Is wartime mobilisation a suitable policy model for rapid national climate mitigation?

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Abstract

Climate science suggests that, to have a high probability of limiting global warming to an average temperature increase of 2ºC, global greenhouse gas emissions must peak by 2020 and be reduced to close to zero by 2040. However, the current trend is heading towards at least 4ºC by 2100 and little effective action is being taken. This paper commences the process of developing contingency plans for a scenario in which a sudden major global climate impact galvanises governments to implement emergency climate mitigation targets and programs. Climate activists assert that rapid mitigation is feasible, invoking the scale and scope of wartime mobilisation strategies. This paper draws upon historical accounts of social, technological and economic restructurings in several countries during World War 2 in order to investigate potential applications of wartime experience to radical, rigorous and rapid climate mitigation strategies. We focus on the energy sector, the biggest single contributor to global climate change, in developed and rapidly developing countries. We find that, while wartime experience suggests some potential strategies for rapid climate mitigation in the areas of finance and labour, it also has severe limitations, resulting from its lack of democratic processes.

Keywords: climate mitigation, wartime mobilisation, non-technical aspects, energy transition

1. Introduction

The German Advisory Council on Global Change (WBGU) calculates that, to keep global warming less than 2ºC above preindustrial temperature (which may not be safe) with a probability of 67%, global greenhouse gas (GHG) emissions would have to peak by 2020 and reach zero by 2040 (WBGU, 2009: Fig. 3.2-1). If the peak occurs after 2020, the maximum reduction rate would have to exceed 9% per year, an almost impossible challenge in the absence of widespread economic collapse. Thus we are living in the critical decade, in which we must turn around the current warming trajectory, which has 'roughly a 20% likelihood of exceeding 4ºC by 2100 and a 10% chance of 4ºC being exceeded as early as the 2070s' (World Bank, 2012:1). Climate mitigation must be an urgent, rapid and effective transition.

This paper is motivated by the need to develop contingency plans now for possible future emergency climate mitigation responses. Considering that these responses entail the mobilisation of a huge volume of resources, we explore the extent to which emergency strategies could be devised reflecting the scale and scope of mobilisation for World War 2 (WW2). To set the rapid mobilisation scenario in motion, we consider a hypothetical sudden major global climate impact that could galvanise governments around the world to take rapid actions. Such an event could be, for example, a sudden global sea level rise of about 2 metres caused by the collapse of part of the West Antarctic Ice Sheet, which is currently being undermined by ocean surface temperatures several degrees warmer than a few decades ago and is losing mass at an increasing rate (Vaughan, 2008:72-76; Rignot et al., 2011). In addition to the already expected emergency adaptation efforts from governments (which is important in addressing immediate threats but is beyond the scope of this paper), the scenario has governments of developed and rapidly developing countries—all OECD countries and newly industrialised countries such as Brazil, India, China and South Africa—agreeing to achieve a global target of close to zero emissions from the energy sector in 25 to 40 years. This international context is a vital component for rapid mitigation, especially in setting up the stage for deep national emission cuts, either in the form of a strengthening of the Kyoto Protocol or as an entirely new protocol. On the assumption that this agreement is quickly forged and places strong targets on all developed and rapidly developing countries, this paper addresses actions at the national level. The focus is on the energy sector—the largest contributor among other GHG sources. In this scenario, technologically advanced countries and countries with substantial renewable energy resources would be required to achieve zero emissions within a period of 25-30 years and substantial excess renewable energy capacity for international exports within 40 years.

The argument that rapid climate mitigation needs economic restructuring of the scale and rapidity as seen in wartime has been used in recent discourses by scientists/academics (eg, Le Quéré 2012; England 2012), politicians, both current and former, (eg, Gore 2008) and climate/environmental activists (Brown 2008; Wright and Hearps 2010) as a policy model for rapid response to climate change.

Although the use of the wartime experience as a model for rapid mitigation has been discussed in the scholarly literature, the treatments are few in number, brief and are scattered into various strategies. A general application of this approach dates back to 2001 when Bartels (2001:229) argued how Canadian war mobilisation programs could be best applied in a case when ‘a widely-perceived increase in the frequency of extreme weather events leads to massive political support for an international effort to reduce GHG emissions’ through rapid production of renewable energy technologies (RETs) and non-methane foods. Delucchi and Jacobson (2011) referred to the rapid mobilisation of war technology in the 1940s, especially in the USA, to bolster their case for a similar rapid mobilisation and deployment of wind, water and solar power technologies on a global scale. Gilding (2011:125) further extends this generic climate-war narrative with the establishment of an international ‘crisis response plan to motivate government policymakers to dedicate adequate resources to a comprehensive version of such a plan, even if it was just a contingency.’ Similar to our scenario, these approaches also recognise that emergency strategies will be more likely to be driven by an event (or series of events) that imposes clear, acute and direct evidence of catastrophic effects of climate change -- a situation that shakes governments out of the Boiling Frog syndrome (i.e. an apt metaphor for their inability to react rapidly to gradually occurring changes in climate). While the plausibility of rapid production and mobilisation of sustainable energy technologies in the magnitude and speed of wartime mobilisation and deployments has been mentioned in these references, the treatments are brief (eg. Delucchi and Jacobson, 2011; Brown, 2008). Moreover, the focus has been on the plausibility of rapid mobilisation in quantitative terms, while omitting to discuss the required strategies for labour, finance and governance for this emergency transition.

