated by startup Internet enterprises like Buy42.com (Buy42.com dedicates a percentage of money made by the redistribution of clothes in its network to charities that assist the poor). Meanwhile, small new social entrepreneurial organizations like sharism.org, sponsor seminars and provide ongoing educational programs to introduce the philosophical principles and day-to-day practices of the sharing economy on the Collaborative Commons, preparing a younger generation of Chinese to make the leap from ownership to access in the new era.

All the various enterprises mentioned in the preceding pages are collaborative in nature, sharable in design, and take advantage of a distributed, laterally scaled IoT architecture. Some of the commerce is shareable in the sense of gift giving, like Couchsurfing. Others are mixed, combining gift giving and exchanges with some form of compensation. Still others are purely profit-seeking enterprises like eBay. If we think of a collaborative economy as both gift giving as well as redistribution and recycling with or without compensation, everyone is covered.

Recent surveys underscore the broad economic potential of the Sharing Economy. A comprehensive study found that 62 percent of Gen Xers and Millennials are attracted to the notion of sharing goods, services, and experiences in Collaborative Commons. These two generations differ significantly from the baby boomers and World War II generation in favoring access over ownership. When asked to rank

the advantages of a Sharing Economy, respondents to the survey listed saving money at the top of the list, followed by impact on the environment, lifestyle flexibility, the practicality of sharing, and easy access to goods and services. As for the emotional benefits, respondents ranked generosity first, followed by a feeling of being a valued part of a community, being smart, being more responsible, and being a part of a movement.

How likely is it that the Sharing Economy will play an ever larger role in the economic life of society in the coming decades? According to an opinion survey conducted by Latitude Research, "75% of respondents predicted their sharing of physical objects and spaces will increase in the next five years." Interestingly, a recent Nielsen study polling more than 30,000 Internet respondents in 60 countries found that while 54% of respondents in Europe and 52% in North America expressed a willingness to share their possessions with others, the Asian Pacific countries scored much higher, with 78% expressing their enthusiasm for the Sharing Economy. Of the sixty countries polled, China scored the highest with 94% of respondents in favor of a Sharing Economy. Many industry analysts agree with these optimistic forecasts. Time magazine declared collaborative consumption to be one of its "10 ideas that will change the world."

“How likely is it that the Sharing Economy will play an ever larger role in the economic life of society in the coming decades?”

#### **ADDRESSING CLIMATE CHANGE AND HEALING THE BIOSPHERE**

The COP 21 UN Climate Conference which occurred

in Paris in December, revolved around a series of benchmarks—an increase in energy efficiency, a reduction of CO2 and other global warming gases, and an increase in renewable energies. However, without an economic vision and development plan for transitioning participating nations into a post-carbon era, governments are reluctant to commit their countries to these benchmarks in a period where GDP is slowing, productivity is waning, and unemployment remains high. They are far more likely to perceive the benchmarks as punishments that will only serve to further constrict their economies. The nations of the world would be far more likely to make commitments to the UN Climate Conference benchmarks if pegged to a new economic paradigm that can increase productivity, create new economic opportunities, and put people back to work, ensuring a more vibrant and sustainable society, while transitioning their economies out of carbon-based energies and technologies and into renewable energies. That vision is now taking hold in the European Union, China, and other countries.

In a fully-digitalized economy, extreme productivity, triggered by the optimization of aggregate efficiency in the managing, powering, and moving of economic activity, decreases the amount of information, energy, material resources, labor, and logistics necessary to produce, store, distribute, consume, and recycle economic goods and services toward near zero marginal cost. The partial shift from ownership to access in a growing Sharing Economy also means more people are sharing fewer items—the birth of the circular

“The partial shift from ownership to access in a growing Sharing Economy also means more people are sharing fewer items.”

economy—significantly reducing the number of new products sold, resulting in fewer resources being used up and less global warming gases being emitted into the earth's atmosphere. In other words, the headlong push to a near zero marginal cost society and the sharing of nearly free green energy and redistributed goods and services in the Sharing Economy is the most ecologically efficient economy achievable. The drive to near zero marginal cost is the ultimate benchmark for establishing a sustainable future for the human race on earth. The Third Industrial Revolution paradigm transforms the UN Climate Conference benchmarks from perceived punitive measures to goalposts on the journey to a more prosperous and sustainable post-carbon economic era.

