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

Leading the Way to the Hydrogen Economy and a Third Industrial Revolution

-The Next Phase of European Integration-

by Jeremy Rifkin

Executive Summary:

It is becoming clear that 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 site 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 global climate and the chemistry of the planet, with untold 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 all of the economic and political decisions we make in the course of the next half century.

There is a growing consensus among the member states of the European Union that the development of alternative energies and a new energy vision and policy is the next critical step in the integration of Europe and the path to realizing the Lisbon Agenda of making the European Union the most competitive economy in the world.

The opportunity now exists to make a 25 year transition out of the fossil fuel era and into the era of non-polluting, renewable energies. Hydrogen provides a universal medium to pool, store, and distribute disparate forms of intermittent renewable energy from across Europe. "Smart-power grids" will allow every business, homeowner, and community in Europe to generate power with locally available renewable energy, and share any surplus with other EU businesses, citizens, and communities across the 25 member states of the Union.

The same design principles and smart technologies that made possible the internet, and vast, decentralized global communication networks, will be used to reconfigure Europe's power grids so that people can begin to share energy peer-to-peer, just like they now share information, creating a new, decentralized form of energy use. The coming together of decentralized

communications technology and distributed hydrogen energy technology marks the next great turning point in the way people organize the energy of the planet.

If the European Union can create an integrated logistics infrastructure, with a seamless transportation, communication, and power grid, so that its 455 million consumers can engage in commerce and trade across their 25 member states, with the same ease Americans do across the 48 continental states, the EU will be able to grow a sustainable economy throughout the remainder of the 21st century and beyond.

The creation of a renewable energy regime, hydrogen fuel cell technology, and smart power grids opens the door to a third industrial revolution and should have as powerful an economic multiplier effect in the 21st century as the introduction of coal and steam power technology in the 19th century, and oil and the internal combustion engine in the 20th century.

The basis for a transition to a renewable energy era and hydrogen economy has already been established by the European Union. The EU has made a binding commitment to produce 22 percent of its electricity and 12% of its energy, using renewable energy resources, by the year 2010. The EU Parliament recently established a non-binding goal of producing 33% of its electricity and 20% of its energy with renewable resources by 2020.

The important point to emphasize, however, is that a renewable energy society is impossible unless the 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. Hydrogen can also be extracted from biomass when agricultural yields are high, and similarly stored.

When the renewable energy contribution to the electricity output becomes significant—between 20% and 33% of the mix—even a temporary lull in solar flow, wind, and water flow, can result in a shortage of supply, a spike in prices, and even 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 renewable energy for all transport.

The European Commission recognizes that increasing reliance on renewable forms of energy must be accompanied by the development of hydrogen fuel cell storage capacity, and in 2003, established the hydrogen technology platform, a 2 billion Euro research and development effort to move Europe to the forefront of the race to a hydrogen future.

By benchmarking an ambitious shift to renewable energy and by funding an aggressive hydrogen fuel cell technology R&D program, the EU has taken the first two necessary steps on the way to a hydrogen future. The next crucial step is the creation of an operational plan to establish a regulatory and commercial framework for the introduction of a third industrial revolution.

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The recent row between Russia and the Ukraine over natural gas is sending shudders across Europe. The European Union relies on Russia for 25 percent of its natural gas and 30 percent of its oil supplies. When Russia temporarily cut its gas supplies to the Ukraine on January 1st in a dispute over a price hike, the rest of Europe suddenly found itself without sufficient natural gas because the pipeline from Russia to Europe runs through the Ukraine. The crisis raised eyebrows again in official EU policy circles about over-reliance on outside suppliers for meeting Europe's energy needs.

The Russian-Ukraine gas dispute is the latest in a series of energy shocks which has unnerved the business community and forced EU member states to sit up and take notice of their increasing vulnerability as Europe and the world enter the twilight of the oil era. Oil prices are currently hovering at $65 US a barrel on world markets, and geologists predict that global oil production could peak as early as 2010, and probably no later than 2040, even assuming the most optimistic forecasts. The global production of natural gas is likely to peak even earlier. Goldman Sachs is already warning of oil spikes of up to $105 US a barrel.

Adding to the woes, we now find ourselves in "real-time global warming". Hurricanes Katrina and Rita that slammed into the US gulf coast last fall, record flooding in the European Alps last summer, and spreading drought in the southern hemisphere are warning signals that the earth's atmosphere is rapidly heating up as a result of burning massive amounts of fossil fuels over the past century. Scientists reported in the November 25th issue of *Science* that the concentration of greenhouse gases in the Earth's atmosphere is greater now than at any time in the last 650,000 years. No wonder political leaders and the business community are running scared. For the first time, the question being asked around the world is how do we prepare society for a post-oil era?

