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The Great Recession and the transition to a low-carbon economy

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The Great Recession and the transition to a low-carbon economy

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Abstract: The objective of this paper is to consider the potential implications of the recent financial and economic crisis on the transition to a low carbon economy. This is unavoidably an exercise in tenuous conjectures given both our proximity to the still unfolding crisis, and the inherent complexity, confusing and highly contested nature of global scale crises. It is also difficult because our understanding of major energy transitions are still very much in their infancy, not to mention the unprecedented nature of a transition to a sustainable energy system. The paper begins with a brief review of the Great Recession, considers what lessons can be drawn from past energy transitions and the potential ways that crises, socio-economic transitions and sustainability might be linked. The historical relationship between past recessions and CO2 emissions is presented along with where we stand with respect to meeting mitigation targets. The Great Recession coincided with a relative peak in climate action and the rise of a Green Growth narrative that provides some hope of a joint attack on climate change and economic malaise. This paper will briefly review the idea of Green Growth and Green Keynesianism and look at the evidence on the extent and effectiveness of green demand stimulus following the Great Recession. The paper will argue that despite some early hope and some worthy global developments on the renewables front, public and political priorities shifted dramatically so that on balance the Great Recession can be associated with a 'policy peak' and a lost

opportunity to propel the low carbon transition. Moreover, it raises concerns that the continued fragility of the economic recovery will further delay the needed transition.

Key words: financial crisis, Great Recession, climate change policy, carbon prices, Green Growth, Green New Deal, socio-economic transitions, low-carbon economy.

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1. Introduction

The objective of this paper is to consider the potential implications of the recent financial and economic crisis on the transition to a sustainable energy system. This is unavoidably an exercise in tenuous conjectures given both our proximity to the still unfolding crisis, and the inherent complexity, confusing and highly contested nature of global scale crises. It is also difficult because our understanding of major energy transitions are still very much in their infancy, not to mention the unprecedented nature of a transition to a sustainable energy system.

Crises can open up opportunities for new institutional pathways if the forces they unleash or the rebalancing of conflicting political and economic interests give rise to changes in existing norms and institutions. Acemoglu and Robinson (2012) provide a sweeping account of the development of nations over millennia and how different crises or historical contingencies were often turning points that could substantially alter the trajectory of a country, locking them into a virtuous cycle of prosperity or sometimes having the opposite effect. Crises throw existing institutions, governance structures and theories that legitimize them into new critical light. Alternative interpretations and narratives compete and these can play a significant role in bringing about change[i] (Geels 2013).

The Global Financial Crisis has raised a number of issues, discussions and some theorizing about the potential links between recessions or crises and climate change or the transition to sustainable societies and energy systems. Do crises give rise to innovations and transitions? How are past crises linked to energy transitions and what lessons can we draw for the present crisis? Does the Great Recession offer opportunities for a new "green golden age" or has it put the needed energy revolution on hold? In the early phase of the global financial crisis green growth was touted as a new way to recover from the crisis and put the global economy on to a sustainable path. Is 'green growth' something new or a repackaging of sustainable development? How effective was the 'green new deal' and is there a more permanent role for 'green Keynesianism' to exploit downturns for sustainability? What are the implications of economic financial crises on the speed and direction of a transition to a low carbon economy?[ii]

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This paper attempts to shed light on some of these questions and the literature that has evolved from these. The second section will set the stage by providing a brief description of the Great Recession, consider what lessons can be drawn from past energy transitions, identify the meaning and challenges of 'sustainability transitions' and consider from a broad perspective potential ways that crises, socio-economic transitions and sustainability might be linked. The third section looks at the historical relationship between past recessions (including the Great Recession) and CO_2 emissions and where we stand in terms of meeting targets to mitigate climate change.

Even the swiftest of energy transitions are long-term affairs. The most momentous transitions have all taken place in the last 200 years and generally require 40 to 100 years for a 'new' primary energy to become a dominant global source. Though market forces were central in driving these transitions, politics have also had a critical role. However, none of these transitions were the result of a conscious policy to protect the environment and introduce a new energy system that is at least initially more expensive then its predecessor. Moreover, the timing of the transition itself is central to the policy objective and is unprecedented in history. Nothing short of an unprecedented politically driven fast track revolution in our global energy system is needed in order to achieve the objective agreed to by the UNFCCC climate talks at Cancun in 2010 of preventing an increase in global temperature above 2 degrees Celcius.

The significance of the Great Recession on the transition to sustainable energy will ultimately depend on the depth and duration of its broader economic and political implications and on the importance that any delay in climate action will have on climate targets and costs of achieving them. The early stages of the Global Financial Crisis coincided with a narrative that had been gaining traction in the bubble phase of multiple reinforcing crises of energy insecurity, food and water crisis, and an increased frequency of extreme weather events associated with climate change. Climate change was increasingly viewed as the overarching impending crisis intimately linked with these other crises in a way that they could only be effectively addressed through a transition to a low carbon economy. When the world economy dived into recession, there were prominent calls for a Green New Deal or the use of Keynesian fiscal stimulus directed towards activities that strengthen the shift towards a low carbon economy. The fourth section will briefly

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review the idea of Green Growth and Green Keynesianism and look at the evidence on the extent and effectiveness of green demand stimulus. A fifth section that provides a birds eye view of recent progress towards sustainable energy targets and ways that the economic and financial crisis has influenced this progress will follow this. The sixth section will provide some data on what appears to be a peaking of public and policy attention in 2009, followed by the conclusion in section seven.

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2. Recession, energy transitions and sustainability

2.1. The Great Recession

The financial crisis began with the collapse of the subprime mortgage market in the US in 2007 and accelerated with the bankruptcy of Lehman Brothers, the largest in US history. The collapse of Lehman Brothers was seen as a key cause of contagion turning it into a global financial crisis. The effects on the real economy are now known as the Great Recession[iii]. It began with a marked global economic decline in December 2007 and then a precipitous downturn in September 2008. This was the deepest and most widespread contraction in the global economy since the Second World War and involved a 2.2%[iv] drop in world GDP in 2009. Though economies varied in the extent to which they slowed, most suffered some setback, making it perhaps the first truly global (simultaneous) crisis. Developing countries of Europe and Central Asia suffered a drop of regional GDP of more than 6% in 2009. Africa grew by only 2% while six African countries saw contraction in their GDP (Keeley & Love, 2010). The largest emerging markets (Brazil, Russia, India and China) that had suffered mainly through the drop in global consumption, resumed growth by July 2009 and helped drive the recovery.

Bailouts of insolvent financial institutions and nationalizations in American and Europe, along with countercyclical monetary and fiscal action throughout most of the world in 2009, averted a general deflation along the pattern of the Great Depression in 1930-1933. In terms of monetary policy the OECD area policy rates (key interest rates) fell to historically extremely low rates. Besides the automatic stabilisers, governments also undertook 'discretionary' stimulus action (fiscal policy).

The signposts marking the beginning of the financial crisis have been the crest of the U.S. housing bubble in mid-2006, the shadow banking liquidity crunch in late 2007 and the bankruptcy filing of Lehman Brothers in September of 2008. Real estate and asset bubbles were present in many parts of the world and had been driven by broad-based credit boom aided also by financial innovation. The *Economist* (2005) described the worldwide rise in house prices as 'the biggest bubble in history". Adding to the increasingly fragile financial situation was the continuing boom

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in commodity prices and especially food and oil[v]. This was largely a result of the rising demand from emerging markets in the preceding decade.

Besides the pressure on global demand arising from the unprecedented sustained growth of China and India after centuries of stagnation a related and critical factor in the forming of the real estate and asset bubbles was the world economy's structural imbalance. Trade surpluses had been forming in China, Japan, other emerging economies from Asia and some oil exporters while the US was amassing large current account deficits. Global interest rates were pushed down by the 'savings glut' in Asia. The European Union was facing similar structural imbalances with large deficits in Portugal, Ireland, Greece, Spain and the United Kingdom offset by surpluses among northern european economies.[vi] The credit bubble and subsequent financial market bust may in large part have been precipitated by the massive credit flows arising from this global imbalance (Barbier 2010b; Cooper 2008; Feldstein 2008; IMF 2009; Lane 2009).

There is a widespread perception that a major cause of the crisis was the inadequate regulation and failure of existing regulations encouraged by the dominant ideology of financial market self-regulation in the US government and Federal Reserve (Ross 2010). Complacency and risk-taking had set in by years of low inflation and stable growth known as the "Great Moderation". Irresponsible, if not criminal, mortgages were doled out to borrowers with low credit rating ("subprime" borrowers). These were pooled and turned into low-risk securities by financial engineers highly sought after as they appeared safe and provided higher returns in a world of low interest rates. Lax capital ratios allowed banks to accumulate debt and shareholder pressure prompted them to get into the game and accumulate risk without increasing their equity (diluting their loss absorbing capacity). Central banks tolerated global current account imbalances and made no attempt to stem the housing bubble and credit boom either by raising interest rates or by lowering the loan-to-value ratios of mortgages or demanding that banks set aside more capital (The Economist 2013).

The bursting of the US housing bubble led to a sharp fall in the value of securities tied to real estate pricing (mortgage-backed securities). These had been marketed around the world so the damage affected financial institutions beyond the US. The losses in the subprime market exposed other over-inflated asset markets and risky loans. Runs began on other parts of the shadow

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bankings system. As these mounted the breakdown of Lehman Brothers on September 15 of 2008 turned market turmoil into a global crisis. The loss of confidence in the US and European banking system meant that banks increasingly hoarded liquidity and this was critical in transmitting the financial crisis into the real and international economy. Unprecedented monetary and fiscal measures by major central banks and governments throughout the world eventually gave rise to signs of stabilization from mid-March 2009 (Gorton & Metrick, 2012).

Drawing on several key documents Gorton and Metrick (2012) find that "a narrative [of the 2008 financial crisis] emerges that is very similar to historical crises, while cloaked in institutional detail novel to this century' (p. 150). According to them a key feature and predictor of all crises in the past two centuries have been the acceleration of system-wide leverage of both the government and financial intermediaries. All major crises after the Second World War were also marked by a rapid increase in housing prices. Banking system panics are also common. A novel[vii] feature of this crisis and that in part may explain why it took economists and policymakers by surprise, was that it took place primarily in the newly evolving "shadow banking"[viii] system. What makes this crisis special is it's global nature, the speed with which it spread to other countries, and that the most affected were advanced economies and the European Union. Similar crises have been generally limited to specific regions or types of economies: Nordic countries (early 1990s), Latin America (mid-1990s), Asia (late 1990s), emerging market economies (early 2000s) (Claessens et al., 2012).

Claessens et al. (2012) compares policy responses in sets of countries in the past with the responses of a group of countries to the 2007-2009 financial crisis. Governments and central banks acted more quickly and forcefully[ix] with regard to monetary and fiscal policies this time around, however, in contrast to previous crises they have put less effort into diagnosing banks' balance sheets and restructuring (removal of bad loans). Their focus was more on stemming the systemic consequences with a blanket approach rather than a more targeted approach to determine and implement restructuring where needed. One reason why a less targeted approach was taken was that the financial institutions were larger, more concentrated and much more complex cross-border entities. So institutions were both 'too important to fail' and their complexity made it difficult to separate viable from less-viable institutions (2012, p. 20). Financial innovations (secuiritizations and traded credit derivatives) and the growth of the nonbank

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financial institutions (shadow banking system) had also substantially increased the interconnectedness of the financial system.

Since the affected countries this time were mostly advanced economies they had the capacity to conduct countercyclical policies without "undue concern about the impact on their interest rates, exchange rates, or public debt" (2012, p. 20). While this early broad based response helped stem the crisis "many of the structural characteristics that contributed to the buildup of systemic risks in financial sectors are still in place today" (2012, p. 20). The shielding of creditors restored confidence but has ultimately increased the concentration of the financial system making it more vulnerable to future crises.

By 2010 the world recovery was looking 'better than expected' (IMF 2010). World growth rebounded reflecting in part continuing and unprecedented monetary action and the ability of the major emerging economies to quickly regain their momentum. A particularly worrisome feature of the recovery in the US was its 'jobless' nature.

The 2010 bounce in the advanced economies was cut short by the emerging debt crisis in Europe. The financial crisis, as in other advanced economies, augmented public debt and increasingly exposed private bad or doubtful debt. Though the Euro area public and external debt levels were lower than those of the United States and Japan, serious flaws in the governance of the EMU became apparent and ultimately precipitated a sovereign debt crisis. Lacking a fiscal and banking union, the capacity of the euro to withstand negative financial shocks had been identified as a serious challenge from its beginning. The introduction of the euro aggravated structural imbalances. It made it easier and cheaper for deficit countries to borrow without allowing currency or interest rate adjustments to redress the growing imbalances. The most intense phase of the boom preceding the crisis took place during 2003-2007 suggesting that it's underlying cause was the dynamics of the global financial system, coinciding with the securitization boom and the decline in financial risk indices. The 2008 global financial crisis triggered a reassessment among investors about the sustainability of the large external deficits in the euro periphery. Significant private sector capital outflows were followed by tightening credit conditions, a halt in construction activity, and growing bank distress from loan loss estimates and a liquidity squeeze in funding markets (Lane 2012). The design flaws of the euro amplified the fiscal impact while the

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restrictions of the monetary reunion "shaped the duration and the tempo of the anticipated post crisis recovery period, along with Europe's chaotic political response and failure to have institutions in place for crisis management" (2012, p. 50). As a whole the Euro area experienced a deeper recession in 2009 and a more anaemic recovery than the United States and dipped into a mild recession again in 2012. The remaining uncertainty primarily in the political and institutional capacity for timely governance and policy reforms to address the triple banking, sovereign debt and growth crises[x] continue to threaten the fragile global economic recovery (2012).

According to Dominquez and Shapiro (2013) the ongoing crisis in Europe has contributed to the slow recovery in the US. Though Reinhar and Rogoff (2009) had suggested that the recovery would be very slow most forecasters (including the IMF) had consistently projected faster recoveries only to find that they had to successively revise their forecasts downward. "The halting recovery—coming from the continued unfolding of joint financial/fiscal crises internationally—has made the recovery from the Great Recession even slower than initially expected" (Dominguez & Shapiro, 2013).

The 'costs'[xi] of the financial crisis can be measured in terms of direct fiscal outlays to support the financial system, increases in public debt and real output. The direct fiscal costs were 5% of GDP on average by 2009 that compares to a median of 15% against past crises. Increases in debt were larger than past crises. The median output losses measured over four years (2008-2012) are 25 percent of GDP. This compares favorably to the past crises of 35 percent. It reflects the beneficial effects of the extraordinary policy measures and the fact that the affected countries had lower growth trends preceding the crisis (2012, p. 15). However, as a percentage of the whole world output losses were 3.3 percent while past crises measure at 0.2 percent.

The recovery from the financial crisis has been weak. Five years after the US pre-crisis peak the World Economic Outlook (IMF 2013b) talked of a 'three speed' global recovery reflecting the continuing strength of the emerging market and developing economies, the recent improvement in US growth projections and the weakness in the Euro area. A year later the story has become a bit bleaker. The most recent World Economic Outlook (IMF 2014) acknowledges that "the crisis legacies have proved tougher to resolve than expected" with potential growth turning lower as reflected in several downward revisions of IMF forecasts in the previous three years. While the

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United States and United Kingdom appear to be leaving the crisis behind their potential growth remains lower than the early 2000s. Lower potential growth is also the dominating factor in emerging markets though their is differentiation among countries. Europe, on the other hand, nearly stalled and the risk of further weakening demand and ultimately deflation has increased. "Should such a scenario play out, it would be the major issue confronting the world economy" (2014, p. xvii).

Martin Wolf (2014) describes how badly things have gone and attempts to explain the absence of a robust recovery. US and UK median incomes are still below pre-crisis levels while there is an average unemployment rate of 12 per cent in Europe and explosive youth unemployment in Spain and Greece. The persistence of global economic imbalances and inequality are identified as the underlying problems. The "global savings glut" that kept real interest rates low and the related "global imbalances" which have been identified as key causal factors behind the pre crisis bubble are still present today. In a sense, even with very low interest rates the world continues to generate more savings than businesses are willing to use. The glut on savings has become a constraint on current demand and with the related weak investment implies slow growth. One response to this glut supported by many economists is to use it to finance a surge to public investment "that might be partly linked to a shift to lower-carbon growth" (Wolf 2013). The need for boosting demand through public infrastructure investment for advanced economies has also been highlighted in the latest World Economic Outlook (IMF 2014).

"Just as moments of epochal geological change are signalled by short-run ecological instability, so major realignments of regional economic power tend to be indicated by crises" (Ross 2010, p. 409). The Great Depression and the two global wars of the 20th century were closely related to the regional shift of global macroeconomic influence from Western Europe to North America. Similar global-scale structural shifts are underway with the unprecedented growth of the two largest economies China and India and the concomitant huge increase in "the global labor force and global market for discretionary consumption" (2010, p. 409). Another 3 billion will enter the middle class by 2030 (McKinsey 2011) and global output is projected to quadruple by 2050 (OECD 2012). This is yet another sense in which the Great Recession is different and it also suggests that we are likely entering a longer period of potentially tumultuous economic and political times.).

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2.2. Lessons from past energy transitions

The structure of the global energy systems has been shaped by two major transitions since the onset of the Industrial Revolution. Limited availability of mechanical power, low energy densities, and lack of ubiquitous and cheap transport systems were the constraints of the pre-industrial energy system that steam power relying on coal helped overcome. It took more than a century for this first technology transition to fully unfold. By the 1920s coal-based steam power accounted for over two thirds of the global energy system. The transition from coal-based steam technology to electricity and petroleum-based technologies constitutes the second major energy transition that is still unfolding. There are various 'grand' patterns that characterize technological transition among which are that end-use applications drive supply side transformations and that the transition (turnover of capital stock) takes decades to well over a century (Wilson & Grubler, 2011).

Even though resource scarcity and price signals were influential at various times, they were not what drove the two major energy technology transitions since the Industrial Revolution. The pattern of historical transitions involved the introduction of better and eventually cheaper energy services (Fouquet 2010). Policy-induced technological change is central to all climate change mitigation scenarios. This is a major departure from past energy transitions. Historical transitions provide little guidance on how alternative policies can drive a transition to low carbon energy systems or affect the speed of the transition and the implications for growth (Wilson & Grubler, 2011). A transition to a sustainable energy system cannot rely on these historic drivers, given the speed and extent of the required transition.

Relative cost and performance advantages over low carbon technologies are what make fossil fuels dominant currently. While performance advantages dominated historical transitions with end-users willing to pay premium prices for flexibility, convenience, versatility, or safety, low carbon technologies offer no such obvious performance advantages and they still remain more expensive under present institutional arrangements. It took a century of gradual incremental innovation for the fossil fuel economy to reach its present state. The magnitude of decarbonization required now leaves no room for gradualism (2011). While increasing scarcity of

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fossil fuels (resource constraints) may play a role in the transition, a substantial proportion of economically viable existing reserves will have to remain underground if we are to meet our climate change objectives.