This paper primarily seeks to investigate the strengths and weaknesses of one possible scenario for rapid climate mitigation. In this scenario governments take executive action as in wartime. The paper addresses primarily the non-technical measures needed for making a rapid transition: governance processes, institutions, finance and labour. However, before we can address these non-technical aspects, we must establish that the energy transition is technically possible. This is done in Section 2, which summarises the literature on radical scenarios for transitioning to an energy system based predominantly on the efficient use of renewable energy. Then Section 3 reviews the literature on WW2 restructuring with respect to institutions, governance processes, finance and labour. Section 4 draws upon this experience to discuss possible broad policy strategies for rapid mobilisation and deployment of climate mitigation technologies in the energy sector within the scenario of executive government control. Although the war model provides insights for some aspects of rapid climate mitigation, it also has its limitations, which are discussed in Section 5.

2. Emergency climate mitigation strategies in the energy sector

Effective climate mitigation must address all the major sources of emissions: energy demand and supply (including transport), forests, agriculture and non-energy industry. Indeed, it's possible that complete restructuring of economies may be required, including the transition to a steady-state economy, initially by the rich countries (Stern, cited in Watts 2009). However, as a first step, recognising length constraints, this paper focuses on energy-based emissions, which accounted for about two-thirds of total global GHG emissions in 2005 (World Resources Institute, 2012). It also focuses on mitigation by developed and/or rapidly developing countries where energy-based emissions are high.

Since our paper is aimed at achieving large, rapid emission reductions from the energy sector, based on commercially available technologies, neither coal power with carbon capture and storage (CCS) nor new nuclear power can play a major role in this scenario. The International Energy Agency (IEA) Blue Map scenario, which halves global CO_2 emissions by 2050, has CCS making a negligible global contribution in 2025 and only overtaking renewables around 2050. It also has new nuclear supplying a small fraction of the new renewable energy contribution in 2025 and indeed out to 2050 (IEA, 2010: Fig. ES.1). While this is a scenario, rather than a forecast, it is the IEA scenario most favourable to CCS, reflecting the situation that coal power with CCS is still in the pilot stage. Both it and nuclear power are big site-dependent construction projects that are very slow to build. Commercially available nuclear power technologies have typically very long construction and deployment times, median nine years plus long planning and siting periods (Koomey and Hultman 2007). In the longer term, when low-grade uranium ore becomes the major nuclear fuel, the nuclear life-cycle will also become a significant GHG emitter (Lenzen 2008). On the other hand, both wind and solar technologies are mass-manufactured and therefore it is not surprising that they have already demonstrated very rapid growth rates. Large-scale wind and solar farms are typically constructed and deployed in two to four years. Similarly, demand reduction based on energy efficiency technologies and energy conservation (behavioural changes) could be implemented rapidly in an emergency situation, as shown in the IEA (2010) and other scenarios. In the medium-term, further demand reduction could be achieved by means of a 'smart' grid and 'smart' devices fitted to appliances. Geoengineering is potentially a rapid means of mitigation, but little is known about its potential impacts and so it offers great risks, as outlined in Section 5.2.

Thus, only RETs and rapid reductions in energy demand could be deployed rapidly and safely enough to make large contributions in emissions reduction from the energy sector within a decade or two (Greenpeace International 2010; Diesendorf 2010a). Rapid deployment of RETs is not completely void of emissions, especially during the manufacturing process. However, for almost all RETs life-cycle GHG emissions are much less than those of fossil fuel technologies (Moomaw et al. 2011). Furthermore, in the longer term, as the energy inputs become increasingly renewable, the life-cycle emissions will decline to zero.

2.1. Rapid mobilisation and deployment of climate mitigation technologies

The need for curtailing of carbon emissions from the energy sector (especially those from fossil-fired power stations and oil-based transport) has received special mention in climate mitigation literature (Hansen, 2009:173; Stern, 2008:7-8; Caldeira, Jain and Hoffert, 2003). This entails the transition from fossil-fuelled energy sources to low carbon, ecologically sustainable energy systems.

The possibility of safe, ecologically sustainable energy systems has been modelled and studied in a number of instances in global, regional and national scales especially in the past five years. Examples of these models and simulations at the global level are those prepared by Sørensen and Meibom, (2000), Greenpeace International (2010), Jacobson and Delucchi (2010), Delucchi and Jacobson (2011), Glasnovic and Margeta (2011), Krajacic et al (2011), Mathiesen, Lund and Karlsson (2011), and World Wide Fund for Nature et al. (2011). Boot and van Bree (2010) and EREC (2010) have both published models for Europe. National models abound: eg. New Zealand (Mason et al., 2010), United Kingdom (Center for Alternative Technology, 2010), Ireland (Connolly et al., 2011), the Netherlands (Kern and Smith, 2008), Denmark (Lund and Mathiesen, 2009; Richardson et al, 2011), Germany (German Advisory Council on Global Change, 2011; German Advisory Council on the Environment, 2011), United States (Makhijani, 2007), and Australia (Wright and Hearps, 2010; Elliston et al., 2012). These studies point to the feasibility of shifting towards a predominantly renewable energy system together with demand reduction. Nonetheless, very few have attempted economic analyses as yet. This is understandable when considering the uncertainties in the future costs of technologies, most of which are deployed at present on a relatively small scale compared with those responsible for the existing polluting system. Although most of the technologies required to build this technical portfolio are already commercially available, either on a large-scale or in limited mass production, in many cases, however, costs have to be brought down by a much larger scale of deployment. Recognising the potential of these technologies is only the first step.

