Leading the Way to the Third Industrial Revolution:

A New Energy Agenda for the European Union in the 21st Century

-The Next Phase of European Integration-

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Executive Summary

We are approaching the sunset of the oil era in the first half of the 21st century. The price of oil on global markets continues to climb and peak global oil is within sight in the coming decades. At the same time, the dramatic rise in carbon dioxide emissions from the burning of fossil fuels is raising the earth's temperature and threatening an unprecedented change in the chemistry of the planet and global climate, with ominous consequences for the future of human civilization and the ecosystems of the earth.

The rising cost of fossil fuel energy and the increasing deterioration of the earth's climate and ecology are the driving factors that will condition and constrain all of the economic and political decisions we make in the course of the next half century. The fundamental economic question every country and industry needs to ask is how to grow a sustainable, global economy in the sunset decades of an energy regime whose rising externalities and deficiencies are beginning to outweigh what were once its vast potential benefits?

While oil, coal, and natural gas will continue to provide a substantial portion of the world's and the European Union's energy well into the 21st century, there is a growing consensus that we are entering a twilight period where the full costs of our fossil fuel addiction is beginning to act as a drag on the world economy. During this twilight era, the 27 EU member states are making every effort to ensure that the remaining stock of fossil fuels is used more efficiently and are experimenting with clean energy technologies to limit carbon dioxide emissions in the burning of conventional fuels. These efforts fall in line with the EU mandate that the member states increase energy efficiency 20 percent by 2020 and reduce their global warming emissions 20 percent (based on 1990 levels), again by 2020. But, greater efficiencies and mandated global warming gas reductions, by themselves, are not enough to adequately address the unprecedented crisis of global warming and global peak oil and gas production. Looking to the future, every government will need to explore new energy paths and establish new economic models with the goal of achieving as close to zero carbon emissions as possible.

THE GREAT ECONOMIC REVOLUTIONS IN HISTORY: THE CONVERGENCE OF NEW ENERGY AND COMMUNICATIONS REGIMES

The great pivotal economic changes in world history have occurred when new energy regimes converge with new communication regimes. When that convergence happens, society is restructured in wholly new ways. For example, the first hydraulic agricultural societies—Mesopotamia, Egypt, China, India—invented writing to manage the cultivation, storage, and distribution of grain. Surpluses of stored grain allowed for an expansion of population and the feeding of a slave labor force which, in turn, provided the “man power” to run the economy. The convergence of written communication and stored energy in the form of surplus grain, ushered in the agricultural revolution, and gave rise to civilization itself. In the early modern era, the coming together of coal powered steam technology and the print press gave birth to the first industrial revolution. It would have been impossible to organize the dramatic increase in the pace, speed, flow, density, and connectivity of economic activity made possible by the coal fired steam engine using the older codex and oral forms of communication. In the late nineteenth century and throughout the first two thirds of the twentieth century, first generation electrical forms of communication—the telegraph, telephone, radio, television, electric typewriters, calculators, etc.—converged with the introduction of oil and the internal combustion engine, becoming the communications command and control mechanism for organizing and marketing the second industrial revolution.

A great communications revolution occurred in the 1990's. Second generation electrical forms of communication—personal computers, the internet, the World Wide Web, and wireless communication technologies—connected the central nervous system of more than a billion people on Earth at the speed of light. And, although the new software and communication revolutions have begun to increase productivity in every industry, their true potential is yet to be fully realized. That potential lies in their convergence with renewable energy, partially stored in the form of hydrogen, to create the first "distributed" energy regimes.

The same design principles and smart technologies that made possible the internet, and vast distributed global communication networks, will be used to reconfigure the world's power grids so that people can produce renewable energy and share it peer-to-peer, just like they now produce and share information, creating a new, decentralized form of energy use. Rudimentary “intergrids” are currently being tested in the United States and Europe.

The creation of a renewable energy regime, partially stored in the form of hydrogen, and distributed via smart intergrids, opens the door to a Third Industrial Revolution and should have as powerful an economic multiplier effect in the 21st century as the convergence of mass print technology with coal and steam power technology in the 19th century, and the coming together of electrical forms of communication with oil and the internal combustion engine in the 20th century. The Third Industrial Revolution looms on the horizon, and the first major region to harness its full potential will help set the pace for economic development for the remainder of the century.