A new smart infrastructure, made up of an interactive Communications, Energy, and Transportation Internet is beginning to spread nodally, like Wi-Fi, from region to region, crossing continents and connecting society in a vast global neural network. Connecting every thing with every being—the Internet of Things—is a transformational event in human history, allowing our species to empathize and socialize as a single extended human family for the first time in history. A younger generation is studying in global classrooms via Skype; socializing with cohorts around the world on Facebook; gossiping with hundreds of millions of peers on Twitter; sharing homes, clothes, and just about everything else online in the Communications Internet; generating and sharing green electricity across continents over the Energy Internet; sharing cars, bikes, and public transport on the evolving Transportation and Logistics Internet; and, in the process, shifting the human journey from an unswerving allegiance to unlimited and unrestrained material growth to a species commitment to sustainable economic development. This transformation is being accompanied by a change in the human psyche—the leap to biosphere consciousness and the Collaborative Age.

The biosphere is the integrated living and life-supporting system comprising the peripheral envelope of the planet Earth together with its surrounding atmosphere so far down and up as any form of life exists naturally. The biosphere sheath extends only about 12 miles up from the ocean floor, inhabited by the most primitive life forms, to the stratosphere. Within this narrow realm, Earth's biological and geochemical processes are continually interacting in a complex choreography that determines the evolutionary path of



life on the planet.

We are beginning to realize that the Earth's biosphere functions more like a self-regulating organism and that human activity that undermines the biochemical balance of the planet can lead to the catastrophic destabilization of the entire system. The spewing of massive amounts of carbon dioxide, methane, and nitrous oxide into the atmosphere over the course of the First and Second Industrial Revolutions has done just that. The rising temperature from industrial emissions of global warming gases has now dramatically altered the Earth's hydrological cycle, throwing ecosystems into rapid decline and ushering in the sixth extinction event in the past 450 million years, with untold consequences for both human civilization and the future health of the planet.

“The Internet of Things is a transformational event in human history, allowing our species to empathize and socialize as a single extended human family for the first time in history.”

Humanity is quickly becoming aware that the biosphere is the indivisible overarching community to which we all belong and whose well-being is indispensable to assuring our own well-being as well as our survival. This dawning awareness comes with a new sense of responsibility—living our individual and collective lives in our homes, businesses, and communities in ways that advance the health of the larger biosphere. Children all over the world are

learning about their “ecological footprint.” They are coming to understand that everything we human beings do—and for that matter every other creature—leaves an ecological footprint that affects the well-being of some other human being or creature in some other part of the Earth's biosphere. They are connecting the dots and realizing that every creature is embedded in myriad symbiotic and synergistic relationships in ecosystems across the biosphere and that the proper functioning of the whole system depends on the sustainable relationships of each of the parts. A younger generation is learning that the biosphere is our planetary community, whose health and well-being determines our own.

Their newfound openness is tearing down the walls that have long divided people by gender, class, race, ethnicity, and sexual orientation. Empathic sensitivity is expanding laterally as quickly as global networks are connecting everyone together. Hundreds of millions of human beings—I suspect even several billion—are beginning to experience “the other” as “one's self,” as empathy becomes the ultimate litmus test of a truly democratic society. Millions of individuals, especially young people, are also beginning to extend their empathic drive to include our fellow creatures, from the penguins and polar bears adrift on the poles to the other endangered species inhabiting the few remaining pristine, wild ecosystems. The young are just beginning to glimpse the opportunity of forging an empathic civilization tucked inside a biosphere community. At this stage, much of the anticipation is more hope than expectation. Still, there is an unmistakable feeling of possibility in the air.

#### **SPURRING NEW BUSINESS OPPORTUNITIES AND MASS EMPLOYMENT IN THE EMERGING DIGITAL ECONOMY**

The build-out of an Internet of Things platform for a Third Industrial Revolution will allow business enterprises and prosumers to produce and distribute information, renewable energy, 3D printed products, and a wide range of other products and services at low marginal cost in the conventional marketplace, or at near zero marginal cost in the Sharing Economy, with vast economic benefits for society.