2.2 Broad strategies for sustainable energy

A brief summary of the broad technological strategies derived from the sustainable energy scenarios cited in Section 2.1 and disaggregated into electricity, transport and heat strategies, is as follows:

> **Electricity strategy**: Retire conventional fossil-based power plants and replace with renewable energy systems, energy efficiency and other demand reduction measures. Rapidly develop and deploy new transmission lines to link renewable energy generation regions with consumers. Accelerate research and development (R&D) of efficient, low-cost batteries and other means of energy storage and continue R&D on

CCS technologies, but not to the extent that it draws funding away from renewable energy.

Transport strategy: Phase out fossil fuel-based passenger transport and replace with improved public transport fuelled by renewable electricity, low-carbon private cars, increased use of bicycles and walking, and other means of demand reduction of private car use. In particular, foster the deployment of electric vehicles whose batteries are charged with renewable electricity for urban use and biofuelled vehicles for rural road and air travel. Phase out fossil fuel-based freight transport and replace with a greater use of rail for long-distance transport, electric urban delivery vehicles, biofuelled truck transport in rural areas and demand reduction measures. Increase R&D on advanced, ecologically sustainable, biofuel production. Integrate urban and transport planning.

Heat and cooling strategy: Implement a comprehensive program to make all inhabited buildings much more energy efficient. Expand cogeneration, trigeneration, geothermal heat pumps, solar space heating and cooling, and solar hot water in appropriate regions. Phase-out high-temperature industrial heat from coal and gas combustion and replace where possible with renewable electricity and, in appropriate locations, solar heat.

Because this paper is focused on rapid transitions to predominantly renewable energy, fossil gas (whether it be natural gas, coal seam methane or shale gas) plays a minor transitional role – mainly in cogeneration, trigeneration, fuelling peak-load gas turbines for the grid, and back-up/boosting for solar heating and solar thermal electricity – but is not used extensively for fuelling motor vehicles or base-load power generation. Simply replacing coal with gas in the latter two energy uses, which are both large, would not achieve sufficient emission reductions to stop the growth in GHG concentrations in the atmosphere (Grattan Institute, 2012).

The technological component of the transition is the easiest aspect to envisage. While studies on the feasibilities of these systems are numerous and far reaching, there have been few studies on how they could be rigorously and rapidly deployed to meet the required urgency to shrink emission levels. Sections 3 and 4 address one scenario for this transition.

This approach is based on the lessons that could be learned from wartime restructuring, mobilisations and deployment. The special conditions that impose massive and rapid changes to industries and economic structure that war provides make it an appropriate case study. Like the proposed rapid mitigation scenario by extensive renewable energy and demand reduction, WW2 had brought forth a demand for new products, the ready expansion of capital funds, and the increased productivity of labour and management.

3. Wartime restructuring

The rapid conversion of the national economy to the manufacture of military munitions (which include, but are not limited to, combat aircrafts, naval vessels, guns, small arms, armoured and unarmoured motor vehicles such as tanks and trucks, ammunition and electronic and communication equipment) became a principal objective in many countries during WW2. This entailed national restructurings that encompassed almost all sectors of the economy. In this paper, we draw upon wartime experiences from the USA, Canada, Australia, Japan, Germany and Russia where radical changes in financial, labour and governance strategies were made.

3.1. Magnitude of wartime restructuring

In general, WW2 brought forth demand for new products, the ready expansion of capital funds, the increased productivity of labour and management, and the systematic intervention of the government. In the USA, less than one month after the attack on Pearl Harbour, President Franklin D. Roosevelt in his State of the Union address in 6 January 1942 called for rapid mobilisation and deployment of war machines and artillery, telling the US Congress that he:

> ...sent a letter of directive to the appropriate departments and agencies of our Government, ordering that immediate steps be taken... to increase our production rate of airplanes so rapidly that in this year, 1942, we shall produce 60,000 planes... next year, 1943, we shall produce 125,000 airplanes...to increase our production rate of tanks so rapidly that in this year, 1942, we shall produce 45,000 tanks; and to continue that increase so that next year, 1943, we shall produce 75,000 tanks...to increase our production rate of anti-aircraft guns so rapidly that in this year, 1942, we shall produce 20,000 of them; and to continue that increase so that next year, 1943, we shall produce 35,000 anti-aircraft guns....And... to increase our production rate of merchant ships so rapidly that in this year, 1942, we shall build 6,000,000 deadweight tons ...And finally,

> we shall continue that increase so that next year, 1943, we shall build 10,000,000 tons of shipping (Roosevelt, 1942).

In the following months, the engines of US war production began rolling. Realising that several sectors, such as the automobile industry, had to give way to the production of these more immediately required implements, Roosevelt imposed material and production controls on these sectors. For instance, private automobile production was halted from April 1942 to the end of 1944 to allow materials and labour to be directed towards war production. From mere $1.9 billion defence expenditure in 1940, US defence budget saw a colossal increase to $90.9 billion in 1944 (which is equivalent to an increase of more than $1 trillion in 2010 dollars), demonstrating the magnitude of the scale and scope of rapid war production (Smith, 1959:4). Similar increases in the magnitude of defence expenditures were evident in Japan where it rose from 4.7 billion 1940 yen to 14.5 in 1943 and 20.2 in 1944 (Milward, 1977:85-86), and in the Soviet Union where military expenditure climbed from 39.2 billion roubles in 1939 to 124.7 in 1943 and 137.7 in 1944 (Milward, 1977:93).

