# A New Energy Paradigm for the Twenty-First Century

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**Summary**

Conventional energy security has been focused on the depletion of natural resources, particularly oil, natural gas and coal resources. More recently, the link between energy security and the military has been made, focused on the defence of international oil tanker chokepoints and the free flow of oil through these trade routes. In the paradigm outlined in this paper, the impacts of climate change have been realized far earlier than most experts expected. This has promoted a transition to cleaner energy technologies long before the depletion of fossil fuel resources. In this scenario, the peak in demand for fossil fuels occurs before the peak in supply and some nations are strongly promoting the development and deployment of clean energy technologies. Some private companies that are well on their way to developing and deploying these technologies will benefit from sudden market expansion, fuelled largely by the world's richest nations struggling to reduce their carbon footprint.

The countries of the world will fall into one of the three categories: (1) the countries willing and able to combat climate change, (2) the countries willing, but unable to combat climate change due to the perceived opportunity cost, and (3) the countries unwilling to combat climate change. In this scenario, the Western Economies will likely fall under the first category. Other key players include the BRIC countries (Brazil, Russia, India, China). These nations are needed in the first category to achieve a viable, powerful, and effective Clean Energy Alliance. The focus will fall on the counties in the second and third categories. The Clean Energy Alliance will need to exercise its economic and political influence to promote, among other things, clean energy technology development and licensing arrangements for the countries in these two categories. In the scenario presented here, however, the cost of fossil fuel based energy may fall due to the high supply and low demand condition, making it difficult for some countries to choose the more expensive path to combat climate change. Some countries will fall into the third category.

One could imagine a worst-case scenario where recalcitrant states that continue to destroy the planet are embargoed and sanctioned by the international Alliance. The capabilities and responsibilities of the Alliance will be decided by the severity of the climate crisis and the perceived need to address the crisis within each member state. In today's world, human rights infractions are unacceptable and are judged and punished on an international stage. In the scenario presented here "climate crime" might be considered an infraction that elicits this sort of intervention.

## Introduction

Energy Security has returned to the top of the international agenda in ways not seen since the oil embargoes of the 1970s. The Russian government, when for the first time hosting the G8 in St. Petersburg in July 2006, put energy security centre stage giving it an international prominence not seen in recent years. Ironically, leading up to the Summit, the country posing the paramount energy security threat to the EU was the one putting the issues at centre state. Rising global energy prices, growing demands for energy in China, conflicts in Africa and the Middle East, and natural disasters constraining the alright tight oil supply is making it difficult to avoid the issue of energy security. Such thinking prompted President Bush, in his 2006 State of the Union address, to highlight the obvious by saying that "America is addicted to oil" [1].

Energy security has been framed primarily around availability and access to fossil fuels. Interruption of the energy supply has been identified by many as the primary threat that faces global energy security. In an era of global terrorism, Daniel Yergin revealed that al Qaeda has openly committed to attacking "the provision line and feeding artery of the crusader nation" [2]. This example is representative of one driver for a fresh perspective on energy security – the perspective of energy and security; both national security and military policy. This is the nexus explored in this paper.

Oil literally fuels the global economy. Both the United States and Japan, as examples, can be used to highlight the potential threat of energy security. With only $1/20^{th}$ of the world's population, the US consumes almost 1/4 of the world's oil and has less than 3% of the world's proven oil reserves [3]. The United States is critically dependent on this imported commodity. Even though the US imports more than 60% of the oil it consumes [4], Japan is more vulnerable to potential instability because it imports more than 90% of the oil it consumes [5]. In addition to the energy security risks associated with a substantial dependence on oil imports, the oil import bill is becoming an increasingly important factor in the trade deficits of G8 countries and in some cases these funds are used to support unfavourable regimes. This situation is further complicated by the artificially low cost of energy in some countries, such as the United States, where the government has not properly reflected the true cost of energy in its price. These are the so called negative externalities, such as environmental impact and costs associated with securing and maintaining access to energy supplies.