Though past energy transitions have not been policy-driven, political decisiveness in confronting vested interests has characterized leading innovator countries. Historical innovation and diffusion, if not policy-driven was at least policy-enabled. New technologies created new vested interests but these required protection at their early and vulnerable stages of their development. Moe (2010) presents major energy transitions and juxtaposes countries that lead innovations with countries that failed in relative terms. In two of these transitions Britain showed the necessary political leadership. The first involves the cotton industry and the rise of coal. As far as energy sources were concerned the early Industrial Revolution linked to the rise of the cotton industry mostly involved maturing of existing technologies like water power and wind, but the rapid growth of coal was setting the ground for the second wave. British ruling elites had greater political autonomy than the French elites and vehemently protected the new industry against physical resistance and against petitions to ban the new technology. Britain was also far more active than France in its efforts to build supportive transportation infrastructure like turnpikes and canals (the latter cutting the cost of transport by 50-80%).

The second major energy transition involved coal, steam and iron. As iron overtook cotton as the main engine of the Industrial Revolution in the 1820-1830s it's rise to prominence was linked to the industrial complex of coal, steam power and railroads. Though Britain was well endowed with coal the scarcity in charcoal prompted its increased use in the face of increasing demand for iron (despite its prohibitive price). In Britain government supported railroads against the vested interests of canal supporters. French bureaucracy stunted railroad growth essentially favoring canals. They also set tariffs on coal imports heeding to domestic coal miner pressure and a powerful mining bureaucracy and ultimately worsening the prospects of the iron industry.

In the case of electricity and the second industrial revolution Germany was the leading innovator while Britain fell behind. The electrical engine had the great advantage of making the machine tool portable and flexible in that it could be applied to big and small businesses. Power could be transmitted over long distances giving rise to economies of scale as machines need not be close

to prime mover. The key bottleneck in Britain was the massive lack of electrical engineers. The state failed to provide mass and higher education with aristocratic vested interests being one obstacle, and strikes against new labor saving machinery another. There was a lack of integration so that electricity was hindered with different local standards and efforts. Municipal gas networks also opposed electrification and cheap coal damped enthusiasm for electricity. Germany faced no strong vested interests. The state had created the strongest education system in Europe with a particular focus on technology and science. While Britain was ahead in lighting, Germany was the clear leader in electrical equipment and appliances. The German network was integrated with larger distribution nets and more uniform characteristics and better performance. "The German state had a very obvious hand in all these developments, pursuing structural change through human capital, infrastructure and institution building" (2010, p. 1736).

2.3. Sustainability transitions

A particular challenge for sustainability transitions is the presence of strong path-dependencies and lock-ins in existing sectors (e.g., Ahman 2008; IEA 2011; Safarzynska 2010). "Established technologies are highly intertwined with user practices and life styles, complementary technologies, business models, value chains, organizational structures, regulations, institutional structures, and even political structures" (Markard, Raven, & Truffer, 2012a, p. 955). For this reason, established socio-technical systems undergo incremental rather than radical changes. The sustainability challenges we presently confront cannot be addressed with incremental changes.

The issue of how to promote more fundamental transformations in the modes of production and consumption (as well as in the energy systems) has been receiving increasing attention in the policy (OECD 2011; UNEP 2011) and social science research arenas. There is a broad range of theoretical approaches that have focused on a many of aspects relating to transitions. Four theoretical frameworks (transition management, strategic niche management, multi-level persective socio-technical transition, technological innovation systems) that focus explicitly on transition studies from a perspective of systemic far-reaching transformation processes of socio-technical systems have recently achieved some prominence (Markard et al., 2012a).

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Socio-technical systems consist "of (network of) actors (individuals, firms, and other organizations, collective actors) and institutions (societal and technical norms, regulations, standards of good practice), as well as material artifacts and knowledge (2012a, p. 956). This systems approach highlights the tight interrelationship and interdependence among the broad array of elements and has critical implications for the dynamics of system transformations. A socio-technical transition involves a fundamental shift in socio-technical systems "through far-reaching changes along different dimensions: technological, material, organizational, institutional, political, economic and socio-cultural. Transitions involve a broad range of actors and typically unfold over considerable time-spans (e.g., 50 years and more)…The emergence of a transportation system with the automobile technology at its core, for example, required a complementary development of road infrastructure, fuel supply systems, traffic rules, services (e.g., maintenance, insurance), user practices, etc. In fact, socio-technical transitions do not just change the very structure of existing systems…but they also affect related societal domains, such as living, housing and working, production and trade, and planning and policymaking" (2012a, p. 956).

Sustainability transitions are then socio-technical transitions that involve shifts toward more sustainable modes of production and consumption. In principle, these transitions could take place at different scales (in time and space) as more or less guided responses to pressures or environmental bottlenecks, and attain different levels of sustainability. History certainly provides many examples of socio-economic transitions emanating from environmental pressures (man made or not)[xii]. The sustainability challenges we face today are many and involve several domains. The energy sector is challenged by greenhouse gas emissions and air pollution, nuclear risks, security of supply, rapid resource depletion and energy poverty (IEA 2011). The water sector confronts challenges of insufficient access in low income countries, extreme events, scarcity. Similarly critical challenges are confronted in the transportation sector (congestion, local air pollution, CO_2 emissions), the agricultural sector, etc. All of these challenges require multi-dimension responses and governance of sustainability transition. The climate change challenge is special in that it pervades nearly all sectors in terms of potentially devastating impacts and requires fundamental non-incremental changes (mitigation of emissions and adaptation) in most

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sectors many of which have been fundamentally molded by the fossil fuel energy system of the twentieth century. It is also special in that only a global and comprehensive response within a very short time frame can adequately protect us from taking on unfathomable risks.

So while the energy system confronts numerous challenges, the climate change challenge dominates all others in terms of the extent and speed of required transition. The demands on globally coordinated comprehensive action are unprecedented. In terms of a transition to sustainable energy systems it is important to note that historical regime transitions were rarely if ever explicitly guided long-term, socially deliberated goals like sustainability (Smith & Stirling, 2010). The nature of transformation demanded to achieve a low carbon energy system means that great institutional, economic and political commitments are needed against the incumbent regime.

2.4. Crises, socio-economic transitions and sustainability

I draw from Geels (2013) to present two narratives of the relations between the financial-economic crisis and environmental problems[xiii] followed by his own multi-level perspective on sustainability. According to one view modern societies are facing a 'triple crisis' in which financial, socio-economic and environmental problems converge. The deeper root of these crises is a cultural problem with modern capitalist societies, whether this is an obsession with growth and debt-fuelled consumption or the exploitation of nature and the dominance of financial capitalism. This triple crisis, and it's signaling of possible planetary breaking points, may help us recognize the deeper cultural and structural nature of these problems. With that understanding fundamental solutions may be in our reach in the form of a zero-growth or de-growth economy, a focus on happiness rather than GDP and redistribution of work, time, income and wealth. [xiv]

A second view sees the financial-economic crisis within a framework of Kondratieff long-wave dynamics. Driven by new pervasive technologies, five techno-economic paradigm shifts (or long waves) are distinguished over the last 200 years by Freeman et al. (1990) and Perez (2002). Figure 1 provides a quick overview of the five techno-economic paradigm shifts. Each techno-economic paradigm shift goes through a number of phases or periods. In the 'installation periods', when new technologies emerge in specific sectors, financial capital and speculative investment tend to

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drive the dynamics. The wider diffusion of these new technologies confronts barriers in the existing socio-economic framework. In order for the new technologies to spread and find wider deployment institutional adjustments are required. Socio-economic crises are seen as the normal and even necessary aspect of broader transitions in the socio-economic framework, overcoming the 'mismatch' between the requirements for new technologies to flourish and the socio-economic framework. Perez (2009, 2013) and Gore (2010) view the current crisis as precisely this kind of mismatch for the ICT-paradigm. In order that the information communications technologies realize their full potential finance needs to be disciplined and reoriented toward more productive long term investments in the real economy. Drawing on these ideas a number of authors Bradfield-Moody (2010), Allianz Global Investors (2010), and Gore (2010) have proposed that "the current crisis also signals the 'installation period' of a sixth green wave, carried by renewable energy, resource efficiency, green nanotechnology, and green chemistry" (Geels 2013, p. 69). A way out of the current crisis could come from the convergence of the ICT-paradigm and the green Industrial revolution (Perez 2013). If finance can be disciplined and reoriented toward greening the economy than the crisis may be the tipping point towards the next green wave. The idea of successive long waves suggests that the whole process is driven by some internal logic that may not be susceptible to human agency. Some theorists (Gore 2010) have argued however that crises may create opportunities for agents to make the necessary policy and institutional changes that will lead to a sustainability transition.

Both these views have elements of optimism regarding a sustainability transition, either that the 'triple crisis' will prompt some deep cultural shift so that growth and destructive forms of consumption and production will be curtailed, or that the crisis will offer the kind of opportunity for fundamental shift in policy and institutional direction. There are also concerns in the degrowth camp that the crisis will simply lead to renewed efforts toward debt-fueled extractive growth (Schneider et al., 2010).

Geels (2013) frames the relationship between the financial-economic crisis and sustainability transitions within a multi-level perspective (Geels 2002; Van Bree, Verbong, & Kramer, 2010). In this perspective sustainability transitions are conceptualized as a struggle of green niche-innovations against unsustainable systems, potentially reconfiguring or replacing these. This

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perspective is part of the broader emerging field[xv] in sustainability transitions that has been receiving increasing attention in social science research and the policy arena.

In the multi-level perspective the financial-economic crisis is a shock that "creates pressures on regimes in concrete empirical domains (food, mobility, energy) where it may affect investor confidence, availability of capital, public concerns, and the political will to act in favour of sustainability" (Geels 2013, p. 71). Green innovations at the niche level struggle against existing regimes. Changes in socio-technical regime may be required for a wider diffusion of green innovations. Consumer and investor practices as well as public policies and public discourse may have to change in a way that favors the transition to sustainability. Geels (2013) points out that some green niche-innovations have been gathering momentum after a decade of emergence, e.g., renewable energy has a share of 9% of primary energy in the European Union, and electric and hybrid-electric car sales peaked in 2007 at between 2% and 3% of overall sales. Three main challenges are identified for moving beyond this 'pre-development phase and into a 'take-off phase' of widespread deployment. Firstly, the need to mobilize large sums of money with the private sector playing a key role in supply of funding and pioneering new technologies. Economic conditions, financial regulation and investor confidence determine the availability. Second, the need for changes in policy and institutional frameworks that are adjusted to the needs of incumbent actors. These entail many of the recommendations for greening the economy (green pricing and regulatory measures, reducing harmful subsidies, green public procurement measures, etc.) but which are often strongly resisted from powerful incumbent interests. Third, the need to secure wider public support and cultural legitimacy as this will provide the necessary incentives for politicians to overcome special interests.

Geels (2013) uses the multi-level perspective to develop insights about the present financial-economic crisis and how it might affect the sustainability transition. He draws some general tentative conclusions regarding the impact of the financial-economic crisis. The green stimulus measures of 2009 provided an initial boost to renewable energy that has run its course as these measures are coming to an end and government expenditure in many countries continues to fall (Korea, Japan among others). The increase in investments in renewables in 2011 was due to incentive programs in Europe and the US that were reaching their expiration. In the US the

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growth came primarily from utility scale projects while Germany and Italy saw a boom in small-scale PV further stimulated by falling PV costs. The cheap competition from China that led to over-capacity and falling prices in solar and wind technology led to bankruptcies and job reductions in Western companies. The problems and the decreasing investor confidence were reflected in the dramatic fall in clean energy share values in 2008. This harmed the green growth discourse as politicians criticized the use of Western government subsidies. The term "renewables bubble"[xvi] became popular among critics of government support.

The shale gas revolution also poses potential threats to the sustainability transition. Though it may help reduce CO_2 emissions as some countries (US and China) switch from coal to gas, it could also hinder the progress of renewable energy and be part of another bust phase in renewables affecting investor confidence for years to come (Geels 2013). In addition, we have already seen that the increase in US coal exports have led to a fall in it price and subsequently a switch away from gas to coal in Europe.

Geels (2013) cautions that most new capacity is still non-renewable, more money is still being invested in new fossil-fuel generating capacity (coal, gas) compared to renewables. The implication is that green energy transition is likely to be slow. A positive development is that the various green niche-innovations appear to have entered the "take-off phase".

3. Recessions, emissions and targets

3.1. Recessions and CO_2 emissions

Given the tight historic link between economic growth and carbon dioxide emissions it is expected that recessions will generally be associated with either lower increases in global emissions or actual decreases in emissions. Figure 2 shows the historic trend in global CO_2 emissions and the most important recent financial crises: the oil crisis (1973), US Savings and Loan crisis (1979), the collapse of the Former Soviet Union (1989), and the Asian financial crisis (1997). The bottom part of the figure also reveals the breakdown for each crisis between growth rates in emissions of the regions most affected by the specific crisis and the emissions from the rest of the world. All these past economic crises were persistent and were associated with extended reductions in greenhouse gas emissions. In contrast to these earlier economic crises the

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2008-2009 Global Financial Crisis led to a steep but short-lived drop in global GDP and by 2010 emissions had fully rebounded to their earlier 'trend' (Peters et al., 2011). The emissions growth in 2010 was the highest total annual growth recorded that swamped the 2009 1.4% drop. This relatively uncharacteristic bounce back in emissions can be attributed to a number of factors: (1) the globally coordinated action of central banks and substantial initial fiscal stimulus by numerous countries that managed to quickly bring back positive growth rates (though with higher levels of unemployment); (2) the immediate easing of energy prices reducing pressure for structural changes in energy consumption; (3) the high levels of growth in emerging economies providing a strong foundation for global economic recovery; (4) the continuing and accelerated increase in coal-fired power contributing to an increase in the fossil-fuel intensity of the world economy (IEA 2013c; Peters et al., 2011).

The drop in emissions in 2009 represented a 40% decline relative to the trend since 2000. Emissions in the developed countries (Annex B of the Kyoto Protocol) fell by 1.3% in 2008 and 7.6% in 2009 and increased by 3.4% in 2010. The high 2010 growth was due in large part to the strong growth of emissions in China (10.4%) and India (9.4%), though lower growth rates in developed economies contributed substantially in absolute terms (Peters et al., 2011). While global real GDP grew by 5% in 2010, CO_2 emissions grew by 5.9% that means that the fossil fuel carbon intensity (FFCI) increased by 0.9% in 2010. In general, growth in global emissions are linked to global GDP growth corrected for FFCI. Improvements in carbon intensity have meant that from 1980 to 2000 FFCI decreased by 1.4%. This trend has deteriorated since 2000 (captured by the diverging red and blue lines in Figure 2) falling to 0.9% by 2011.

Variations in carbon dioxide emissions over time are larger than variations in GDP. CO_2 emissions have seen declines at ten disparate years since 1970 while global GDP has had negative growth only three times. In times of crisis it appears that countries maintain economic output by reducing their dependency on energy-intensive activities. All major economic crises since the 1960s have led to noteworthy changes in the global trends of fossil-fuel use and CO_2 emissions. The oil crises in 1973 and 1979 brought about the greatest decoupling of economic growth and fossil fuel use (and global carbon dioxide emissions). These crises were the result of persistent price shocks that led to a reduction in global reliance on oil and an increasing use of natural gas. The crises that

followed were also accompanied by decreases in emissions but these were mostly the result of economic downturns (and political developments in the case of the collapse of the FSU) and not to structural changes in energy consumption and production (Peters et al, 2011).

It is also worth noting that while production based emissions of the developing countries (non-Annex B) had surpassed the production based emissions of the developed countries (Annex B) by 2005, consumption based emissions[xvii] of developing countries first overtook those of developed countries in 2009 (2011). "The GFC was an opportunity to move the global economy away from a high emissions trajectory. Our results provide no indication of this happening, and further, indicate that the GFC has been quite different from previous crises….The GFC has helped developed countries to meet their production/territorial-based emissions commitments, as promised in the Kyoto Protocol and Copenhagen Accord, yet the GFC had a minimal impact on emissions growth in emerging economies…Although the GFC was an opportunity to reverse some of the trends leading to increased CO_2 emissions, the return to high emissions growth in 2010 may make the GFC a lost opportunity" (Peters et al, 2011, p. 4).

Since 2010 Global CO_2 emissions have grown by 3% in 2011, 2.2% in 2012, 2.3% in 2013 and are projected to grow by 2.5% in 2014 (The Global Carbon Project). Over the last ten years (2004-2013) global CO_2 emissions have had continued steady growth of 2.5% per year, though there has been a significant regional redistribution in emissions shifting from large developed countries to emerging economies. For the period 2012-2013 China accounted for 57% of the growth in global emissions, USA for 20%, India 17%, while the EU28 dampened the growth rate by -11% (Friedlingstein et al., 2014).

The Great Recession has meant lower economic growth especially for the developed economies and this has certainly been reflected in the rate of growth in emissions. There have also been improvements in the global carbon intensity but the rate of improvement has not been similar to that in the past and nowhere near what is needed if targets are to be achieved. The present global rate of emissions growth still leads to a long-term temperature increase of 3.6°C (IEA 2013a).

3.2. Brief overview of meeting targets

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The Global greenhouse emissions are growing and are already considerably higher than the emissions level needed to meet the 2°C target. Even if country pledges made in Cancun in 2010[xviii] are fully implemented there will be a considerable "emissions gap" between estimated emissions based on current data and emissions consistent with the agreed 2°C target (UNEP 2012, 2013). This gap is likely to be on high end of projections (and not far below business as usual projected levels) given the increasing uncertainty that high end pledges will be met and that stringent international accounting rules will be agreed to. Missing the 2020 target means that later action will involve higher mitigation rates and levels of "net negative emissions" (Friedlingstein et al., 2011), increased costs of mitigation (Clarke et al., 2009; Jakob et al., 2012; Ipcc 2014), higher rates of energy efficiency improvements than have been ever realized, and higher likelihood of failure. It is still technically feasible to meet the 2°C target at estimated marginal costs below US$50-100/t CO_2e reduced. It's a matter of time and pace and avoiding further "locking in" of current investments in infrastructure (buildings, transportation systems, factories, etc.).

It's useful to put the emission gap in historic perspective. Industrialized countries as a group seem likely to achieve their 2008-2012 target of reducing greenhouse gases by 5.2% relative to the 1990 emissions. Based on country reporting the total reductions will be 20-22% with almost all individual countries likely to meet their target. Policy action has helped but the reductions have been significantly influenced by the economic collapse in the transition economies in the late 1990s (that had not been foreseen in the Kyoto emission commitments) and the economic recession of 2008-9. Industry modernization and changes in the economic structure of the former Soviet Union and Eastern European countries meant that collectively they were 36% below their 1990 level in 2008. Furthermore, given the relatively low price of Certified Emission Reductions, Annex I countries are likely to buy them all, which would mean that domestic emission reductions will be only half of what they would be without the Clean Development Mechanism. So while industrialized countries are likely to achieve their targets for reasons related to overestimating the growth rates of their emissions, total global emissions are growing at rates inconsistent with the 2020 targets because the growth rates of emissions from developing countries have been greatly underestimated (Metz 2013).