Huge spending translated directly into impressive production outputs. Between July 1940 and Victory in Europe Day in May 1945, for example, American industry produced 299,300 airplanes, 86,700 tanks, more than 100,000 naval vessels, more than 20 million rifles, 2.4 million trucks and jeeps, 41 billion bullets and millions of other war-related items (Cardozier, 1995:157). While other economies could not approach the level and volume of American production, they nevertheless exhibited similar expeditiousness and intensity that had forever changed the industrial landscape—see for example Plumptre (1941) for Canadian war production, Walker (1947) for the Australian experience, Overy (1982), Kaldor (1945-1946) and Klein (1948) for the German experience, Kaldor (1945-1946) for armaments outputs in the United Kingdom, and Milward (1977:85-86, 93) for the Japanese and Russian efforts.

3.2. Financial strategies

The huge cost of the war, as shown in Section 3.1, reflected the mammoth scale and intensity of funds mobilised. The Manhattan Project to create an atomic weapon, the pinnacle of US government-led innovations during the war, cost approximately $22 billion in 2008 dollars (Stine, 2009:6). In meeting the requirements for capital, almost all nations adopted a two-pronged strategy: taxation and borrowing.

Wartime taxation was based on the principle of spreading the burden of war fairly, equitably and, as much as possible, evenly across segments of the society. Direct taxation policy, especially through income taxes, became a prominent wartime capital sourcing in Canada (Plumptre, 1941:123), USA (Cardozier, 1995:128), Australia (Walker, 1947:231), and Germany (Walker, 1939:128-129; Overy, 1995). To illustrate the magnitude of direct tax collection, the US Government collected $45 billion from taxpayers in 1945, much greater than the 1941 collection of $8.7 billion (Tassava, 2010). War taxation also entailed the siphoning of funds from resource-competing consumer goods towards resources required for war purposes. Indirect taxes were collected on articles such as motor cars, radios, and cameras, which required labour and materials of types especially needed for war purposes in Canada (Plumptre, 1941:123-125). Other forms of wartime indirect taxes included an entertainment tax in Australia (Walker, 1947:237) and taxes on 'luxuries' (such as alcohol, cigarettes, cosmetics, and movies) in Canada (Bartels, 2001).

Borrowing provided another avenue to source wartime capital. Celebrity-promoted American war bonds, for instance, were purchased in vast numbers and enormous values by the American public, so that by the time the sales of these bonds ended in 1946, 85 million Americans had acquired more than $185 billion in 1946 dollars worth of securities (Tassava, 2010), an amount equivalent to $2.2 trillion in 2010. The scale of government borrowing for war purposes, mostly as war bonds, had also reached their all-time high in Canada (Plumptre, 1941:152-155), Germany (Walker, 1939:129), and Australia (Walker, 1947:238-242).

Governments provided an enabling environment to ensure rapid fund mobilisation during the war. This came through new fiscal policy (primarily through new legislations on taxation), stricter financial and banking controls (such as for foreign currency exchange), interventions (especially in banking and lending), and other mechanisms (eg. war bonds) that had never been thought of before. Taxation policy was modified to ensure maximum collection. In 1942, for example, the Australian states had agreed to a uniform income tax scheme applicable throughout the country to increase wartime revenues. (Prior to 1942, income tax was levied separately for federal and state governments in Australia.) Although there was strong consensus towards wartime taxation, raising taxes, in reality, was challenging. There is the technical problem of raising taxes quickly (as any tax policy has to be legislated first before actual collection can commence) and the repercussions to politicians when voting for tax increases (Rockoff , 1998:109).

3.3. Labour strategies

While the gains in productivity in armament production are of enormous importance, that feat could not be achieved without substantial labour support – perhaps the most important resource in wartime mobilisation. The US, for instance, produced about 40% of the world's armaments due largely to higher output per person-hour (Milward, 1977:67). By 1944, some 7.7 million more Americans were employed in civilian work than have been in 1939 (Cardozier, 1995:149). While mainly due to the outpouring of financial capital, the success of the Manhattan Project was also due to the number of people it directly and indirectly employed, which was in excess of 100,000 (Tassava, 2010). Across the Atlantic and even as far as Australia, nations saw the largest mobilisation of labour in industrial history. Germany mobilised its labour force in an unprecedented scale, such that between 1941 and 1944 the total number of Germans mobilised for civilian labour and armed forces (not counting foreigners and prisoners of war) rose from 40.5 to 41.4 million (Kaldor, 1945-1946:37). Of these, workers in armament production increased from 4.7 million Germans in 1941 to 6 million in 1944 (Kaldor, 1945-1946:51). In the United Kingdom, people engaged in similar work grew from 3.6 million in 1942 to 4.2 million in 1944 (Kaldor, 1945-1946:51). Increase in labour force was also observed in Australian factories where employment rose from 549,000 in 1939 to 753,000 in 1944 (Walker, 1947:148).

