POTENTIAL APPLICATIONS OF INNOVATIVE "GREEN" MILITARY TECHNOLOGIES IN EUROPEAN SECURITY, GEOPOLITICAL STRATEGY AND DIPLOMACY

1. THE SINGLE GEOPOLITICAL IDENTITY OF ENERGY TECHNOLOGIES

There is a tendency in Europe to treat various energy technologies as different and mutually competitive. For instance, we usually consider renewable energy sources as competing with oil or coal and all three with nuclear energy. This segregation is due, to a certain extent, to what the various forms of energy actually mean to people: thus they are regarded by a significant part of the public as eco-friendly or otherwise, beneficial to the global climate or destructive, good or bad. In reality, however, within a broader geopolitical framework, various energy sources may work in synergy and should probably be examined as constituents of a single system, rather than as competitors.

Based on this viewpoint, the present paper shall attempt a holistic and synthetic analysis of the energy map of the future and of the role that could be played by the so-called "green" energy technologies, mainly those derived from military research and development, in Europe's high strategy.

To begin this presentation, we should start by examining whether energy technologies developed within the framework of military programs are evolving fast and substantially enough to be differentiated from the development of similar commercially available systems; in other words, the question is whether one may actually speak of a "Green Energy Revolution in Military Affairs" (GE RMA). There is no easy answer to this question. While officially

there is no relevant project, initiative, plan or anything else that might be considered as energy RMA, there does appear to be a large-scale effort by the US military to develop oil-alternative energy technologies, the extent and depth of which appear to be such so as to allow it to be labeled as revolutionary.

Furthermore, the development of green energy technologies is keeping pace with the broader developments in the art and science of war. This may be combined, *inter alia*, with more recent views on network-centric warfare, which place emphasis on decentralizing models of military operations.

2. THE ENERGY TRANSFORMATION OF THE US MILITARY

In a very general sense, in order to maximize their energy-saving efforts, the US military focuses mainly on:

A. Using cheaper commercial fuel and applying more economical flight methods[1].

B. Using synthetic fuel, the effort being spearheaded by Fischer-Tropsch, which is already being used in USAF B–52s and C–17s. The USAF alone spends around 4.7 billion dollars per year on fuel alone. This amounts to approximately 50% of the Pentagon's energy expenditures. Fischer-Tropsch may be extracted from natural gas, coal, and other sources.

Among other advantages, Fischer-Tropsch fuel is expected to decrease the vapor trails behind aircraft, making them more difficult to be spotted by enemy aircraft and air defenses[2]. Efforts to synthesize fuel started as early as World War II in Germany, and have continued during oil crises. However, to this day they do not appear to have yielded adequate results[3]. Nevertheless,

specialists like Julius Pretterebner, director of Cambridge Energy Research Associates (CERA) Global Oil advisory group, maintain that synthetic fuels such as Fischer-Tropsch are impractical and uneconomical, mainly because they require massive and expensive installations. Furthermore, he claims that a Fischer-Tropsch processing plant requires five times the capital needed for an oil refinery[4].

C. Biofuel. The Pentagon's Defense Advanced Research Projects Agency (DARPA) intends to develop alternate fuels, including biofuels that can be synthesized from plants, plant by-products, or organic waste like sawdust. Similar organic materials may be used to synthesize ethanol or biodiesel[5]. In 2009, DARPA awarded a US$25 million contract to SAIC for the development of a new fuel that would replace JP-8 jet fuel and that would be manufactured from algae, aiming at a production cost of no more than US$3 per gallon of fuel produced[6].
By the end of 2013, the US Air Force aims to have all its aircraft running on HRJ biofuel (Hydro–treated Renewable Jet fuel) mixtures with oil-derived fuels[7]. On the other hand, on 22 April 2010, the US Navy used camelina-based (a plant in the mustard family) biojet fuel to power the test flight of an F/A-18 "Green Hornet"[8].

The Secretary of the Navy, Ray Mabus, in an interview with the Defense News review (18 January 2010), mentioned among other things that for 2020, the vision shared by both the Navy and the Marine Corps is to have reduced their dependence on fossil fuels, namely oil, by 50%. Another aim is to have created by 2016 an aircraft carrier strike group that will not be using oil at all[9].

So far, the largest purchase of biofuels by the Pentagon has been 450,000 gallons from Dynamic Fuels and Solazyme Corp in 2011, to supply ships and aircraft participating in the "Great Green Fleet" demonstration during the Pacific Rim international military exercise in July 2012. The fuel had an average cost of US$25 per gallon, and the price has dropped considerably since then. The above quantity was, of course, but a drop in the ocean. The Pentagon has the largest fuel consumption in the US, accounting for 1.5-2% of the total fuel consumed in the country. Oil consumption amounts to 375,000 barrels per day, the annual cost amounting to US$17 billion[10].

The future of the Pentagon's plan to develop advanced drop-in biofuel initiatives has however been threatened by a bill preventing it from signing long-term contracts (over five years) for the supply of biofuels at a steady price, while the respective time allowed for electric power contracts is 30 years. Long-term contracts are crucial for the research and development of pertinent technologies, since they allow manufacturers to approach financial institutions in order to secure financing that will improve their capabilities[11].

D. Diesel-electric hybrid vehicle engines.

E. Fuel cell hydrogen engines.

F. Renewable energy sources. Such systems also include the exceptionally ambitious artificial photosynthesis systems[12].

G. Systems utilizing microscopic energy sources, such as human body heat, which are considered of no commercial value or interest. Some of these systems shall be further examined later in this paper.

H. The development of batteries of much larger capacity, combined with much smaller size and weight than today's', for a number of applications, ranging from the electronic equipment of soldiers to submarine batteries[13].

It should be pointed out that a key element in all these efforts is the attempt to develop systems of the smallest possible size and weight, as well as cost, which would allow them to have military applications[14].

3. «GREEN» ENERGY TECHNOLOGIES AND US GEOSTRATEGY

Green energy technologies appear to offer a series of advantages for the United States, ranging from high strategy to military power tactics. It should be noted that the development of such technologies is part of the wider reorganization of the global energy map. More precisely, in parallel with its investments in biofuels and alternative forms of energy, the US has also invested greatly in the development of technologies that will allow the financially viable extraction of oil and natural gas from alternative sources (such as schist deposits or pisolite mines) or from deposits that were hitherto considered economically unviable, like the ones that may be found at extreme sea depths. This effort, according to the World Energy Council, appears to be progressing quite well, and is expected to soon allow the US to become autonomous in terms of energy, which could have enormous potential repercussions for the international system[15]. As already argued above, contrary to some extremely popular beliefs, "green" energy technologies do not necessarily compete with hydrocarbons, but are complementary-at least within the framework of American geostrategy.