At the end of 2005 British Petroleum placed proven world oil reserves at 1.2 trillion barrels [4]. Even if no further probable reserves are classified as proven, which is extremely unlikely, and an increase in energy efficiency offsets some of the increase in consumption associated with an expanding global economy, the proven reserves can be expected to meet our needs (80 million barrels per day, rising to 119 million barrels per day by 2025 [6]) for the next 30 or more years without any transition to alternative feedstocks. This conventional thinking, whereby the peak in supply will come before the peak in demand, was postulated by M. King Hubbert in the 1950's [7]. Such thinking posits that 'peak oil' exists and that once past the peak, oil supply will decrease, prices will rise, demand will fall and innovation into alternatives will occur. Experts, such as M.A. Adelman, suggest that the peak oil hypothesis and the notion that the world faces a serious reduction in oil reserves is flawed [8]. The peak oil hypothesis, neglects, among many things, the vast reserves of unconventional oil available in the form of tar sands. For example, bitumen (mined from tar sands) in Alberta, Canada is technically challenging to convert, but these unconventional reserves are huge, estimated to

be on the order of ¼ trillion barrels [9]. In addition, these reserves are highly profitable. In 2006 Shell reported that synthetic crude, made from bitumen, generated a post-tax profit of nearly $22/barrel, approximately $10/barrel more than Shell's average profit per barrel of crude [10]. Sustained high oil prices will continue to drive exploration and development in Alberta's tar sands.

Rather than face a peak in supply it appears that we will always have access to oil, if we want it. A more sophisticated assessment leads one to the notion that there could be a peak, but that it will be a peak in demand not supply, or to be more precise the peak in demand will come before the peak in supply. This position has been popularised via the aphorism attributed to the former Saudi Oil Minister Sheikh Zaki Yamani when he reportedly said "the stone age did not end for lack of stone, and the Oil Age will end long before the world runs out of oil" [11]. This assessment lies behind the paradigm shift to be presented later in this paper.

Much of our international geopolitical energy security is locked in the orthodox mindset that tells us that our efforts in commerce, diplomacy and military power must be devoted to keeping open the global trade in fossil fuels until eventually they run out [12]. The timescale of the collapse of this endeavour being measured in terms of the depletion of fossil fuel energy reserves, on a timescale of the next 30 or more years.

The 2006 UK Energy Review summarised this current prevailing attitude to the challenge of global energy security when it said on page 19: *"We need …a strong international agenda to promote more open and competitive markets"* [13]. The UK DTI Energy White Paper 2007 continues the sentiment of the 2006 Energy Review stating on page 35 [14]:

> *1.22 Our international strategy is built [on …]:*
> ***1. Promoting open, competitive energy markets*** *which provide fair access to energy supplies, foster investment throughout the energy supply chain and deliver diverse, reliable supplies at competitive prices. Governments are responsible for establishing the market framework, based on clear, stable and non-discriminatory rules, and for the effective regulation of the market. Effective markets will ensure that the world's finite natural resources are used in the most efficient way and ensure that we make the transition to a low carbon economy at least cost. Governments also have a role in planning for contingencies (such as major disruption to supplies), where markets alone would be unable to manage the impact.*

As shall become clear, this paper presents a radically different paradigm for the future.

The major international oil companies are today dominated by concerns for their reserve replacement ratios on which their share prices depend. This concern has led oil majors to maximise their holdings of *equity oil*. This practice appears wholly unsustainable and begs a question: When and how will this end?

On an even shorter time-scale, the strategies of companies that develop energy technologies are greatly influenced by government regulations (US sulfur emissions cap-and-trade, EU Emission Trading Scheme, etc). As a consequence, technology development is sometimes spawned after or during government legislation, which results in a significant lag between the legislation and the technology entering the marketplace.