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4. The promise of a green recovery

4.1. Green growth

With the financial and economic crisis of 2008-2009 terms like 'Green Economic Growth' and "New Green Economy' drew increasing policy and media attention (Mundaca & Cloughley, 2012). While green growth has become a buzz word there is no clear definition of what it means but most analysts would associate it with growth in human well-being that is environmentally sustainable, low carbon and climate-resilient (Bowen & Fankhauser, 2011). On a close examination of alternative definitions offered in the literature it would probably be fair to say that the broad characterizations do not differ substantively from the economics of sustainable development or the more recent 'sustainability economics' (Baumgärtner & Quaas, 2010; Mundaca & Cloughley, 2012). The use of the term 'green economics' is not new and can be found in the early works in the 1960s on economic answers to environmental problems that laid the foundations of environmental economics (Mundaca & Cloughley, 2012). Pearce et al.'s (1989) 'Blueprint for a Green Economy' was a seminal example of how a broader scope of economics of sustainability was treated explicitly. "In that work, the authors framed Green Economics around technology innovation, resource efficiency, natural capital, ecological risks and human development" (Mundaca & Cloughley, 2012).

This still leaves the question of why the heightened recent interest in 'Green Economics' and whether there is something 'New'. Bowen and Fankhauser (2011) suggest that the green growth narrative has analytical and strategic benefits. The strategic advantages come from recasting environmental protection as a question of opportunity and reward, rather than costly restraint. Some have argued that climate talks (Barrett 2007; Barrett, Scott 2003; Hourcade & Shukla, 2013) have been too focused on burden sharing (obligations, targets and penalties) making it more difficult to reach agreement or engage the public in support of agreements. By focusing instead for example on how clean energy can provide multiple benefits (environment protection, energy security), including financial rewards (competitiveness, new markets), arguments will be won and progress will be more easily achieved.

A 'strategic' narrative may simply be a better way of gaining support for particular measures, 'getting to yes' or framing agreements. No doubt there are good arguments for the importance of

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rhetoric and framing of a discourse. In the mildest version of the 'strategic' argument, economists involved in policy formation are aware of how different ways of presenting the same analytical message can affect the outcome of the policy debate through its influence on voters, stake holders and decision makers. If this is the case the new focus on Green Economics is essentially repackaging of environmental and ecological economic analysis. To the extent that economic narratives matter there is far more scope and need to understand how these influence the debate. No doubt a political economy and public choice analysis of the climate policy forming process would provide important insights on this matter.

Bowen and Fankhauser (2011) suggest that the analytical argument behind the 'Green Economics' crescendo is perhaps more fundamental and that it relates to the economics of climate change. In this view the 'green growth' agenda abandons a more narrow focus[xix] in past work on climate economics. "In doing so the emerging green growth literature can draw on many long traditions of economic thinking that encompass the work of, among others, John Maynard Keynes, Arthur Cecil Pigou, Joseph Schumpeter, and Henry George" (2011, p. 1157). They summarize this broadening scope under four headings: (1) the Keynesian perspective (2) the Pigouvian perspective (3) the Schumpetarian perspective and (4) the Georgian perspective. The Keynesian perspective reconnects the 'green growth' focus on long-term sustainability issues with short-term macroeconomic fluctuations, unemployment, fiscal sustainability and global saving-imbalances. This is certainly the most novel and most distinctive development of the 'new' green growth agenda that is also a direct outcome of the Great Recession. It first appeared[xx] at the height of the economic crisis as a call for a green fiscal stimulus[xxi] and an appraisal of its potential form and effectiveness. Two key insights are (a) that governments can exploit the need for fiscal stimulus in times of recession by spending on social and environmental capital and thus tying in the short term imperative with the long term need to put the economy on a more sustainable track, (b) the need to recognize the potential implications of 'boom and bust' cycles when thinking about long term trajectories of cumulative greenhouse gases. An unforeseen (as is usually the case), major recession will lead to a permanently lower GDP trajectory and thus warrant downward revision of the target greenhouse gas concentration (Bowen & Fankhauser, 2011). One could argue, however, that booms and persistent high growth rates can be also be

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'unpredictable' as has been the case with the record growth rates of the emerging economies over the last couple of decades. Indeed, as recent global emissions data suggest, past scenarios have actually underestimated emission growth paths with the growth of emerging market emissions outpacing the slackening of the developed economy emissions.

The Pigouvian perspective of the 'green growth' essentially expands on the long standing microeconomic focus on multiple environmental externalities by taking a more systematic view of market failures that involve, inter alia, network externalities, information failures and asymmetries and constraints in innovation. The Schumpeterian perspective moves beyond marginal economic change by recognizing that changes required for sustainability involve deep structural systemic changes akin to a new industrial revolution. Non-marginal policy shifts toward strong environmental policies could kick start a process of "creative-destruction" leading to prolonged periods of higher and greener growth. The Georgian perspective relates Henry George's (1839-1897) arguments that good governance and ingenuity would help overcome the Malthusian trap to a present view that green policies can ignite technical progress to move the economy towards low carbon trajectory (2011).

Climate economics have certainly been drawing on a broader set of analytical tools and traditions. The buzz around 'green economics' and 'green growth' is part spin, or an attempt to reframe the economics of climate change in order to gain greater traction among policy makers, civil society and voters. The analytical broadening is partly the outcome of the growing attention given to climate change by economists both within and beyond the 'confines' of the sub-disciplines of environmental, ecological and resource economics. It is partly a response to the intensifying demands on economists to provide concrete policies in view of the heightened concern emanating from the multiple crises (food, energy, water, extreme weather events) in the run up to the Global Financial Crisis. In fact the narrative that had been gaining ground before the GFC was of an interrelated set of multiple crises that could be best addressed jointly through stronger and more effective climate action. Nicholas Stern's (2007) Review of the Economics of Climate Change reflected the broadening understanding of the centrality of economics and economic policy to the climate debate. It became a catalyst of intense debate among economists, often revisiting and questioning deeper assumptions like how to discount values across

generations or how to take account of deep structural uncertainty inherent in low probability large scale catastrophes. It also marked a shifting in the 'median' view of economists that a relatively gradual approach to greenhouse mitigation was warranted to a view that early and strong climate action was needed to avoid potentially catastrophic outcomes.

The Great Recession essentially broke out at the peak of an intense discourse propelled by a set of critical issues linked to the boom phase rather than the bust phase. The financial economic crisis found the climate policy community at a peak in its readiness, with unprecedented public support, as the 2009 Copenhagen Summit (perhaps a formal turning point in the level of attention on climate change). The unprecedented 'green fiscal' stimulus adopted by some G20 countries over the 2008-2009 fiscal year is likely the outcome of the 'fortuitous' juncture of policy makers and analysts primed for climate action confronting a new imperative: how to bring back the global economy from the precipice. Green Keynesianism was born.

4.2. Green Keynesianism

In the depths of the financial crisis concerns were raised regarding the extent to which economies can afford short-run costs of GHG mitigation policies and other environmental improvements. Eight EU member countries suggested that targets for CO_2 emissions should be revised in view of 'serious and financial uncertainties'.[xxii] Environmental economists responded to the new priorities by suggesting that the economic and climate crises could be tackled jointly through fiscal stimulus that supported a transition to a sustainable energy system. This response was supported by theoretical arguments. The traditional Keynesian response to a recession is government stimulus that will raise aggregate demand as fast as possible and that this short term goal more than anything determines the composition of fiscal expenditures. There are a number of possible theoretical grounds to support green stimulus. It could be that there is enough coincidence in the aims of maximizing short-term aggregate demand to boost employment and expenditures for GHG mitigation, or that at least there is room for some trade-off between short term and long term goals. Green spending on some activities may be warranted on theoretical grounds while others less so, e.g., there are standard 'public good' grounds for public spending on research and development in low carbon energy but which has a low impact on short term aggregate demand,

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but 'weaker' market failure arguments for certain kinds of 'industrial policy' like supporting specific biofuel options. Lastly, one could question the cyclical nature of the downturn. If the employment and growth problems are substantially structural in nature, then the composition of expenditure (targeting the structural weaknesses) acquires greater salience even though this becomes less of a Keynesian argument.

The scale of climate change and the action needed to address it render partial equilibrium analysis inadequate. Both the potential damages resulting from climate change and the policies used to tackle it can have significant macroeconomic consequences (Bowen & Stern, 2010).

Governments can opportunistically exploit a period of under-utilization of resources resulting from aggregate demand deficiency to invest in public capital to protect the environment and focus on temporary government spending that partially corrects for the misallocation associated with externalities. Projects will exist that will be worth undertaking sooner as the downturn reduces their costs. If there has been a recent step up in concern about environmental goals (as has been the case with climate change) there is also likely to be a backlog of projects to be undertaken. The case is further strengthened when there is a smaller risk of crowding out private investment as in times when monetary authorities are ensuring that interest rates are not pushed up by public spending. The adoption of a new climate policy regime is likely to involve adjustments in capital stock that will have significant macroeconomic effects, while also leading to accelerated depreciation of existing capital stocks. At times of slowdown the opportunity costs for these adjustments will be lower including for set up costs for regulatory frameworks (2010).

If the depth and breadth of a recession is enough to alter the long term trajectory of global economic growth then a downward revision of emissions targets could be warranted. Whether and by how much the carbon price should be lower in such a case will also "depend on the extent to which the long-run trend is itself affected; a large recession may both shift down the starting point of the future long-term trend and lower its slope, with both effects trending to reduce the increase in the warranted discount rate" (2010, p. 142) No doubt, trajectories will have to be reevaluated taking into consideration the possibility of unexpected booms as well as other unforeseen consequences like the potential impact of a recession on fossil fuels in a way that increases the carbon intensity of energy.

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To the extent that liquidity and solvency are less impaired in the public sector in times of financial distress, it can substitute for the private-sector where finance will not be forthcoming. Financial assistance to banks can be tied to increased lending on their part and this can also be targeted to specific sectors. This targeting can reflect an assessment of social returns (2010).

Spending measures that will promote quick recovery may not coincide with measures that help a transition to a low carbon economy. A number of criteria can be used to assess the effectiveness of spending measures along several dimensions: recovery, low-carbon transition, energy independence, overcoming market failures, etc. Criteria that have been considered along the 'recovery' dimension include speed or timeliness, job creation or employment multiplier and likely domestic output, targeting parts of the economy with slack and existence of exit strategy (Bowen et al., 2009; Houser et al., 2009). Criteria along other dimensions include: impact on energy prices, impact on dependence on imported fuels, impact on carbon dioxide, ability to 'lock in' low carbon technologies, contribution to tackling market failures, technology hurdles and infrastructure bottlenecks obstructing climate change mitigation efforts (Bowen et al., 2009; Houser et al., 2009). Studies by (Bowen et al., 2009; Houser et al., 2009) generally found a significant variation in scores across alternative spending measures with not all 'green' proposals scoring well against recovery effectiveness (see Table 1). Large-scale energy infrastructure suffered from long planning and implementation lags while energy improvements in buildings are particularly effective.

Numerous studies have considered the extent to which low carbon transition expenditures will increase demand for labor at times of high involuntary unemployment. Kammen (2006) suggests that renewable energy industries (especially during initial construction stage) are more labor intensive than the traditional energy sector. Roland-Holst (2008) find that energy efficiency effectively generated jobs in California. Pollin et al. (2008b) argue that a switch to clean-energy is likely to be relatively labor intensive. On a more negative note Alvarez et al. (2009) study the employment impacts of renewable production support in Spain accounting for the lost opportunities to support employment in alternative sectors. They find that two jobs are lost in the rest of the economy for each job created in the renewable sector. Support is more expensive per job created in the renewable sector and business costs are increased in alternative sectors as

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electricity prices increase (via feed-in tariffs). Another negative outcome comes from (CEPOS 2009) that found high government subsidy expenditures per worker for Danish wind energy production over the period 2003-2008. Ragwitz et al. (2009) provide the most comprehensive study of employment effects arising from the EU plan for scaling-up renewable production. The report assesses the potential crowding out other activities as well as the disincentive impact of rising energy prices resulting from renewable support schemes. It concludes that the employment effects will not be very large.

Overall, the direct evidence of employment generating effects from green stimulus policies is still scant[xxiii]. Biomass processing facilities and some transport initiatives that involve large capital investments are likely to help in the long run rather than the short run. On the other hand, revenues can be raised and used for short-term and long-term purposes if fiscal measures are used to correct energy-related price distortions. Removal of environmentally harmful subsidies or under-taxation can also provide important climate- or enviroment-related "co-benefits" (Strand & Toman, 2010).

Bowen and Stern (2010) and Houser et al. (2009) argue that green stimulus will only be effective if it is part of a comprehensive climate policy. In particular, carbon pricing would amplify the effectiveness of green fiscal initiatives by strengthening other incentives for investment in low-carbon activities. It would also prevent a recurrence of 'boom and bust' cycles in new green technologies following shifting priorities over time.

Any discretionary green stimulus hinges on the view that activist fiscal policy is the right response to a downturn. Bowen and Stern (2010) provide a summary of the analytical debate concerning activist fiscal policy, empirical evidence, and criteria to assess fiscal initiatives. As far as the Great Recession is concerned they find that a global fiscal response was warranted in view of the diagnosis of its causes. "[T]he crisis primarily reflects a sharp slowing in nominal demand growth, not counter-inflationary policies or adverse supply shocks; it is global; monetary policies are accommodative but of less predictable benefit by themselves; and, judging by risk premia on government debt, initial levels of debt are not calling into question the long-run sustainability of fiscal frameworks" (2010, p. 150).

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While Bowen and Stern (2010) find that there is a strong case for aggressive environmental policy in the case of the global slowdown of 2008-9, it is far less easy to draw conclusions for environmental policy and business cycles. Here too they offer a number of insights.

While there was much discussion about of green fiscal policy in the early phases of the financial and economic crises there has been less once the initial recovery took hold despite the ongoing fragility in the global economy and the ongoing sovereign debt crisis in Europe. From the onset of the sovereign debt crisis the EU led by Germany has espoused a tough austerity posture as the only way to regain competitiveness and sustained growth. Fiscal stimulus, green or otherwise, has been completely off the official agenda despite a vocal anti-austerity opposition. Only recently has there bin a grudging shift in sentiment in response, inter alia, to fears of political destabilization in southern Europe and partly due to mounting pressure outside the EU, e.g., IMF's (IMF 2013b) criticism that the developed world governments have been too quick to tighten spending.[xxiv] It is too soon to tell whether this changing of heart will continue and ultimately influence policy, and if so, whether a green component will reappear.

Sachs (2011) offers a very different view in support of green investments as a response to the underlying causes of the financial and economic crisis, at least in the context of the US economy. He believes that the recovery was impeded by structural factors that are not susceptible to a Keynesian diagnosis or to a Keynesian remedy. The structural problems "include to large-scale offshoring of jobs, large-scale automation of jobs, decline in demand for low-skilled workers, mismatches, broken infrastructure, and rising global energy and food prices" (Sachs 2013). Instead of treating the crisis as primarily the result of a cyclical fall in aggregate demand, what was and is needed is public investment in long-term infrastructure and job skills carried out over a decade rather than two years. "A massive renewable energy program" (urban smart grids, renewable power generation, new transmission grid) for instance building the long term infrastructure. The administration's rush to implement a stimulus program to avoid a Great Depression was the wrong response to the wrong diagnosis. The late 2008 crisis was a financial crisis relating to intense panic and a credit squeeze and not an aggregate demand crisis. The Fed rightly responded to this by flooding the market with liquidity and this rather than the fiscal stimulus[xxv] prevented a depression. He also calls Keynes to his defence, arguing that he was

subtle in his analysis and in 1937 when British unemployment continued to stay around 10% he suggested that more structural policies were required rather than "applying further general stimulus to the center".

4.2.1. A green approach to global imbalances

The global imbalance led to massive credit flows that are likely to have precipitated the credit bubble and the subsequent collapse of the financial markets. The persistence of such imbalances continues to fuel the uncertainty and instability of the world economy. A green recovery could also help alleviate global imbalances. Barbier (2010b) suggested that a global green recovery could help reduce the volume of fuel imports into deficit economies[xxvi] and help stem the rise in world prices, and alleviate global imbalances by reducing current account deficits and surpluses of oil exporting economies. He acknowledges that the role of global green recovery strategy in reducing chronic trade surpluses in Asia is more complex, but suggests that the prescriptions advocating moderating the excessive reliance on exports and export-promoting investments and expanding imports for capital goods for key sectors, may actually be helped by a global green recovery strategy. "The fostering of clean energy investments from domestic sources and overseas financing would also be consistent with shifting the output structure of emerging market economies from labor-intensive goods to skill, capital and technology-intensive production" (2010b, p. 168). Emerging markets could help reduce global imbalances by increasing the import of low-carbon capital and technology goods rather than relying on exports. What is important for growth in developing nations is the output of non-traditional tradables as long as domestic demand expands at the same time. Historical evidence from Japan, South Korea and China suggest that periods of high-growth came from their ability to undertake rapid structural transformation as they moved from 'traditional' to 'modern' activities (Rodrik 2009).

4.3. Was there a fiscal green demand stimulus

As a response to the Great Recession a number of countries that adopted expansionary policies also incorporated a sizeable 'green fiscal" component. Wide ranges of measures were included in

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this category, e.g., support for renewable energy, energy efficiency, carbon capture and sequestration, public transport and rail, investments and incentives for environmental protection. Green expenditures or tax breaks represented around one sixth of worldwide fiscal stimulus over 2008-9. Nearly the whole global green stimulus came from the G20 countries. China and the United States accounted for over two thirds of the global expenditure on green fiscal stimulus. While green measures accounted globally to around 16% of all fiscal spending, only a few devoted a large proportion of their total fiscal expenditures. South Korea stood out with an allocation of 80% of its total expenditure on green investment. Even though green stimulus represented a high proportion (around 60%) of EU fiscal expenditures total fiscal expenditures were low. Overall, only six countries spent more than 1% of their GDP on green investments during the recession (Barbier 2010b).

In general governments accepted a case for fiscal stimulus to address the 2008-9 slowdown. There are difficulties in calculating accurately the proportion of fiscal stimulus devoted to environmental measures as the classification of what counts for environmental spending is not straightforward. Rain infrastructure investments, for instance, may reduce emission from cars and reduce congestion but it could stimulate overall spending on fuel for transport (Bowen & Stern, 2010). Still, there have been a number of efforts to identify the green component of the stimulus and Table 2 provides a summary of some of these efforts. From a total of identified proposed stimulus spending of US $2.8 trillion, about 15% has been classified as "green". More that two-thirds of the "green" component is for heavy infrastructure (rail, power grids, water and sanitation). Increased building efficiency and low-carbon vehicles also play a role and are more obviously carbon-reducing activities (Strand & Toman, 2010).

"Spending by G20 governments on low-carbon and other environmental investments over 2008-9 fell short of a sustained global 'green recovery' effort. Substantial fossil fuel subsidies and other market distortions in G2 economies, as well as the lack of effective environmental pricing policies and regulations, have also diminished the incentives for stimulating both public and private investment in green sectors" (Barbier 2010b, p. 171).