The EU has begun the journey toward a Third Industrial Revolution by mandating that 20 percent of all EU energy be generated by renewable sources of energy by 2020. By committing itself to a renewable energy future, the EU has laid the foundation pillar for a zero emission, sustainable economic era. Completing the foundation, however, will require the laying down of two additional pillars: the introduction of hydrogen fuel cell technology and other technologies, including batteries and differentiated water pumping, to store intermittent forms of renewable energy; and the creation of a continent-wide, intelligent utility network, or smart “intergrid”, to allow distributed forms of renewable energy to be produced and shared with the same access and transparency we now enjoy in producing and sharing information on the internet.

This paper describes, in detail, the three pillars that will need to be put in place to establish the foundation for the Third Industrial Revolution and a new energy era for the European Union. The report also examines the critical role that the Third Industrial

Revolution will play in advancing key EU priorities including integration of the single market, sustainable economic growth, expansion in employment, energy security, and the democratization of the globalization process. The paper concludes with key recommendations for implementing the Third Industrial Revolution across the EU.

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THE THREE PILLARS OF THE THIRD INDUSTRIAL REVOLUTION

There are three essential pillars of the Third Industrial Revolution which must be simultaneously developed and fully integrated for any one of these components to fully realize its potential and for the new economic paradigm to become operational: renewable energy, storage technology, and smart power grids.

THE FIRST PILLAR: RENEWABLE ENERGY

Renewable forms of energy—solar, wind, hydro, geothermal, ocean waves, and biomass—make up the first of the three pillars of the Third Industrial Revolution. While these sunrise energies still account for a small percentage of the global energy mix, they are growing rapidly as governments mandate targets and benchmarks for their widespread introduction into the market and their falling costs make them increasingly competitive. Billions of euros of public and private capital are pouring into research, development and market penetration, as businesses and homeowners seek to reduce their carbon footprint and become more energy efficient and independent.

THE SECOND PILLAR: STORAGE TECHNOLOGY

The introduction of the renewable energy pillar of the Third Industrial Revolution requires the simultaneous introduction of a second pillar. To maximize renewable energy and to minimize cost it will be necessary to develop storage methods that facilitate the conversion of intermittent supplies of these energy sources into reliable assets. Batteries, differentiated water pumping, and other media, can provide limited storage capacity. There is, however, one storage medium that is widely available and can be relatively efficient. Hydrogen is the universal medium that "stores" all forms of renewable energy to assure that a stable and reliable supply is available for power generation and, equally important, for transport.

Hydrogen is the lightest and most abundant element in the universe and when used as an energy source, the only by-products are pure water and heat. Our spaceships have been powered by high-tech hydrogen fuel cells for more than 30 years.

Hydrogen is found everywhere on earth, yet it rarely exists free floating in nature. Instead, it has to be extracted from either fossil fuels, water, or biomass. Today, the most cost-effective way to produce commercial hydrogen is to harvest it from natural gas via a steam reforming process. Yet the supply of natural gas is finite like our oil supply, and therefore not a dependable source. Hydrogen could also be extracted from coal and oil sands, but that would mean a dramatic increase in the emission of carbon dioxide into the atmosphere. Nuclear power could also be utilized, but that would vastly increase the amount of dangerous radioactive waste, significantly increase the use of available fresh water to cool the reactors, pose serious security threats in an age of terrorism, and greatly increase the cost that taxpayers and consumers have to pay for their energy.

But there is another way to use hydrogen—as a storage carrier for all forms of renewable energy. Renewable sources of energy—solar cells, wind, hydro, geothermal, ocean waves—are increasingly being used to produce electricity. That electricity, in turn, can be used, in a process called electrolysis, to split water into hydrogen and oxygen. Hydrogen can also be extracted directly from energy crops, animal and forestry waste, and organic garbage—so called biomass—without going through the electrolysis process.

The important point to emphasize is that a renewable energy society becomes viable to the extent that part of that energy can be stored in the form of hydrogen. That's because renewable energy is intermittent. The sun isn't always shining, the wind isn't always blowing, water isn't always flowing when there’s a drought, and agricultural yields vary. When renewable energy isn’t available, electricity can't be generated and economic activity grinds to a halt. But, if some of the electricity being generated, when renewable energy is abundant, can be used to extract hydrogen from water, which can then be stored for later use, society will have a continuous supply of power. Other storage technologies including flow batteries, pump hydro, flywheels, ultra-capacitors and the like provide niche storage capacity along the intelligent utility network and complement hydrogen in maintaining a secure supply of available energy. Hydrogen can also be extracted from biomass and similarly stored.

Brazil stands as an object lesson for other countries of the consequences of relying on intermittent renewable energy for electricity, without factoring in the need to store some of the energy, in the form of hydrogen, in order to assure a steady supply of electricity to the grid. More than 80% of Brazil’s electricity is generated from a renewable source of energy—hydro.[1] In 2001, Brazil experienced a drought. The flow of water slowed, and electricity generation sputtered, causing electrical outages in various parts of the country. Had a hydrogen infrastructure been in place, Brazil could have used some of its surplus electricity, generated when the water table was high, to electrolyze water, and store hydrogen for back-up generation during the drought.