Erecting the Internet of Things infrastructure for a digital Third Industrial Revolution economy will require a significant investment of public and private funds, just as was the case in the first and second

industrial revolutions. European investment on infrastructure-related projects totaled \$741 billion in 2012, much of it to shore up a second industrial revolution general purpose technology platform that is outmoded, and whose productivity potential has long since been reached. If just twenty five percent of these funds were redirected and earmarked in every region of the European Union to assemble an Internet of Things infrastructure, the Digital Union could be phased in between now and 2040. China, like Europe, has, until recently, devoted billions of dollars in infrastructure investment in the build out of an outmoded Second Industrial Revolution infrastructure. Now, however, China is beginning to reprioritize its infrastructure investments to expedite a transition into a Third Industrial Revolution paradigm.

In both the EU and China, the communication network will have to be upgraded with the inclusion of universal broadband and free Wi-Fi. The energy infrastructure will need to be transformed from fossil fuel and nuclear power to renewable energies. Millions of buildings will need to be retrofitted and equipped with renewable energy harvesting installations, and converted into micro power plants. Hydrogen and other storage technologies will have to be built into every layer of the infrastructure to secure intermittent renewable energy. The electricity grid of the European Union and China will have to be transformed into a smart digital Energy Internet to accommodate the flow of energy produced by millions of green micro power plants. The transportation and logistics sector will have to be digitalized and transformed into an automated GPS-guided driverless network running on smart roads and rail systems. The introduction of electric and fuel cell transportation will require millions of charging stations. Smart roads, equipped with millions of sensors, feeding real-time information on traffic flows and the movement of freight will also have to be installed.

The establishment of the Third Industrial Revolution Internet of Things infrastructure will necessitate the active engagement of virtually every commercial sector, spur commercial innovations, promote Small and Medium Sized Enterprises (SME's), and employ millions of workers over the next forty years. The power and electricity transmission companies, the telecommunication industry, the construction industry, the ICT sector, the electronics industry, transportation and logistics, the manufacturing sector, the life-sciences industry, and retail trade will all need

to be brought into the process. Many of today's leading companies, as well as new commercial players, will help establish and manage the Internet of Things platform, allowing millions of others—small, medium, and large sized businesses, nonprofit enterprises, and prosumers—to produce and use renewable energy, transportation and logistics, and a panoply of other goods and services at low marginal cost in the exchange economy or at near zero marginal cost in the Sharing Economy.

“The establishment of the Third Industrial Revolution Internet of Things infrastructure will necessitate the active engagement of virtually every commercial sector.”

Semi-skilled, skilled, professional, and knowledge workers will need to be employed across every region of Europe and China to construct and service the three Internets that make up the digital platform of a Third Industrial Revolution economy. Transforming the European and Chinese energy regimes from fossil fuels and nuclear power to renewable energies is extremely labor intensive and will require millions of workers and spawn thousands of new businesses. Retrofitting and converting hundreds of millions of existing buildings into green micro-power plants and erecting millions of new positive micro-power buildings will likewise require tens of millions of workers and open up new entrepreneurial opportunities for energy-saving companies (ESCOs), smart-construction companies, and green-appliance producers. Installing hydrogen and other storage technologies across the entire economic infrastructure to manage the flow of green electricity will generate comparable mass employment

and new businesses as well. The reconfiguration of the European and Chinese electricity grids into an Energy Internet will generate millions of installation jobs and give birth to thousands of clean Web app start-up companies. And finally, rebooting the transport sector from the internal-combustion engine to electric and fuel-cell vehicles will necessitate the makeover of the road system and fueling infrastructure. Installing millions of charging stations along roads and in every parking space is labor-intensive employment that will require a sizable workforce.

The massive build-out of the IoT infrastructure for a Third Industrial Revolution in every locality and region of Europe and China is going to spur an extended surge of mass wage and salaried labor that will run for forty years or more, spanning two generations. The business at hand will be to provide both retraining for the existing workforce and the appropriate skill development for students coming into the labor market to ease the transition into the new job categories and business opportunities that come with a massive build-out of an Internet of Things infrastructure around the world.