The rise in labour availability and productivity during the war was also due to significant government interventions. War saw a number of new labour policies issued, such as conscription, increased working hours, and changes in policy on strike action. Labour supply from industries producing inessential civilian items had to be redirected into industries producing munitions (Broadberry and Howlett, 1998:54). Despite this, manpower was still so scarce that industries had to tap the female labour force (see Rockoff, 1998:103 for the USA; Broadberry and Howlett, 1998:55 for the UK). In other countries, even children (in Japan) and the elderly (in the Soviet Union) were conscripted to work in munitions factories. Prisoners of war at labour camps in Germany, Russia and elsewhere were also significant component of wartime labour force. Among the Allies, big business made some huge profits (Cardozier, 1995:155; Lumer, 1954:37) and there were public concerns about corruption (Poole, 2012:55-59; Fleming, 2001:247). To prepare the labour force for these huge undertakings, governments led most of the training programs, to augment new skill requirements in tank building and machine gun production for example. Working hand-in-hand with provincial governments, the Canadian Government trained more than 10,000 workers per year with new skills during the rapid mobilisation (Plumptre, 1941:50). In Australia, engineering trade skills were intensified either through an upgrading of existing skills or new technical training conducted on-the-job, in technical schools and in special annexes in factories (Walker, 1947:307). To ensure timely delivery, working hours in munitions factories were increased: for example, in US factories, workers had to work for an average of 47 hours a week in 1944, up from the average 43.4 in 1940 (Rockoff, 1998:100). Wages were likewise stabilised (Rockoff, 1981; Henig and Unterberger, 1945).

3.4. Governance and institutional arrangements

WW2 had shown two rapid changes in governance: (1) the primacy of governments over the market; and (2) the creation by governments of new institutions and change structures to fit wartime requirements. As mobilisation for war intensified, the need for governments to take over the market became apparent. Governments did it by assuming control and direction of war production programs. In the US, for example, the federal government directly controlled over 40% of the country's wartime output of goods and services (Lumer, 1954:208). It is important to note though that, although the government became the operator of important industries, it was never the proprietor of these industries (at least in the USA). Although most of the time governments handled the setting-up of production goals and the supervision and management of industries, the private sector was also allowed some complementary roles which included participating in production contracts and orders (such as in Canada, see Plumptre, 1941:38), and in providing technical skill and managerial activities (such as in Australia, see Walker, 1947:153-154). Despite their minimal roles in supervision and management, the private sector still benefited during the war production years. In fact, big businesses, especially monopolies, flourished as guaranteed and lucrative contracts, large subsidies, and tax rebates freely flowed in (Lumer, 1954:208-210; Cardozier, 1995:155).

The ability of governments to rapidly organise and change governance structures during WW2 is exemplified in the proliferation of wartime agencies. In the US, for instance, around 162 agencies were formed strictly for war purposes (Dickinson, 1997:118; Cardozier, 1995:104). Most of these agencies were created, revised and abolished mainly (and often only) through executive orders. While this set-up describes a weak legislative body and a dominant executive, this arrangement actually made sense, especially at the conclusion of the war, since dissolution became easier than it could be if these agencies were created through statutes (Dickinson, 1997:118-119). The entire war mobilisation efforts clearly became the province of the executive branch, which means that few people controlled war administration. Named as '*war czars*' (in the US) or 'Controllers' (in Canada), this elite group was granted almost unlimited powers, including the power to determine how ammunition and other war items were to be rated as priorities (Plumptre, 1941; Walker, 1939:75) and could even force manufacturers to accept military contracts, to requisition private properties and to stop the production of specific goods and services (Dickinson, 1997).

While some may see this arrangement unacceptable in a democracy, its utmost importance in an emergency setting became more apparent in the US case. America, according to Dickinson (1997), had significant delays in converting the country to a war economy, partly because of Roosevelt's administrative style of taking all the decision-making to himself. Henry Lewis Stimson, his Secretary of War between 1940 and 1945, said Roosevelt was the "poorest administrator [he] ever worked under in respect to orderly procedure and routine of his performance" (Stimson and Bundy, 1971:495). Only when Roosevelt finally yielded some of his powers to a war czar, Donald Nelson who chaired the War Production Board, did war production in the US become more intense. By appointing a single-person authority, problems related to coordination in an obviously bloated bureaucracy and competition between civilian and military mobilisation agencies were likewise reduced (Dickinson, 1997).

4. Potential rapid climate mitigation strategies

Having examined in Section 3 the radical changes in financial, labour and governance strategies during WW2, we now discuss the implications for developing strategies for the rapid transition to achieving large, rapid emission reductions from the energy sector.

4.1. Financial strategies

Contemporary means of providing capital and investor confidence for the technological requirements of the energy transition appear in various forms and can be categorised as to recipients: (1) governments receive revenues from direct taxation (eg, carbon tax or auctions of tradeable emissions permits), development aid (bilateral and multilateral support), and the Kyoto mechanisms (Clean Development Mechanism and Joint Implementation projects); and (2) private entities receive proceeds from direct private investment, government subsidies (such as low-interest loans and loan guarantees), among others. Despite this wide range of financial mechanisms, and to some point the increasing volume of funds available for climate mitigation (see for instance Heinrich Böll Stiftung and Overseas Development Institute, 2012), studies continue to point out the dearth of the required capital to support the mobilisation and deployment of substantial technology cost of the transition (Olmos et al., 2012; Delina, 2011). This is because funding for the above schemes is generally capped.

Where markets fail, substantial government investment is needed, especially for R&D, for energy infrastructure such as transmission lines, gas pipelines and railways, and for education and training. Large public investments are an important means of bringing down the price of sustainable energy and accelerating its global deployment (Atkinson and Ezell, 2012; Shellenberger et al., 2008:113). Since many parts of the energy supply system would need replacement or upgrade, large infrastructure investment would be needed. While it could be an expensive undertaking to the private sector, governments can raise substantial capital both through taxation and public borrowing, a feat that most governments accomplished during WW2.