While the costs of harnessing renewable energy is fast becoming competitive, the cost of hydrogen is still relatively high. However, new technological breakthroughs and economies of scale are dramatically reducing these costs every year. Moreover, hydrogen powered fuel cells are at least twice as efficient as the internal combustion engine. Meanwhile, the direct and indirect costs of oil and gas on world markets are going to continue to rise. As we approach the nexus between the falling price of renewable energy and hydrogen and the rising price of fossil fuels, the old energy regime will steadily give rise to the new energy era.

The basis for a transition to a Third Industrial Revolution was established by the Council of the European Union in March 2007. The European Union has become the first superpower to make a binding commitment to produce 20 percent of its energy, using renewable energy resources, by the year 2020.[2]

When the renewable energy contribution to the electricity output becomes significant, even a temporary lull in solar flow, wind, and water flow, can result in a shortage of supply, a spike in prices, and brownouts and blackouts. Using hydrogen as a "storage carrier" for renewable energy will be essential if the European Union is to ensure a reliable supply of energy. Hydrogen is also the way to store and utilize renewable energy for all transport.

The European Commission recognizes that increasing reliance on renewable forms of energy would be greatly facilitated by the development of hydrogen fuel cell storage capacity and, in 2003, established the Hydrogen Technology Platform, a massive research and development effort to move Europe to the forefront of the race to a hydrogen future.[3]

Regions and national governments across Europe have already begun to establish hydrogen research and development programs and are in the early stages of introducing hydrogen technologies into the marketplace.

In 2006, the Federal Republic of Germany committed €500 million to hydrogen research and development and began readying plans to create a nationwide hydrogen roadmap, with the stated goal of leading Europe and the world into the hydrogen era by 2020.[4] Chancellor Angela Merkel and members of her cabinet have called for a Third Industrial Revolution in public addresses in 2007.[5]

In October 2007, the European Commission announced a multi-billion Euro public/private partnership to speed the commercial introduction of a hydrogen economy in the 27 member states of the European Union, with the primary focus on producing hydrogen from renewable sources of energy.

THE THIRD PILLAR: THE SMART POWER GRID

By benchmarking an ambitious shift to renewable energy and funding an aggressive hydrogen fuel cell technology R&D program, the EU has erected the first two pillars of the Third Industrial Revolution. The third pillar, the reconfiguration of the European power grid, along the lines of the internet, allowing businesses and homeowners to produce their own energy and share it with each other, is just now being tested by power companies in Europe.

The smart intergrid is made up of three critical components. Minigrids allow homeowners, small and medium size enterprises (SMEs), and large scale economic enterprises to produce renewable energy locally—through solar cells, wind, small hydro, animal and agricultural waste, garbage, etc.—and use it off-grid for their own electricity needs. Smart metering technology allows local producers to more effectively sell their energy back to the main power grid, as well as accept electricity from the grid, making the flow of electricity bi-directional. Smart grid technology is embedded in sensing devices and chips throughout the grid system, connecting every electrical appliance. Software allows the entire power grid to know how much energy is being used, at any time, anywhere on the grid. This interconnectivity can be used to redirect energy uses and flows during peaks and lulls, and even to adjust to the price changes of electricity from moment to moment.

In the future, intelligent utility networks will also be increasingly connected to moment to moment weather changes—recording wind changes, solar flux, ambient temperature, etc.- giving the power network the ability to adjust electricity flow continuously, to both external weather conditions as well as consumer demand. For example, if the power grid is experiencing peak energy use and possible overload because of too much demand, the software can direct a homeowner's washing machine to go down by one cycle per load or reduce the air conditioning by one degree. Consumers who agree to slight adjustments in their electricity use receive credits on their bills. Since the true price of electricity on the grid varies during any 24 hour period, moment to moment energy information opens the door to “dynamic pricing”, allowing consumers to increase or drop their energy use automatically, depending upon the price of electricity on the grid. Up to the moment pricing also allows local minigrid producers of energy to either automatically sell energy back to the grid or go off the grid altogether.

The smart intergrid will not only give end users more power over their energy choices, but also create significant new energy efficiencies in the distribution of electricity.