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5. Progress towards sustainable energy targets and the impact of the financial economic crisis

Since we still lack anything resembling an index of sustainable GDP, 'green growth' or 'green energy economy' we rely largely on numerous indicators to get a general sense of progress in moving towards a low carbon economy. The International Energy Agency' annual Tracking Clean Energy Progress reports (2014b) provide recent data on developments in "clean" energy. Even though its reports provide measures of progress for individual technologies it emphasizes that "what matters most is the successful transition of the whole energy system to a clean energy platform" (2013c, p. 10). The individual areas it covers are power generation, carbon capture and storage, end use sectors (industry, fuel economy, electric and hybrid-electric vehicles, biofuels, buildings), systems integration, energy technology RD&D and innovation. Table 3 provides a quick color-coded snapshot of the overall progress and policy recommendations. For most technologies that could provide energy savings and reductions in CO_2 emissions "progress is alarmingly slow".

5.1. Renewables

The only sectors on track to reach the 2°C goal (as based on (IEA 2014a) scenarios[xxvii]) are renewable power and electric-hybrid vehicles. This assessment while encouraging should be put in perspective. It derives from the specific scenarios used by IEA that include a significant role for nuclear and carbon capture and sequestration. If one or both of these options were not 'allowed' then the weight of the energy transition would shift substantially towards more 'revolutionary' transitions in the other sectors. Renewables would have to grow at higher rates to achieve the 2°C target.

The most dynamic sectors among renewables were the mature technologies including solar photovoltaic (PV), onshore wind, biomass and hydro. In 2012 growth in solar PV capacity was 42% and wind saw a 19% increase. Global policy developments in renewables gives a mixed picture with China and Japan strengthening both targets and policies while German, Italy and Spain (among others) scaled back incentives.

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Figure 3 gives a good overview of the renewable investment data from 2004 to 2013. Global investments in renewables grew from $39 billion in 2004 to a peak of $302 billion in 2011. In 2012 it fell by 11% and then another 14% in 2013 (Frankfurt School of Finance and Management gGmbH (in collaboration with Bloomberg New Energy Finance) 2014). The declines in 2012 and 2013 reflect investor concern about continued commitment to renewable energy support policies in the longest-established markets (Europe and the US)(Frankfurt School of Finance and Management gGmbH (in collaboration with Bloomberg New Energy Finance) 2013, 2014). In addition to the policy uncertainty and "stop-and-go" policy decision-making in key regions, the fall in investments also reflects the significant and sustained decline in renewable power equipment costs (especially solar photovoltaic and onshore wind turbines) and the challenging financial conditions (IEA 2013c). Even with the drop in investment in 2012 and 2013 given the sharp fall in prices both years saw record levels of new capacity in PV installations (31GW in 2012 and 39GW in 2013) (Frankfurt School of Finance and Management gGmbH (in collaboration with Bloomberg New Energy Finance) 2013, 2014). PV module prices fell by nearly 50% due to economies of scale in manufacturing, the increase in low-cost Chinese production and global over-capacity. This created substantial corporate distress for the solar sector but led to booming rooftop installations in Germany and Italy, the spread of small-scale PV to other countries and a spike in large-scale solar thermal electricity projects in the US and Spain (Pew Charitable Trusts 2013).

Table 4 and Figure 4 provide a geographic breakdown in distribution of investments. Europe was the largest investor up until 2012 but after a sharp decline in 2013 was surpassed by China. The spike in US investments in 2011 is owed to the fact that three important incentive programmes for renewable energy were either scheduled for expiry or reached expiry. Clean energy investment fell in the United States by 37% in 2012 ($35.6 billion). Clean energy investment also fell in Germany by 27% in 2012 as it curtailed incentives though it remains the G-20's third-leading destination. "The center of gravity in the clean energy world has shifted from the United States and Europe to China" (2013).

The slowdown in investment was particularly marked for wind generation in the United States and is attributed to uncertainty regarding the possible expiration of a production tax credit for

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wind generation. While a one-year extension on tax credit was enacted in the beginning of 2013 there is still uncertainty on long-term policy. Wind investments also fell in India where uncertainty remains over the reinstatement of after tax and generation-based financial incentives that expired in 2012 (IEA 2013c).

The solar PV markets saw the largest shifts in economic incentives either because their deployment had accelerated due to rapid cost reductions or because of the deteriorating economic conditions (or both). Many of the decreases in incentives involved changes in feed-in tariffs and the introduction of mechanisms to reduce FITs for future projects over time (2013c, p. 28). Figure 5 provides an overview of policy shifts for renewables.

The euro area sovereign debt crisis began to impact the supply of funds for renewable energy projects in Europe by late 2011. Banks were affected by the sharp increases in their costs of funding and heightened assessment of risks involved in lending to borrowers in Southern European countries. Governments have also been more reluctant to pass measures that might put up energy prices. In view of the plummeting cost of renewables European governments made efforts to adjust solar power feed-in tariff subsidies. The problems and the decreasing investor confidence were reflected in the dramatic fall in clean energy share values in 2008 (Figure 6). This harmed the green growth discourse as politicians criticized the use of Western government subsidies (Geels 2013). The term "renewables bubble"[xxviii] became popular among critics of government support. PV project developers enjoyed greater than intended returns and installations boomed in Germany and Italy. Governments have responded by cutting subsidies sharply. "The danger however is that hastily-made cuts in support might make a serious dent in investment in developed economies in 2012-14 - before wind and solar can reach that goal of competitiveness. That would be a damaging blow not just for businesses in those industries but also for hope of limiting carbon emissions and climate change, and for those working in the emerging "green economy"" (Frankfurt School of Finance and Management gGmbH (in collaboration with Bloomberg New Energy Finance) 2012).

Feed-in-tariffs introduced in the late 1990s in Europe were meant to provide the necessary boost to solar technology to help meet environmental and energy security goals, to provide the necessary protection for a new technology to reach economies of scale and to make Europe a

leader in green technology and jobs. This win-win strategy is now under strain. In September 2012 the EU launched its biggest ever investigation of imports of low-cost solar equipment from China. In May 2013 the EU trade commissioner Karel De Gucht recommended the imposition of stiff import duties (averaging 47%) against unfair pricing and unfair Chinese subsidies to their manufacturers. While this is part of a broader (beyond solar equipment) anti-dumping effort against China, it reveals some difficult choices over what now appear to be conflicting policy aims. Within about four years China moved from exporting almost no-solar panels to Europe to capturing 80% of the market in 2011.[xxix] With global over-capacity, many Western companies went out of business as panel prices fell from $4 per watt to less than $1. Even Chinese companies have been hurt[xxx]. Stiff duties, however, could seriously curtail the growth in installed solar capacity, already dampened with the scaling back of European subsidies. For some European solar companies cheap solar panels are a boon as they are able to capture significant shares of the value chain (installation and other equipment) and many green jobs will increase with further expansion of solar energy. Competitiveness and environmental protection are not as nicely aligned as initially touted (Chaffin 2013; Dalton 2013). Germany led a majority of EU members to oppose the punitive duties and in August the EU decided against imposing preliminary anti-dumping tariffs, opting instead to wait another four months to assess the levies (Stearns 2013b). Eventually an amicable solution was reached that presented, inter alia, a balance between demands by European producers and some importers to levies on the renewable-energy technology (European Commission 2013; Stearns 2013a).

5.2. Coal and the carbon bubble

While renewables and electric and hybrid vehicles have stayed on trajectory for a 2DS, the rise in coal-fired power generation has increased around 6% between 2010 and 2012 and presents a major threat to a low-carbon future. From 2000 to 2010 coal-fired generation grew by 45% far outpacing the 25% increase in generation from non-fossil energy sources (see Figure 7. Coal is now the main source of electricity generation by far representing 41% of global generation (IEA 2014b). China and India are key drivers of growth in demand for coal. China accounted for 46% of global coal demand in 2011 while India's share was 11%. The shale gas boom in the United States

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meant low prices for gas domestically, but it led to increased coal exports from the country that brought about a fall in coal prices from $130/t in March 2011 to a low of $85/t in May 2012. This led to a marked increase in coal demand in Europe where it took a share from gas whose price in Europe is tied to oil. The concomitant recent rise in emissions, most notably in Germany, Spain and the United Kingdom has started to put a strain on emission targets in Europe (2013c, p. 48). The collapse of the EU ETS carbon price has itself contributed to the gas-to-coal generation switch.

According to calculations of Carbon Tracker (2013)[xxxi] the world's currently indicated fossil fuel reserves equate to 2,860bn tonnes of carbon dioxide. To have an 80% chance of keeping below a 2C rise in temperature only 31% of these reserves could be burned (38% for a 50% chance of 2C or less). Even with an optimistic CCS technology scenario only an additional 4% of fossil fuel reserves could be burned. This "carbon bubble" reflecting the over-valuation of oil, coal and gas reserves held by fossil fuel companies, means that if the internationally agreed targets for climate change are held, the reserves held by companies will be unburnable and will lead to massive market losses. Still the stock markets are betting on inaction on climate change. Instead of reducing efforts to develop fossil fuels, the top 200 companies spent 1% of global GDP ($674bn) in 2012 to find and exploit new resources. The report is also meant to make these carbon risks more transparent to companies and to help them develop new business models that will account for the steep decline for their products and to help avoid a new financial crisis. As with all speculative bubbles, there is the possibility that investors are presently riding the upside hoping to abandon it before it bursts..

5.3. Other sectors

Nuclear is also behind the IEA 2DS trajectory even though construction began on seven nuclear power plants in 2012. Public opinion appears to be 'improving' in many regions. Carbon capture and sequestration is only 25% of the 2DS 2020 target with no large-scale integrated projects in the power sector. Eight projects were publicly cancelled. RD&D budgets for low-carbon technologies still represent a small share of total RD&D investments. After peaking in 1980 to more than 10% it has varied between 3% and 4% since 2000. Funding received a substantial

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increase with the "green stimulus" spending programs of 2009, but levels have decreased since as concern over budget deficits set in. Industry energy and emissions-reduction policies have notched up in several regions including Europe, South Africa and Australia. There have also been several important policy measures taken in 2012 to promote energy-efficiency in buildings and appliances. Progress has been made in demonstration and deployment of smart-grid technologies but better data and indicators are needed to measure developments in this area (IEA 2013c).

5.4. Carbon intensity

One of the most worrying findings is the evolution of the Energy Sector Carbon Intensity Index (ESCII) (See Figure 8). The ESCII measures how many tonnes of CO_2 emissions are emitted for each unit of energy supplied. Over the last 40 years carbon intensity has largely remained flat. The biggest drop (only 5%) in the ESCII occurred between 1975 and 1985 with a shift away from oil replaced by a massive expansion of nuclear capacity and a switch to natural gas. From 1990 to 2010 there was only a 1% drop in the ESCII. While natural gas took the place of oil reducing emissions, coal also expanded offsetting any gains. In order to achieve the 2020 2DS target an average improvement of 0.5% per year in the ESCII is needed. This represents the equivalent of replacing on a yearly basis 1% of global annual coal production with renewables (2013c).

5.5. Fossil fuel subsidies

Energy subsidies (on a "pre-tax" basis) for petroleum products (electricity, gas and coal) declined with the collapse of international energy prices but rebounded with the price increase (see Figure 9). In general energy subsidies follow international energy prices. Global pre-tax subsidies reached $480 billion or 0.7% of global GDP. Fifty percent of the global energy subsidies are accounted for by the Middle East and North Africa region. In 2011 fossil fuel subsidies were almost seven times higher than the support for renewable energy (2013c).

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On a "post-tax" basis that accounts for negative externalities from energy consumption subsidies reach $19 trillion or 2.5% of global GDP (IMF 2013a). This is another way of looking at the advantage that fossil fuels get from not including a carbon price that reflects social cost of externalities (congestion, air pollution, climate change, etc.). Without these subsidies CO_2 emissions would decline by 13%. Despite continued calls for phasing out of fossil fuel subsidies and the fact that energy subsidies involve substantial fiscal costs, encourage excessive energy consumption and deplete natural resources, governments continue to support them. Energy producers and other vested interests strongly defend them and they are also portrayed as helping the poor. In oil producing countries they are defended on the grounds of 'distributing' the profits from oil production while in oil importing countries they are seen as preventing energy poverty in times of high fossil fuel prices.

5.6. Collapse of carbon markets

The recession has been linked to the precipitous drop and eventual collapse of the carbon price of the EU's flagship climate policy, its emissions trading scheme (see Figure 10. From its inception the EU ETS had suffered from a glut of allowances. Initial emission allowances were allocated freely to industry based on the industry's own emission projections. Some sectors, especially German utilities, grossly overestimated their emissions. A tighter cap was announced by the EU Commission (for Phases II and III) in the form of annual reductions of the EU emissions cap of 1.74% and a switch to requiring that companies purchase allowances in the new phase of the scheme from Jan 1 2013. These had helped the carbon price regain ground in 2008, but then the recession suppressed manufacturing which, in conjunction with the success of other emissions reductions policies and a large influx of international credits, created a huge oversupply of carbon emission allowances. The price dropped by 70% from €30 in June 2008 to around €8 in mid-February of 2009. The price regained some lost ground staying around €15 till June 2011 after which it has steadily declined reaching a price of below €3 by the end of April 2013. The more recent decline, though linked to the ongoing recession, has been further aggravated by what appears to be a lack of resolve to address the recession-induced oversupply of allowances. The European Commission came up with a measure known as "back loading" which would withhold

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900 million allowances from auctioning over the next three years, to be reintroduced around in 2019 and 2020. A European Parliament vote on April 16 2013 defeated this plan by a narrow margin. This led to a further price drop to €2 and reinforced a growing perception that the EU is wavering on climate policy (Clark & Chaffin, 2013). On July 3 2013 the plan was narrowly passed by the European Parliament and was later adopted by the Council.[xxxii] The continuing low price of carbon means that heavily polluting carbon dioxide coal-to-power stations have become attractive relative to cleaner gas burning technology.[xxxiii] More generally it has put into to question the role of the EU ETS in inducing innovation.

Those who argued in favour of the back-loading scheme pointed to the need to maintain a high enough price to incentivize low carbon technologies while those against it argued that industry should not be further burdened in times of recession, especially in view of the US gas revolution. To the extent that recession does not trigger major downward revisions in estimates of marginal abatement cost and damage costs of emissions, the fall in carbon prices is greater than justified by the economics of climate mitigation (Bowen & Stern, 2010).[xxxiv] The cap that had been set by the EU in 2008 appeared at the time ambitious but it had been chosen to bring about an approximate allowance price of €30tCO_2. This was deemed necessary to drive Carbon Capture and Sequestration and alternative energy supplies (Convery & Redmond, 2013).

Interestingly, recent empirical analysis counters the widely held view that the economic crisis, renewable deployment and international offsets explain the fall and the persistently low emission price (Koch, Fuss, Grosjean, & Edenhofer, 2014). These market fundamentals that affect the demand for emission allowances are found to account for only 10% of the price variation. The remaining 90% is largely unexplained. (2014) use stock price movements and the Economic Sentiment Indicator to determine the influence of economic activity and sentiments (including the crisis) on the price of emission allowances. While these are shown to have a greater influence than renewable deployment or international offsets they still only explain a small percentage of the variation. (Edenhofer, Normark, & Tardieu, 2014; Koch et al., 2014) suggest that the key explanation for the persistently low price may be the lack of political credibility of the long term ambition to keep the supply of emissions adequately low. Unlike other markets where the supply is determined by resource constraints, with carbon markets scarcity (supply) is politically

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determined. The markets are pricing in expectations that climate policy will not be particularly ambitious and this more than the present oversupply of emission allowances has been the dominant factor. This interpretation can actually be seen to enhance the potential role that the Great Recession has had on the carbon price. Rather than the impact being through the lower growth of the economy and thus emissions or the expectations of economic growth (the impact that was effectively tested), it could be that the recession fundamentally altered the political narrative around the political desirability and feasibility of climate action. If that's the case, it's not the immediate impact of oversupply in emission allowances that is unduly dampening their price but the change in beliefs about political commitments to more ambitions caps in the future.

The EU carbon market has been touted as the hub of what could eventually become a global carbon market. Australia recently announced agreement establishing a two-way link between the EU ETS and the Australian emissions trading scheme. "In the meantime, repercussions of [the April 16 2013 vote against backloading] are spreading far beyond the EU to other nations with carbon market plans, including Australia, Korea and China" (Chaffin, Clark, & Hume, 2013). The EU parliament vote that initially prevented backloading came on the heels of a number of other decisions that raise questions about the EU commitment to tough climate action. Brussels agreed to suspend plans to force international airlines to pay for their carbon emissions after protests from the US, China and other trading partners. A €1.5 billion fund to help companies build carbon capturing equipment collapsed after several governments failed to provide the matching funds for some projects. Responding to political concerns about rising energy cots, Germany announced moves to freeze and cap green electricity generation incentives (2013).

The crisis along with the availability of low cost shale gas has affected the other long-standing emissions trading system in the US known as the RGGI (Regional Greenhouse Gas Initiative), which announced a 45% cut in its carbon budget (IEA 2013b).

5.7. IEA recognizes the shift in priorities

The World Energy Outlook special report in 2013 (2013b) was perhaps indicative of the change in policy priorities. It points to "the disconnect between the level of action that science tells us is required to meet the 2°C climate goal and the trajectory the world is currently on" (2013b).

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Acknowledging the delay in global climate action partly reflected in the timeframe set for a new protocol in 2020 and the heightened priority placed on economic growth and jobs in view of the economic slowdown, it suggests a short term "GDP-neutral" strategy to keep the 2°C target window open at a time of economic fragility and limited political will. Essentially it keeps the world almost on the track of the 450 Scenario for the next few years while focusing on actions that will also avoid "harm to national economic growth", e.g., less money spent on energy through energy saving and efficiency or avoiding higher cost energy investments through lower overall energy consumption. "It seems unlikely that national policy makers will implement actions that are challenging to their national economy given the economic situation in many countries" (2013b, p. 44). The report uses the catchy "4-for-2°C" to recommend four priority areas for short term mitigation. Specific energy efficiency measures will provide 49% of the reductions relative to current policies. The rest will come from limits to the use and construction of inefficient coal power plants (21% of reductions), minimising methane releases in oil and gas production (18%) and a partial phase-out of fossil-fuel subsidies (12%). The measures are meant to be practicable and implementable in a short time frame with significant impact on global greenhouse-gas emissions.

The two core assumptions underlying the 4-to-2°C short term strategy are that the measures are readily available today (at least proven in some countries) and that when taken together the measures do not adversely affect economic growth in any given country or region (though they involve initial deployment costs the net economic benefits are positive). Post 2020 far more profound changes in energy use patterns and technologies will be required, e.g., in the transportation sector electric and plug-in hybrid vehicles will have to rise to one-quarter share of all PLDV sales by 2035. "The pivotal challenge is to move the abatement of climate policy to the very core of economic systems" (2013b, p. 81) with carbon pricing being a central means of success.