Some potential advantages that would be offered to US geopolitical strategy by this new and more "pluralist" energy map in general, and "green" energy technologies in particular, are broadly the following:

a. An enhancement of US efforts to become autonomous in terms of energy and to break free from dependence on Middle Eastern hydrocarbon deposits, given that this area of the world is mainly controlled by unstable and/or anti-western regimes.

b. Breaking free from their dependence on Middle Eastern hydrocarbons will allow the USA to intensify its presence in the Pacific Ocean and China, which is the new geopolitical "center of the world" for declared US strategy.

c. Becoming independent of (or at least drastically reducing dependence on) Middle Eastern hydrocarbons may facilitate opting for aggressive action in order to neutralize Iranian nuclear installations, if deemed necessary by those in charge of the US. At this point it should be noted that although such an attack would probably aim at destroying nuclear installations in and around Tehran, mainly in Natanz and Fordow, it cannot be certain that this would be a swift bombing operation that would not cause serious disturbances in the international energy market. First of all, it is highly likely that it would be necessary to attack Iran's anti-aircraft defenses, but mainly its ballistic missiles, so as to neutralize the country's capability to retaliate. It is even more likely that this would not suffice, and it would then be necessary to destroy not only operational ballistic missiles, but also their production facilities, in an attempt to eliminate Iran's potential to strike back. This, in turn, means that the need might arise for an extended, large-scale campaign, the consequences of which (albeit only psychological)

would be significant for the energy market. And all this, of course, without even mentioning Iran's capacity to create problems for navigation through the Strait of Hormuz, which would have enormous repercussions on the international energy market. It should be noted that even if the United States manages to become autonomous in hydrocarbons, the energy market is a globalised one. An oil crisis would therefore also exert pressure on the US energy market. The green energy infrastructure could in turn thus serve as a shock-absorber for similar cases. In other words, **it is possibly not enough for the United States to become autonomous in terms of hydrocarbon consumption, as they would also have to be in a position to support the rest of the world as far as energy is concerned. Which means that they would not only require energy autonomy, but energy sufficiency; a second tier of energy sources apart from hydrocarbons might be green energy technologies.** Of course, if an oil crisis were to break out over the next years, as a result of an attack by Iran or for any other reason, it would be very difficult for green energy technologies to have matured enough to play such a role. They may, however, offer a way out, by showing that there is, in fact, a long-term solution: if there is a belief that an alternative energy architecture is actually feasible, then an oil crisis may constitute a creative shock that will provide a critical thrust to green energy technologies. All the more so, should such a crisis be the result of a war incident, underscoring in its turn the broader financial, ecological and geostrategic dimensions of alternative energy technologies.

d. Investing in green forms of energy makes it possible to enhance US soft power, as well as the country's image the world over and mainly Europe, an image that suffered badly as a result of the US refusal to ratify the Kyoto Protocol and because of its negative

attitude towards greenhouse gas emissions control-a stance that was entirely incompatible with the concerns of European societies.

4. MILITARY ADVANTAGES AND GREEN ENERGY TECHNOLOGIES

At the level of military strategy, green energy technologies may offer significant advantages, some of which are the following:

a. They are expected to enhance the capability of the American armed forces to deploy troops all over the planet faster and at a smaller cost than today. This is because the increase in combat unit energy autonomy results in a reduction of the time needed for preparation before a campaign is launched, mainly due to the need to ensure energy resupply "queues". This problem is particularly troubling for the American military. According to Ray Mabus, Secretary for the Navy, in order for a gallon of gasoline to reach a Marine unit stationed in Afghanistan, it will have to cross the Pacific Ocean and then be transported through Pakistan. However, in this day and age of makeshift explosive devices and ambushes, supply convoys are considered particularly vulnerable. According to Pentagon sources, in June 2008 alone, 44 vehicles and 220,000 gallons of fuel were lost as a result of attacks or other incidents. As to the financial cost, according to the Pew Project on National Security, Energy and Climate, delivering a gallon of fuel to units in Afghanistan costs approximately US$400[16]. Therefore, it would be best if combat units could meet their energy requirements using anything they can find on location; which means renewable energy sources.

b. Green energy technologies such as hydrogen fuel cell engines may reduce the size and weight of military vehicles, thereby

increasing their strategic mobility and further improving their rapid military action capabilities at a global level, at a reduced cost.

c. Renewable energy source technologies may reduce the operating cost of armed forces, both in times of peace and war, by reducing fuel consumption. It should be noted that the US Pentagon is the single largest consumer of oil in the States and is responsible for 1.5-2% (see above) of total national consumption, spending approximately US$17 billion per year on fuel[17]. About 60% comes from countries outside the USA. Furthermore, the US military consume 3.8 billion kWh of electric energy per year for the operation of its bases and other installations. The aim of high-ranking US military officials is to be able to cover 25% of their energy needs through the use of renewable energy sources by 2025[18].

d. Green forms of energy may be combined with models of network-centric and decentralizing warfare operations[19]. Such models often disperse friendly units geographically, without any physical contact between those units, even behind enemy lines. They are operationally unified through robust information networks and long-range high-precision weapons systems. Such a way of thinking necessitates a drastic enhancement of the energy autonomy of each individual unit, since the need for safe refueling channels would contradict their very *modus operandi*. These kinds of decentralized operation models also happen to be particularly important in counter-insurgency (COIN) operations in geographically inaccessible environments such as the mountainous areas of Afghanistan. In such missions, small isolated groups of foot soldiers need a very high degree of energy autonomy to accomplish their operational goal[20].

e. The escalating digitization of modern troops is forcing even individual solders to expend significant amounts of energy to keep their ever-increasing electronic equipment in operation. At the same time, modern soldiers' load has reached disproportionate levels[21]. Consequently, the requirements are now for cheap, light-weight and versatile systems supplying environment-harvested energy, allowing soldiers to keep their electronic equipment operational over extended periods. Modern-day (and mainly future) soldiers carry far too many electronic devices requiring numerous batteries, which in turn is greatly increasing the weight of each soldier's load. Therefore, a battery charger would be ideal, except for the fact that -unfortunately- there are no power outlets to be found in nature. As a result, chargers using either environment-harvested energy or their own power sources (such as fuel cells) are required.

Fuel cell systems are much more effective for use by "digitized" soldiers, thanks to their far superior energy efficiency, in comparison with traditional systems, while they also combine the added advantages of having a smaller thermal signature and reduced weight[22].

f. Green energy technologies favor the development of high operational flexibility weapons systems, such as high-altitude and high-autonomy unmanned aerial vehicles and airships, which may be used as cheap satellite substitutes. The most typical example in this category is the aerial vehicle developed within the framework of the Vulture project[23].

Green energy technologies, such as renewable energy sources, are of great importance on the battlefield in expanding the use of unmanned systems such as mini-, micro- and nano-UAVs and unattended sensors that gather information and monitor extensive

areas, which is of paramount importance for the infocentric/ network-centric armies of the future[24]. Similar systems may have widespread security applications, such as critical infrastructure protection and border control.

g. Green energy technologies may offer a series of tactical advantages in the battlefield. For instance, hydrogen fuel cell engine vehicles have a reduced acoustic and thermal signature, and probably have greater survivability after being hit.

h. As for domestic security, internal oil transport networks, refining and storage are susceptible to terrorist or other attacks and increase the country's overall level of insecurity. Consequently, autonomous local networks of green energy technologies may offer a more decentralizing energy architecture, which could also be safer against terrorist acts and all sorts of asymmetrical attacks. At this point we should, however, stress that similar services may also be offered by flexible nuclear energy systems, the use of which has already been examined by the competent American defense and security services. For instance, in 2009 the United States Department of Energy, following a Congressional order, examined the feasibility of equipping military installations with energy-producing nuclear reactors. Among the reasons given for the study, was the proposition that civilian conventional energy production and distribution networks are extremely vulnerable to cyber-attacks and other terrorist acts. Furthermore, civilian power grids are generally more vulnerable to failures and malfunctions, rendering them unreliable, as was mentioned in a General Accounting Office (GAO) report. According to the same report, between 2006 and 2008 at least 24 out of 34 most critical assets suffered power supply disruptions, some of which lasted up to seven days[25].