In summary, governments could implement a large and steadily increasing carbon price, increase taxes on luxury goods, and introduce an expedited sale of climate bonds to supplement funds generated from climate taxation to support the rapid transition. Nonetheless, not all investment has to come from government. For instance, feed-in tariffs, funded by a small increase in electricity prices paid by all consumers, are a proven strategy for growing renewable electricity (Couture and Gagnon, 2010). As the penetration of renewable energy increases and fossil fuels are displaced, the wholesale spot price of electricity decreases, offsetting at least partially the price increase from the feed-in tariffs (Sensuss et al., 2008; Lund et al., 2010).

Taxation and public borrowing are policies that need ample time to process. As such, it would take time to legislate, levy and finally collect new taxes and issue climate bond certificates. In the context of rapid financing, therefore, it may be imperative for governments to think of ways to expedite these processes. Even with these conventional funding sources, there is still the need to develop new schemes to meet the requirement of rapid mitigation. In a time when the world is only starting to recover from a financial downturn (and the possibility of having a new recession is already looming in the horizon), meeting this requirement can be a task. Considering that global emissions must start declining as soon as possible, there is little time to wait for a favourable economic climate. Governments could, in turn, bank on the current state of the economy to overhaul their tax systems towards taxing polluters and big emitters and restructure public investments towards promoting sustainable infrastructure including the transition towards a predominantly renewable energy system. Forms of funding, other than governments', such as those emerging from community organisations and private businesses, should also be allowed to develop and should be facilitated by governments.

4.2. Labour strategies

The scale and scope of the transition in a rapid mitigation scenario would definitely create both risks and opportunities. One important concern for many people is the impact of the transition on employment. This has always been fiercely debated, especially since several politicians hinge their support for climate policy on the condition that it would not cost jobs. Fortunately, the employment effects of renewable energy vis-a-vis fossil-fuel-based energy have been widely discussed in the literature and demonstrated in practice. Wei et al. (2010) summarised fifteen studies of this kind and pointed out that RETs generally generate more jobs per unit of energy produced than the fossil fuel sector (cf. Fankhaeser et al., 2008). Meanwhile, Chapman and Lounkaew (2011:18) conclude that job losses due to climate policy (the Australian Emissions Trading Scheme in this case) are 'close to invisible particularly when considered over a ten year time horizon.' In the short term, particularly during the early years of the transition, however, jobs are expected to be lost in directly affected sectors while new ones are created in large numbers in replacement industries. Therefore, the role of government is to ease the transition, by means of retraining, relocation, incentives for new factories to be located in disadvantaged regions.

In summary, wartime experience suggests that rapid climate mitigation would benefit from conducting a labour availability and requirement analysis. This would be followed by rapidly retraining and retooling existing workers, primarily those from the fossil fuel industries who will be otherwise out of work during the transition, on the manufacture, installation and maintenance of transition infrastructure and technologies. Curricula for professional and technical education should be developed that allow for rapid instruction of required skills, especially for engineers, electricians, energy auditors and plumbers. Incentives should be provided for the development and expansion of university and technical courses relevant to the transition. The rights of workers and labour unions should be protected during the transition.

4.3. Governance and institutional arrangements

Since attempts to reach international agreements on reducing GHG emissions have had very limited achievements so far, the main emphasis of our approach is at the national and state/provincial levels. Restructuring institutions and changing the organisation of markets are two principal goals of this approach to rapid transition. Governance and institutional arrangements at all levels, when faced with abrupt shifts in biophysical realms and changes in economic and social systems, comprise the larger challenge in rapid transition. Governing already complex systems will definitely bring much more complications and stress during the rapid transition period as new processes and institutional arrangements are introduced. Under these conditions, the executive-dominated model of governance—as in the approach used in wartime—has a number of advantages. First, it has the capacity to distribute powers and responsibilities between itself, regional and local governments, and civil society (Hirst, 2000). Second, it remains the main institution of democratic legitimacy that most citizens understand and are willing to accept – a crucial asset, especially during the rapid transition period when large-scale actions are required (cf. Levi, 1997). Wartime experience shows that rapid changes in governance structure to fit the necessity and urgency of the transition process are possible.

Furthermore, based on the slow pace of previous energy transitions (Smil, 2011), a much stronger role for government may be essential. At very least, stronger governments and their agencies will have to implement financial incentives (eg, feed-in-tariffs, loan guarantees and tradeable certificates) and disincentives (eg, a rapidly increasing carbon price and taxes) to shift energy investments; raise capital (Section 4.1); implement labour strategies (Section 4.2); organise funding for the construction of key infrastructure such as transmission spines, railways and pipelines (Section 2.2); fund R&D in key areas where there are gaps (Section 2.2); set and monitor energy efficiency standards for buildings, appliances and equipment; increase funding for education, training and retraining of key professions and tradespeople; and provide incentives for the new manufacturing industries to be located in regions where the old are being phased out.

Under an executive government approach that follows the wartime model, the following new statutory institutions of governance could be formed.

- A special Ministry for Transition to a Low-Carbon Future as the principal agency of rapid mitigation activities to conduct technical requirement studies, set and enforce production goals of RETs, institute efficient contracting procedures, cut through the inertia and 'red tape' inhibiting institutional changes, and serve as the coordinating agency for all transition activities.

- A separate institution, independent of the Executive and the above Ministry, reporting directly to Parliament/Congress and the community at large, to prepare a transition timeline specifying the period when executive control starts and ends; to conduct appropriate checks and balances; to scrutinise government/executive actions, especially those of the Ministry for Transition; and, through legal powers, to ensure that the government/executive sticks to its transition mandate.