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In summary, the scale up of a smart digitalized Internet of Things infrastructure across the European Union and China will generate new business opportunities in both the market economy and the Sharing Economy, dramatically increase productivity, employ millions of people, and create an ecologically oriented post-carbon society. The employment of millions of workers will also stimulate purchasing power and generate new business opportunities and additional employment to serve increased consumer demand. Infrastructure investment always creates a multiplier effect that reverberates across the economy as a whole.

The alternative, staying entrenched in the sunset of the Second Industrial Revolution, with fewer economic opportunities, a slowing of GDP, diminishing productivity, rising unemployment, and an ever-more polluted environment is unthinkable, and would set the European Union and China on a long-term course of economic contraction and decline in the quality of life of their citizenry.

### **TURNING A SLOWDOWN INTO AN OPPORTUNITY IN CHINA**

China's gross domestic product grew at only 7% in

“Infrastructure investment always creates a multiplier effect that reverberates across the economy as a whole.”

the first quarter of 2015, marking its slowest growth since the global financial crisis in 2009. The news sent shockwaves across the global economy where just a year earlier, financial analysts were heralding China's ascension as the heir-apparent to the United States as the world's leading economic power. Several - but not all - of the major economic indicators in China now point downwards. Factory output grew at only 5.6% in March 2015, down from 6.8% in the first two months of the year. Fixed asset investment on infrastructure, factory equipment, and property construction were also down, as was retail sales, which recorded a 9 year low of 10.2%. China's growth has decelerated 30% in the past half-decade.

The heart of the problem is a real estate bubble that for years helped fuel China's remarkable economic growth. China's economy has grown at an average annual rate of 9.5% since 1978, when the government began introducing a market-oriented economy. The real estate sector and accompanying construction sector has long been a major player in China's growth as the government pursued an ambitious goal of resettling rural populations in new urban centers in an effort to improve the lives of millions of Chinese people. Since 1998, real estate investment has grown at an average of 20.2% annually, nearly double the country's GDP growth.

China's real estate sector is now slowing. Despite stimulus measures, including the easing of credit and the lowering of interest rates, and a 4.5% drop in housing prices over the past year - the first such decline in 20 years - millions of apartments lie empty,

with few buyers in sight. In the first quarter of 2014, real estate sales were down 7.8% compared to the same time period a year earlier. Construction of new homes was down 22.1%. Ghost cities with unoccupied commercial and residential buildings are widespread and an ever-present reminder of the real estate bubble hovering over the country's economy. China's real estate bubble is not unusual. Virtually every major industrial power has experienced similar real estate bubbles during the growth spurts that accompany the build out and scale up of new industrial paradigms.

The real estate sector, by some estimates, accounts for 25-30% of China's GDP, when other industries like steel, cement, glass, furnishings, and appliances that provide material support are factored in. The fate of these other accompanying industries is now inseparably tied to the future prospects of the real estate sector. When Bill Gates, the founder of Microsoft, tweeted in June 2014 that China used more cement in the last three years than the U.S. used in the entire 20th Century - much of it to feed the boom in residential and commercial real estate construction and the accompanying infrastructure, the stark reality of China's real estate bubble became even more apparent.

The residential real estate sector in China also accounts for 24% of the country's steel consumption. The real estate and construction sectors combined, also consume upwards 58% of the total output of non-metallic mineral products including building materials and a significant share of output for metal, furniture, transportation, and storage services.

In the wake of the global economic collapse in 2008, the Chinese government required its state-owned banks to extend massive credit, most of which went into stimulating an additional expansion of construction in the real estate sector and accompanying industries that service it including cement, steel, glass, and factories manufacturing televisions, refrigerators, washers and dryers, furniture, lighting, and other materials and products for homes, offices, and stores. Chinese debt quadrupled over the past 6 years from 7 trillion to 28 trillion in 2014 and is now at 282% of GDP and continuing to rise, making China's debt obligations larger, in relative terms, than the U.S. and Germany's debt.

Local governments soaked up much of the credit and debt to finance urban construction and the scale up of new commercial and residential building stocks.

Localities relied on land sales, in turn, for more than 35% of local government revenues. Now, with the real estate sector slowing, localities find themselves with less revenue from land sales and mounting debts, limiting their ability to provide for basic public services.