Most characteristic of the strategic, operational and financial advantages gained for the US armed forces by the development of non-oil-based forms of energy is a study by the bipartisan, non-profit group PEW Charitable Trust's Project on National Security Energy and Climate, "From Barracks to Battlefield: Clean Energy Innovation and America's Armed Forces", made public on 21 September 2011. The study examines how the US armed forces mission's effectiveness improves through the use of clean, alternative non-oil-based energy technologies, and how the Pentagon is nurturing renewable energy sources by using commercially available technology. Among other things, it also investigates the risks involved in transporting liquid fuel to the battlefield and through it; intense oil price fluctuations; the impact of oil dependence on the operational capability of troops; the fragility of energy supply for forces that must ensure sufficient energy 24 hours a day etc.

Researchers stress that the Pentagon's investments in renewable energy sources and efficiency increased by 300% between 2006 and 2009, skyrocketing from US$400 million to US$1.2 billion. The US Pentagon currently has renewable energy sources projects amounting to US$450 million, and in 2010 it produced or purchased "green" energy covering 9.6% of its energy needs for the that year. Unlike oil, the prices of renewable energy source technologies and systems have dropped considerably over the past years. For instance, the cost of photovoltaic systems fell by 60% between 2009 and 2011. The study concludes that the annual expenditure of the US Department of Defense for advanced energy technologies is expected to amount to US$10 billion by 2030[26].

4.1. GREEN RMA OR UNCHAINED EFFORTS?

It should, however, be noted that-to the best of the author's knowledge-there is no specific plan or doctrine of total energy transformation for the American Military, but rather individual efforts that are not necessarily interconnected. Moreover, the American Military is currently in a transitional phase, and it is difficult to say which direction it will be moving in. Nevertheless, one could predict that due to extensive cuts in the US defense budget, the military will intensify efforts that would allow it to operate more economically both in peacetime and during war, and that green energy technologies may play an important role in such efforts.

We could therefore say with a considerable degree of certainty, that there exists-at least potentially-a "green" energy RMA, for which there is no guarantee that it will remain a US monopoly for much longer. In this globalized "flat" world that we live in, other countries may also undertake similar endeavors. A candidate *par excellence* is of course China, which may invest in developing green energy technologies in an organized, holistic and long-term attempt that could be combined with a broader modernization of Chinese military power. The mere fact that the large-scale effort to upgrade Chinese military capabilities has many innovative elements allows the author to consider that such an eventuality is very likely indeed. And therein lies a big question: Does Europe want to stay out of these efforts? If Europe opts to stay out, what dangers can she be in; and if, conversely, she consciously goes ahead with such an effort, either in collaboration with the USA or on her own, what benefits could be in it for her?

5. THE CURRENT INTERNATIONAL ENVIRONMENT AND GREEN ENERGY TECHNOLOGIES

At the international level, some of the factors expected to have a drastic impact on the international system and its form in the years to come are the following:

a. The United States has turned its attention towards the Pacific Ocean and China, putting Europe on the back burner.

b. China is emerging as a future first-class superpower.

c. The power and influence of a series of other countries in the international system is on the rise, placing them on the list of potential key powers within the framework of an international multipolar system. At the top of the list is India, followed by countries such as Brazil.

d. Russia is currently undergoing a reshaping process in its military capabilities, but it is still unclear what course her geostrategy will actually take over the next decades. The dynamics of Russia's relations with, *inter alia*, the USA, the EU and China have yet to crystallize sufficiently. Although Russian suspicion vis-à-vis China is constantly increasing, and might give rise to a framework of cooperation between the US and Russia, at least on a tactical level, Russia's distrust of the West is still very much in evidence and might even increase in the future. One of the reasons behind the deterioration of Russia-West relations is NATO's antiballistic endeavors. An increase in tension is likely to cause problems to sensitive geosystems such as the Baltic States.

e. The Middle East, which is still the planet's energy center, after the renowned "Arab Spring" has been turned into a geopolitical black hole. That is to say, there is a considerable degree of vagueness as to how the area's regimes will develop and what

geopolitical choices they shall be presented with. Apart from that, there is also a serious chance that the anti-western elements of many Arab countries might gain momentum.

f. After the Fukushima Daiichi accident, nuclear power was slandered anew and its potential to play a role in Europe's energy self-sufficiency became virtually non-existent-at least for the foreseeable future. Not only will Europe not build new nuclear plants but she is shutting down existing ones. This means that Europe is becoming even more dependent on hydrocarbons, which mainly come from either the unstable region of the Middle East or Russia.

g. As to the geography of energy, the factor that might drastically change international geopolitical relations and equilibriums is the fact that within the next few years the US may become energy-independent-or, at the very least, set the groundwork for achieving it -, while at the same China is becoming increasingly dependent on foreign energy sources, particularly Middle Eastern ones[27].

5.1. TOWARDS A CHINESE ENERGY RMA?

Consequently, China is also likely to strategically invest in a Military Affairs energy revolution, based on renewable energy sources. The main reason for such an eventuality is that it is becoming increasingly dependent on foreign energy sources. In fact, should the American plan to "imprison" China in the China Seas prove successful and block the country's ability to decisively project power abroad in order to safeguard its vital interests, a key component of which is the unimpeded influx of hydrocarbons, China shall be further impelled to invest in alternative forms of energy. This trend is expected to receive a significant boost, due to the US quite probably breaking free from its dependence on Middle Eastern oil, natural gas and the region altogether. US energy self-sufficiency

allows it to utilize, without any fear of repercussions, the oil weapon against other forces; in the near future, the most dependent country in the world on oil will be China, which will be unable to defend its interests oversees using military power. So it is likely to invest (and it should) in alternative forms of energy limiting its reliance on foreign sources hydrocarbons-thereby reducing its geostrategic vulnerability-and at the same time augment its capability to decisively project power outside its borders, so as to defend its vital interests abroad.

A factor that might drive China to invest in "green" energy technologies for military use is the very size of the country's armed forces-its Army in particular. Among other things, Chinese Army modernization is making imperative its further mechanization. For example, the Russians are worried that by the year 2020 China will have added a massive 20,000 new tanks to its armed forces. However, similar attempts pose a risk of creating an army of such immense energy requirements that it would collapse under its own weight. At this point it should be noted that the US Army is a comparatively small branch in relation to the country's overall population and financial profile. Yet the People's Liberation Army will find it very hard to follow suit, mainly due to its vital role in the political and social structure of both the country and the nation. In other words, modernization will bring with it a tremendous increase in energy needs and the subsequent creation of a logistic queue, which will be very difficult to accept. Energy autonomy is of the utmost importance, especially on the Indian front, due to the inaccessible and harsh terrain which makes it difficult to provide adequate logistic support to combat forces and makes their decentralized actions and operations an imperative.

China’s very energy dependence does not allow for such luxuries. The country simply cannot afford to squander colossal quantities of oil to keep its armed forced mobile, at the same time as this oil is needed for other purposes.

The most important thing, however, is that a modernized and more powerful Chinese Army shall be hostage to the countries supplying China with oil. For instance, the more powerful the armed forces grow, the more countries such as Russia will be able to extort China. On the other hand, at least to a certain extent, the future Chinese Army will probably be created and deployed as a form of applying pressure on Moscow, which would render this attempt meaningless (to say the least), leading to an increase rather than a decrease of Russia’s ability to control China.