The discussion around energy security in Brussels in the coming months will be a critical test as to whether the European Union can break loose from the pack and introduce a new energy vision for the world in the 21st century. The reality is that the technological and commercial opportunity now exists to open the door to a new energy era, and the European Union is in the ideal position to lead the way.

We are on the cusp of a new energy regime that will alter our way of life as fundamentally as the introduction of coal and steam power in the 19th century and the shift to oil and the internal combustion engine in the 20th century. The hydrogen era looms on the horizon, and the first major industrial region to harness its full potential will set the pace for economic development for the remainder of the century. 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.

Setting a goal to become the first fully integrated hydrogen economy in the world is a grand idea worthy of the next phase of European integration. Indeed, preparing the EU for a third industrial revolution gives the European Union a fresh new cooperative operational roadmap that can not only address the critical priorities and objectives of each of the member nations, but in a way that complements the aspirations of each country without compromising the aims of the other: a kind of win-win scenario for both the member states and the European Union as a whole.

The historic shift to a hydrogen economy will spur commercial growth, create millions of new jobs, facilitate the integration of Europe, ensure sustainable development, and foster energy security.

Qualitative leaps in productivity, economic development, and employment always occur during periods in history when new energy regimes are being established and accompanying infrastructures are being laid out. The harnessing of coal and steam power and the laying down of a rail infrastructure in the late 19th century and the introduction of the oil-powered, internal combustion engine and the laying down of roads in the 20th century spawned great leaps in productivity, created millions of jobs, and made possible all sorts of new goods, services, and markets. Today, renewable energies and hydrogen powered fuel cell technology are entering the commercial arena. Their widespread dissemination will likely have a greater impact on the global economy than any other single development in the foreseeable future.

In 2003, the European Union unveiled a two billion Euro R&D plan—The European Hydrogen and Fuel Cell Technology Platform—for making the transition out of the fossil fuel age and into a fully integrated renewable energy based hydrogen economy. I was serving, at the time, as an informal, personal advisor to Romano Prodi, the President of the European

Commission, the governing body of the European Union. In that capacity, I provided President Prodi with the initial strategic memorandum that led to the EU hydrogen energy initiative. President Prodi said that the transformation of Europe's energy regime would be the next great development in European integration after the introduction of the Euro, and likened the effort to the American Space program in the 1960s and 1970s, which spawned the subsequent high-tech economic revolution of the 1980s and 1990s.

Leaders of all 6 major European political parties - The Popular Party, The Party of the European Socialists (PES), The Alliance of the Liberal Democrats of Europe (ALDE), The Green Group, The European United Left (GUE), and The Union for Europe of the Nations (UEN) - have made the commitment to push ahead on plans to make the EU the first renewable energy hydrogen economy in the world. The EU Parliamentary Leadership Group for a renewable energy, hydrogen economy includes the President of the European Parliament, Joseph Borrell. Moreover, the European Parliament Hydrogen Group is led by Dr. Vittorio Prodi of the Liberal party, a world-class physicist with 40 years of experience on energy-related issues, and an expert on Hydrogen Energy. I currently serve as the principle senior advisor to the EU Parliamentary Leadership Group for a renewable energy, hydrogen economy.

Hydrogen has the potential to end the world's reliance on imported oil and help diffuse the dangerous geopolitical game being played out in the oil-rich Persian Gulf. Hydrogen will dramatically cut down on carbon dioxide emissions and mitigate the effects of global warming. And because hydrogen is so plentiful, every human being could be "empowered," making it the first truly democratic energy regime in history.

Hydrogen is found everywhere on earth, yet it rarely exists free floating in nature. Instead, it has to be extracted from either hydrocarbons, 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 as finite as 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, 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 produce hydrogen—one that uses no fossil fuels in the process. Renewable sources of energy—solar cells, wind, hydro and geothermal—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, agricultural waste and forestry waste, and organic garbage—so called biomass—without going through the electrolysis process. (A partial shift in subsidies away from agricultural crops and toward energy crops could provide a long-term solution to the question of how to address the agricultural subsidies issue within the European Union.) Once produced, the hydrogen can be stored and used, when needed, to generate electricity.

The important point to emphasize, however, is that a renewable energy society is impossible unless the 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. Hydrogen can also be extracted from biomass when agricultural yields are high, 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. Nearly 95% of Brazil's electricity is generated from a renewable source of energy—hydro. 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.

The European Union has already agreed to a goal of generating 22% of its electricity and 12% of its energy from renewable energy by 2010. The European Parliament has established a non-binding goal of producing 33% of its electricity and 20% of its energy from renewable sources by 2020. When the renewable energy contribution to the electricity output becomes

significant—between 20% and 33% of the mix—even a temporary lull in solar flow, wind, and water flow, can result in a shortage of supply, a spike in prices, and even 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 renewable energy for all transport.