Interestingly, the new EU energy plan anticipates the intergrid, with the demand that the power grid be unbundled, or at least made increasingly independent of the power companies that also produce the power, so that new players—especially small and medium size enterprises and homeowners—have the opportunity to produce and sell power back to the grid with the same ease and transparency as they now enjoy in producing and sharing information on the internet. The European Commission has also established a European Smart Grid Technology Platform and prepared a long-term vision and strategy document in 2006 for reconfiguring the European power grid to make it intelligent, distributed, and interactive.[6]

In 2007, the EU Parliament passed a written declaration calling for a transition to renewable energies, a hydrogen economy, and intelligent power grid generation—the three fundamental pillars of the Third Industrial Revolution.[7] An overwhelming majority of EU parliamentarians signed the measure, along with the titular leaders of all seven of Europe’s leading political parties, and Hans Poettering, the president of the EU Parliament. The EU Parliament thus became the first legislative body in the world to officially endorse the three pillar strategy to ushering in the Third Industrial Revolution.

THE NEXT STAGE OF EUROPEAN INTEGRATION

The European Union began with bringing together European nations around a common energy policy, first with the coal and steel community, and shortly thereafter, with the formation of EURATOM. Now, on the 50th Anniversary of the formation of the European community, energy policy has once again become central to Europe's future.

European industry has the scientific, technological, and financial know-how to spearhead the shift to renewable energies, a hydrogen economy, and an intelligent power grid and, by so doing, lead the world into a new economic era. The EU's world class automotive industry, chemical industry, engineering industry, construction industry, software, computer and communication industries, and banking and insurance industries, give it a leg up in the race to the Third Industrial Revolution. The European Union also boasts one of the world's largest solar markets and is the world's leading producer of wind energy.

The EU is also the leader in hydrogen fuel cell R&D and commercial applications. Portable, stationary, and transport fuel cell technologies are being developed and tested across Europe, and the first products are just entering the market. Indeed, scores of hydrogen powered fuel cell forklifts, scooters, cars, busses, and trucks are being tested on the roads in EU member states. The first German hydrogen powered submarine is operational, the first hydrogen powered ferries are in development in the Netherlands and Germany, and Europe's first hydrogen powered train is scheduled for completion in 2010.

Launching a Third Industrial Revolution can help facilitate the integration of Europe's infrastructure to realize the EU-Lisbon agenda of making Europe the most competitive economy in the world. While there's been much talk about implementing a Services Directive to ensure greater labor mobility across the EU, far less attention has been paid to the mutually important task of creating a seamless transportation grid, power grid, communication grid, and an energy policy to ease the flow and exchange of information, goods and services, across the 27 EU member states. By fostering renewable energies, a hydrogen infrastructure, and a continent-wide intelligent intergrid, the EU and its member states can help create a sustainable economic development plan and make the European Dream of a single integrated market a reality for nearly 500 million citizens in the first half of the 21st century.

GROWING THE EU ECONOMY

Reconfiguring the energy infrastructure of the European Union will create new business opportunities and millions of new jobs over the next twenty-five years. And because the installation of renewable energy resource technologies and the establishment of a hydrogen infrastructure and intelligent utility networks are geographically tied, the employment generated will all be within Europe.

Global investment in renewable energies topped a record €74 billion in 2006[8], and is expected to leap to €250 billion by 2020, and €460 billion by 2030.[9] Today, renewable energy manufacturing, operations, and maintenance provide approximately two million jobs worldwide.[10] A recent study found that the number of jobs created per euro invested (and per kilowatt-hour produced) from clean renewable energy technologies is 3 to 5 times the number of jobs created from fossil fuel based generation.[11]

The European Union is ideally suited to lead the Third Industrial Revolution. By becoming the first superpower to establish a mandatory target of 20 percent renewable energy by 2020, the EU has set in motion the process of vastly enlarging the renewable energy portion of its energy mix. Reflecting the new commitment to higher renewable energy targets, the European Investment Bank has ratcheted up its renewable energy investments and is slated to finance loans totaling more than €800 million per year.[12] In Germany, alone, the renewable energy industry boasted an annual turnover of €21.6 billion and 214,000 workers in 2006, and the industry projects to grow to between 244,000 and 263,000 jobs by 2010, 307,000 to 354,000 jobs by 2020, and 333,000 to 415,000 jobs by 2030.[13]

The 26 other EU member states are also creating new jobs as they bring renewable energy sources online to meet their objective of achieving a near zero carbon emission policy. Renewable energy in the EU generated €8.9 billion in earnings in 2005, and is expected to leap to 14.5 billion euros by 2010.[14] More than 700,000 jobs are expected to be created in the EU by 2010 in the field of electricity generation from renewable energy sources.[15] By 2050, renewable energy is projected to provide nearly half the primary energy, and 70 percent of the electricity produced within the EU, and account for several million new jobs.[16]