There is, of course, always Middle Eastern oil: the Chinese have -theoretically speaking-the luxury of opting for no dependence whatsoever on Russian hydrocarbons, by increasing their energy collaboration with countries such as Iran. However, given that the US is now in a position to achieve energy autonomy, its potential for adopting aggressive policies against the Middle Eastern oil-producing countries increases, since the latter’s potential for exerting pressure on the USA decreases. This would mean that the Middle East might become the soft underbelly of China, allowing American geostrategy to exploit it by applying pressure.
Furthermore, even if China were in fact able to find non-US-controlled energy sources, immune to American activities, it would be very difficult to ensure an unobstructed flow of energy to Chinese soil; this is simply because the country is unable to secure the necessary sea routes. Such an endeavor would require world-class naval power, with capabilities matching (at the very least) those of the US Navy. That, however, would be very difficult (if not

impossible) to achieve over the next decades, even if the Chinese manage to see through their project for the creation of a Deep Blue Water Navy with three new, locally designed and constructed aircraft carriers. This force would, on the one hand, be most impressive but would also, on the other, definitely not compare to the US Navy, and would hardly be able to survive a hypothetical conflict against the US off the shores of China.

As for the modernized Chinese Army, it will most probably be a hybrid of conventional power elements, such as an emphasis on large numbers of traditional weapons systems, together with the adoption of innovative doctrines and war methodologies that will highlight decentralizing action, flexibility and adaptability. This chaotic-decentralizing massive army of small units will be able to use green energy technologies that will allow their vehicles and infantry units to remain autonomous over prolonged periods of time; it will limit the dependence on logistics "queues" that supply forces in the front with fuel, allowing a speedy and "care-free" penetration of enemy lines without any (or, at least, with limited) risk of being cut-off from supply lines. Also, energy autonomy will enhance current trends for breaking up land forces into small autonomous units. Naturally, this is all speculation. However, the fact that similar models have already appeared in other methods of power-projection adopted by China-such as the "thousand grains of sand" philosophy applied in cyberwarfare makes it look quite realistic[28]. Furthermore, traditional Chinese strategic thought places emphasis, albeit indirectly, on similar ways of thinking, while the overall focus of Chinese military thought on asymmetrical and unconventional approaches that has arisen due to the quantitative and qualitative supremacy of the USA and other countries in the China Seas, may very well permeate China's war practice in general.

Thus we have yet another element in favor of unity in the international system, as well as of the factors that shape it (in this case, military power). More specifically, China's effort to develop a new variety of unconventional military capabilities in the China Seas may give rise to (or may have already have done so) a new type of Chinese military thinking that will, sooner or later, also be reflected in land power. This may lead to a new Chinese land war machine, which will pose a direct threat to Russia. Such an eventuality might either be intentional in Beijing' mind or simply an unintentional collateral effect of China's initial attempt to face the USA and subdue Taiwan. However, regardless of the underlying etiology, should it in fact happen, it would then set in motion a mechanism for the production and propagation of results, entirely different from the wishes and planning of those who originally envisioned it. Therefore, China might attract Russia's suspicion and enmity-on top of that of the USA. This fact would increase China's vulnerability vis-à-vis its interests abroad, and enhance autonomist tendencies in strategic sectors, particularly that of energy. This means an increase in trends to develop green energy technologies, among others. It should be stressed at this point that China does not share the same apprehension and sensitivity as Europe regarding nuclear power. So, it is quite possible that this situation might lead to China intensifying its efforts to further develop its nuclear energy infrastructure; and in particular, if the country does adopt a decentralizing philosophy of defense planning, then it is highly likely that it may invest in a flexible nuclear infrastructure, comprising a large number of small and movable nuclear reactors. Also, such an over-nuclearization of China may cause chain reactions in the global *status quo* of a series of issues, the examination and analysis of which is not within the limited scope of this paper.

Quite naturally, India might follow the same path, if she does not wish to be left lagging behind China, and to slide into a position where she would be controlled by the latter.

It is the author's opinion that, as far as China is concerned, it would be best for green energy technologies to be channeled to it by the West within the framework of a broader geostrategic negotiation, rather than allowing it to develop them itself. **And, of course, it is imperative for such a military energy revolution to occur in the West first, since if we do not do it, China most certainly will not.** Then the situation would be reversed, with Europe becoming China's hostage. Therefore, the point is not only about having an energy RMA: the question is who will make it happen.

5.2. GREEN MILITARY ENERGY TECHNOLOGIES AND IRAN'S MILITARY STRATEGY

One should not rule out the possibility of Iran developing its own green energy infrastructure. As mentioned above, green energy technologies are combined with decentralizing combat models, and Iran is based precisely on such models. The autonomy of operation and action of disseminated units is a key requirement in the Mosaic Warfare doctrine, adopted by the Islamic Revolutionary Guards Corps (IRGC or Army of the Guardians of the Islamic Revolution); consequently, energy autonomy plays a pivotal role in this effort. The same may also be true of the Revolutionary Guards' Navy's operational philosophy, stressing the importance of autonomous action and the operation of small action teams[29].

It would therefore be preferable to have a controlled flow of green energy technologies directed at this country, which would be utilized within the framework of a high strategy placing emphasis on mild power and the attempt to integrate Iran into the international

community rather than reducing it to a *cordon sanitaire* of weapons systems. In any other case, it might take Iran more time, but the country is highly likely to acquire these technologies on its own and incorporate them in its war endeavors, thereby increasing the challenge for western military strategy. Such technologies may offer increased offensive capabilities to the Iranian armed forces' autonomous combat teams of various configurations, capable of waging what could be described as 'sophisticated guerilla warfare'.

6. GREEN ENERGY TECHNOLOGIES AND EUROPEAN GEOSTRATEGY

6.1. EUROPE'S GEOPOLITICAL IDENTITY TODAY AND THE DYNAMICS OF GREEN ENERGY TECHNOLOGIES

Glancing at Europe's geopolitical position of today, one may ascertain, among other things, that one would be stating the obvious were one to say that the course of EU political unification is currently not at its best, given the considerable slowing down of the potential for further deepening of the process, while the suspicion between North and South increases, threatening to create a particularly dangerous rift.

Further, Europe's technological-industrial lead may be placed in jeopardy over the next decades, due to the rise of a series of countries, notably China. This development may have serious repercussions on the European economy, as well., If China managed to develop products of comparable quality with, *inter alia,* European ones in a variety of crucial industrial sectors such as the aerospace industry, and if these products were to be made available on the industrialized international market at highly competitive prices, then Europe would be in serious trouble. The fact that China is currently a world champion in patents and the fact that the

country places such great emphasis on research and development are strong indications that in a few years China will manage to make a dynamic entrance into the field of high-value industrial products, threatening to depose Europe. Given that Europe appears to have decided to essentially abolish its defense expenditure, she risks depriving her broader industrial base of a particularly important mechanism for creating technological innovations.

In other words, the fact that Europe's military capabilities are currently in a state of vertical dive is having repercussions not only on European security and Europe's geopolitical autonomy, but is also contributing to the further industrial and technological depreciation of the wider European geostrategic potential, since military research and development is traditionally the locomotive for the creation of new technologies. Unlike in the USA or other countries, the deconstruction of Europe's military power (and the subsequent decay of a series of high-technology industry branches) is due not only to the financial crisis, but also to European societies' exceptionally negative perception of defense expenditure, This is also true of European countries facing serious security problems, such as Greece.

Investing in green energy technologies for military applications may reverse this situation. Europe needs a new type of defense capability, and a key role in this effort may be played by green energy technologies.