While the costs of harnessing renewable energy and extracting hydrogen are still high, new technological breakthroughs and economies of scale are dramatically reducing these costs every year. Moreover, hydrogen powered fuel cells are 2 times more efficient than 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 renewables and hydrogen and the rising price of fossil fuels, the old energy regime will steadily give rise to the new energy era.

Commercial fuel cells powered by hydrogen are just now being introduced into the market for industrial, office, and home use. Large stationary fuel cells are being purchased by manufacturing and service related companies to provide backup power generation during periods of peak electricity load on the grid or in case of rolling brownouts or blackouts. Linde AG installed a state-of-the-art hydrogen fuel cell power plant recently at the Munich Airport. Hitachi and Toshiba are planning to bring the first portable fuel cells to the market in 2007. Consumers will be able to power up their cell phones, lap top computers, digital cameras, Mp3 players, and PDA's for 8 to 35 hours with a single cartridge. The major automakers have spent billions of dollars developing hydrogen-powered cars, buses, and trucks. Hydrogen powered buses and automobiles are currently being test driven on roads across Europe and the first mass-produced vehicles are expected to be in the showrooms between 2012 and 2014.

The hydrogen economy 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 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. If just 25 percent of drivers used their vehicles as power plants to sell energy back to the grid, all of the power plants in the European Union could be eliminated.

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

In order for millions of people to become producers, as well as consumers of energy, it will be necessary to redesign the power grid. That's where the software and computer revolution converge with the new hydrogen energy regime. The communications revolution will play a critical role in ushering in a new energy era. The great pivotal 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 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 and early twentieth centuries, the telephone converged with the introduction of oil and the internal combustion engine, becoming the command and control mechanism for organizing the second industrial revolution.

A great communications revolution occurred in the 1990's. 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 the new distributed hydrogen energy regime.

The same design principles and smart technologies that made possible the internet, and vast, decentralized global communication networks, will be used to reconfigure the world's power grids so that people can begin to share energy peer-to-peer, just like they now share information, creating a new, decentralized form of energy use. The coming together of decentralized communications technology and distributed hydrogen energy technology marks the next great turning point in the way people organize the energy of the planet.

The key to a self-sufficient and secure post-oil energy regime for the EU will be the ability to produce energy and electricity locally from readily available renewable energy sources, storing some of the energy in the form of hydrogen, for back up power on the electricity grid, and for transport, and sharing surplus electricity across smart power grids that connect every community in Europe.

The European Union contains vast renewable energy potential. Hydrogen provides a universal medium, or carrier, for pooling and storing the various forms of potential renewable energy that exist across the European continent. Smart power grids allow millions of local producers of renewable energy- small and medium size enterprises (SMEs), producer cooperatives, large corporate enterprises, industrial and technology parks, commercial buildings, retailers and homeowners- to share their electricity with each other across a region stretching from the Irish Sea to the doorsteps of Russia. Stored renewable energy, in the form of hydrogen, produced locally and regionally, could also be used for all modes of transport. A continent-wide distributed energy regime allows localities, regions, and nations, to be both energy self-sufficient, and at the same time, energy interdependent.

Just as the Euro provided a universal currency to facilitate the commercial integration of Europe, renewable energy, stored in the form of a universal medium- hydrogen- and distributed across smart power grids and used for transport, facilitates the integration of the energy infrastructure of Europe. A distributed hydrogen energy regime promotes both local and regional autonomy and European integration, and is the next chapter in solidifying European commercial and political space.

National hydrogen associations now exist in fifteen leading industrial nations. All the major automobile and chemical companies, as well as many of the world's leading electronic companies are in a race to the hydrogen era. Energy companies like BP and Dutch Shell sport hydrogen divisions. Japan is making hydrogen technology a critical national priority in its energy plans. The state of California— the worlds fifth largest economy— is operationalizing a broad program to become a fully integrated renewable energy-based, hydrogen economy over the next two decades. Korea, China, and India have also established hydrogen roadmaps to the future. Local regions across Europe are introducing hydrogen R&D projects. Seventeen of the twenty governing regions of Italy have endorsed the vision of a renewable energy, hydrogen

economy. The cities of Hamburg and Potsdam and the Aragon region of Spain have ambitious renewable energy hydrogen projects.

European industry has the scientific, technological, and financial know-how to spearhead the shift to renewable energies and a hydrogen economy and 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 hydrogen era. The European Union also boasts one of the world's largest solar markets and is the world's leading producer of wind energy.

The European Union and its member states should establish a deep collaboration with the business community and civil society organizations to begin mobilizing the public, private, and civic resources of each country to the task of establishing an infrastructure for a 21st century hydrogen economy.