Falling revenues from local land sales is likely to worsen as demand for new housing and commercial office space declines, with growing unemployment. According to a survey by The Financial Times Confidential, labor demand contracted in July 2015 for the first time since 2012 with the index of labor demand dipping to 49.3% from an average of 67.8% in the first half of 2015 (an index reading below 50% signals a decline in demand for workers).

### **A NEW ECONOMIC PARADIGM FOR CHINA**

In July 2015, the People's Bank of China made available \$100 billion dollars to two state-owned "policy banks" to fund local government infrastructure. The two banks will also be allowed to issue trillions of Renminbi in bonds to underwrite lending to localities. The idea is to "swap" short-term local government debt for longer term lower cost bonds, to give localities breathing room on their interest payments.

Buying time, however, will not, by itself, put China back on the path to strong economic growth. China, like every other nation in the world, finds itself in the

“Falling revenues from local land sales is likely to worsen as demand for new housing and commercial office space declines, with growing unemployment.”



throes of declining productivity. According to Ernst & Young, growth in total factor productivity in China has declined from an annual average of 4.7% between 2001 and 2007 to 2.8% between 2008 and 2010. A study conducted by JP Morgan Hong Kong shows an even steeper decline in total factor productivity between 2008 and 2013 to 1.1%, while a Conference Board study reports that total factor productivity edged into negative territory between 2007 and 2012 at -0.9%. The last time total factor productivity was this low in China was 1971-1977.

Inefficient state-owned enterprises are sometimes faulted for not making timely improvements in productivity. Industrial overcapacity is also cited as a factor in declining productivity. The increase in labor costs are also seen as a major contributing factor to a decline in total factor productivity. Still, labor costs are only 1/5 of average U.S. wages.

A growing number of economists, however, are beginning to point to a far more important factor in the decline in total factor productivity - the high cost of energy which is estimated to be four times more expensive than in the U.S. The building sector in China currently uses 28% of the total energy consumed in the country. By 2015, an additional 350 million people will be living in cities, increasing the energy used by commercial and residential buildings by 40% before 2030.

While everyone agrees that a dramatic rise in total factor productivity is essential if China is to dig out from an unfolding economic slowdown, there is little consensus as to how to bring it about. The irony is that the real estate bubble is not only China's overarching liability but also potentially its most important asset in driving up total factor productivity, increasing employment, improving wages, and creating a more ecologically sustainable economy to achieve President Xi and Premier Li's vision of the Chinese Dream.

To turn the real estate bubble from a crisis to an opportunity, we need to think of the massive build out of urban infrastructure and new cities as a half finished work in progress. The next phase in China's economic journey is to convert the residential, commercial, and industrial building stock and accompanying infrastructure, into a smart green Internet of Things matrix to usher in a Third Industrial Revolution across China.

“Inefficient state-owned enterprises are sometimes faulted for not making timely improvements in productivity.”

As mentioned in the book, *The Third Industrial Revolution*, the great economic paradigm shifts in history occur when new communication technologies, energy sources, and modes of transportation emerge and converge to create a new general purpose technology platform for managing, powering and moving economic activity. The Second Industrial Revolution infrastructure of centralized telecommunication technology, fossil fuel and nuclear power, and internal combustion road, rail, water, and air transport peaked in the U.S. and other highly-developed nations in the 1990s with aggregate efficiency - the primary metric for measuring productivity - leveling off at around 13% in the U.S. and Europe and around 20% in Japan. Productivity has been slowly declining ever since as every other economy matured its Second Industrial Revolution infrastructure. In short, there is very little, if any, additional productivity gains to be reaped in the managing, powering, and moving of economic activity on a Second Industrial Revolution platform, be in in the United States, China, or any other nation.

China's mission, henceforth, is to transform its building stock - residential, commercial, and industrial - and its existing infrastructure into smart, digital nodes and networks across an Internet of Things platform to usher in a Third Industrial Revolution. Every building connected to the Internet of Things infrastructure becomes a data center, green micro power plant, energy storage site, and transport and logistics hub to manage, power, and move economic activity in a Smart Green China. The build out and scale up of a Third Industrial Revolution can advance aggregate efficiency

from 13% to more than 40% over the course of the next 25 years, dramatically increasing productivity and reducing marginal costs, making China the most competitive and ecologically sustainable commercial space in the world.