The European Union has also pushed ahead in research and development funding for the hydrogen economy. The overall European hydrogen market was estimated to be worth approximately €283 million in 2005, and is expected to grow at an annual percentage rate of 15 percent to €569 million by 2010.[17] The European Commission Hydrogen Technology Platform has already devoted more than €500 million in preparing hydrogen power and fuel cell technology for commercial use.[18] The private sector is projected to spend an additional €5 billion in bringing hydrogen to the market over the course of the next 10 years.[19] EU public funds, in the range of €320 to €350 million per year are expected to be brought to bear between 2007 and 2015, making a total estimate of €7.4 billion available to make the hydrogen economy a reality during the second decade of the 21st century. The European Fuel Cell industry could yield upwards of 500,000 jobs by 2030.[20]

The prospect of operationalizing the third pillar of the Third Industrial Revolution, the EU intelligent utility network, is also meeting with growing enthusiasm both in the public and private sector, as Europe wrestles with the challenge of overhauling an inefficient and outmoded half century old power grid, transforming it from a second industrial revolution electro-mechanical infrastructure to a Third Industrial Revolution digital infrastructure.

The Third Industrial Revolution will require a wholesale reconfiguration of the transport, construction, and electricity sectors, creating new goods and services, spawning new businesses, and requiring new job skills.

The transportation sector is the third leading cause of human induced global warming gas emissions, after buildings and livestock production.[21] The transport industry currently accounts for seven percent of the European GDP, and 5 percent of the employment.[22] The transition from gasoline-powered internal combustion engines to hydrogen-powered zero emission fuel cells for most modes of transport—forklifts, scooters, cars, trucks, busses, trains, boats and passenger ships—in the second and third decades of the 21st century, will create substantial new business opportunities and generate new employment across all of the transport related industries, and throughout the EU member countries. Retooling transport will require the large scale commercial manufacture of fuel cells, the mass production of hydrogen fuel, the building of a continent-wide fueling infrastructure, vehicle redesign, and new transport related software, all of which will give rise to new synergies and have substantial multiplier effects.

It is estimated that building a full-scale hydrogen transport system in the EU to accommodate 100 million vehicles could cost upwards of several hundred billion euros. Although the costs are considerable, when measured against the costs of maintaining the existing gasoline and internal combustion transport economy, the figures become attractive. The World Energy Council projects it will cost more than $1.3 trillion, from wells to wheels, over the next 30 years, to maintain and expand the existing North American gasoline economy.[23] Since the European Union has roughly the same number of cars as the United States, the price tag is likely to be comparable.[24] Of course, the cost could go much higher as we approach global peak oil production, and as real-time climate change begins to create negative ecological and economic impacts across the continent. The critical issue is whether to continue to fund a sunset energy regime and transport system, or begin making the transition into renewable energies and an accompanying hydrogen economy for most modes of transport.

The construction industry is the largest industrial employer in the EU and, in 2003, represented 10 percent of the GDP, and 7 percent of the employment in the EU-

15.[25] Most of the industry is engaged in the construction of buildings, which are the major contributor to human induced global warming. Worldwide, buildings consume 30 to 40 percent of all the energy produced and are responsible for equal percentages of all CO_2 emissions.[26] In Europe, these figures rise to 40 to 45 percent, respectively.[27] This industry, like transport, will account for many of the new business opportunities and employment gains, as Europe moves deeper into the operationalization of the Third Industrial Revolution.

The EU's recently announced energy efficiency mandate and renewable energy benchmarks are already spawning a growing involvement in "green construction". For example, Spain is mandating that all new construction incorporate solar energy technologies directly into the infrastructures.[28] The "greening" of construction is going to create thousands of new businesses and services and create millions of new jobs between now and 2030, as existing and new construction metamorphosizes from second industrial revolution to Third Industrial Revolution designs, materials, technologies, and building standards and codes.

In the future, all three pillars of the Third Industrial Revolution will be built into both buildings and all modes of transport.

The electricity sector in the EU had an annual turnover of about €112 billion in 2003, and contributed 1.5 percent to the EU GDP.[29] The industry employed 608,000 workers in the EU-15 in 2004.[30] The reconfiguration of the entire power grid of the EU over the course of the next 30 years to create an intergrid, along the lines of the internet, is projected to cost in excess of €750 billion and will generate tens of thousands of new jobs.[31] Many of the jobs will require reskilling workers in energy engineering and information and communications technology (ICT).