Consideration of energy security in the context of global climate change has until recently been somewhat naïve and uncritical, overshadowed in EU by pipeline politics with Russia and overshadowed in the US by rising oil prices and strained relations with the Middle East.

Perhaps in part this is because those concerned for ecological stability and those concerned for geopolitics and defence are sometimes not amiable acquaintances. However, circumstances are changing and influential reports are appearing concerning the impact of fossil fuel combustion (via climate change) on energy security. For instance one such example is the International Energy Agency's recently published report entitled *Energy Security and Climate Policy – Assessing Interactions* [15]. Also, and as mentioned previously, the new *energy and security* approach leads one to consider the relationship between energy security and national security. One example in that space is the suggestion from a recent US Council on Foreign Relations independent task force chaired by John Deutch and James Schlesinger that the United States must "*integrate energy issues with its foreign policy"* and that the US must "*transition to an economy that relies less on petroleum"* [16]. This paper explores the notion that in the decades to come foreign policy backed by military force might, for reasons of a climate change crisis, be used to militate against unconstrained fossil fuel combustion. There have been few voices of leadership thus far in this direction, but the recent words of Governor Schwarzenegger of California are noted with interest:

> *I believe in free trade, and I believe that it lifts everyone's standard of living. But eventually we will look at those countries that produce goods without regard to the environment the same way as we look at countries that produce goods without regard to human rights …such as those who allow sweatshops. My guess is that within the next decade or so, if an economy ignores the damages that it's doing to the environment, the civilized world will impose environmental tariffs, duties and other trade restrictions on those countries. This is a matter of fair trade. Nations cannot dump their products, and one day in the near future, they will not be able to be allowed to dump their carbon or their greenhouse gases either. It gives them an unfair advantage*
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> 12 April 2007 meeting of the Council on Foreign Relations [17]

**New Technologies Are Essential; a US case study**

Advancements in technology will be the only way the human race will discover sustainable, renewable, safe, low-cost, and secure energy sources. There will be no single technology, but rather a combination of many technologies that collectively meet the globe's energy needs. Much of this innovation will originate in the most developed economies. The development and deployment of these technologies will be driven by both naturally emerging market conditions and markets created by government policy.

One example of such an innovation will be the path to commercial deployment for Integrated Coal Gasification Combined Cycle (IGCC) electricity generating plant. This is an advanced technology, driven not only by US government policy, but also by the prospect of higher thermal efficiencies as compared to conventional Pulverised Coal (PC) plants. IGCC is well suited to the later deployment of carbon capture and storage (CCS), providing the possibility of continued coal combustion consistent with climate-friendly action. Despite the expected higher thermal efficiencies, IGCC with CCS will be a significantly more expensive way to generate electricity than simple and conventional PC plant in those jurisdictions where there is little or no value for greenhouse gas emissions.

In a climate change constrained economy, CCS offers a unique opportunity drastically to reduce carbon emissions and enable many coal-rich countries to consume their vast endowments; estimated in the US to last 250 years at the current level of consumption [18]. Electricity generated from coal represents the largest share of US power generation and is a fuel with strong energy security benefits, sourced from many States. Another technology that offers increased energy security in the United States is the plug-in hybrid vehicle (PHEV). In

the US, the PHEV creates an opportunity to "fuel switch" from gasoline, refined from imported petroleum, to electricity, generated from domestically sourced coal.

In a world incapable and/or unwilling to reduce its carbon footprint, the energy security benefits of increased coal use could be outweighed by a catastrophic climate tragedy. Pulverized coal plants are popping up in China at a rate of two 500MW coal-fired power plants each week [19]. The availability of IGCC and CCS technology will not only offer China a solution for improving its dreadful air quality, but also allow China to constrain its carbon emissions. Widespread deployment of IGCC could be on the order of less than 10 years, while penetration of CCS technologies may be as many as 20 or more years away. But the technology development is in the earliest of stages and could be accelerated by US policy that promotes cleaner coal technologies. In the case of Plug-in hybrid vehicles, technology development is underway, but widespread adoption and significant penetration of the technology is at least 10 years away.