6. Attention and policy peaks

6.1. International climate change negotiations

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A look at the international negotiations on climate change linked to the annual UN Conferences of the Parties (COP) paints a picture of growing momentum and interest that peaked in the 2009 "traumatic" conference in Copenhagen that was broadly regarded as a failure. Since then international negotiations have looked more like last minute furtive attempts to prevent total dissolution. By 2010 in Cancun the aspirations had scaled down to simply reaching an agreement whatever that could be (Grubb 2011). In 2011 at Durban it was agreed to extend the Kyoto Protocol until a new 'protocol, another legal agreement with legal force' would take its place in 2015. The establishment of the Green Climate Fund was probably the most important new development though there was no clear signal on how long term finance to support developing countries will be raised. In 2012 at Doha there was agreement to move forward on core elements of the Durban Agreement that included a work plan to begin negotiating the 2015 legally binding agreement. "Doha…had probably the lowest profile of any COP since Nairobi in 2006. From the outside, it may have appeared to justify the epithet 'expectations were low, and they were fulfilled' (Grubb 2013). It would seem that COP 2013 at Warsaw managed to reach an even lower point with little in the way of achievements (except an agreement to a two-year timetable to start working on finer detail) and even a watering down of wording regarding what is to be attained under a new deal in 2015. China disagreed about countries coming forward with 'commitments' preferring the word 'contributions' without 'prejudice to their legal form'. The conference came close to backtracking from the position at Durban 2011 that all the world's major economies, including China, sign up to emission reductions.

"It would be facile to describe the glass as half full. Global emissions are still rising sharply, the UNFCCC remains mostly 'talk talk', and few countries really want to contemplate binding commitments…The structural problems of Kyoto have hardly even been acknowledged. Without facing them, Kyoto remains a dead end. The Green Fund has little funds, and the Technology Mechanism has no technology. Perhaps most severely, the UNFCCC, to a large extent, still behaves like a narrow world unto itself, largely divorced from dominant international structures (e.g. the 'G20', the World Trade Organisation (WTO), and many others of obvious relevance) and from geopolitical trends" (2013).

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Despite this harsh assessment Grubb (2013) argues and explains why the negotiating process are not a 'dead beast' and that there were noteworthy achievements (in Doha). The point here, is not to discuss the progress or potential for substantive developments in international agreements but to convey the striking shift in political priorities that may reflect an unavoidable transition phase as these negotiations confront the post-Kyoto challenges but certainly also reflect the headwinds of the Great Recession and the slow and fragile economic recovery.

With regard to the international climate change negotiations it looks like the world has pressed the pause button while putting off any potential ambitions of attaining agreed targets to the 21st Conference of Parties in Paris (COP21) in 2015. Two recent developments have provided heightened hopes that some kind of breakthrough may be possible yet. President Obama presented a Climate Action Plan on June 25 of 2013 that included a series of measures that the administration could take without congressional actions endorsing them. Though these measures on their own would not be enough to reach the administration's stated goal of reducing emissions by 17 percent from 2005 levels by 2020, they raised the aspirations for a more meaningful global agreement. In retrospect they can also be seen as paving the way for the US-China joint announcement on climate change and energy in Beijing on November 12 2014. China has agreed to a clear target to reach a peak of CO_2 emissions at latest and hopefully earlier than 2030 (with carbon free energy sources accounting for 20% of what is consumed by that year) while the US promised that by 2025 its emissions will be at least 26 percent lower than it was in 2005. The pledge of action by the two largest emitters, along with the EU compromise deal on climate targets for 2030 (*2030 Framework for Climate and Energy Policies - European Commission* n.d.) certainly appears to give the world a fighting chance in view of the upcoming negotiations in Paris in 2015 (Sachs 2014).

6.2. Public attention peak

Polling results have generally shown that the financial economic crisis has significantly affected people's priorities and attention. An opinion poll conducted in the UK by Ipsos MORI[xxxv] (Figure 11) in May 2012 shows that environment and pollution have completely dropped off the list of people's concerns. Economy and unemployment swamp other concerns, while there is notable

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concern also for immigration, inflation, national health service, law and order, education, poverty and pensions. Tracing over time the percentage of a sample of 1000 adults ranking 'environment/pollution' as one of the most important issues facing Britain reveals the spiking of concern in May 2007 when EC proposed carbon emission cuts of 20% by 2020 and another lower peak with the publication of the Stern Report. After that there is a continuing decline indicating the shift in priorities.

A sharp rise starting 2004 and then peak in public attention to climate change just prior to the recession is also revealed in an analysis of British newspaper counts (Figure 12). A number of high profile events are likely to have strengthened the upward trend starting in 2004 (Geels 2013): hurricane Katrina (2005), Al Gore's movie *An Inconvenient Truth* (2006), the Stern Review on the Economics of Climate Change (2006), and the Fourth IPCC Assessment Report (2007) as well as the building momentum in the high profile COP Climate Summits. It is also likely that the rising price of fossil fuel and the concomitant energy insecurity had its role to play too. Following the recession greater attention also turned to the potential costs of low-carbon options leading to higher electricity bills (Pearson & Watson, 2012).

Scruggs and Benegal (2012) refer to widespread evidence from national public opinion surveys in the United States that show a dramatic decline in the public's concern for climate change following the 2008-9 recession. This is reflected in beliefs about the existence, immediacy and seriousness of climate change. Using over 30 years of public opinion data (aggregate opinion trends from the Pew, Gallup and Stanford/Ohio State polls) they estimate the percentage of population saying that there has been global warming as a function of three variables: weather, media bias, and the condition of the economy. While there has been speculation about a 'crisis in confidence' in climate science and a number of explanations have been offered for this change of heart, they argue that poor economic conditions and more specifically, the recent economic downturn, provides the best explanation. Declining concern is not unique to the United States. More generally, they find that labor market conditions "appear to be more important in affecting concern than does news coverage of "anti-warming" claims, the "climategate" scandal, or changes in short-term weather conditions" (2012).

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Shum (2009) using opinion data from Europe found that citizens' attitudes on climate change are affected by short-run economic conditions at both the European and national levels. "Pessimism concerning the prospects of new climate regulations winning broad public support during an economic recession is therefore well-founded in fact" (2009, p. 46). Van den Hove et al. (Van den Hove, Le Menestrel, & de Bettignies, 2002) have shows how the Global Climate Coalition's (GCS) strategy to influence public opinion in order to undermine the US ratification of the Kyoto Protocol has relied on this understanding. In short, it suggests how attitudes or priorities can be exploited by interest groups.

Scruggs and Benegal (2012) also conducted their own statistical analysis on opinion polls in Europe, using the same opinion polls as Shum (2009) but regressing on unemployment. They found that a shift in national unemployment rate from 5 to 9% from April 2008 to September 2009 leads to a 10 percent drop in people reporting global warming as a serious issue. This is very close to the change for the equivalent question in the United States.

This does not mean that policy awaits opinion. Major environmental policy improvements have occurred in the past even during difficult economic times (Scruggs & Benegal, 2012). Certainly a more nuanced analysis may be required to make the connection between public opinion and policy. In the case of climate change, legislation and other initiatives seemed to peak after the onset of the GFC but this is certainly due to the momentum built up before the crisis (Townshend et al., 2013).

6.3. Green policy peak

The number of existing laws or regulations related to climate change is certainly far from an adequate measure of effort or action to mitigate CO_2 emissions or adapt to climate change. Laws can be broad and integrative or narrow in scope. Countries can produce large numbers of legislation by taking a legislative approach while others prefer a regulatory approach. US governments, for instance, having failed to pass climate change legislation, are using their powers under the Clean Air Act to regulate carbon emissions. Many developing countries integrate climate policy into development plans rather than legislating. Climate action often

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takes place at subnational level, as is the case with federal states (Brazil, Canada and the US) and supranational levels (2013). A survey of 33 countries conducted by the Global Climate Legislative Initiative[xxxvi] shows the timing of laws (GLOBE International 2013). The spike in legislation in 2009 and 2010 (see Figure 13 probably reflects the increased pressure from some governments, civil society and international organizations that culminated with the 15th Conference of the Parties to the United Nations Framework Convention on Climate Change (COP15) in Copenhagen. Many countries underpinned their commitments relating to the national pledges made under the Copenhagen Accord by undertaking domestic legislation. The decrease in 2011 and 2012 may reflect a change of priorities resulting from the financial and economic crisis and the continuing fragility of the economic recovery in the developed economies. It could also reflect the fact that some countries have already introduced comprehensive climate change legislation as well as the diminished international political pressure given a new climate change deal is not expected until 2015 (Townshend et al., 2013).

The sectoral scope of climate change legislation is understandably broad with energy being the most popular category. Nearly all countries have legislation on energy efficiency. Twenty-five out of the thirty-three countries studied incorporate adaptation in legislation. A number of countries have made moves towards carbon pricing: in 2011[xxxvii] Australia passed legislation to develop a national trading scheme by 2015; China is planning a national scheme by 2020 and is starting with pilot emissions trading schemes in seven municipalities and provinces; South Korea has enacted legislation for a national emissions trading scheme by 2015; Japan introduced a carbon tax in 2012; South Africa has proposed a carbon tax; India has started a levy on coal with revenue earmarked for clean energy research (2013).

While the broad global picture of legislative activity may be one indicator of the ramifications of the Great Recession on climate policy, ultimately a more detailed appraisal of its impact on the big emitters and potential leaders may be more informative of potential implications for global action. In some sense the collapse of the EU emission allowance price was symptomatic of the impact that the ongoing economic crisis has had on the EU's resolve to sustain its leadership role in climate policy. (Skovgaard 2014) looks at the implications of the crisis for EU climate policy in terms of a deepening division between 'policy frames' or those that saw climate-change policy as

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detrimental to growth (tradeoff) and those that saw it as beneficial (synergy).[xxxviii] He concludes that the crisis made both policy frames more salient, enhancing the conflict and ultimately strengthening the 'more economically' oriented actors (such as DGs Energy and Industry and national ministries of finance and economy) who focused on the negative impact of mitigation costs to growth and competitiveness.[xxxix] In the United States (Schor 2014) finds that the discourse about climate had also been strongly affected by the economic crisis towards that of 'tradeoff'. "The economic situation was a game-changer that climate deniers and the fossil fuel industry used to engineer an aggressive U-turn on the state of play of climate legislation" (2014, p. 3). The impact is apparent both in the failure of the first attempt at a national cap and trade bill referred to as Waxman-Markey as well as the near total silence on climate change in the Presidential election of 2012.

7. Conclusions

With the Great Recession the public concern and the political will for climate action took a serious blow. The drop seems precipitous from the heights of public concern and political momentum in face of the multiple and interrelated water-food-energy-climate crises appearing in the run up to Lehman's collapse. The confluence of these separate but clearly linked threats provided hope that the necessary political will for bold action was materialising. Yet along with the Great Recession precipitated by the burst in the subprime bubble these earlier very tangible threats appeared to deflate in importance in the public's mind. This is reflected both in polls and in governments' words and deeds and in the near collapse of UN climate talks. Food prices and fossil fuel prices did initially drop (though much less than may have been expected) as did global greenhouse gas emissions. Attention turned squarely to addressing the financial crisis and rising unemployment. Several years have gone by since the start of the Great Recession and while formally the US is out of the recession there is only very recently an uptick in public concern[xl] in the US for climate change which is likely to be related to recent extreme weather events (summer wildfires and Hurricane Sandy) and continuing evidence of accelerating climate volatility. It may also reflect the recovery underway. In the UK, a strong climate action advocate, the change in priorities is

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palpable with the recent discussion prompted by Ed Miliband's promise to freeze energy bills for 20 months. Regarding this new debate about energy prices in the UK an FT editorial captures the new mood: "Bold undertakings to reduce emissions were popular when they were announced at the height of the boom. Yet that moment of Malthusian anxiety was also one of economic cheer, and little attention was paid to sacrifices that expensive energy entails" (Editorial 2013).

One might have hoped that the lost political time might be made up by a fall in greenhouse gas emissions due to lower economic activity but in striking contrast to previous economic crises, while CO_2 emissions dipped briefly in 2009 the high growth in 2010 swamped these initial gains. While the downturn helped the developed economies meet their emission targets, the growing dominance of emission growth in the emerging markets and especially China and India pushed global emissions to record highs.

Data on clean energy developments provided some smidgeons of hope. Renewable power and electric-hybrid vehicles showed some continued dynamism. China and Japan strengthened renewable policy and targets while Europe scaled back. Policy uncertainty and falling equipment cost negatively impacted renewable investments. The problems and the decreasing investor confidence were reflected in the dramatic fall in clean energy share values in 2008. The dramatic drop in PV module prices created corporate distress but also signalled the move from a 'niche' market to take off phase. While clean energy maintained some momentum, largely propelled by pre recession policies, the brown energy news has been bad. More money is still being invested in new fossil-fuel generating capacity (coal, gas) compared to renewables. Coal has become the main source of electricity generation by far with China and India driving the demand growth. Coal demand in Europe also rose as coal prices fell and EU ETS carbon prices plummeted temporarily putting strains on meeting emission targets. While economic slowdowns are generally linked to drops in CO_2 emissions they can also shit the energy mix away from clean energy. This would be a particularly worrying threat if it affects long term investments.

The collapse of the EU carbon market was partly an expected market adjustment to the recession though the extent of the collapse would seem to be more related to the uncertainty about carbon market governance and climate policy resolve. This weakening of political resolve, evidenced in the difficulties of passing amendments in the EU parliament that would help support the carbon

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price is the greater concern. It undermines the constancy in regulatory goals that is needed by clean energy investors, it partially maligns the perceived effectiveness of carbon pricing policies, and it signals faltering leadership of the EU.

Though it might be expected that climate policy (or concern for climate change) and unemployment are inversely related, climate risk is linked to global accumulation of GHGs and any rebound in brown economic activity will only exacerbate the problem. In this vein, one of the more positive impacts of the Great Recession was a call for Green Economic development or Green Keynesianism. Though in many ways Green Economic growth is a repackaging of the broad concept of sustainable development, the new element (or emphasis) was to see the financial crisis as an opportunity for fiscal stimulus directed at accelerating the transition to sustainable energy; a kind of Green Keynesianism. This growing literature may help provide important policy insights about ways to combat recessions and downturns while maintaining and strengthening a shift to a low carbon economy. Much as the Great Depression eventually brought about an economic and political response in the form of the New Deal, the Great Recession could give rise to a New Green Deal. Understandably, many climate economists and international organizations, concerned with losing momentum, pointed to this 'double dividend' of economic recovery and generating jobs while laying the foundations for the clean energy revolution. In 2009 some governments heeded the calls and ensured that at least a significant portion of stimulus packages were directed toward sustainable energy activities. This initial intervention has run its course and since then government expenditure on clean energy continues to fall. Given the enormity of the transformation in energy systems required the initial green fiscal boost does not appear to be a strong enough impetus but this may depend on whether it eventually leads to a more permanent mindset towards large scale clean energy infrastructure investments. It will also depend on a broader debate on the nature of government intervention and sustainable energy. The debate on government intervention per se has certainly already shifted ground, as the mainstream market fundamentalist paradigm has been wounded on several fronts, including the role of banking, deregulation of finance and globalization of finance. This shift has been too little and too slow, and there are few indications that the lessons of green growth or green Keynesianism are bringing about the needed change in climate policy. Despite the depth and

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immediacy of the Great Recession the reforms remain far from adequate to bring about a sustained recovery or to reduce the risk of recurrence. That adequate reforms are not undertaken in the financial system even when the crisis is at its most intense phase does not bode well for undertaking the far more extensive overhaul required for low carbon energy revolution.

Crises are painful and often destructive. They can be the outcome of underlying transitions afoot that strain the existing institutions and mindsets. They can be precursors to fundamental change in the spirit of creative destruction. They present societies with opportunities for new pathways as they unleash a rebalancing of conflicting political and economic interests. The world crisis derives from the Ancient Greek word κρίσις, meaning the power of good judgment. Many found signs of hope in the multiple crises (financial, economic and environmental), especially in the phase just prior to the Great Recession. A look at past techno-economic paradigm shifts might suggest that we are confronting a breaking point of resistance to institutional changes that will usher in new technologies with a matching socio-economic framework conducive to a green wave of renewable energy, resource efficiency and information communication technology. There are problems, however, with drawing parallels to past techno-economic shifts when considering the required transition to sustainable energy societies. Socio-technical transitions take long periods to unfold and there is no a priori reason why the timing of any underlying transition related to the present crisis will meet the very tight time frame for a sustainability transition. The window of opportunity for avoiding dangerous levels of GHG accumulations is closing fast especially given the long term lock-in associated with energy investments. Though political forces were often involved in past socio-technical transitions, they were driven by economic interests exploiting technical advances to provide services attractive to consumers and industry. Political forces aligned with these when they recognized gains for consumers and industry that translate into votes. Unlike past transitions, a transition to sustainable energy systems, except by luck, must be a largely policy driven transition. It cannot rely on the market pull of superior quality of energy services. The technology itself must be guided in a specific low carbon direction, rather than simply being the outcome of economic and national competition. Unlike past transitions that began in one country and spread to others, it has to take place on a global scale guided by policy in the major economies of the world. Most worrying, is that the time frame available is much

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shorter than any previous energy transition. In short, while there may be some sings of hope from developments on the clean energy front they do not add up to the kind of momentum that we should be seeing even in times of economic distress (perhaps especially in times of distress if one abides by some forms of Green Keynesianism). The peak of policy momentum was at the height of the global financial bubble when energy security appeared to align with climate action as a way to address the multiple crises associated with a 'booming' global economy. Climate action could be more easily sold to a public worried that it's lifestyle was threatened by high energy prices, food prices and extreme weather events. This narrative was lost in the recession and it's hard to see how the policy momentum will be regained without it being part of a future bubble which would not be a solution anyway.

It is instructive to consider the three scenarios used in Bloomberg New Energy Finance to project future growth in renewable energy[xli]. The Traditional Territory (TT) scenario assumes a subdued world economy with a real cumulative annual growth rate (CAGR) of 2.2%. Fossil fuels become cheap due to the expanding production of shale gas. Environmental concerns are moderate and mostly appeased by more use of gas. Trusted technologies of gas, coal and energy draw most investments. Support for new energy technologies weaken while grid investments focus on maintaining the existing centralized infrastructure. The New Normal (NN) assumes some hangover from the crisis but with higher rate of growth (2.7%). Fuel prices rise as demand for energy from developing countries outstrip supply. Environmental concerns remain stable but carbon prices rise as EU and Australian policies remain intact. Existing clean energy policies continue till 2020 and are replaced by carbon prices in key countries. Investment in grid accommodates moderate new distributed technologies. The Barrier Busting scenario assumes full economic recover following trend of past 20 years with high fossil prices, heightened environmental concern and stronger policies with stronger investment in grid technologies (Tuner 2013).

Among these scenarios the subdued world economy one appears to be the most threatening in terms of climate change. Based on some of the anecdotal information presented in this paper the Great Recession seems to have done more harm than good for the transition to sustainable energy systems. Given the centrality of policy guidance in this transition, the greatest damage

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seems to come from the shifting government priorities. The real objective must be for governments to induce the first policy guided unprecedented speedy socio technical revolution that provides a way out of recessions (present and future) and is robust to the winds of economic and political change. A tall order indeed but this is how it must be.