The conversion of the building stock is a four-part process. First, every building in China will have to undergo a complete retrofit, to seal its interior, minimize energy loss, and optimize efficiency. Second, smart Internet of Things technology will need to be installed throughout the interior and exterior space surrounding every building. Each building becomes a node connected to every other building across the infrastructure to allow families, businesses, and communities to monitor Big Data flowing along the value chains and use analytics to create algorithms and apps that can increase their aggregate efficiency, dramatically increase their productivity and reduce their marginal cost in the conventional market, and increasingly in the emerging Sharing Economy. Third, renewable energy harvesting technologies - solar, wind, geothermal, biomass, and small hydro - will need to be installed in and around every residential, commercial, and industrial site to collect energy and convert it to green electricity for off-grid use or sale back to the electricity grid. Energy storage technologies, including hydrogen fuel cells and batteries, will be installed alongside the renewable energy harvesting technologies to store intermittent green energy for use or sale back to the electricity grid to ensure a reliable supply of energy across China. Fourth, electric charging stations will need to be installed in or alongside every building to power electric and fuel cell vehicles for use on the automated, GPS-guided and driverless Transport and Logistics Internet. A November 2014 report by the International Renewable Energy Agency (IRENA) forecasts that electric vehicles will account for 20% of car demand in China by 2030.

The return on investment in energy efficiency and energy savings can be as few as four to seven years, after which the owner or renter enjoys a reliable stream of savings on their energy cost for decades. Studies show that retrofitted energy efficient buildings enjoy a higher market value, higher rents, and higher occupancy rates. A typical study of residential buildings across France shows a 40% increase in market value for buildings receiving the top energy performing certificates.

More importantly, transforming every building into an Internet of Things data center, green micro power generating facility, energy storage site, and automated transportation hub greatly enhances their economic value by providing a range of high-tech services that dramatically increase aggregate efficiency and productivity and lower marginal cost in the managing, powering, and moving of economic activity. The increase in productivity and reduction in marginal costs, when amplified by millions of buildings that become nodes linked to an Internet of Things infrastructure, not only appreciates the value of the building stock but also advances the economic growth of the Chinese economy.

“The increase in productivity and reduction in marginal costs advances the economic growth of the Chinese economy.”

The existing lands owned by local governments or their financial subsidiaries, which are currently unsellable because of the oversupply of unused building space, also become a valuable asset in the transformation to a smart, green, digital China. Vast swaths of publically-owned open land in and around urban jurisdictions can be used by local governments as large-scale renewable energy power sites to generate and store high volumes of green electricity for sale back to the national electricity grid. Local governments take on a new role as energy producers, with the revenue stream used to reduce their debt loads and increase their revenue generating capacity.

#### **EVERY BUILDING BECOMES A NODE IN A SMART GREEN DIGITAL CHINA**

Retrofitting every residential, commercial, and

industrial building in China is a herculean task, but also an essential pre-requisite for transforming the economy into an Internet Plus Third Industrial Revolution. The Chinese government has set an ambitious goal of at least a 40-45% reduction in carbon intensity across the country by 2020, based on 2005 carbon levels. To reach this goal, 1.25 billion M2 of new buildings and 90 million existing buildings will need to be insulated each year in the 13th Five Year Plan (FYP) between 2016 and 2020.

Insulating existing and new buildings is projected to create an extra annual market of \$43 billion during the 12th Five Year Plan. Installing more efficient windows and door products created a \$60 billion market by 2015 and is expected to grow significantly as China ramps up the retrofitting of existing buildings and builds new buildings between 2015 and 2020. Each one million dollars of spending on the manufacture and installation of envelope improvements generates 16.3 jobs when adding together direct employment, indirect employment, and induced employment. China currently boasts the largest HVAC market in the world and is the largest manufacturer of HVAC products. Installing new, more efficient HVAC equipment in several hundred million dwellings as part of a nationwide retrofit of China's building stock is going to dramatically increase HVAC sales. The HVAC market is already increasing by 20% annually and is expected to be worth approximately \$16 billion by the end of 2015 and will continue to expand well past 2020. Each one million dollars of spending on HVAC improvements generates 13.3 direct, indirect, and induced jobs. Highly efficient LED lighting began to be introduced in China's buildings in 2011. By 2020, LED lighting is expected to reach a 69% market share of \$17 billion. Each one million dollars of spending on LED lighting creates 12.9 direct, indirect, and induced jobs.