In many cases, the timescale of technology development and widespread deployment is typically longer than 10 years, even with significant government incentives and market demand. The shift in public opinion needed to enable greater government support of clean energy technologies could occur months or even years in the future. When the shift finally occurs, it could occur sooner than the timescale of technological innovation. In the event of a climate catastrophe the world could find itself scrambling for a solution.

**Three Timescales**

The three timescales critical to the paradigm shift described in this paper are: (1) natural resource depletion, (2) climate change, and (3) technology deployment. The first timescale is the slow timescale of resource depletion (given current emphasis on oil and gas this is conventionally expected to be somewhere in the second half of the twenty-first century). The other two timescales to be considered are the timescales of climate change usually regarded as somewhat more than 50 years and the third is the timescale associated with technological innovation and substitution. Conventionally this third timescale is predicted to be around 20 years. While, of course, it is spurred by external drivers from, for instance, energy security or climate change there are certain incompressible factors, for instance human resources and training. Generally speaking, the resource depletion and climate change timescales are thought to be broadly similar, and as both are regarded as lying a long time in the future, there is usually no incentive to examine the details or to adjust consideration of energy security policy from that which would be arrived at from a consideration of resource depletion alone. We assert that much policy for energy security, perhaps incorrectly, relies on resource depletion as the pacesetter rather than climate change.

The energy security paradigm differs from the conventional "energy and security" paradigm presented earlier and as highlighted in the recent eponymous book edited by Kalicki and Goldwyn [20]. The purpose of this paper is to propose an alternative and perhaps somewhat disconcerting vision for the future of global energy and security. The plausible paradigm shift described here is not a prediction of the future, it is merely one possible future in a world trajectory popularised by James Lovelock in his polemical but persuasive book, *The Revenge of Gaia* [21]. One could imagine this paradigm emerging in a world that is initially slow to address climate change, and which is then triggered to act by a growing awareness of a crisis far more serious than has previously been expected. In the 20-30 years of merely moderate interest in addressing climate change, the world would experience sustained high world oil

prices, and a technology push and market pull to develop technologies that will enable clean, safe, low-cost and sustainable energy production. In such a scenario it will be the changing timescales of climate change that will drive innovation and technological substitution not the timescale of fossil fuel resource depletion. Climate change might eventually be sufficiently pressing that innovation will not be able to occur easily and with sufficient speed to allow our society to transition away from dirty fossil fuel combustion in vehicles and in electric power generation to cleaner, more sustainable energy production. There will be no shortage of fossil fuels, but the way in which society uses these fuels will be very different than today.

The paradigm differentiates between those countries that are ready, willing and able to shift away from dirty fossil fuel combustion in the absence of the threat of resource depletion, and those countries that are not ready, willing or able. Furthermore, some private companies will be able to deliver the energy technologies that are needed in a carbon-constrained economy. Some companies are committed to and are already making significant returns on clean energy ventures, such as wind and solar power, and cleaner coal IGCC. This type of response from private industry has appeared to be visionary in today's business world. It is these types of companies that will benefit if the scenario presented here emerges. At the outset of significant carbon policy, these few companies will experience additional, unprecedented demand for their products. These companies will meet the demand of countries that have accepted the need to constrain their carbon emissions and are willing to pay to do so. Clearly this list must include the nations of the European Union, the United States, Canada, Japan and Australia.

In the United States there has been a reluctance to formalise federal requirements to reduce greenhouse gas emissions, however the Administration is slowly recognizing the need to act. The timescale of such a transition in attitude at the national level is surely much smaller than any of the three timescales referred to earlier. The Presidential election in 2008 will be an important step in the anticipated process of transition, though challenges remain: the US relies heavily on coal-fired electricity generation and has a history of favouring domestic policies, such as sulphur emissions trading, over international agreements, such as the Kyoto Protocol. The countries referred to in the previous paragraph are needed in the scenario presented here, though their efforts alone are not sufficient.