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Figures and Tables

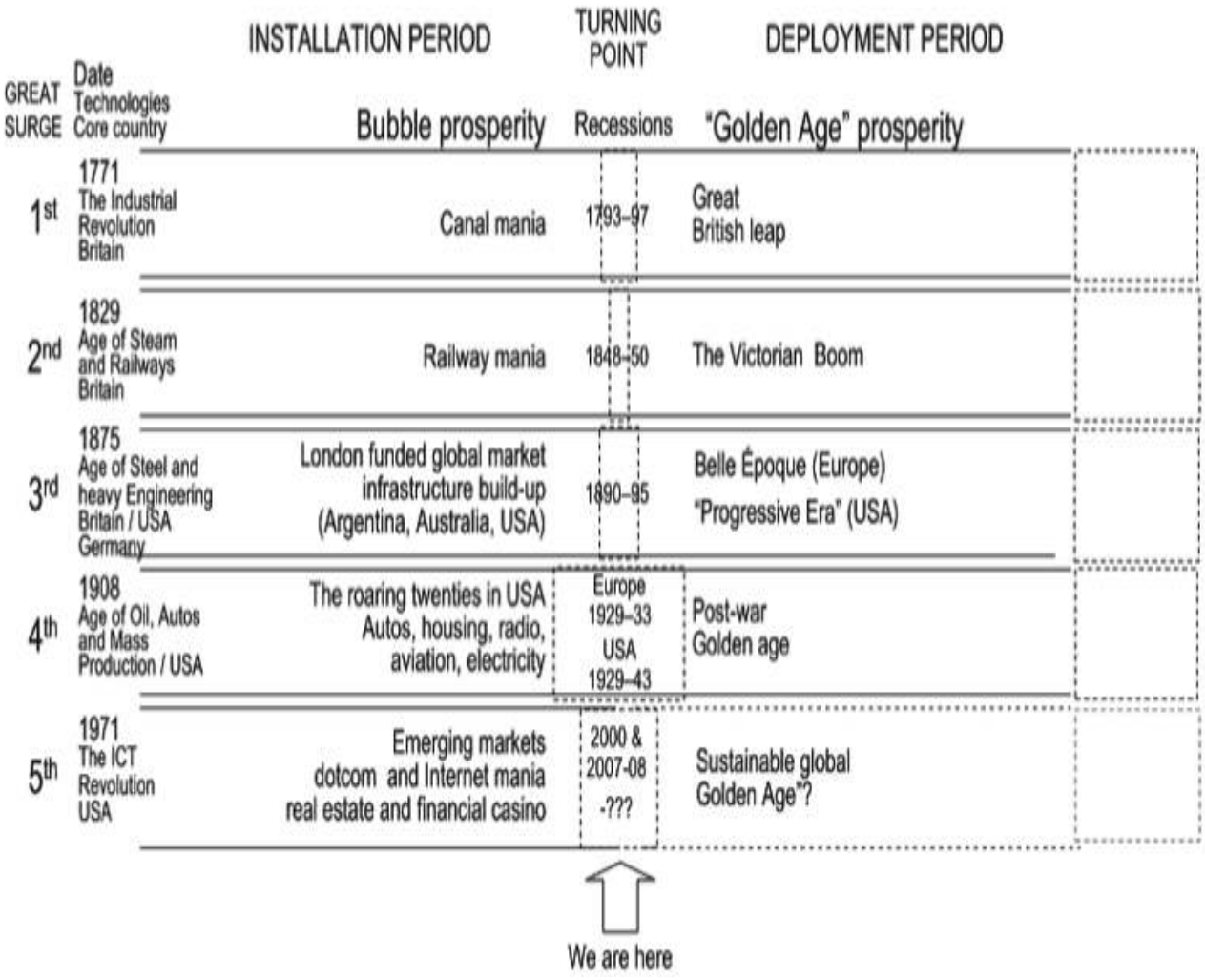

Fig. 1 Crises and energy transitions

Source: (Perez 2013)

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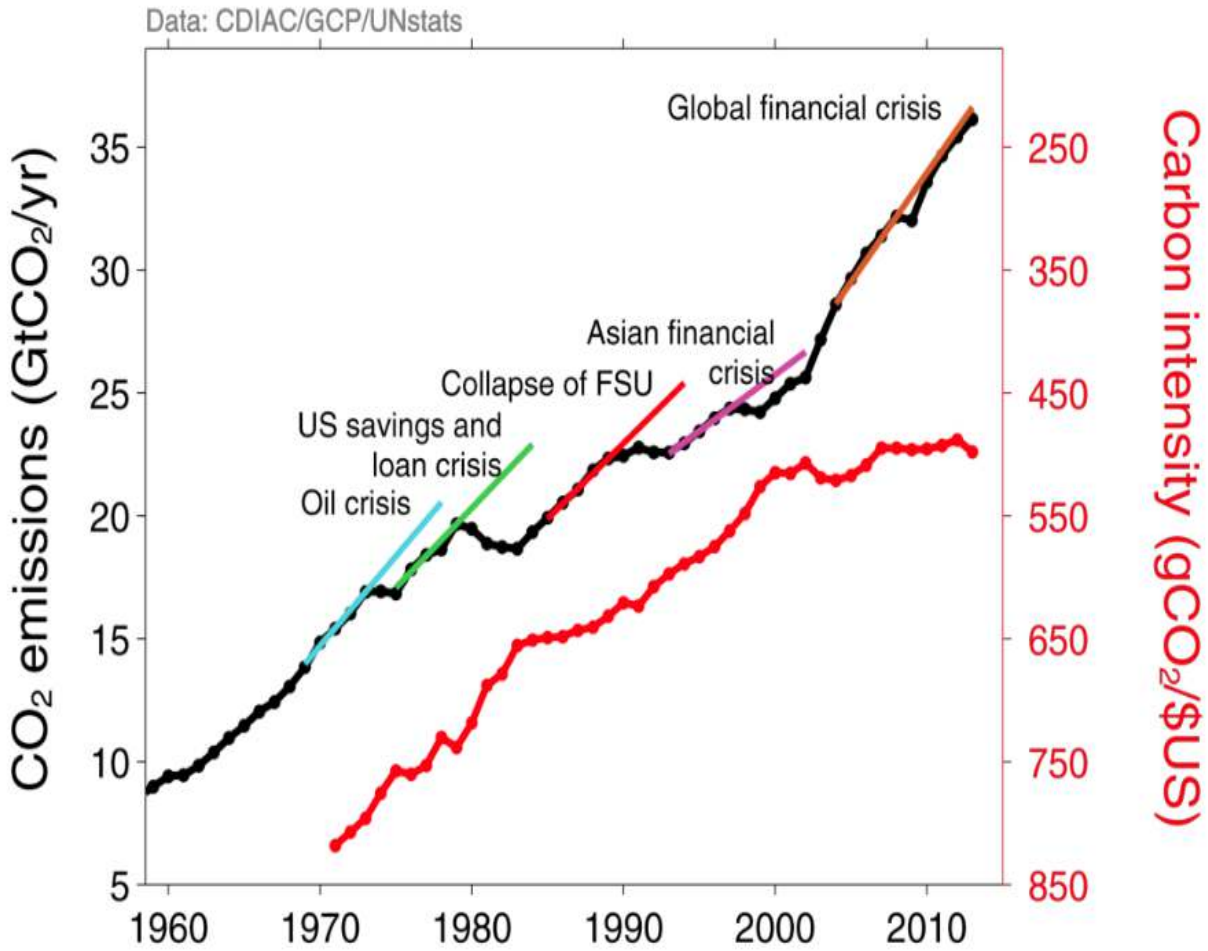

Fig. 2 Financial crises and CO_2 emissions

Source: CDIAC; (Le Quéré et al., 2014); Global Carbon Budget 2014

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Table 1 Impact of US$1 billion additional spending on "direct green stimulus" activities. Projected for U.S. under the Obama economic stimulus bill.

"Green" program	Overall employment impact, job years, initial year	Energy cost saving, US$ million annually, 2012-2020	CO_2 emissions reduction, 1000 tons annually 2012-2020	Private share, overall generated, average
Household weatherization	25100	207.8	440.7	0
Federal building retrofits	25300	386.7	546.9	0
Green school construction	25200	609.2	905.8	0
PTC extension	39100	562.5	727.7	76.1
ITC increase	33300	208.7	213.4	47.0
CCS demo projects	28500	225.3	341.6	68.8
"Cash for clunkers"	46900	433.0	1112.5	86.8
Hybrid tax credit	11100	-	-	0
Battery R&D	22500	1278.8	1332.8	0
Mass transit	34500	23.6	87.3	27.4
Smart metering	40000	918.0	207.4	50.0
Average for green stimulus	30100	450	593	-
Road investment	25200	-32.8	-35.4	0

Source: (Houser et al., 2009)

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Table 2 Summary of direct stimulus programs (March 2009) and their "Green" components

				Power		Energy Efficiency				
Country	Total stimulus (in $US billion)	"Green" Stimulus(in $US billion)	"Green Stimulus" (%)	Renewable	CCS/Other	Building Efficiency	Low carbon vehicle	Rail	Grid	Water/ Waste
Australia	26.7	2.5	9.3	-	-	2.48		-		-
China	586.1	221.3	37.8	-	-	-	1.5	98.65	70	51.15
India	13.7	0	0	-	-	-	-	-	-	-
Japan	485.9	12.4	2.6	-	-	12.43	-	-	-	-
South Korea	38.1	30.7	80.5	-	-	6.19	-	7.01	-	13.89
Thailand	3.3	0	0	-	-	-	1.8	-	-	-
EU	38.8	22.8	58.7	0.65	12.49	2.85	1.94	-	4.86	-
Denmark	-	1.8	-	0.9	-	-	0.9	-	-	-
Germany	04.8	13.8	13.2	-	-	10.39	0.69	2.75	-	-
France	33.7	7.1	21.2	0.87	-	0.83	-	1.31	4.13	-
Italy	103.5	1.3	1.3	-	-	-	-	1.32	--	-
Spain	14.2	0.8	5.8	-	-	-	-	-	-	-
UK	30.4	2.1	6.9	-	-	0.29	1.38	0.41	-	0.83
Other EU states	308.7	6.2	2	1.9	-	0.4	3.9	-	-	0.03
Canada	31.8	2.6	8.3	-	1.08	0.24	-	0.39	0.79	0.13
Chile	4	0	0	-	-	-	-	-	-	-
US	972	112.3	11.6	32.78	6.55	30.74	4.76	9.92	11.92	15.58
Total	**2,796.00**	**436**	**15.6**	**38**	**20.1**	**66.8**	**15.9**	**121.8**	**91.7**	**81.6**

Source: (Strand & Toman, 2010)

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Table 3 Overall progress and policy recommendations

On track?	Status against 2DS targets in 2025	Policy recommendations
Renewable power	Rapid progress, particularly in hydro, onshore wind and PV, on global scale; slightly slowing momentum in OECD. Offshore wind, bioenergy, concentrated solar power (CSP), ocean and geothermal technologies are lagging.	▪ Maintain a balance among sustainability, affordability and competitiveness while designing renewable power policies. ▪ For maturing markets, integrate renewables with greater exposure to market pricing and competition. ▪ Shift focus from high economic incentives to long-term policies that provide predictable and reliable market and regulatory frameworks offering a reasonable degree of certainty over remuneration. ▪ Reduce risks associated with policy uncertainty that ultimately drive up capital and project costs for capital-intensive renewable; avoid retroactive measures by all means.
Nuclear power	Installed capacity in 2025 likely 5% to 25% below 2DS target. Both new-build activity and long-term operation of existing reactors required.	▪ High capital and low running costs create need for policies that provide investor certainty, e.g. through more favourable market mechanisms and investment conditions. ▪ Implement safety upgrades in existing nuclear plants in a timely manner to ensure public confidence.
Gas-fired power	Decreasing power demand, overcapacity, the rise of renewable energy and low coal prices make the situation for gas power challenging, particularly in Europe.	▪ Carbon prices and other regulatory mandates needed to drive coal-to-gas switching outside the United States. ▪ Scaling up unconventional gas extraction requires careful regulation and monitoring to avoid adverse effects on the environment.
Coal-fired power	Current trends of increasing coal-fired power are incompatible with the 2DS. Accelerated development of carbon capture and storage (CCS) required.	▪ Policy incentives to drive emissions reductions, such as carbon pricing and regulation, are vital to control pollution and reduce generation from inefficient units. ▪ New coal power units should, at minimum, achieve the efficiency of supercritical units and be CCS-ready to have the potential to reduce even further the impact of coal use.
CCS	Global capacity of around 50 $MtCO_2$/yr in 2020 if projects in advanced stages reach operation. In the following decade, the rate of capture and storage must increase by two orders of magnitude.	▪ Demonstrate financial and policy commitment to CCS demonstration and deployment. ▪ Near-term policies should be supported by credible long-term climate change mitigation commitments. ▪ Recognise the large investments and long lead time required to discover and develop viable storage sites. ▪ Introduce CCS as a solution to address CO_2 emissions from industrial applications.
Buildings	Progress continues in most regions, but is insufficient. The 2DS target for 2025 constrains energy demand growth to 0.7%/yr from 2012; trend since 2000 is more than double at 1.5%/yr, throwing the sector off track.	▪ Promote deep energy renovation during normal refurbishment, and increase significantly the annual rate of renovation (to at least 2%). Pursue zero-energy building goals from 2020 onwards for all new construction, which will require significant effort now. ▪ Implement mandatory building codes that promote advanced building materials, integrated using a systems approach to reduce heating, cooling and lighting energy demand. Build capacity and infrastructure in emerging economies to promote building code development and compliance. ▪ Set MEPS to improve efficiency; continue and extend where possible. ▪ Apply labelling policies and standards to promote uptake of energy efficient models; develop measures to curtail increasing demand.

Not on track Improvement, but more effort needed On track, but sustained deployment and policies required

On track?	Status against 2DS targets in 2025	Policy recommendations
Industry	Some progress in energy efficiency, but energy use must be cut by 25% and direct CO_2 emissions by 17% by 2025.	▪ Promote widespread application of best available technologies (BATs) to help overcome the challenges of slow capacity stock turnover, high abatement costs, fluctuation in raw material availability, carbon leakage and industrial competitiveness. ▪ Support RD&D programmes to bring to technical and commercial maturity new low-carbon technologies that enable the use of low-quality feedstocks; demonstrate and deploy emerging energy- and emissions-saving technologies, including CCS. ▪ Promote technology capacity building in emerging economies.
Transport	Although OECD recently shows high vehicle efficiency improvement rates for PLDVs, and despite recent progress in hybrid and EV deployment the sector is lagging.	▪ Implement fiscal policies that reflect actual costs, e.g. remove fuel subsidies to incentivise switching to fuel-efficient vehicles. ▪ Continuously adapt ongoing policies such as fuel economy and emission standards, feebate systems, or emission-based taxes for PLDVs; develop and implement fuel economy policies for HDVs. ▪ Use urban development strategies, access restriction and congestion charging to manage travel demand and influence modal choice, promoting shifts to collective transport modes and stimulating innovative vehicle technologies. ▪ Apply market-based instruments, such as emissions trading, to internalise GHG-related costs, and regulatory measures to foster the uptake of efficient technologies in the aviation and shipping sector.
Electric and hybrid electric vehicles	Slow growth compared with previous years; tracking indicator dipped from green (2013) to orange. Annual sales must increase substantially for both EVs (80%) and HEVS (50%) until 2020.	▪ Direct subsidies, tax exemptions, feebate schemes and favourable conditions in urban areas enhance cost-competitiveness of EVs/HEVs and boost manufacturer and consumer confidence. ▪ Extend policy measures and programmes to give industry confidence that market demand will continue to grow in the short term. ▪ Develop standards for charging stations and integrate EVs in city mobility programmes (e.g. car sharing) to underscore broader benefits, including reduced local air pollution.
Biofuels	Global production must triple; advanced biofuels capacity must increase 22-fold.	▪ Develop fiscal measures that reduce investment risk associated with first commercial-scale advanced biofuels projects, to achieve technology learning and cost reductions. ▪ Promote international harmonisation of sustainability certification schemes, without creating unwanted trade barriers. ▪ Create a long-term policy framework to ensure sustained investments in production and use of sustainable biofuels that perform well in terms of emissions reduction and land-use efficiency, as well as economic and social impact.
Co-generation and district heating and cooling	Slow progress despite their enhanced conversion efficiency; deployment of co-generation accounts for only 9% of global electricity, and penetration of efficient district heating and cooling (DHC) is limited.	▪ Make the efficiency and flexibility benefits of co-generation visible by creating market conditions that reflect the real cost of generation. Facilitate investments in modernisation and improvement of networks. ▪ Develop strategic local, regional and national heating and cooling planning to identify cost-effective opportunities to develop co-generation and expand DHC networks. ▪ Streamline grid interconnection standards to achieve the flexibility potential of co-generation technologies.
Smart grids	Steady growth, but available deployment data do not give a full picture; current rate of deployment is insufficient.	▪ Develop and demonstrate new electricity regulation that enables practical sharing of smart-grid costs and benefits. ▪ Support the development of international standards to accelerate RDD&D. ▪ Promote the development metrics, national data collection and international data co-ordination.