In contrast to Europe, China's titanic continuing struggle to develop innovative as well as traditional military capabilities is bound to offer technological advantages to its broader productive basis. Within a few years, the current comforting fantasy of low-quality Chinese industrial products will most probably be a thing of the

past. And then, Europe shall have to face China amidst a peculiar mix of geo-economic competition and interdependence, but also geostrategic suspicion.

Based on all the above, the first thing green energy technologies have to offer Europe is a means to counter its technological-industrial and subsequent financial and geopolitical degradation. As already mentioned, China's exponential rise, among other reasons, may lead the European high-tech industry to decay. The EU needs a weapon that will allow it to keep its first place among the planet's great powers. Green energy technologies may offer the European Union the chance to carry on dealing with the rising powers on equal terms. A technological and concomitant financial deterioration of Europe, in the face of the new, rising powers of the planet - particularly China-may lead to its marginalization it and turn it into a museum that will have nothing left to show but the relics and memories from its past grandeur, for wealthy tourists from China, India or South America to visit.

Furthermore, the military power gap of European countries, and the possible detachment of the USA and the Arab countries' ambiguous political geography, are factors favoring the wisdom of developing an alternative energy infrastructure. Its high technology allows Europe-and the geopolitical circumstances impose it-to become an energy producer; and the best candidate for this is alternative energy sources.

Adopting green energy technologies will also allow the strengthening of Europe's defensive capabilities in a way that does not cause adverse reactions in European societies, which are very sensitive towards the question of defense expenditure. Advanced energy technologies combined with decentralizing combat models and some other technologies and systems, such as long-range

precision-guided munitions (PGM), may allow the building of a new type of armed force, small in size and economical in operation, which can be used in a wide variety of operational situations. Conversely, oil-centric war machines run the risk of turning into white elephants in the complex war environment of the 21st century, and collapse.

A green revolution in military affairs shall offer Europe:

a. The chance to remain an equal-terms interlocutor and partner of the USA. Such a choice would also allow a coupling between the US and EU technological potential, thereby significantly accelerating this effort.

b. A green energy architecture will allow Europe to develop a more balanced relationship with Russia. This relationship will be mutually complementary rather than one of dependence-which is the case today as regards energy. Yet in fact, in the future, Europe might be more dependent on Russia in relation to its energy supply, given that the situation in the Middle East may remain unstable and nebulous, while Europe is being deprived of the military power that would allow her to secure by force her geostrategic interests, and while the US is moving away having, on the one hand, ensured its energy autonomy and, on the other, because it is turning its attention to China and the Pacific. This one-way relationship between the EU and Russia is not the best foundation on which to build well-balanced, mutually beneficial and creative relations between the two parties. Quite the contrary: it leaves room for friction between the EU and Russia on a series of issues, such as the underlying tension in the Baltic States, the examination and analysis of which is not within the limited scope of this paper. The creation of an advanced green infrastructure may lead to a relationship of creative mutual dependence, which would also lead to a far more balanced situation. Western Europe will still be in need

of Russia, since green energy technologies, even if they were to develop at a very fast pace, are not in a position to immediately replace hydrocarbons, while Russia will need Europe so as to adequately prepare for the day after, when hydrocarbon deposits become inevitably depleted.

c. A European family of advanced green energy technologies shall offer an alternative energy source for China, thus limiting its dependence on foreign sources and thereby reducing its military vulnerability vis-à-vis the USA. Many may object to that, since they will consider that China's vulnerability vis-à-vis American power extinguishes the possibility of a Sino-American war breaking out and, as a consequence, promotes wider Western interests, so that there is no reason for the Europeans to undermine American high strategy and find themselves on a collision course with the US. The response to this is primarily that Europe must have its own high strategy if she wishes to be a discernible geopolitical entity. Moreover, one must keep in mind that it is by no means certain that China's increasing dependence on the USA will necessarily bring them peace and stability; the exact opposite is quite plausible-and it appears to be already happening, due to the financial interdependence. The state of holding it an 'energy hostage' will increase Beijing's suspicion and vengefulness, as well as its sense of insecurity vis-à-vis the US, possibly leading the Chinese to develop alternative methodologies for exerting pressure on the Americans (including military ones), in an attempt to neutralize or limit the pressure exerted by the USA on them, thanks to the latter's control over the flow of energy. In other words, dependence will bring tension. Thus the European green energy infrastructure may act as a safety valve, in the form of an alternative energy source for China, albeit unconventional, limiting the dynamics of this stranglehold between the USA and China, from which is extremely

probable that either one (or both) will decide to break free. Consequently, Europe appears as a distinct third pole in the game between the US and China, thus reinforcing its international role.

d. This choice gives Europe a potential "mild power" weapon for use against Iran, offering similar technology in return for the neutralization of Iran's nuclear program, which-at least officially-aims at energy production. Furthermore, it reduces Iran's capacity to cause an 'energy strangulation' of Europe, in the case that it succeeds in shutting down the flow of hydrocarbons through the Strait of Hormuz, following a putative attack against it. By "positively" influencing Iran, Europe also indirectly influences China, which depends to an important extent on Iranian hydrocarbon sources.
This European technology also creates synergies with Japan-which may also contribute to this effort- and, secondarily, with Australia.

e. Similar technologies may offer important solutions for Brazil and other countries the world over, with extensive surfaces and inaccessible areas, which means that they need a disseminated, decentralized energy architecture, the creation of which is made possible by renewable energy sources and hydrogen technologies. Additionally, green military energy technologies would offer Brazilian defense and security services the possibility to better control the country's vast and extremely inaccessible areas by providing, for instance, satellite systems substitutes based on high-autonomy airships and aerial vehicles. Similar capabilities may be of interest to other countries, such as Indonesia-to name but one.

f. As far as Europe's defense and security strategy is concerned, such technologies facilitate the creation of an energy infrastructure with a high chance of survival against symmetric and asymmetric

threats of chaotic/spider web type. Also, green technologies combining decentralizing combat models, long-range precision-guided munitions (PGM), Non-Line-of-Sight and Beyond-Line-of-Sight capabilities (NLOS and BLOS, respectively), like the Israeli Nimrod 3 and Spike NLOS missiles, can allow the drastic improvement of the deterrence capability of small military forces in a financially realistic way, in environments such as that of the Baltic States[30].

g. Finally, the green RMA may be one of the last chances for the poorer countries in the south of Europe, which nonetheless have considerable potential through renewable energy sources, to bring their economies up to the level of those of northern Europe.

7. WHY A MILITARY GREEN ENERGY REVOLUTION?

It is a given fact that even those who agree in part or entirely with the above considerations and opinions might very understandably also wonder why European efforts for the development of advanced green technologies have to be in any way related to military purposes. The answer to such a question is rather complex. Firstly, some of these efforts are clearly a crucial component in the building of a new type of military capability on the part of European countries, compatible with the particular sensitivities of European societies; they will be financially viable, even in times of hardship; and they will have a pan-European rather than a national character. The most important thing, though, is that-as already mentioned above-a way for Europe to keep being a key player in the international geopolitical poker game, having hard and mild power and safeguarding itself (at least in part) from the turbulence of the volatile international geography of energy, is to use its technological potential (for as long as the latter exists) and to stage a green

energy revolution; and for this effort to earn the title of "revolution", it must be swift and decisive. A method of achieving this would be to connect it to an international effort to transform its military capabilities due to the special challenges arising from geopolitical developments.