Before implementing a stronger government approach, governments should inform the public of the situation, explaining the need for urgent action, and obtain a mandate for an initial specified period (at least a decade) for the creation of the above two institutions and for the kinds of strategies to be implemented. Ensuring strong public support during the rapid transition is fundamentally vital. Although wartime mobilisation strategies did not involve much participatory democracy when they were implemented, inherent public support primarily took over public psyche in light of the consequences of defeat (Bartels, 2001). Building public support for emergency climate mitigation is more challenging, because the population in some regions of the world (eg, the USA, Poland and Australia) is divided on the need for climate action. It needs separate research. It would certainly be greatly assisted by an acute climate emergency.

5. Limitations of the war experience as a policy model

The scenario suggested, on how to rapidly mobilise and deploy RETs at wartime rates, could be critiqued on the following grounds.

5.1. Limitations regarding rate of deployment

Kramer and Haigh (2009:568) argue that 'there are physical limits to the rate at which new technologies can be deployed.' Smil (2011: Chapter 4) sees similar limitations in his critiques of rapid energy transitions, arguing that the change would require generations, not years, based on historical experience and the massive and expensive character of energy production, processing, transport and distribution means. Nevertheless, this broad position is debateable and some of Smil's specific statements and arguments are unconvincing.

For example, his statement that there is negligible probability of China achieving its 2020 target of supplying 15% of primary energy from renewable sources, omits to mention that China over-achieved its previous renewable energy targets by large margins and actually grew wind power capacity at 100% per year for five consecutive years commencing in 2005. On a global scale, wind capacity has been growing at 20-30% per year and solar PV at 30-40% per year for decades. Such high rates of growth are possible because wind and solar technologies are manufactured in factories and the installation is generally standardised and rapid. On the other hand, coal and especially nuclear power stations are gigantic site-dependent construction projects that inevitably take much longer to construct than wind and solar farms. Another argument by Smil (2011: Chapter 4), namely that the low power densities (power capacity per square km) impose severe constraints on wind and solar, does not take into account the fact that wind farms are compatible with agricultural land, only occupying 1-3% of land area spanned, and a large fraction of solar PV can be installed on roofs. Although central solar power stations do require dedicated land, the countries with the best solar potential also have the largest areas of non-agricultural land with little vegetation, eg, Australia, the Middle East, North Africa, north-west China, north-west India and south-west USA. Provided international trade in renewable energy takes place, Sørensen & Meibom (2000) have shown by means of a GIS study that 100% renewable energy is possible without conflict with food production. Furthermore, there is little basis for Smil's belief that scaling up wind energy necessarily entails further scaling up of turbine sizes to 20 MW or more. Although Smil's analysis deserves a more detailed examination than can be given here, we trust that our brief responses (above) indicate that there are grounds for debate.

There is also common ground: we agree with Smil that 10-year transition scenarios, such as proposed by Al Gore (2008) for the USA and Wright and Hearps (2010) for Australia, are naïve and impossible (Diesendorf, 2010b). However, our scenario is that, under circumstances of strong government intervention, 25-30-year transitions are possible for a number of developed countries, and so is a 40-year global transition, provided we allow for international trade in renewable energy –see Sørensen and Meibom (2000). This seems to be consistent with the most optimistic transition timescale envisaged by Smil (2011).

5.2. Limitations on governance approaches

The wartime narrative has strong limitations in its application to governance. Although the legal systems of democratic states contain provisions for extraordinary emergency powers, these powers are unlikely to be invoked by politicians unless a threat is properly justified and becomes imminent and there is support for emergency action by a large majority of the population. Many governments, especially in the developed world (and in emerging economies in recent years), have shown little interest in responding effectively to climate change. It is unlikely therefore that governments would adopt emergency responses to climate change unless life-threatening situations became more apparent. Since rapid climate mitigation responses on the scale and scope of warlike mobilisation mean that governments may have to turn away from business-as-usual and predominantly market solutions to place more emphasis on centrally-organised and publicly funded activities, politicians are less likely to support emergency climate actions for the fear of losing corporate support and, in countries with large fossil fuel reserves, tax revenues (Diesendorf, 2009:85). Moreover, politicians are often reluctant to support any policy on tax increase, especially on the scale required by climate mitigation, for the simple reason that it could mean losing support and votes. Unless the climate action movement can exert strong, growing pressure on governments, by means of lobbying backed up with media, public education, legal actions, building alternatives and nonviolent direct action, it seems unlikely that governments will undertake emergency mitigation (Diesendorf, 2009), even when life-threatening climate disasters occur.

The short time-horizon of democratically elected governments introduces other risks that the executive approach needs to address and manage. There may be a need to institutionalise climate mitigation policies and programs so that they cannot be easily terminated by a change of government but this, in itself, is a challenge. Perhaps, government agencies for rapid mitigation can be structured such that they are purposely insulated from various political pressures and shifts in policy direction. Contemporary examples of these government structures include Central Banks, elements of the judiciary and the office of the Ombudsman. Although these agencies have not been granted sweeping and sustained emergency powers by statute, policymakers could use these structures as blueprint for the agencies suggested in Section 4.3. However, it's essential that government agencies for rapid mitigation are not insulated from action by the institution (also proposed in Section 4.3) to act as a countervailing force to ensure that the government follows its initial mandate and does not, for example, devote the majority of its climate mitigation resources to antidotal approaches.