Being first to market will position the European Union as a leader in the Third Industrial Revolution, giving it the commercial edge in the export of green technological know-how and equipment around the world. Producing a new generation of renewable energy technologies, manufacturing portable and stationary fuel cells, reinventing the automobile, redesigning Europe's buildings and aging infrastructure using green architectural best practices, reconfiguring the electrical power grid, as well as producing all of the accompanying technologies, goods and services that make up a high-tech Third Industrial Revolution economy, will have an economic multiplier effect that stretches well toward the mid decades of the 21st century.

ENERGY SECURITY

Growing concern over dependency on Russian natural gas and Persian Gulf oil is fueling much of the debate around the question of how best to ensure EU energy security. With the price of oil now over €52 per barrel on world markets, EU governments, industry, and consumers are feeling increasingly vulnerable and anxious to assert their energy independence. The emergence of China and India as major economic powers has put additional strain on a dwindling supply of fossil fuels. There is also mounting concern over the escalating political violence in the Middle East and fear that growing political instability could jeopardize the flow of oil to Europe. The prospect of vastly expanding nuclear power generation is also increasing the sense of unease among Europeans. The coming online of scores and perhaps hundreds of nuclear power plants around the world in the coming decades provides a soft target for terrorist attacks. In addition, the likelihood of large amounts of uranium and plutonium in transit in an era of escalating political and religious extremism is an unsettling thought.

The key to “energy security” for the EU will be the ability to produce energy and electricity locally and regionally from readily available renewable energy sources, storing some of the energy in the form of hydrogen and other storage technologies for back up power on the electricity grid and for transport, and sharing surplus electricity across a smart intergrid that connects every community in Europe.

Many of the same security considerations and concerns that led to the development of the internet are at work in the fledging development of the intergrid. The Pentagon created the precursor to the internet in the late 1960’s. The Department of Defense (DOD) was anxious to save money on the cost of providing expensive new supercomputers to academic and defense contracting researchers, and it began to explore ways of sharing computers among people who were separated over long distances. The military was also concerned about the potential vulnerability to attack, or other forms of disruption, of centrally controlled communications operations. They were looking for a new kind of decentralized communications medium in which all of the parties could produce information and send it to one another in a way that would continue to function even if part of the system was disrupted or destroyed. The solution came in the form of the ARPANET, developed by the DOD’s Advanced Research Projects Agency. The first host computer became operational in 1969. By 1988, more than 60,000 host computers were connected. The National Science Foundation soon created its own NSF net to connect university researchers across the country. When ARPANET shut down in 1990, the NSF net became the main vehicle for connecting computers and eventually metamorphosed into the internet.[32] Like the internet, a distributed intergrid will ensure that if disruptions in the flow of electricity occur anywhere along the network- be they military, political or environmental in nature- other parts of the network will continue to operate.

A continent-wide, fully integrated intelligent intergrid allows each EU member country to both produce its own energy and share any surpluses with the rest of Europe in a “Network” approach to assuring EU energy security. Italy can share its surplus solar energy with the United Kingdom, and the United Kingdom can share its excess wind power with Portugal, and Portugal can share its abundant hydropower with Slovenia, and Slovenia can share its culled forestry waste with Poland, and Poland can share its agricultural biomass with Norway, etc. When any given region of the European Union enjoys a temporary surge or surplus in its renewable energy, that energy can be shared with regions that are facing a temporary lull or deficit. Hydrogen -buttressed by other niche storage media – provides a universal carrier for all forms of renewable energy, for use in transport, or for conversion back to electricity when needed to feed the power grid.

By optimizing the harnessing of locally and regionally generated renewable energies, storing them in the form of hydrogen and other storage media, and sharing them across Europe by way of a continental intergrid, the EU can create a truly integrated and sustainable energy regime, bolster energy security, facilitate the completion of the internal market, reach the Lisbon Agenda of becoming the world's most competitive economy, and help lead the world into a Third Industrial Revolution.

DISTRIBUTED POWER: FROM GEOPOLITICS TO BIOSPHERE POLITICS

Fossil fuels and nuclear power are, by their very nature, elite energies that represent the old top-down centralized approach to managing resources that was so characteristic of the 19th and 20th centuries. Because they are only found in some places, coal, oil, natural gas and uranium have often required huge military investments to secure them and equally high capital investment to process and market them. The result has been a widening gap between those who hold and wield power, and those who are literally and figuratively powerless.

Renewable energy, however, is distributed everywhere on Earth. Solar flow, the wind, hydro, geothermal, ocean waves, agricultural and forestry waste, and municipal garbage are all broadly accessible across the world. If pooled and stored in the form of hydrogen and disseminated as electricity across smart intergrids, renewable energy has the potential to be shared peer-to-peer in a distributed fashion just as we now share information and communication on the internet.