The countries of central concern are another block of nations, called the "BRIC" – Brazil, Russia, India and China. These powerful, rapidly developing geopolitical powerhouses must be advocates of action against climate change if the planet's climate is to be stabilised. These countries must be persuaded to adopt the clean technologies urgently developed by the richer countries in the former group. Favourable economics, national equity in the investment and a desire to address poor air quality should help motivate these countries to adopt clean energy technologies. It will be necessary for these countries to subscribe to international best practice. The paradigm makes this optimistic assumption, because if the optimism is misplaced, Professor Lovelock could be correct with some of his more pessimistic predictions.

**BRIC; the Critical Nations**

Global energy consumption is being driven by soaring demand in Asia. In 1970, Asia consumed 15% of the total global energy consumption. In 2000, Asia consumed 27%, and it is expected that Asia will consume 35% by 2030 [5]. Since 1995, the number of cars in China has almost tripled and it is expected that there will be more than 50 million cars in

China by 2010 [22]. Soaring consumption is leading China to purse oil production beyond its borders in the Middle East, Russia and Africa [23]. In Russia, the story is somewhat different. Russia is the world's second largest exporter of crude oil and holds the world's largest reserves of natural gas [23]. This gives Russia enormous political strength through its state-owned pipelines, oil companies, and gas companies. Competition for Russian energy supplies is fierce. Russia is acutely aware of the opportunity provided by China and other Asian economies for its gas exports. In India and Brazil, rapid economic growth is fuelling demand for energy, however these two countries hold greater potential for different models of energy production. Brazil is widely known for its prospering sugarcane ethanol industry that emerged from significant government investment over the past decades [24]. India's largely rural population holds potential for distributed generation systems, being fed by renewable energy sources, such as biogas produced from the anaerobic digestion of animal waste and distributed solar Photovoltaics. As Brazil and India's energy demand soars—to meet the growth of their economies—early adoption of renewable energy alternatives will initiate best practices in these nations. These four nations not only represent a large proportion of the human race, but also the future centres of energy demand.

In a world where the peak in fossil fuel demand occurs before the peak in supply, the price of fossil fuels may fall to the point where one of two things may happen: (1) BRIC countries may opt for the same cheap fossil fuels that rapidly grew Western economies over the past century, or as is considered in this paper (2) BRIC countries may be persuaded to join the alliance of clean consumer nations, using technologies issued under favourable licensing terms. It is even possible that a decrease in demand from the Western economies (including the BRIC states) might hurt the economies of some producer regions, fueling further political stability and potentially even undermining OPEC, where six of the eleven OPEC countries (Saudi Arabia, Iraq, United Arab Emirates (UAE), Kuwait, Venezuela, and Iran) hold two-thirds of the total world oil reserves [5].

Even if the BRIC countries are on-board, the future is not assured, and it is in this way that we finally arrive at the paradigm that prompts our interest. There are many countries not named above whose actions will also be important. The participation of these countries is not directly vital to global climate stability, as is the case for the BRIC nations, but nevertheless the contribution of countries in this third group is important to global climate and also to ensure that these states do not enjoy undue economic advantages as a result of favourable market conditions (relatively low cost fossil fuels) that promote dirty practices.

For the sake of argument, Indonesia can be taken as an example of a country that might find itself in this third group. In 2002 Indonesia created 40% of all anthropogenic carbon dioxide emissions through deforestation [21]. Indonesia is, and of course will continue to be a sovereign state. Today it has the right to combust imported and domestic fossil fuels in any way it chooses. Importantly in December 2007 Indonesia demonstrated positive leadership hosting the UN Framework Convention on Climate Change in Bali. Some nations, however, may opt to not follow the clean consumer nations. These countries will benefit from the low cost fossil fuels brought about by falling demand. For these nations to join the clean consumer nations, clean energy technology solutions will have to be cost competitive with current energy production. It is our hope that Indonesia, and States like it, would choose voluntarily to join the group discussed earlier, but it will be inevitable that some states choose not to join others in adopting the best practice. The decision to join will rely on many factors, including the political climate and the severity of the climate crisis.