Let us not forget, for instance, that World Wars I and II played a decisive role in the dramatic progress of airplanes. The same could happen today as well, with progress in the field of renewable energy sources. Although we are not at war, we appear to find ourselves at the beginning of an extensive transformation of war capabilities and ensuing military equilibriums all over the world, due to a great extent to the development of novel war capabilities on the part of China. We are ultimately led to a world of extreme nebulousness that might have serious repercussions on both deterrence and coercion strategies, as well as on threats to peace (or even the very ability of people to comprehend threats to peace). In this world of asymmetric and, therefore, murky military capabilities and subsequent balances of power, geopolitical relations and security architectures, green forms of energy may play the role of a crucial catalyst. At a historic time of great asymmetry in military capabilities at an international level, and resulting vagueness as to who is powerful and who is powerless, in what sort of military conflict and where, the development of economical and innovative defense capabilities by Europe may have a greater geopolitical significance than we think.

It should also be noted that combining green energy technologies with an effort to develop innovative military capabilities and power projection methodologies, does not necessarily accelerate the development of such technologies due to the allocation of more money in R&D; this, as a matter of fact, is not even a necessity. It is hoped that accelerating the above process and offering

competitive applicable technologies will result from the special demands of military energy technologies: for instance, the requirements for miniaturizing and reducing the cost of systems collecting energy from the environment to be used by small and isolated special ops or infantry teams; or overcoming constrictions related to the need for energy supply chains for the development of oil-free vehicles; or defeating the nightmare of economic cost and technological and financial risk that is impeding the commissioning and entering in active duty of newly introduced technologies, at the same time as old, mature and safe technologies are working well. Military systems may break free from these restrictions by offering other types of advantages, like for instance increased survivability following a hit; stealth capabilities; increased tactical and strategic flexibility; increased operational capabilities in a net-centric environment and within decentralizing battle models that will include the dispersion of friendly forces within the area and quite possibly behind enemy lines, where they will have no physical contact with the energy supply chain.

The most significant element is that the development of new military and broader geostrategic capabilities that might stem from the advances in sophisticated green energy technologies sets the latter free from the bonds of their financial comparison with hydrocarbons. As long as there is relatively cheap oil and natural gas, the development of alternative energy technologies shall keep coming up against an impenetrable barrier. When, however, new elements are factored into the equation, such as new-type military capabilities and geostrategic safety, this barrier may actually prove quite vulnerable.

7.1. DOWNSIZING ENERGY SYSTEMS

As was mentioned above, it is the author's opinion that a key element that renders military R&D for energy systems groundbreaking is the special needs of soldiers for miniature energy supply systems, which is not the case for the civilian market, where requirements are significantly less. These needs are pushing research to its limits, thereby allowing the development of new technologies that can subsequently have wider applications, allow the reduction of cost, etc. Furthermore, another special feature of military battlefield energy systems is that they do not disregard even the most minuscule quantities of energy (they can salvage from anywhere), which is hardly the case with other applications. Such technologies may act as catalysts to drastically accelerate research on renewable energy sources and to overcome various obstacles[31].

Therefore, had there not been the special defense and security requirements, tiny-sized alternative sources of energy would probably have remained on the fringe.

8. CONCLUSIONS

Over the past years, there has been a tendency to create a more pluralist, composite and complex energy geography on the planet, with the inclusion of various sources of energy, becoming part of, and constituting, an integral geostrategic value, the identity and composition of which are constantly changing, alongside the respective equilibriums, synergies, competition, and roles of the individual forms of energies that compose this unified entity.

It should be stressed that this composite and active entity is interacting dynamically with a series of other factors that shape the international environment, such as weapons systems technologies,

combat methodologies and military power projection capabilities, in a way never before seen in the past.

These advances have provided the EU with an opportunity to reconstitute and reinvent its technological-industrial base, linking it to an attempt to develop innovative military capabilities, adapted to the sensitivities of European societies. Thanks to green energy technologies, Europe may, within a synergistic framework, integrate geopolitical entities that are usually in a competitive relationship with each other, by enhancing military capabilities and the mild power that is the result of initiatives for environmental protection. With a concerted and combined effort to develop advanced, oil-alternative technologies and its interconnection with the development of innovative military capabilities, Europe may reinforce its internal cohesion; ensure an equitable relationship with the USA and Russia; improve its capacity to handle problems in its energy supply; and increase its potential for influence over China, India, Iran, Brazil and a host of other countries of vital importance for the international system over the next decades.

[1] For instance, in 2009, the Air Force Petroleum Agency (AFPA) stated that they would commence an annual research program that would explore the viability of using cheaper jet fuels instead of the more expensive military JP-8.
The widespread use of commercial fuels, apart from being cheaper (precisely because it will be widespread), would also reduce transportation costs, since it could be moved using standard oil pipelines.
Furthermore, the US Air Force made an attempt to change its pilots' "driving" behavior, so as to reduce energy consumption. For example, it was recommended that they only turn on their engines immediately before take-off, to fly higher and slower and to only use their afterburners when absolutely necessary.

Sources:
Harrington, Caitlin, "USAF plans to explore using cheaper jet fuel", *Jane's Defence Weekly*, 18 November 2009, p. 11.

Rolfsen, Bruce, "USAF to Pilots: Slow Down, Save Gas", *Defense News*, June 14, 2010, p. 33.

[2] Harrington, Caitlin, "USAF promotes fuel alternative", *Jane's Defence Weekly*, 21 March 2007, p. 11.

[3] Harrington, Caitlin "USAF leads fuel derivative drive", *Jane's Defence Weekly*, 2 August 2006, p. 31.

[4] Cowan, Gerard, Harrington, Caitlin, "Adding fuel to the fire. As such a major consumer of energy, the US Department of Defense has been eager to secure supplies of energy at stable prices as well as look to alternatives", *Jane's Defence Weekly*, 26 November 2008, p.29.

Harrington, Caitlin, "DARPA awards SAIC contract to develop new jet fuel alternative", *Jane's Defence Weekly*, 4 February 2009, p.11.

[6] Algae are very promising as far as biofuel production is concerned, since they can grow in hostile environments, such as brackish and salt waters that are unfit for drinking purposes. Also, algal biofuels have very high energy efficiency, while their boiling point due to heat, solidification due to cold and their viscosity are very close to those of JP-8. The problem is that they require vast areas for cultivation.

Harrington, Caitlin, "DARPA awards SAIC contract to develop new jet fuel alternative", Jane's Defence Weekly, 4 February 2009, p.11.

[7] Harrington, Caitlin, "USAF launches new biofuel testing programme", Jane's Information Group website, 4 February 2009.

[8] Matthews, William, "US Military Expands Green Energy Campaign", *Defense News*, April 26, 2010, p.11.

[9] Cavas, P., Christopher, Interview. RAY MABUS. US Navy Secretary, *Defense News,* 18 January 2010, p.22.

[10] Lindeman, Eric, "USAF, USN biofuels initiative may take budget hit…", *Jane's Defence Weekly,* Volume 50, Issue 7, 13 February 2013, p. 13.

[11] In December 2012 the Congress, in the Fiscal Year 2013 Defense Authorization Bill, passed an order by virtue of which the Pentagon may purchase biofuels only if the price is competitive to conventional, oil-derived fuels, as well as to carry on with R&D on related programs. However, both the Pentagon and the biofuel industry consider that in 2016 it will be possible to produce biofuels at oil-competitive prices.
US Navy Secretary Ray Mabus, on 16 April 2012, defended before Congress his choice to promote biofuels and reduce the consumption of oil-based fuels, despite the latter being much cheaper. The Secretary stated that '*reliance on fossil fuels is a military vulnerability*' and a weak spot for national security and stressed that '*it would be completely irresponsible to look at a national security vulnerability without acting*'.