The Third Industrial Revolution makes possible a broad redistribution of power, with far-reaching beneficial consequences for society. Today's centralized, top-down flow of energy becomes increasingly obsolete. In the new era, businesses, municipalities and homeowners could become the producers as well as the consumers of their own energy—so-called "distributed generation." Even the automobile itself is a "power station on wheels" with a generating capacity of twenty or more kilowatts. Since the average car is parked most of the time, it can be plugged in, during non-use hours, to the home, office, or the main interactive electricity network, providing premium electricity back to the grid. Fuel cell powered vehicles thus become a way to store massive amounts of energy in the form of hydrogen, that can, in turn, be converted back to electricity to fuel the main power grid. If just 25 percent of drivers used their vehicles as power plants to sell energy back to the intergrid, all of the power plants in the European Union could be eliminated.[33]

Noting the many striking similarities between what has already occurred with the internet and what is now getting under way with distributed generation, the Electric Power Research Institute (EPRI), the think tank for the American utilities industry, concluded in its "Perspective on the Future" that distributed generation is going to unfold

> In much the same way the computer industry has evolved. Large mainframe computers have given way to small, geographically dispersed desktop and laptop machines that are interconnected into fully integrated, extremely flexible networks. In our industry, central-station plants will continue to play an important role, of course. But, we're increasingly going to need smaller, cleaner, widely distributed generators…all supported by energy storage technologies. A basic requirement for such a system will be the advanced electronic controls: these will be absolutely essential for handling the tremendous traffic of information and power that such a complicated interconnection will bring.[34]

In the future, power and utility companies will increasingly become the bundlers of distributed energy, by aggregating and pooling renewable energy generated locally and regionally, storing energy in the form of hydrogen, and other storage media, and distributing power on smart power grids across the European continent.

The coming together of distributed communication technologies and distributed renewable energies via an open access, intelligent power grid, represents "power to the people". For a younger generation that's growing up in a less hierarchical and more networked world, the ability to produce and share their own energy, like they produce and share their own information, in an open access intergrid, will seem both natural and commonplace.

The shift from elite fossil fuels and uranium based energies to distributed renewable energies, takes the world out of the "geopolitics" that characterized the 20th century, and into the "biosphere politics" of the 21st century. Much of the geopolitical struggles of the last century centered on gaining military and political access to coal, oil, natural gas, and uranium deposits. Wars were fought and countless lives lost, as nations vied with each other in the pursuit of fossil fuels and uranium security. The ushering in of the Third Industrial Revolution will go a long way toward diffusing the growing tensions over access to ever more limited supplies of fossil fuels and uranium and help facilitate biosphere politics based on a collective sense of responsibility for safeguarding the earth's ecosystems. The half century transition from the second to the Third Industrial Revolution, and the concomitant shift from geopolitics to biosphere politics is going to have a far reaching impact on globalization.

The Third Industrial Revolution is likely to have the most significant impact on developing nations. Incredibly, over half of the human population has never made a telephone call and a third of the human race has no access to electricity.[35] Today, the per capita use of energy throughout the developing world is a mere one-fifteenth of the consumption enjoyed in the United States.[36] The disparity between the connected and the unconnected is deep and threatens to become even more pronounced as world population is expected to rise from the current 6.2 billion to 9 billion people in the next half-century.

Lack of access to electricity is a key factor in perpetuating poverty around the world. Conversely, access to energy means more economic opportunity. In South Africa, for example, for every 100 households electrified, 10 to 20 new businesses are created.[37] Electricity frees human labor from day-to-day survival tasks. It provides power to run farm equipment, operate small factories and craft shops, and light homes, schools and businesses. Making the shift to locally generated renewable energy, partially stored in the form of hydrogen, and creating distributed generation intergrids that can connect communities all over the world, holds great promise for helping to lift billions of people out of poverty.

Were all individuals and communities in the world to become the producers of their own energy, the result would be a dramatic shift in the configuration of power. Local peoples would be less subject to the will of far-off centers of power. Communities would be able to produce goods and services locally and sell them globally. This is the essence of the politics of sustainable development and re-globalization from the bottom up.

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The key question that every nation needs to ask is where they want their country to be in ten years from now: In the sunset energies and industries of the second industrial revolution or the sunrise energies and industries of the Third Industrial Revolution. The Third Industrial Revolution is the end-game that takes the world out of the old carbon and uranium-based energies and into a non-polluting, sustainable future for the human race.