Not on track Improvement, but more effort needed On track, but sustained deployment and policies required

Source: (IEA 2014c)

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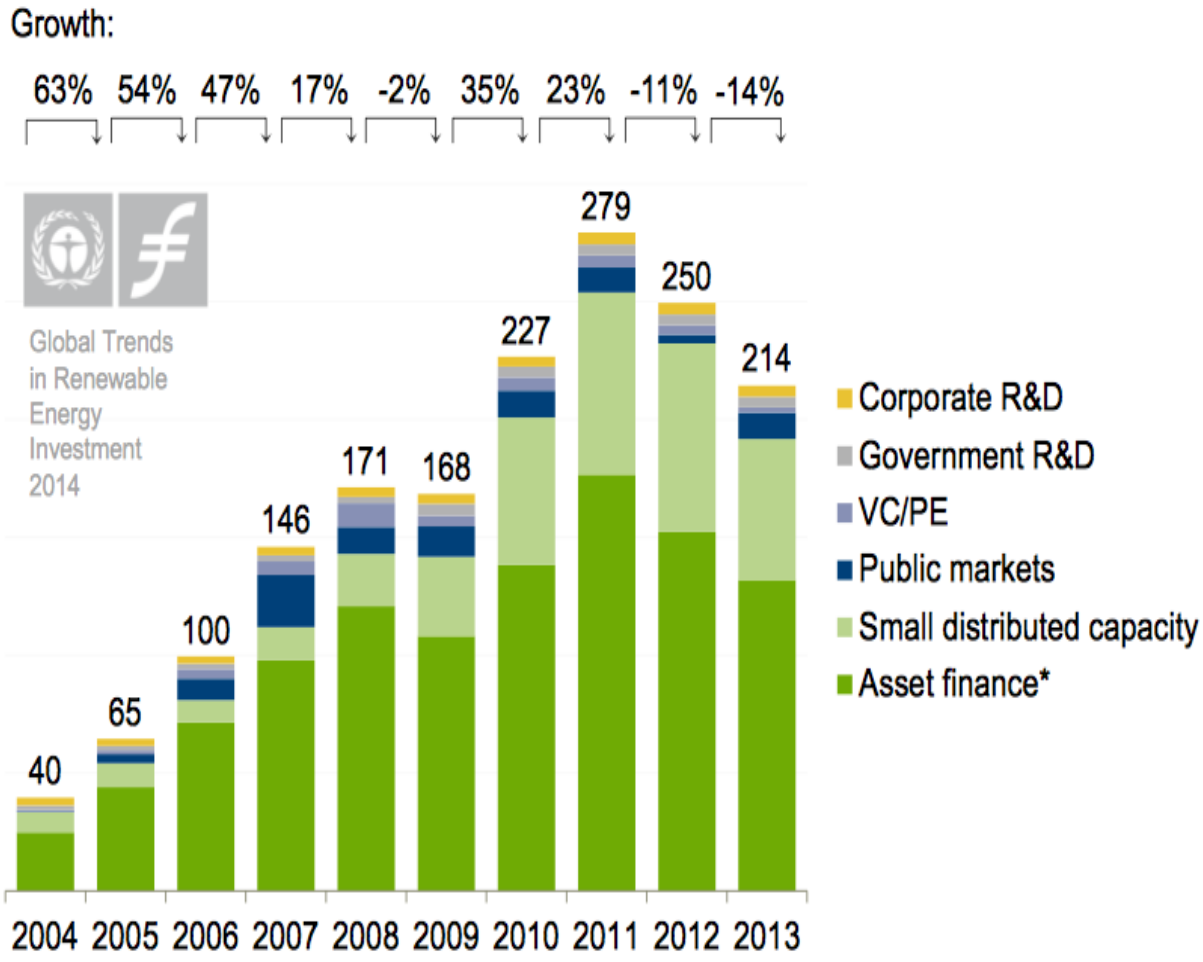

Fig.3 Global investments in renewables (2004-2013)

Source: (Frankfurt School of Finance and Management gGmbH (in collaboration with Bloomberg New Energy Finance) 2014, p. 12)

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Table 4 Overall progress and policy recommendations

Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2012-13	2004-13
New Investment by Geography Unit	$bn	$bn	$bn	$bn	$bn	$bn	$bn	$bn	$bn	$bn	Growth %	Growth %
United States	5.5	11.7	28.2	33.6	35.9	23.5	34.7	53.4	39.7	35.8	-10%	23%
Brazil	0.6	2.6	4.6	11	12.2	7.8	7.7	9.7	6.8	3.1	-54%	21%
AMER (excl. US & Brazil)	1.4	3.3	3.2	4.9	5.8	6.1	11.5	8.7	9.9	12.4	26%	27%
Europe	19.7	29.4	391	61.8	73.4	75.3	102.4	114.8	86.4	48.4	-44%	10%
Middle East & Africa	0.5	0.5	0.9	1.6	2.3	1.4	4.3	3.2	10.4	9	-14%	37%
China	2.4	5.8	10.1	15.8	24.9	37.1	36.7	51.9	59.6	56.3	-6%	42%
India	2.5	2.9	4.4	6.3	5.4	4.2	8.7	12.6	7.2	6.1	-15%	10%
ASOC (excl. China & India)	6.8	8.2	9	10.9	11.4	12.9	20.7	25.3	29.5	43.3	47%	23%
Total	39.5	64.5	99.6	145.9	171.2	168.4	226.7	279.4	249.5	214.4	-14%	21%

Source: (Frankfurt School of Finance and Management gGmbH (in collaboration with Bloomberg New Energy Finance) 2014, p. 15)

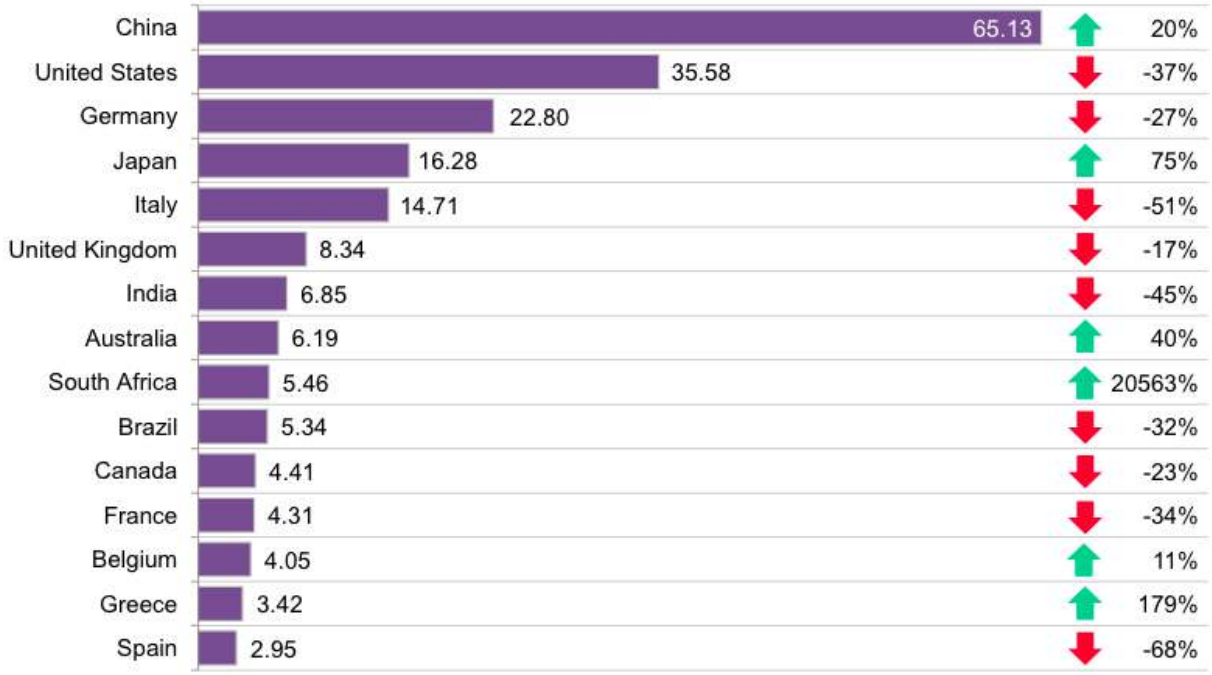

Fig.4 Total renewable investments in 2012 by country

Source: (Frankfurt School of Finance and Management gGmbH (in collaboration with Bloomberg New Energy Finance) 2014, p. 61)

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	Incentive	Countries
Change of regime		Japan: feed-in tariffs (FITs) replaced renewable portfolio standard (RPS).
		South Korea: RPS system replaced FITs.
		Sweden and Norway: introduced joint Green Certificates Market.
Increase	FITs	Indonesia: tariffs for geothermal energy implemented.
		Jordan, Malaysia, Rwanda and Ukraine: FIT systems introduced.
	Other economic incentives	Australia: AUD 2 billion for investments via Clean Energy Finance Corporation.
		Brazil: introduced discounts on transmission and distribution fees and net metering.
		China: waived charges for grid connections for small-scale solar PV.
		Romania: implemented allocation floor for Green Certificates.
Decrease	FITs	Australia:[3] FIT levels for solar PV reduced by 41%.
		Canada:[4] FIT levels reduced for wind by 15% and and solar PV by 9.6%-31.5%.
		Germany: under EEG 2012, FIT rates revised down and degression rates increased for several technologies, particularly solar PV.
		Italy: FIT levels for solar PV lowered by 20% and annual support cap imposed.
		Portugal: moratorium on FITs for new installations.
		Spain: moratorium on FITs for new installations.
	FITs and other economic incentives	Bulgaria: FIT cuts of 10%-50%. Biggest decrease of tariffs for solar PV. Retroactive tax for solar PV operators introduced.
		Greece: FIT levels reduced up to 46% for solar PV, new licenses for solar PV installations were suspended and retroactive tax on renewable systems introduced.
		United Kingdom: cuts in FIT levels up to 40% for solar PV. Announced future adjustments to Renewable Obligation Certificates (both increases and decreases depending on technology).
	Other economic incentives	Belgium:[5] adoption of a retroactive grid access tariff for the use of the grid for PV systems benefiting from net-metering.
		United States: expiration of cash grant programme (Section 1603). Uncertainty over the expiration of the production tax credit (extended for one year at the start of 2013).
		India: expiration of accelerated depreciation and generation-based incentives.

Fig. 5 Changes in key national economic incentives for the renewable electricity sector in 2012 Source: (IEA 2013a)

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Fig. 6 WilderHill New Energy Global Innovation Index (index of global clean energy companies) compared to other indices.
Source: (Frankfurt School of Finance and Management gGmbH (in collaboration with Bloomberg New Energy Finance) 2014)

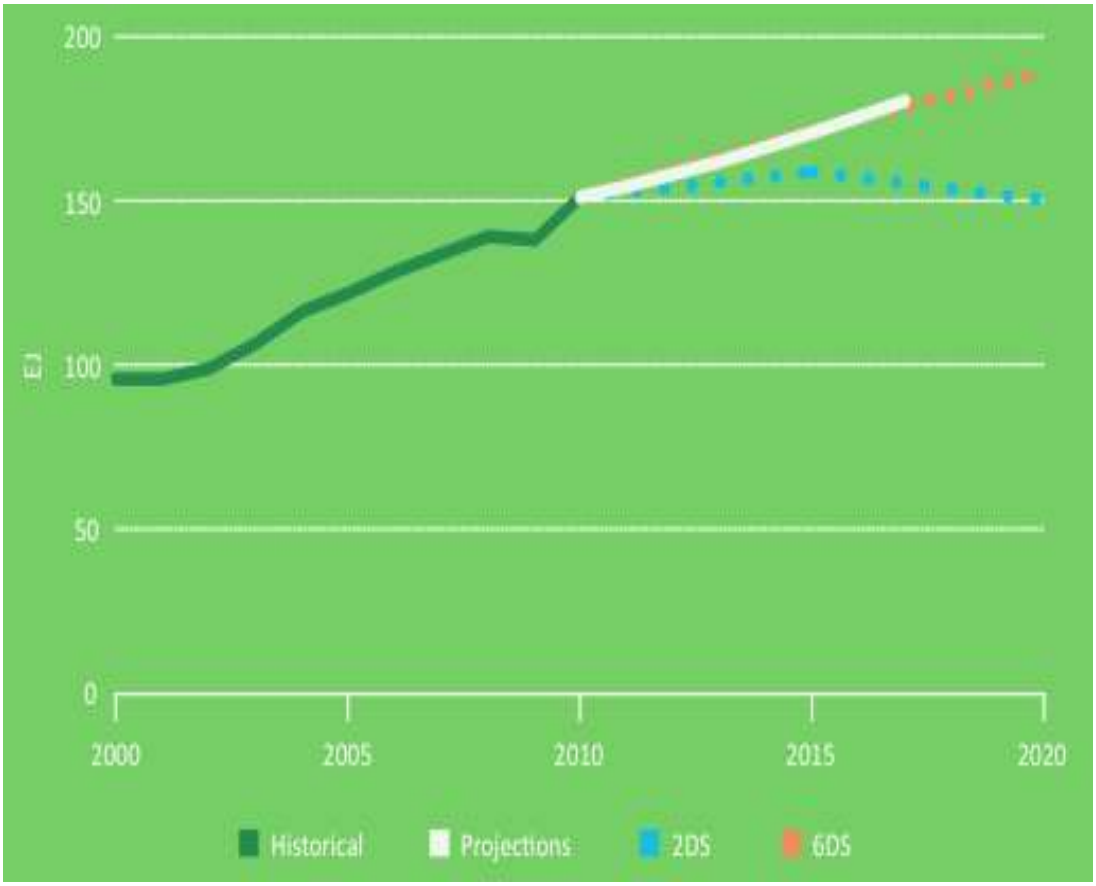

Fig. 7 Global coal demand (past and projected)
Source: (IEA 2014c)

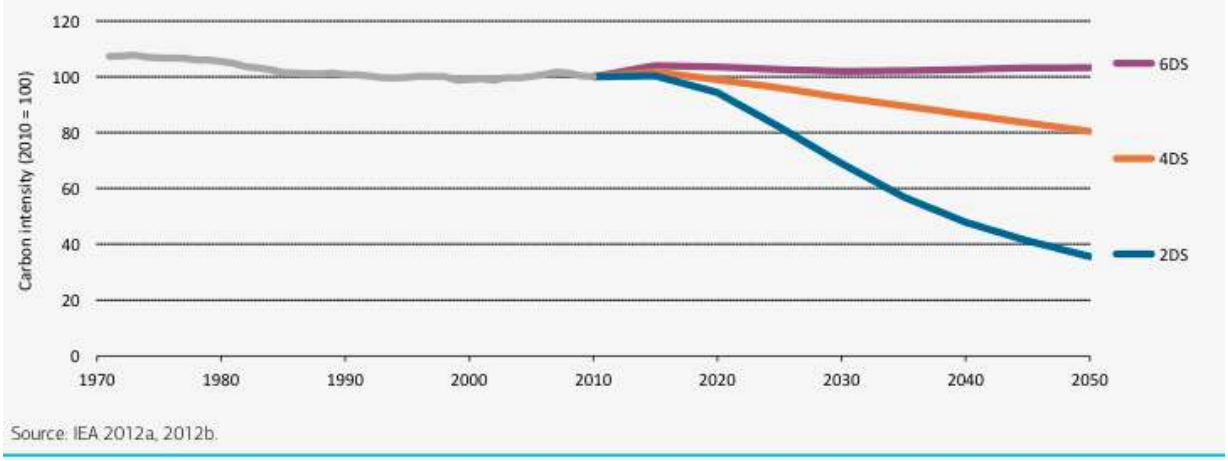

Fig. 8 Carbon intensity over time
Source: (IEA 2013c)

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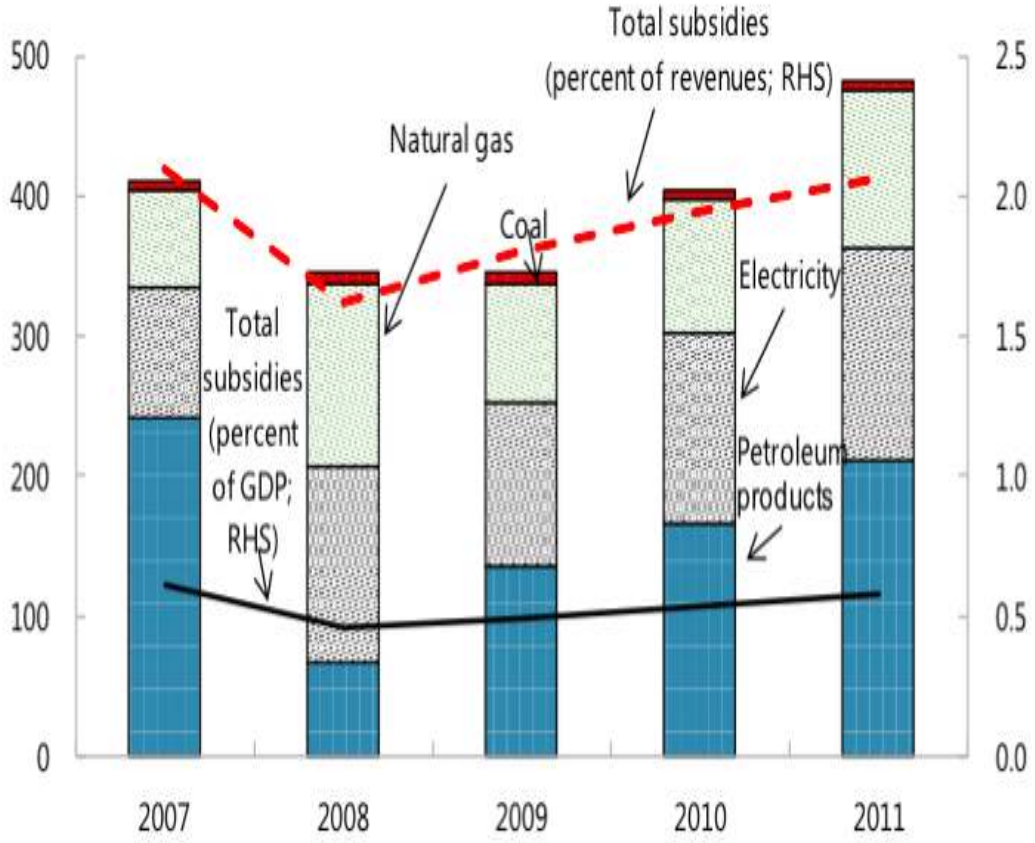

Fig. 9 Pre tax energy subsidies, 2007-11
Source: (IMF 2013a, p. 10)

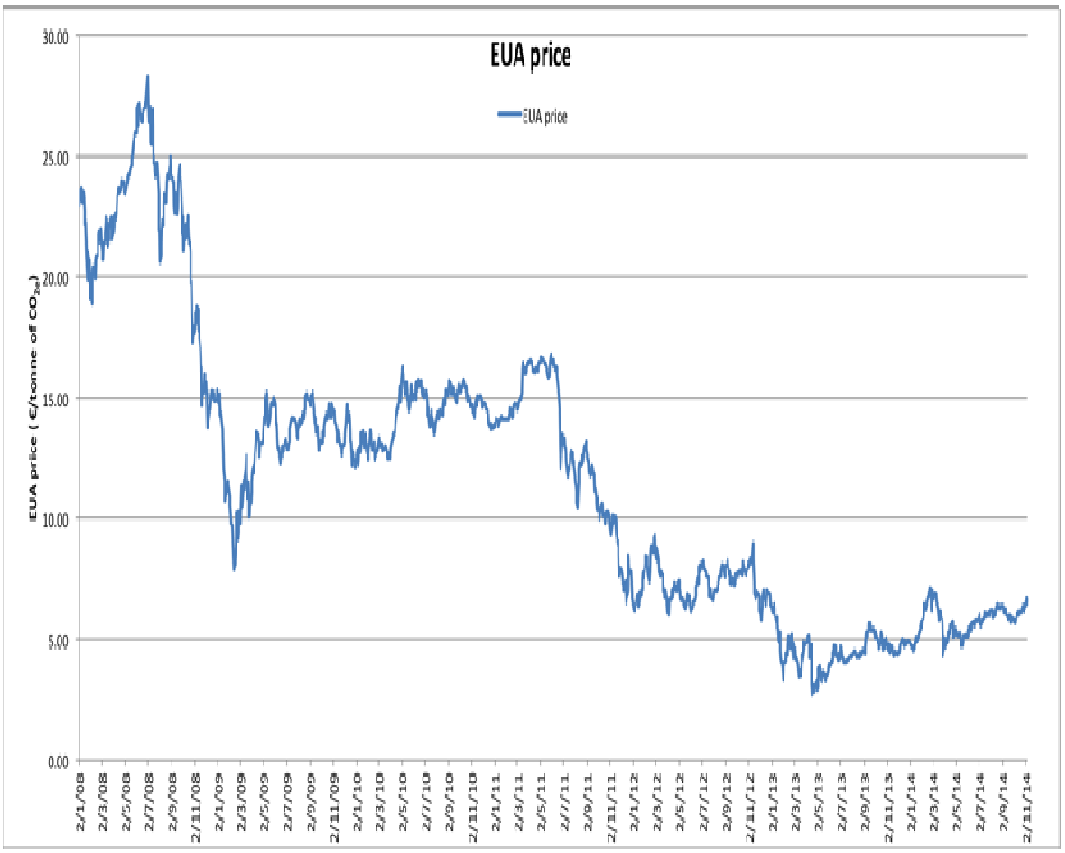

Figure 10: EU emissions allowance spot price over time
Source: SENDECO2 (http://www.sendeco2.com)