Sources:
Lindeman, Eric, "US Navy Secretary defends biofuels programme", *Jane's Defence Weekly*, Volume 49, Issue 17, 25 April 2012, p.12.

Lindeman, Eric, "Senate restores biofuels to DoD bill", *Jane's Defence Weekly*, Volume 49, Issue 49, 5 December 2012, p. 11.

[12] For example, a few years ago, the USAF Office of Scientific Research commissioned the MIT to research whether and to what extent artificial photosynthesis systems are capable of storing energy for commercial and military purposes.
The MIT program, under the supervision of research leader Daniel Nocera, used cobalt as catalyst and phosphate as a proton acceptor, in order to develop a method for splitting water into hydrogen and oxygen molecules under ambient conditions.

Savage, Michele, "Photosynthesis Power", *Defense News*, November 3, 2008, p.24.

[13] For instance, Altair Nanotechnologies Inc., a company based in Reno, Nevada, completed the 500th full depth cycle of a new lithium-titanate battery it developed for the US Navy. The battery boasts very high energy efficiency in comparison to current ones and is expected to drastically reduce fuel consumption in modern-day ships. Tests revealed that the battery had only lost 1% of its capacity. In the future it is possible for similar or even more evolved super-batteries, combined with advanced systems of air-independent propulsion to be able to tremendously increase the autonomy of diesel-powered submarines, making them practically equal to nuclear-powered ones in terms of autonomy, in a wide range of tactical and partly strategic applications.

Savage, Michele, "New Batteries for US Navy", *Defense News*, September 29, 2008, p.16.

[14] For instance, the US MoD concluded a few years ago a contest intended to pave the way for the development of a 'wearable power pack' for infantry troops. The DuPont/Smart Fuel Cell (SFC) team beat off competition from the other two finalists that made it into the DoD Research and Engineering office's final shortlist, Michigan-based Adaptive Materials and Virginia's Jenny 600S. This was the Wearable Power Prize Competition to identify effective portable energy systems. The objective was to develop and the test a system weighing less than 4kg, capable of providing an average of 20 watts of power for more than 96 hours.
The million-dollar first prize was awarded to the DuPont/SFC team for the M-25 portable fuel cell system, which comprises a DuPont direct methanol fuel cell integrated by SFC. According to the manufacturers, the M-25 is approximately 80% lighter than traditional energy production systems, while being capable to provide power to a wide variety of devices, ranging from GPS systems to computers and battery chargers.
Furthermore, MIT researchers sponsored by the US Army Research Laboratory through the Institute for Collaborative Biotechnologies, used genetically modified viruses as templates for semiconductors and metals in controlled arrays, to create efficient miniature batteries that can be used in soldiers' gear.

Sources:
Hodge, Nathan, "US moves towards 'wearable power' for individual soldiers", *International Defence Review*, December 2008, p.22..

Savage, Michele, "Tiny Sensor Harvests Energy", *Defense News*, February 22, 2020, p.32.

Savage, Michele, "Virally Templated Batteries", *Defense News*, April 5, 2010, p.17.

Savage, Michele, "Greener Fuel Cells", *Defense News*, May 10, 2010, p.32.

Savage, Michele, "Mini Thrusters for Big Tasks", *Defense News*, March 29, 2010, p.16.

[15] The Paris-based International Energy Agency (IEA) in its World Energy Outlook (WEO) 2012 report states that 'the extraordinary growth in oil and natural gas output in the United States will mean a sea change in global energy flows'. The report was made public on 12 November 2012 during a press conference in London. In other words, the report maintains that the USA will achieve a significant degree of independence from international oil and natural gas flows in the near future, thanks to shale oil and gas, tar sands oil and technologies such as hydraulic fracturing and horizontal drilling, as well as thanks to the growing field of renewable energy sources. This fact could actually redefine military commitments on behalf of the US, thereby forging new regional dynamics that could recast one of the US military's principal missions: protecting Middle Eastern sea lanes.
Today, while the USA is already importing less than 20% of its oil from Persian Gulf countries and the rate is constantly dropping, China covers half of its needs in oil from these areas and the rate is constantly rising.
According to the report, although the OPEC will maintain its power, after 2020 (?) the USA will rise as the new net oil exporter, accelerating the switch in oil direction of international oil trade, with almost 90% of Middle Eastern oil exports being drawn by 2035to Asia, then to India and later on to Japan and South Korea.

Lindeman, Eric, "New energy flow direction could redefine US strategy", *Jane's Defence Weekly*, Volume 49, Issue 47, 21 November 2012, p. 8.

[16] Matthews, William, "US Military Expands Green Energy Campaign", *Defense News*, April 26, 2010, p.11.

[17] An older article, dating back to 2008, maintained that the US MoD was responsible for ca. 1% of the total energy consumed then by the United States, including both the public and private sectors. This means that US$13.6 billion were spent on approximately 100 million barrels of oil -that is to say roughly 300,000 barrels per day. This amount corresponded to the energy consumed by the entire State of Israel.

Cowan, Gerard, Harrington, Caitlin, "Adding fuel to the fire. As such a major consumer of energy, the US Department of Defense has been eager to secure supplies of energy at stable prices as well as look to alternatives", *Jane's Defence Weekly*, 26 November 2008, p.29.

[18] Matthews, William, "US Military Expands Green Energy Campaign", Defense News, April 26 2010, p.11.

[19] On the development of decentralizing methods of action in modern war theory, based on a scientific paradigm that places emphasis on the principles of Chaos

and Complexity, see: Bousquet, Antoine, *The Scientific Way of WARFARE. Order and Chaos on the Battlefields of Modernity,* Columbia University Press, New York, 2009.

[20] For information on the pertinent efforts, among others, see:

Lindeman, Eric, "USMC looks to man-portable technology", *Jane's Defence Weekly*, Volume 49, Issue 01, 4 January 2012, p.10.

Savage, Michele, "Sun-powered Field Gear" *Defense News*, 14 December, 2009, p.25.

Lamothe, Dan, "Corps Pushes For Better Portable Power Sources", *Defense News*, November 14, 2011, p.3.

Lindeman, Eric,. "US Army begins training on new 'tactical energy' systems", *Jane's Defence Weekly*, Volume 49, Issue 13, 28 March 2012, p.11.

[21] The combination of personal armor, equipment and other material often increases the weight carried by US troops today in Afghanistan to 45kg (100 lbs.). As a result, soldiers are worn down and suffer orthopedic injuries. A large part of the 20,000 soldiers removed from active duty is due to weight-induced damage.

Wasserbly, Daniel, "US looks to lighten the soldier's load", *Jane's Defence Weekly,* 18 February 2009, p. 8.

[22] A company working on the production of fuel cell portable battery chargers is Voller Energy Group, the designs of which have both civilian and military applications. Also MTI Micro is developing on behalf of the American military fuel cell systems using methanol.
In Europe, the German company Smart Fuel Cell (SFC) has designed the Fuel Cell Power System (FCPS), a high energy density direct methanol fuel cell (DMFC). The company's M500 fuel cell battery charger weighs a mere 0.47kg and is hot-swappable, while it measures 18cm x 8cm, which is particularly small. According to the company, their system will allow a weight reduction in the batteries carried by soldiers by 80% for missions of up to 72 hours. An even more advanced system is currently under development.
Additionally, the companies Protonex and Millennium Cell have developed and demonstrated a 'portable soldier power system' (P2) supplying 30W of power, for long duration missions. The system weighs 5kg and its manufacturers maintain that it can supply as much power as 14kg of batteries usually carried by an average American soldier on a 72-hour mission.
In late 2005, the US Army assigned a contract to Millennium Cell, in the framework of the SBIR phase I programs, to develop hydrogen battery technologies. According to the company, the 'Hydrogen on Demand' technologies under development can use salted water for the production of energy.
As regards the use of renewable energy sources for digitized foot soldiers, an interesting program is that of developing coin-sized micro-generators, using miniaturization technologies.