In the event of a major climate crisis there will be strong pressure on governments, from both vested interests and genuinely concerned people, to direct their policies and resources predominantly towards the 'quick fix' antidotal approaches of adaptation and geoengineering, instead of the corrective approach of cutting greenhouse gas emissions. Adaptation is of course necessary, but it will have limited effectiveness in the absence of mitigation. Nevertheless, in the short term it is easier for governments to create the appearance of effective action, rather than the substance, by funding sea walls, flood controls, dams and improved wild fire protection, instead of funding a transition over several decades to ecologically sustainable energy. The prime purpose of the countervailing institution is to keep the principal focus of the government on mitigation.

Although geoengineering is considered in various spaces as an important antidote that may temporarily help slow climate change (eg. Lenton and Vaughan, 2009; Schneider, 2008; Carlin, 2007), it is a policy response that has been seriously questioned in the literature. Without either adequate science or governance frameworks, further large-scale experimental interference (largely unproven and very expensive) with the climate system would be very risky (Davies, 2010). In addition to unforeseen impacts, the possibility of system failure leading to abrupt climate change is another risk that geoengineering entails (Fleming, 2010; Matthews and Caldeira, 2007). The geoengineering approach would fail to stop the acidification of sea-water and also has potential negative side-effects that could affect the environment and the people in various ways (see Heckendorn et al., 2009; Naik et al., 2003). Despite all its risks, it offers a quick fix to governments and in our opinion will have to be resisted by the proposed countervailing agency and the community at large.

Even in a case when an emergency mitigation response is administered by a government executive or a multi-party transition cabinet with extraordinary powers to execute warlike mobilisations and deployments, there lurks the fear of coercive governments: that a climate emergency situation will be used as warrant for heavy-handed government intervention in national and even global economic activity, and perhaps control of individual activities (Oreskes, 2011:224). Moreover, there is no guarantee that a state of normal democracy would return afterwards. Martin (1990), in his analysis of post-emergency political affairs, showed that voluntary termination of emergency powers has not always occurred, despite constitutional requirements to prevent the extension of authoritarian regimes. In a number of cases, relinquishing emergency powers only occurred after strong and widespread public condemnation of governments for continuation of often repressive powers.

Another concern is that a centralised, top-down approach by executive government would fail to gain the support of a large majority of the population. Without community support a 'wartime' response to climate change is likely to fail. A more democratic approach also has the advantage of enlisting the ideas of the wider community. Transforming the energy system will need cooperation and creatively from as many people as possible. But this inevitably takes time. An investigation of possible means of speeding up a democratic climate mitigation scenario is needed as a complement to the present analysis.

6. Conclusion

Our analysis of the wartime experience as a policy model for of rapid climate mitigation suggests that financial and labour strategies could be quickly implemented. Some of the actions discussed could be undertaken without major threats to democracy, while others would be difficult to implement without executive control. For a government to gain public support for radical emergency action, compromises may have to be made. An approach suggested in this paper is to create both a powerful special Ministry for Transition to a Low-Carbon Future and a countervailing institution, independent of the Executive and the above Ministry, reporting directly to Parliament/Congress and the community at large, with legal powers to ensure that the Ministry and the government/executive stick to their transition mandate. This is simply an application of the principle of checks and balances within a democratic system. Public support should also be solicited by involving communities in large-scale behavioural change programs particularly on energy conservation.

The historical evidence that war can bring about sweeping technological, financial, and institutional realignments contributes to the plausibility of a rapid energy transition. Nonetheless, it should be taken as a suggestion rather than a prescription. While some of the strategies presented in this paper may seem unrealistic by the standards of today's debate, they may seem far less so when climate crises strike or society finally decides that it does not want to be a perpetual Boiling Frog. There will still be major obstacles to overcome and limitations to consider. While the scholarly literature on the technological component of the energy transition is far reaching, another important facet of the rapid transition narrative, the 'how to do it' component, however, needs more work. The goals of ensuring that systemic structural (and behavioural) changes are initiated and current structural (and behavioural) challenges and impediments are overcome as quickly as possible, remain important in the transition agenda. While climate policies and associated institutions should be focused on the medium- and long-term, rather than being subject to the cyclical government changes and political opinion swings that characterised contemporary democracies, the process of making this happen remains a challenge.

Although the active drive towards the transition within a very short period of time is envisaged, in the war model, as an executive national government-led effort, all levels of government, from local to state/provincial to national, as well as international agencies, must be involved, along with civil society and the private sector. Getting all these acts done in a coordinated and democratic/participatory manner is definitely a huge challenge.

In the context of international cooperation for rapid mitigation, the war experience could also provide a rich narrative that is beyond the scope of the present paper. The US Lend-Lease Program and the Marshall Plan for restructuring Europe and Japan could provide lessons to support rapid transition activities not only in developed but also in developing countries. Moreover, the dynamics among nations deliberating an international agreement for rapid mitigation is an important strand in achieving deep emission cuts.

Further development of contingency plans must go beyond the energy sector and consider especially forestry and agriculture. Radical climate strategies should also be extended beyond the necessary technological transition to address transitions in the other two important drivers—growth in population and growth in consumption per person (Diesendorf (2010a)—and the underlying behavioural causes of denial that there is a serious problem to be faced (Orekes and Conway 2010; Washington and Cook 2011).

These issues, which are currently beyond the scope of this paper, need to be carefully and strategically considered. Although there is much that we can learn from wartime experience, lessons of wartime mobilisation are but one way of envisaging policies and strategies for rapid mitigation. Restructuring the existing socio-economic system is more complex than fighting a war.

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