The introduction of an Internet of Things infrastructure in every building and between buildings to monitor and manage energy efficiency, while still nascent, is also expected to grow exponentially in the next few years as China transforms its building stock into smart, digital nodes interconnected in vast digital networks. Each one million dollars of spending on Internet of Things technologies fosters 13.0 direct, indirect, and induced jobs.

There are more than 200 million homes and millions of apartments in China that will need to be retrofitted in the coming decades. China is already gearing up

to engage in the largest retrofitting project in history. The initiative will create millions of new jobs while saving millions of existing jobs in the manufacturing, engineering, construction, and real estate sectors.

“The introduction of an Internet of Things infrastructure in every building to monitor and manage energy efficiency is expected to grow exponentially in the next few years.”

Germany's vast experience in retrofitting provides a metric for the job creating potential in China as it embarks on a nationwide retrofitting project. The German Alliance for Work and the Environment is credited with the most ambitious retrofitting project to date. 342,000 apartments were retrofitted, creating 25,000 new jobs and saving 116,000 existing jobs, or more than 140,000 new or saved jobs. While German employment figures might vary somewhat from China, they can be used to project the potential employment opportunities in the mass retrofitting of China's dwellings. Extrapolating from the German figures, 100 million apartment retrofits in China could generate upwards of 42 million new and saved jobs.

### **ZERO MARGINAL COST ENERGY**

As mentioned earlier, China has the most abundant solar and wind potential of any country in the world. It also has vast untapped potential in tidal and wave renewable energy as well as small hydro. In November 2014, President Xi surprised the world community by announcing his country's commitment to increase the use of non-fossil fuel energies - primarily solar and

wind - to 20% by 2030. More ambitious long term plans, currently under discussion, would have 2/3 of all the power generated in China coming from solar and wind by 2050. This would mean that the majority of energy powering the Chinese economy would be generated at near zero marginal cost. As mentioned earlier, even as the fixed cost of manufacturing and installing renewable energy technology on buildings and surrounding sites and the build out of the Energy Internet are being paid back, the marginal cost of harvesting solar and wind energy is free. The sun and the wind do not send a bill. Operating an economy on near zero marginal cost energy will make China the most productive commercial space in the world.

A 2014 report on the future of renewable energy in China prepared by IRENA, concludes that it is feasible to increase the share of renewable energy in China to 26% by 2030, surpassing the country's recently-announced 20% target. To reach this goal would require 145 billion dollars of investment annually between 2014 and 2030. While a considerable sum, the projected savings would be between 55 billion and 228 billion, well worth the investment.

“It is feasible to increase the share of renewable energy in China to 26% by 2030.”

In the high end scenario, IRENA projects that the share of renewable energy in the power sector will increase from 20 to 40 percent by 2030. Nearly 40% of the renewable energy would come from “distributed” sources. In other words, millions of buildings and surrounding sites would be transformed into micro power generating nodes, harvesting, storing, and sending electricity back to the national electricity grid.

To make this happen, China's electricity grid would have to be transformed into a digital renewable Energy Internet to manage the collection and distribution of green electricity generated by millions of residential, commercial, and industrial buildings. That change is

now unfolding. In September 2013, the Xinhua News Agency reported that Premier Li Keqiang had read The Third Industrial Revolution book that I authored and had instructed the National Development and Reform Commission and the Development Research Center of the State Council to read the book and follow up with a thorough study of the ideas and themes it puts forth. Subsequently, I traveled to China for two official visits in September 2013 and October 2014, where I met with Vice Premier Wang Yang and other key government officials to discuss the Chinese transition into a Third Industrial Revolution economy. During both visits, the Vice Premier expressed his government's determination to ensure that China is among the leaders in ushering in a Third Industrial Revolution.

Three months after my first visit in September of 2013, the government of China announced an \$82 billion four year initial commitment to lay out a digital Energy Internet across China, so that millions of Chinese homeowners and apartment-dwellers and thousands of Chinese businesses can produce their own solar and wind generated green electricity in and around their residential, commercial, and industrial buildings, and share surpluses with each other on the national electricity grid.