**The Clean Energy Alliance**

In this paradigm the 2030s will see a world very different from the world we enjoy today, and that will not be simply as a consequence of the eroding climate. Globalisation will have led to an increased internationalisation. Intervention by the great powers in the affairs of lesser powers might be commonplace with, or without, the gloss provided by endorsement from the United Nations. Intervention might occur to prevent genocide, to protect the rights of women and children, and even to prevent 'climate crime'. Those recalcitrant states that obstinately refuse to transition from dirty fossil fuel burning technologies to cleaner technologies will risk facing military-backed embargoes. The great powers at the heart of the collective action will protect their own economic and environmental security by constraining the energy policies of others via foreign policy and military action. In such a scenario international fossil fuel trade will require a robust system of permits with, for instance, end-user certificates (perhaps not unlike those used for munitions shipments today) indicating that the cargo carried is indeed to be used in a qualified clean combustion system such as the named IGCC power plant with CCS. Somewhat different tactics would be required to constrain pipeline shipments and most difficult of all would be attempts to constrain domestic fossil fuel use in local power plants. Nevertheless international permitting would send a powerful signal of the international community's attitude to recalcitrant states that persist irresponsible behaviours. The countries that subscribe to the principle of a prompt transition from fossil fuels to cleaner technologies and favour fossil fuel trade constraints would form the membership of the proposed Clean Energy Alliance.

A Clean Energy Alliance conjures up ideas of a NATO-style military alliance to ensure the stable flow of energy resources around the globe and/or an OPEC-style consumer (instead of producer) alliance that operates as a "counter-cartel of consumer nations." [25] An energy alliance that brings some of the principles of both alliances could open a dialogue between counties to identify common energy security interests and to develop joint military planning in order to secure energy supplies. The Clean Energy Alliance could share the burden of military costs and provide a common voice for members of the Alliance. The mechanism for engagement (i.e., the United Nations, the G8, NATO, OECD, etc) and the degree in which nations are committed will emerge based on the severity of the climate crisis. In the case of a severe threat, one could envision a world in which nearly all citizens share a common desire to accept relatively slight economic penalties (higher taxes, higher fuel costs, etc) to address climate change.

Such an alliance could also be responsible for international policy for defending global oil tanker chokepoints (Straits of Hormuz between Oman and Iran, through which most Gulf oil is exported, and the Straits of Malacca between Malaysia and Indonesia, through which 80% of Japan and South Korea's oil imports are transported) (see [26] in [12]), monitoring critical energy infrastructure, training local soldiers, co-ordinating energy terrorism intelligence, protecting international companies and their employees, and managing the response to energy crises. Thus far the cost of securing the energy supply has largely been borne by the US military; one of the few organizations capable of completing such a task from an operations and cost standpoint [12]. The Institute for the Analysis of Global Security reports that the cost of defending the sea lanes of communication and providing military assistance to partners in oil supplying nations costs the US $50 billion per year [27]. The contribution of the US military to securing global oil supplies is clearly substantial, but equally important may be the opportunity cost of these military efforts. While a move to constraints on fossil fuel shipments might appear burdensome it should be remembered that the vast majority of shipments would

proceed unimpeded. Secondly any concern that costs of such a future scenario might be unmanageable should be compared with the high costs associated today with military and foreign policy support of the current situation.