RECOMMENDATIONS FOR IMPLEMENTING THE THIRD INDUSTRIAL REVOLUTION

GOVERNANCE

Eighteen of the EU Commission cabinet secretariats are involved in policies, programs, and activities that address specific aspects of the Third Industrial Revolution.

In addition, several of the EU community agencies have mandates and engage in programs that are critical to mobilizing a Third Industrial Revolution. There are also 19 separate EU Commission technology platforms working in program areas that are essential to the ushering in of a Third Industrial Revolution in the European Union.

The European Commission should establish a Third Industrial Revolution "master plan" and institutionalize a formal operating network made up of the appropriate cabinet secretariats, community agencies, technology platforms, and joint technology initiatives.

The master plan should establish joint goals, along with specific targets and benchmarks, with the objective of having a rudimentary Third Industrial Revolution infrastructure in place across the European Union by 2020.

The 27 EU member states, should, in turn, each create a “mirror” Third Industrial Revolution master plan and formal operating networks, bringing together their appropriate cabinet secretariats, agency programs and technology platforms. The member states’ Third Industrial Revolution networks should be in continuous formal engagement with both the European Commission’s Third Industrial Revolution network and each other to share best practices, cooperate on joint programs, and work together to advance overall EU targets and benchmarks.

FINANCING THE THIRD INDUSTRIAL REVOLUTION

The EU Commission should establish a formal financial committee made up of the appropriate cabinet secretariats. The financial committee should be tasked with establishing a portfolio of recommendations for funding public private partnerships; stimulating investment capital for research, development and market penetration; creating tax and fiscal criteria to level the playing field between subsidies to the old energy industries and the new renewable energies; and encouraging early adoption by government agencies, critical industries, small and medium size enterprises (SMEs), and consumers. A detailed report containing recommendations should be submitted to the EU Commission and the 27 member states within 12 months.

ESTABLISHING UNIVERSAL CODES, STANDARDS, AND REGULATIONS

The EU Commission should establish common codes, standards, and regulations for all three pillars of the Third Industrial Revolution—renewable energies, hydrogen fuel cell and other storage technologies, and the smart intergrid—to avoid costly duplication, ensure early adoption, facilitate seamless commercial integration and rapid market penetration. By being first to institutionalize common codes, standards, and regulations, the EU will be positioned to transfer technology to the rest of the world and establish itself as the leader in Third Industrial Revolution technology exports.

CONDUCTING A CONTINENT-WIDE RENEWABLE ENERGY AUDIT

The European Environmental Agency should be tasked with conducting a thorough energy audit of all 27 member states to assess the short term, mid term, and long term potential availability of all renewable energy resources. The studies should be reference spatially and temporally and take into consideration the effects of climate change on renewable energy potential as well as demographic, technological, and other changes. The energy audit should be completed within 12 months and submitted to the EU Commission and to the 27 member states to help assist the governments in future energy planning.

CONDUCTING A CONTINENT-WIDE ECONOMIC FORECAST

The appropriate EU secretariat should commission a series of studies on the potential economic impacts of the Third Industrial Revolution by sector and industry. Using various scenario forecasting models in terms of market penetration, the studies should provide snapshots of revenue streams and employment data by region and nation as well as at the EU level, and should include potential technology exports in the formulations. The model should be dynamic allowing for the emergence of yet-to-be technology breakthroughs and synergies and multiplier effects, to more realistically assess the future potentials of Third Industrial Revolution trends and developments. The study should be completed within 12 months.

CREATING THIRD INDUSTRIAL REVOLUTION LIGHTHOUSE COMMUNITIES

The EU Commission should create public-private partnerships with the goal of establishing a "state of the art" Third Industrial Revolution "lighthouse" community in all 27 member states. Each of the member states should designate a community of 5,000 or so in population, made up of both commercial enterprises and residential homeowners, for retooling into a Third Industrial Revolution modality. The communities will serve as real world laboratories for testing Third Industrial Revolution technologies and best practices, and act as showcases for public education and for mobilizing public support for the transition into the Third Industrial Revolution.

*   *   *

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Personal correspondence with Alan Lloyd regarding a not-yet-released DOE study on the fuel cell industry. Dr. Lloyd is currently Chairman of the Hydrogen and Fuel Cell Advisory Committee (HTAC) that was created under the Energy Act. HTAC reports directly to the Secretary of Energy of the US Department of Energy. The employment potential for the EU fuel cell industry is extrapolated from the not-yet-released DOE study regarding employment potential in the US market. Because the hydrogen economy is further advanced in the EU and the internal market of the 27 member-states is larger than the US internal market, the employment extrapolation is likely a conservative figure.

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