On December 5, 2013, the Chairman of the China State Grid Corporation, Liu Zhenya, published an article titled “Smart Grid Hosting and Promoting the Third Industrial Revolution.” In the essay, Liu Zhenya lays out China's ambitious plan to digitalize the electricity grid and transform it into an Energy Internet. The distributed, collaborative, peer-to-peer, and laterally scaled energy infrastructure will fundamentally alter the economic life of China, while establishing its commanding leadership in the next great economic revolution.

The announcement made by Liu Zhenya of the decision to introduce the Energy Internet as the “intercontinental backbone network” for a new economic era represents a game changing moment in the history of China. According to Chairman Liu Zhenya, if we “can firmly grasp the historical opportunity for the Third Industrial Revolution [it] will largely determine our position in future global competition.”

China's renewable energy sector already employs 3.4 million people. The manufacturing, installing, and servicing of solar and wind harvesting technology on



and around millions of buildings and the conversion of the country's electricity grid from a servo-mechanical system operating on fossil fuels and nuclear power to a digital renewable Energy Internet will spawn millions of additional jobs in the coming three decades.

Financing the transition of China's building stock to millions of nodes that serve as data centers, micro power generating plants, storage sites, and automated transport hubs, is beginning to be carried out by a unique new business model called Energy Savings Companies (ESCOS) and a novel financial instrument known as Energy Performance Contracts, also called Shared Savings Agreements. ESCOS finance the retrofits upfront with their own capital or bank loans, and the investment is paid back by the energy savings over time. The owner or occupant gets a free ride and after the payback period has ended, reaps the full value of the energy savings from there on. ESCOS services generally include energy audits, project design, financing, purchase of equipment, and operation and maintenance.

The ESCOS industry in China has grown exponentially. Between 2003 and 2013, the annual investment in energy performance contracts increased from \$100 million to \$12 billion, spurred in part, by generous government incentives and tax advantages. Given the steep exponential curve in the growth of the ESCOS market and Performance Contracting, it is likely that this mechanism, along with government incentives, will play a critical role in the conversion of millions of China's buildings into Third Industrial Revolution nodes to manage, power, and move economic activity across a smart green Internet of Things infrastructure. The transformation of China's residential, commercial, and industrial buildings and sites into multi-purpose nodes that serve as data centers, micro power renewable energy plants, energy storage facilities and automated transport and logistics hubs, linked laterally across a nationwide Internet of Things infrastructure, brings China into the digital Third Industrial Revolution paradigm.

The prospect of every building being outfitted and equipped to mine Big Data and use analytics to create algorithms and apps to dramatically increase aggregate efficiency and productivity and reduce marginal costs in the managing, powering, and moving of economic activity marks a giant leap forward for humankind. In the new Internet Plus era, everyone becomes their own efficiency expert and chief productivity officer,

continually creating new apps to improve aggregate efficiency across their respective value chains.

The prospect of hundreds of millions of families, thousands of communities, and hundreds of thousands of businesses generating their own renewable energy in and around their buildings, at near zero marginal cost, and sharing it with one another across a national renewable Energy Internet changes the very notion of collective responsibility for the society and the planet we live in. In the Biosphere Era, everybody becomes a steward of the clean renewable energy that bathes the Earth, paving the way to a more ecologically sustainable society.

We are on the cusp of a promising new economic era, with far reaching benefits for humankind. The newly organized Asian Infrastructure Investment Bank, with 57 member states, is likely to play an important role in financing the build out and scale up of the "one belt, one road" Internet Plus Third Industrial Revolution infrastructure across Eurasia over the course of the next half century, transforming the region into the world's largest integrated commercial space. What's required now is a China/EU commitment to phase in the one belt, one road Internet Plus platform across Eurasia and facilitate the transition to a Zero Marginal Cost Society, if we are to avert catastrophic climate change and create a more prosperous, humane, and ecologically sustainable civilization.

*Jeremy Rifkin is the author of *The Zero Marginal Cost Society: The Internet of Things, the Collaborative Commons, and the Eclipse of Capitalism* and *The Third Industrial Revolution: How Lateral Power is Transforming Energy, the Economy, and the World*. Mr. Rifkin is an advisor to the European Union and to heads of state around the world, and president of the Foundation on Economic Trends in Washington, DC.*