Bryant, Mike, "Power-hungry soldiers seek enhanced batteries and state-of-the-art fuel cells", *International Defence Review,* January 2007, p.55.

[23] DARPA signed a transaction agreement with Boeing, Chicago, for the phase II development and demonstration of the Vulture Flight Demonstrator. DARPA's support team includes AFRL and NASA.
The Vulture will develop and demonstrate the technology to enable a single high-altitude UAV to operate continuously on-station, unreplenished, for five years.

Savage, Michele, "Vulture Enters Phase II", *Defense News,* September 27, 2010, p.32.

[24] For instance, according to Tim Owings, US Army's deputy program manager for unmanned aircraft systems, in an interview with JANE´S DEFENCE WEEKLY on 16 April 2010, the US Army is pursuing the development of an entire family of unmanned aerial vehicles that will bridge the gap between the tactical UAV RQ-4 Shadow and the smaller RQ-11 Raven. Two of them will be developed by Aerovironment and will be based on the Wasp. In 2008, this aerial vehicle achieved a 9-hour flight, using a fuel cell battery hybrid propulsion.
In another attempt, on 16 and 17 November 2009 at the Aberdeen Proving Ground in Maryland, the US Navy's Ion Tiger small experimental aerial vehicle set a new flight duration record for hydrogen fuel cell aerial vehicles, by staying airborne for 26 hours and one minute. The fuel cell engine it is equipped with is built by Protonex and is considered the most efficient in this size category and is capable of producing 550 watts of power. According to the manufacturer, the hydrogen engine produces seven times more energy than that supplied by batteries of an equivalent weight and four times that of an internal combustion engine. The aerial vehicle is exceptionally silent and has a minimal thermal signature, rendering it very difficult to detect.

Sources:
Harrington, Caitlin, "US Army to expand its UAS capabilities", *Jane's Defence Weekly,* 28 April, 2010, Volume 47, Issue 17, p.11.

Matthews, William, "Ion Tiger's Feat of Endurance for US Navy. UAV Takes Fuel-Cell Technology Far, But Not Far Enough", *Defense News*, November 30, 2009, p.24.

Hewish, Mark, "Micro air vehicle flies under fuel cell power", *International Defence Review*, July 2003, p.21.

[25] The nuclear reactors proposed for the program in question by Hyperion Power Generation would have an estimated width of 3ft. and a height of 8ft. They were of modular design and their projected weight amounted to approximately 20 tons, while their cost would be roughly US$50 million per unit. Their small size and weight would render them easy to transport by train, road or on river barges. The factory was supposed to ship them in sealed steel containers, to be installed in concrete vaults.
They would use enriched uranium nitrides and produce 25MW worth of thermal energy, generating enough electricity to power 20,000 households. Their lifespan would be of ten years, after which they would be decommissioned. They would remain closed throughout this period for safety reasons. "Like you don't open a double-A battery, you just plug [the reactor] in and it does its chemical thing inside of it. You don't ever open it or mess with it", to quote Deborah Blackwell, a vice president of Hyperion Power Generation.
During its ten-year-long lifespan, the reactor was expected to produce nuclear waste the size of a basket ball, which, as soon as the reactor "died" and was opened up, would be recycled and reused.

Matthews, William, "The Nuclear Option. Are New, Small Reactors Answer to US Military's Power Needs?" *Defense News*, February 15, 2010, p. 16

[26] Lindeman, Eric, "US DoD gets good grades for clean energy initiatives", *Jane's Defence Weekly*, Volume 48, Issue 39, 28 September 2011, p.10.

[27] It would probably not be groundless to assume that the excess of hydrocarbons might allow the US at some point in the future to become even an exporter of natural gas to China, thereby further increasing the interdependence between the two countries and confirming the 'Chimerica' neologism coined by Niall Ferguson and Moritz Schularick to describe the symbiotic relationship between them and increase the former's control over the latter. Additionally, they would also reduce China's dependence on Iranian natural gas and oil and limit the risk of witnessing the creation of a Beijing-Tehran geopolitical axis, further curtailing the Iranians' role. Therefore, a second energy layer, comprising green energy technologies might allow the US to reduce their domestic consumption of hydrocarbons, resulting in converting their energy autonomy into a surplus, consequently influencing other countries in the world, including China.
On the other hand, it is by no means certain that China would be happy should it become an energy hostage of the USA. Therefore, it is quite possible that it would be led to seek alternative sources of hydrocarbons on the planet, in an attempt to create a more pluralist market but also to develop its own green energy infrastructure.

[28]Minnick, Wendell "US Report Accuses China of Cyber Warfare", *Defense News*, December 8, 2008, p.22.

[29] On the philosophy of action of the Iranian Revolutionary Guard Corps Navy (IRGCN) see: Binnie, Jeremy, "BRIEFING Iranian naval forces. Gulf guerrillas". *Jane's Defence Weekly*, Volume 50, Issue 6, 6 February 2013, p.p. 34-40.

[30] On the capabilities of these projectiles, see: Jennings, Gareth, "Rafael debuts Spike NLOS system", *Jane's Defence Weekly*, 10 February 2010, Volume 47, Issue 6, p.10.

[30] Opall – Rome, Barbara, "Rafael Unveils New Spike Missile", *Defense News*, December 7, 2009, p.14.
White, Andrew, "Rafael unveils Spike NLOS", *Jane's Defence Weekly*, 9 December 2009, p.16.

[30] Opall – Rome, Barbara, "Israel Builds Infantry-Focused Combined Arms Combat Force", *Defense News*, June 14, 2010, p.29.

[30] Rodan, Steve, "IAF integrates Nimrod missile with Sea Stallion", *Jane's Defence Weekly*, 9 January 2002, p.15.

[31] For instance, large war technology companies, such as Lockheed Martin, are constantly seeking increasingly sophisticated ways to achieve new methods of producing and saving energy. Piezoelectric crystals and nanowires can convert the hum of an electric motor, for example, into electric power. Conceivably, the same can happen using the sound of the human voice.
Furthermore, special antennae may harvest radio waves and convert them into electricity. The same principle may be used in harvesting the heat escaping from a vehicle's engine, as well as the electromagnetic field created around high-voltage power lines, but even with the heat produced by the human body. This "recyclable" energy may be a very promising field of research.

Lockheed Martin is now cooperating with Infinite Power Solutions, a small, Colorado-based company specializing in clean energy (as is characteristically stated in the Defense News article, whence this information was retrieved), so as to develop tiny long-lived energy sources for both military and civilian applications.
Similar sources may provide electric power of mere milliamperes and milliwatts, i.e. tens of thousands less energy than is required to power a light bulb. However, this energy may be sufficient to power autonomous, wireless, miniature sensors, a most useful feature for military applications.
Similar miniature sensors could detect chemical weapons, report gunshots and sense vibrations from oncoming vehicles, according to Tim Bradow, vice president of business development and technical marketing for Infinite Power Solutions.

Matthews, William, "Harvesting Energy. Stray Sounds, Waste Heat, Radio Waves Promise Power for Military", *Defense News*, February 2, 2009, p.16.