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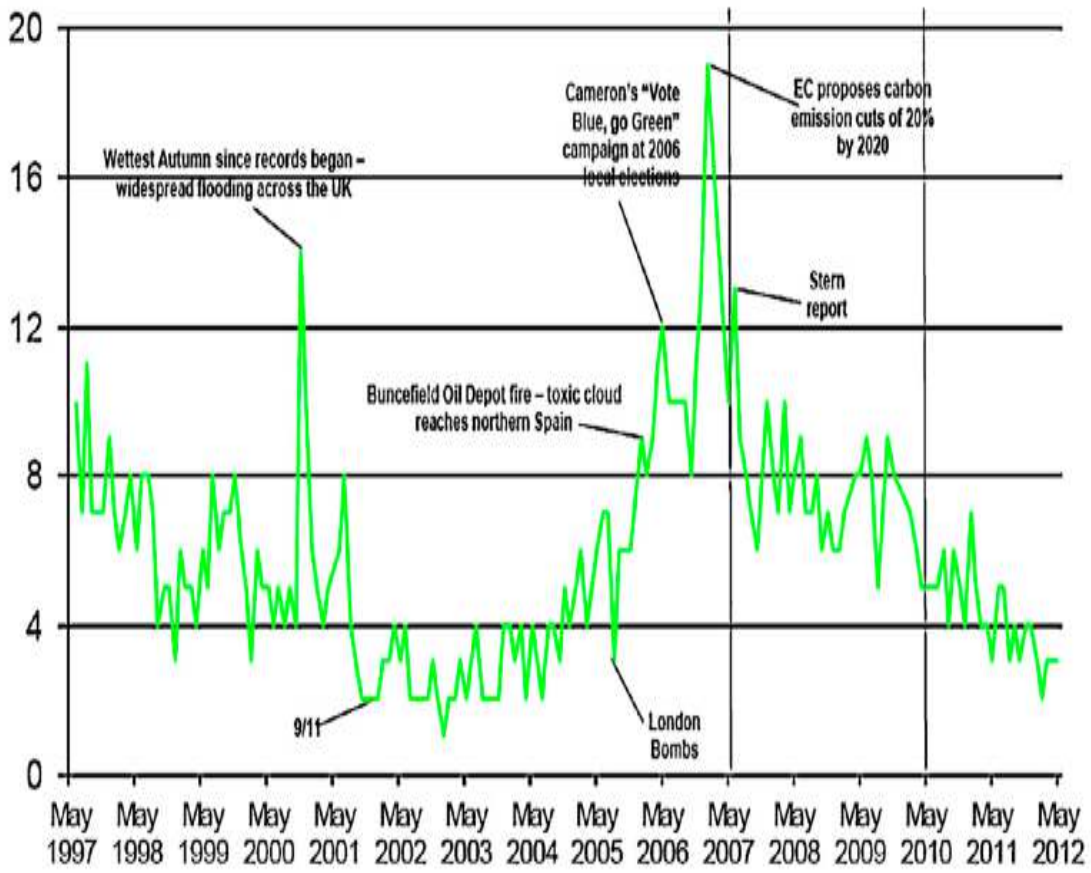

Figure 11: Percentage of a sample of 1000 adults who rank 'environment/pollution' as one of the most important issues facing Britain
Source: Economist/Ipsos MORI (downloaded from here: http://www.ipsos-mori.com/researchpublications/researcharchive/2967/ EconomistIpsos-MORI-May-2012-Issues-Index.aspx)

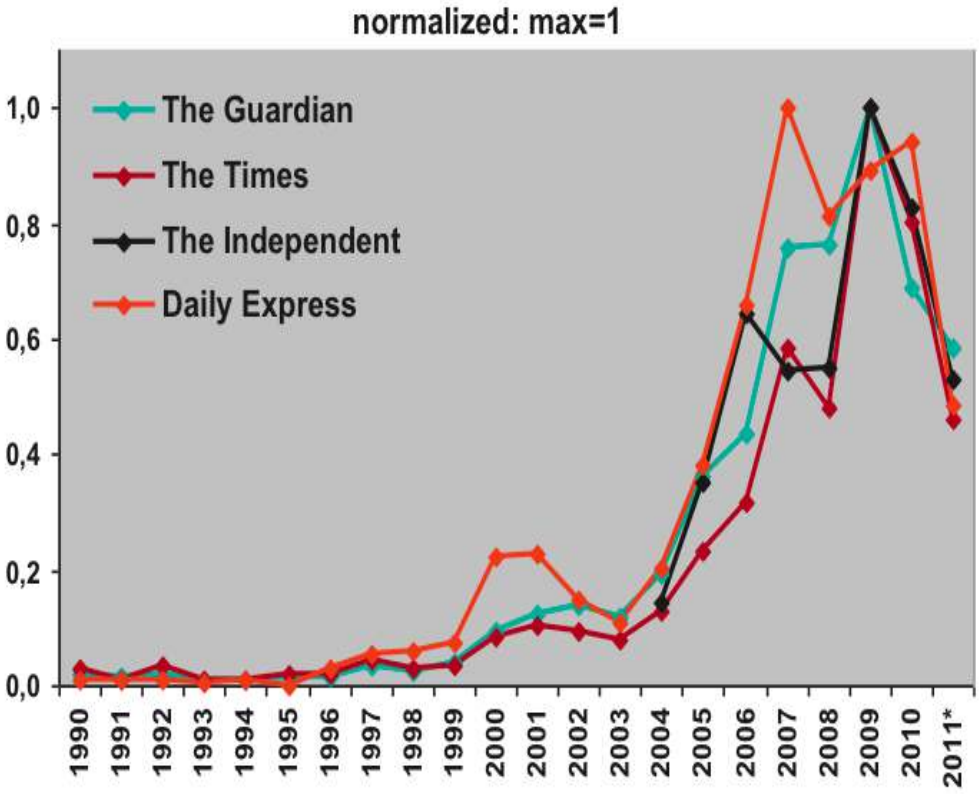

Figure 12: Years numbers of articles in UK national newspapers containing the word 'climate change'.[xlii]
Source: Geels (2013)

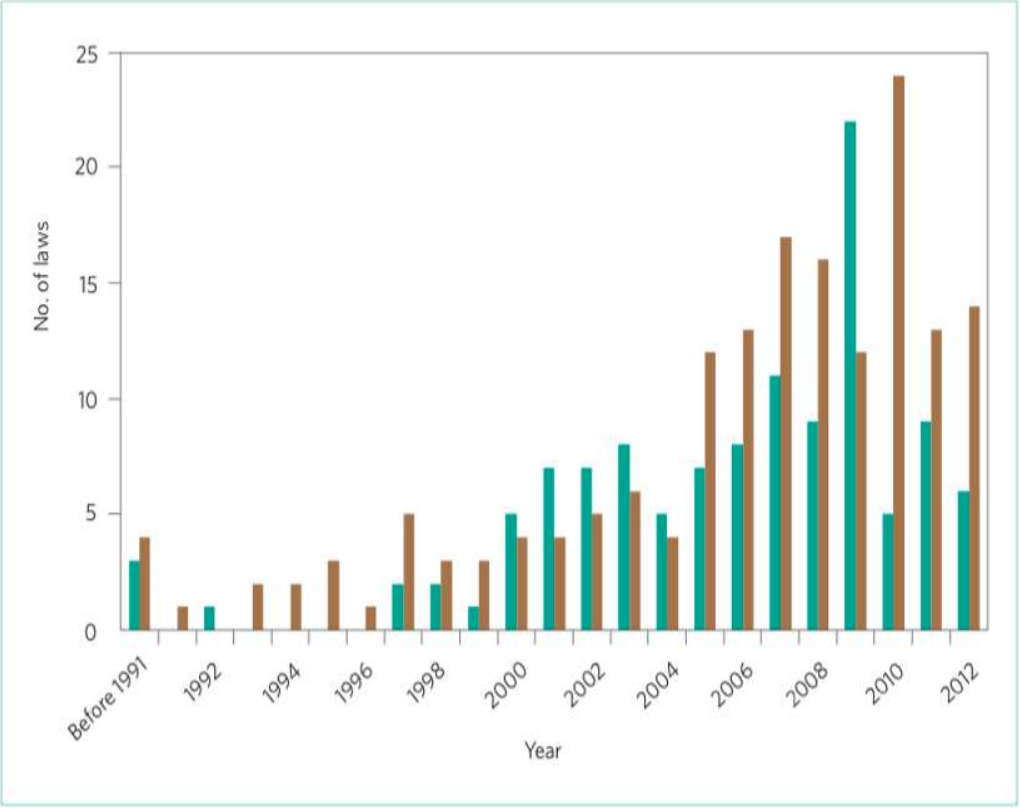

Figure 13: Climate change laws enacted over the years
Source: (GLOBE International 2013; Townshend et al., 2013)

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[i] Blyth (2002) uses the economic crises of the 1930s and 1970s to illustrate how new ideas that dominate these periods of uncertainty can shape the future.

[ii] A recent Special Issue of the journal Environmental entitled "Economic-financial crisis and sustainability" hosts a range of papers with a broad multi-disciplinary perspective drawing, inter alia, on recent developments in transition and innovation literature (van den Bergh 2013).

[iii] Also referred to as the Global Financial Crisis, the Lesser Depression, the Long Recession or the global recession of 2009.

[iv] 2.2% (when based on market exchange rates) and 0.6% based on PPP (IMF 2012). Advanced economies had a markedly greater contraction of -3.6% (PPP based). There were only two other years since WWII where there world experienced recessions. There was a decline of 0.8 percent in world per capita GDP in 1982 related to a number of problems in advanced countries including the Latin American debt crisis. In 1991 the decline was 0.2 percent related to simultaneous financial crises in many parts of the world, difficulties in US credit markets, banking crises in Europe, and the burst of an asset bubble in Japan (Kose, Loungani, & Terrones, 2013).

[v] Rising oil prices have preceded 10 out of the last 11 US recessions (Hamilton 2013).

[vi] Austria, Belgium, Germany, Finland, the Netherlands, Luxembourg; Sweden and Denmark (non-euro area countries) have all had relatively large surpluses since the late nineties (European Commission 2012).

[vii] While the particular form of financial innovation was novel, financial innovation itself is also a common feature of speculative bubbles (Roubini & Mihm, 2011).

[viii] Shadow banks are non-bank financial intermediaries providing similar services to traditional banks but are not subject to the same regulation. It includes, inter alia, money market mutual funds, repurchase agreement markets (repos), and securitized investment conduits.

[ix] Excepting the downturn of the 1930s the measures taken by the rich countries were unprecedented and included nationalization of parts of private sectors in the US and financial sectors in Britain, Switzerland, Holland and others.

[x] See Shambaugh (2012) for a description of the interconnected triple crises.

[xi] "Costs of crises can be assessed in different ways. These include the direct fiscal costs, encompassing direct outlays to support the financial system and for resolving nonperforming assets; the broader fiscal costs, measured as the increase in public debt over some chosen horizon (which include the direct fiscal costs); and the real output losses" (Claessens et al., 2012).

[xii] For some more recent accounts of major transitions that include environmental pressures as drivers see Acemoglu, Aghion, Hemous, & Bursztyn (2012), Diamond (2005), and Morris (2013; 2010).

[xiii] I should note that (2013) covers the same theme as this paper, the only difference being that I am focusing more narrowly on sustainable energy systems as opposed to sustainability more broadly, though the two are inextricably related.

[xiv] Geels (2013) refers to Gough (2010), Jackson & Victor (2011), and Wray (2009) as representative of this approach. For a recent overview of the degrowth approach see Schneider, Kallis, & Martinez-Alier (2010).

[xv] Markard et al (2012) provide a great overview of the different strands of this emerging field, its historical origins and the increase in its influence.

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[xvi] The term came from a study of employment impacts of Spanish support for renewables (Alvarez, Jara, Julián, & Bielsa, 2009). The study referred to the specific conditions in Spain but provided a catch phrase for critics.

[xvii] Consumption based emissions exclude emissions associated with export but include those associated with imports. The developed economies (Annex B) continue to be net importers of embodied carbon dioxide emissions.

[xviii] Pledges to meet 2°C and 1.5°C were recognized in December 2010 at the annual Conference of Parties of the United Nations Framework Convention on Climate Change (UNFCCC) in Cancun, Mexico.

[xix] For instance, a focus on ways of estimating costs, differences between top-down and bottom-up integrated assessment models.

[xx] It should be noted that elements of Keynes thinking have shaped modeling work from the earliest instances of integrated assessments of climate change, e.g., Terry Barker's GEM-E3 model (*E3ME Manual* n.d.).

[xxi] An indicative sample: (Barbier 2010a; Bowen, Fankhauser, Stern, & Zenghelis, 2009; Edenhofer et al., 2010; Houser, Mohan, & Heilmayr, 2009; Jones & Keen, 2009; Pollin, Garrett-Peltier, Heintz, & Scharber, 2008a)

[xxii] BBC news report, 15 October 2008.

[xxiii] See Bowen (2012) for a recent survey of the literature on 'green growth' and 'green jobs'.

[xxiv] The Rheinhart-Rogoff debacle has also played into this.

[xxv] Sachs also argues that the fiscal stimulus was mostly of the form of temporary tax and temporary transfer payments that were ill suited to stimulate aggregate demand.

[xxvi] At the time he mentioned the US but its domestic shale gas and tight oil boom makes its deficit less sensitive to fossil fuel prices.

[xxvii] All projections on energy system trends and CO_2 emissions rely on scenarios incorporated in models. Scenario outcomes can vary substantially across models depending on model structure and underlying assumptions. One dimension, for instance, is what assumptions are made about shares of energy sources and technologies. If nuclear and carbon capture and storage are expected to play a substantial role in mitigation (as is the case in the IEA scenarios) then the demands on renewables will be less. See MacKay (2009) for a juxtaposition of energy paths with particularly stark differences in energy technology choices.

[xxviii] The term came from a study of employment impacts of Spanish support for renewables(Alvarez et al., 2009). The study referred to the specific conditions in Spain but provided a catch phrase for critics.

[xxix] China's capacity for producing panels grew tenfold.

[xxx] Suntech, one of China's biggest solar companies, declared bankruptcy and it is likely that many will shut down.

[xxxi] The reports warnings are supported by organisations including the International Energy Agency, HSBC, Citi, Standar and Poor's.

[xxxii] The amendment to the ETS Directive was signed by the commissioner on February 25, 2014 (COMMISSION REGULATION (EU) No 176/2014 http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2014.056.01.0011.01.ENG).

[xxxiii] Even though there has been a switch from gas to coal in some EU countries so that demand for EUAs (for this reason) increased, the overall impact of the recession and inflow of international credits have brought about a substantial surplus of EUAs(Convery & Redmond, 2013).

[xxxiv] Cap-and-trade schemes tend to generate price volatility due to the inelastic supply of quotas (Metcalf 2009). Fankhauser and Hepburn (2009) present equity and efficiency considerations for using mechanisms like borrowing, banking, prices caps and price floors to dampen carbon price swings. The UK has introduced a carbon tax starting April 1 2013 essentially to put a floor on the EU carbon price and to provide a longterm signal to low carbon investors (Shankleman n.d.). In addition there have been arguments that the political control over the supply of allowances is partly to blame for its instability. A carbon bank or an independent governing board with authority primarily over price management could address stability issues by increasing the confidence in the system ("A Carbon Bank: Managing Volatility in a Cap-and-Trade System," 2011; Whitesell 2011).

[xxxv] http://www.ipsos-mori.com/researchpublications/researcharchive/2967/ EconomistIpsos-MORI-May-2012-Issues-Index.aspx

[xxxvi] http://www.globeinternational.org/index.php/legislation-policy/policy-programmes/climate-change

[xxxvii] In 2012 it passed legislation to partially link this trading scheme to the EU ETS from 2015.

[xxxviii] See also Egenhofer & Alessi (2014) for a discussion on EU climate policy after the crisis.

[xxxix] Interestingly, he notes that in terms of country positions there is no clear correlation between climate ambitions and depth of economic malaise, e.g., Greece, Spain and Portugal remained committed to ambitious climate targets.

[xl] "Latest Polling Finds Strong Support For Clean Energy And Stricter Carbon Pollution Standards | ThinkProgress." Accessed February 22, 2013. http://thinkprogress.org/climate/2013/02/21/1623531/latest-polling-finds-strong-support-for-clean-energy-and-stricter-carbon-pollution-standards/.

[xli] A partial equilibrium energy model is used called Global Energy Emissions Model (GE^2M)

[xlii] The graph is based on data from a keyword search in the digital archives of these newspapers. Duplicated articles were excluded. To facilitate visual comparison between different datasets, the authors normalized the time series so that 1 refers to teh year with the maximum number of counts.

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THE ABSTRACT OF THE PROJECT IS:

The research programme will integrate diverse levels, methods and disciplinary traditions with the aim of developing a comprehensive policy agenda for changing the role of the financial system to help achieve a future which is sustainable in environmental, social and economic terms. The programme involves an integrated and balanced consortium involving partners from 14 countries that has unsurpassed experience of deploying diverse perspectives both within economics and across disciplines inclusive of economics. The programme is distinctively pluralistic, and aims to forge alliances across the social sciences, so as to understand how finance can better serve economic, social and environmental needs. The central issues addressed are the ways in which the growth and performance of economies in the last 30 years have been dependent on the characteristics of the processes of financialisation; how has financialisation impacted on the achievement of specific economic, social, and environmental objectives?; the nature of the relationship between financialisation and the sustainability of the financial system, economic development and the environment?; the lessons to be drawn from the crisis about the nature and impacts of financialisation? ; what are the requisites of a financial system able to support a process of sustainable development, broadly conceived?'

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Participant Number	Participant organisation name	Country
1 (Coordinator)	University of Leeds	UK
2	University of Siena	Italy
3	School of Oriental and African Studies	UK
4	Fondation Nationale des Sciences Politiques	France
5	Pour la Solidarite, Brussels	Belgium
6	Poznan University of Economics	Poland
7	Tallin University of Technology	Estonia
8	Berlin School of Economics and Law	Germany
9	Centre for Social Studies, University of Coimbra	Portugal
10	University of Pannonia, Veszprem	Hungary
11	National and Kapodistrian University of Athens	Greece
12	Middle East Technical University, Ankara	Turkey
13	Lund University	Sweden
14	University of Witwatersrand	South Africa
15	University of the Basque Country, Bilbao	Spain

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