**An Historical Parallel**

From the supply side, transitioning to cleaner energy technologies such as IGCC with CCS, wind power, solar power, plug-in hybrid electric vehicles, and sustainably produced biofuels will be a gradual process. Similarly, from the demand side, increasing vehicle fuel economy, energy efficiency and energy conservation will also be a gradual process. The rate at which we transition away from fossil fuels will be driven by the economics of these, and other, cleaner technology alternative. However, the process of weaning ourselves off fossil fuels will be accelerated by any identifiable environmental impact that can be unequivocally attributed to climate change. Drought, flooding, and hurricanes could prompt recessions. Death and destruction will know not differentiate between members and non-members of the Clean Energy Alliance. Private companies and governments who are accepting of this paradigm, and who are prepared for this transition, will fare better than those who are unprepared. The aftermath of a climate change catastrophe will have two routes. If BRIC countries were to join the alliance of cleaner consuming nations, change may be rapid. If BRIC countries do not join the alliance then the future is very uncertain.

The scenario described here is presented from the fear that perhaps it may unfold. Some will counter that such a strategy is impossible because of its sheer hypocrisy. How can these great powers that currently use their navies to keep open fossil fuel trade routes, re-deploy their forces within a generation to enforce a constrained fossil fuel economy? How can we imagine such a volte-face in good conscience? Let us examine history for a possible parallel. One such possibility comes from the late eighteenth and early nineteenth century when, arguably, Britain was the world's only superpower.

In the late eighteenth century the Royal Navy had many functions including keeping open the trade routes for what was to become the British Empire. An awful truth is that much of this power and finery was deployed to maintain the unconscionable trade in African slaves – innocent individuals ripped from their homelands, demeaned and sold into the hands Caribbean planters who treated them most cruelly. Within a generation, however, this trade was gone. Britain closed down its transatlantic slave trade first with a domestic ban on slavery and finally and much more importantly across British dominions. Slavery had made Britain rich and indeed it exhibits certain hypocrisy that the UK then pressured others to leave the trade. Despite the hypocrisy it was most definitely the only right thing to do.

The British slave trade of the late Eighteenth Century had made many people very rich, whole cities in the UK such as Liverpool had developed on the back of the trade. Western powers did not conquer or colonise the African supplier states, instead negotiated and bribed intermediaries in order to access the scarce resource. Generally, there were only modest European investments in direct infrastructure, for instance in African forts. Naval protection, however, was of key importance for the viability of the British Slave trade. In particular Royal African Company forts and assets had been protected by Royal Navy warships at the request of the company [28].
In considering this possible historical parallel it is important to note that the abolition of slavery was accompanied by redefinition of British identity as a free civilised society. Key parts of the history of abolition include the acts and battles leading up to 1811, when it was

made a felony to participate in the slave trade [29] [30]. Importantly in the period 1807-66 the Royal Navy intercepted more than 500 slaving vessels. Enforcing the shutting-down of the Atlantic slave trade was costly and tied up significant naval resources. The slave trade continued beyond Britain's borders. The United States finally abolished slavery in 55 years later, in 1865.

The story of Britain's *volte-face* on slavery serves, perhaps, as a helpful analogy for the severe climate change-initiated paradigm described in this paper. The world's largest economies have become rich from the unsustainable use of fossil fuels. It will be the duty of these same countries not only to alter their own behaviour, but also to stop others from continuing with the same unsustainable actions. A move to such a future must be built upon consensus and persuasion, but as is explained here, for the recalcitrant few, coercion may be an unfortunate necessity.

## Concluding Remarks

If climate change is as severe and as pressing as some fear, leadership will be needed from those nations who are most capable of responding to the crisis. Within a generation, in the early twenty-first century, the superpowers might find themselves shifting from keeping trade routes open to constraining the same trade. The timescale of serious climate-change could be short and even approach the timescale of technological innovation. Short timescales of twenty years not only apply to the invention, development, and deployment of new energy technologies, but also to the time it takes to plan and build up new military technologies and infrastructures. The purpose of the preceding description is to remind the reader that our world may need new military and foreign policy options as well as new energy technology options in the years to come.

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