To ensure the successful transition to renewable energies, hydrogen fuel cell storage technology, and smart power grids, the member states and the European Union will need to reform regulations governing access to national power grids and national markets so that every locality, business, and consumer within the EU, can be connected and participate in a distributed energy infrastructure, without experiencing discrimination. The smart power grid needs to be as transparent and open as the internet, so energy can be shared with the same ease as electronic information.

How do we pay for a new hydrogen energy regime and infrastructure? Serious consideration ought to be given to expanding "tax-shifting" legislation. The idea is to tax environmentally destructive practices and activities and earmark the revenues to positive economic activity. In the future, "tax shifting" laws could be directed to raising revenue to help subsidize the development of renewable energies and hydrogen fuel cell technologies.

Environmental Fiscal Reform (EFR), as it is sometimes referred to, has been taken up successfully by a number of countries including Sweden, Denmark, the Netherlands, the U.K., Finland, Norway, and Italy. Germany, which is among the most enthusiastic supporters of "tax shifting," has phased in an increase in taxes on gasoline, heating oil, and electricity, and used the revenue to reduce payroll taxes. The gasoline tax resulted in the decline in motor fuel use by 5 percent in 2001 over 1999 and a growth in carpooling by 25 percent.

At present, environmental tax shifting comprises only about 3 percent of tax revenues worldwide, but the potential is enormous. A tax on fossil fuels alone could raise more than a trillion dollars annually. Ending environmentally harmful subsidies to polluting industries could free up an additional $500 billion per year globally. The revenue, in turn, could be used to invest in the shift to renewable energies and a hydrogen future.

Interestingly, the evidence shows that while increases in taxes on corporate pollution is not very well received by the companies, it forces them to eliminate resource inefficiencies and makes them more competitive in world markets. Studies show that many of the countries "that have the highest levels of environmental taxes also have industries that are the best in international competitiveness."

Along with "tax shifting" legislation, the European Union and the member states should provide generous tax credits and incentives to industry, small businesses, local regions and municipalities, as well as to homeowners and consumers, to encourage both research and development and early adoption of renewable energies and hydrogen fuel cell related technologies.

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

Equally important, launching a third industrial revolution and making the transition to a green hydrogen era 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 25 EU member states. By fostering a European-wide, renewable energy, hydrogen infrastructure, 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 its 455 million citizens in the first half of the 21st century.

Being first to market will also position the European Union as a leader in the third industrial revolution, giving it the commercial edge in the export of H_2 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, reconfiguring the electrical power grid, as well as producing all of the accompanying technologies, goods and services that make up a high-tech hydrogen economy, will have an economic multiplier effect that stretches well toward the mid decades of the 21st century.

The transition to a fully integrated, hydrogen energy regime will not occur overnight. It will take 25 to 30 years to put the infrastructure in place. In the interim, the European Union—and every other country—needs to establish a parallel track for radical energy efficiency and conservation. The European Commission has laid out a detailed survivor's guide—a roadmap of what every individual, family, community, and country can do immediately to cushion the cost shock of rising oil prices. It's called "The Green Paper on Energy Efficiency". According to the report, the European member states alone, could save at least 20% of their present energy consumption, for a net savings of 60 billion euros per year, by enacting tough energy conservation programs across the swath of European society—in homes, commercial buildings, factories, and transport. The average EU household could save as much as 1000 euros per year in cost-saving energy efficient practices, thus offsetting much of the increased price of oil.

The EU green paper is replete with detailed information on how to overhaul every aspect of our lives to achieve more energy-efficiency. Proposals include: incentives to purchase energy-efficient cars, reducing the national speed limit to 55 milers per hour, making alterations in homes and commercial buildings, like installing special insulation and storm windows, using long-lasting electric light bulbs, introducing software into appliances to save energy, renovating the nation's power grids to be more efficient, and other energy-saving practices.

Governments will need to employ a range of strategies including taxation, public subsidies, economic incentives, and partnerships with industries, communities, and homeowners to make the transition to a truly energy-efficient society.

While government, industry, and consumers will have to spend some money up front to usher in literally thousands of energy efficient "best practices," the investment will boost the EU economy by creating upwards of a million new jobs across the EU. Moreover, the cost savings of improved energy-efficiency will mean more money will be freed up to invest in renewable energy technologies and the hydrogen infrastructure.

Leading the way to a hydrogen economy and a third industrial revolution should be an urgent priority and the next phase of European integration. Opening the door to a new energy era is the best contribution the European Union can make to the world in the coming global era.

Jeremy Rifkin is the author of <u>The Hydrogen Economy: The Creation of the World Wide Energy Web and the Redistribution of Power on Earth</u> (Tarcher/Penguin: 2002). Mr. Rifkin teaches at the Wharton School's Executive Education Program at the University of Pennsylvania and is President of the Foundation on Economic Trends in Washington, DC.