
Rethinking the green recovery through renewable energy expansion

Emna Omri*

Research Unit in Development Economics,
Faculty of Economics and Management of Sfax,
University of Sfax,
Route de l'Aéroport Km 4, 3018 Sfax, Tunisia
and
GREDEG (Research Group on Law Economics and Management),
Higher Institute of Economics and Management (ISEM),
University of Nice Sophia-Antipolis (UNS),
UMR CNRS 6227, 250, rue Albert Einstein,
06560 Valbonne, France
Email: em.omri@gmail.com
*Corresponding author

Nouri Chtourou

Research Unit in Development Economics,
Faculty of Economics and Management of Sfax,
University of Sfax,
Route de l'Aéroport Km 4, 3018 Sfax, Tunisia
Email: Nouri.Chtourou@fsegs.rnu.tn

Damien Bazin

GREDEG (Research Group on Law Economics and Management),
Higher Institute of Economics and Management (ISEM),
Department of Human Science (MSH),
University of Nice Sophia-Antipolis (UNS),
UMR CNRS 6227, 250, rue Albert Einstein,
06560 Valbonne, France
Email: damien.bazin@unice.fr

Abstract: The world today is facing the worst economic and environmental crises in generations. Hence, we need policies that can stimulate recovery and at the same time reach the sustainability. United Nations Environment Programme (UNEP et al., 2008; UNEP, 2009a, 2009b, 2011) and many economists (e.g., Barbier, 2009a, 2009b, 2010; Edenhofer and Stern, 2009; Robins et al., 2009) advocate the need for a 'green recovery'. This concept means that the economic crisis should be grasped by governments as an opportunity to reduce carbon dependency and put economies on a path of 'green growth' by using green stimulus packages. Many papers and international reports advocate that the renewable energy sector is an essential

step in the path of green recovery. The main aim of this paper is to review a selection of responses to the double crisis by international institutions and to focus on the achievements made in the renewable energy sector.

Keywords: climate change; economic crisis; green growth; green recovery; green economy; renewable energy; sustainable development.

Reference to this paper should be made as follows: Omri, E., Chtourou, N. and Bazin, D. (2015) 'Rethinking the green recovery through renewable energy expansion', *Int. J. Sustainable Development*, Vol. 18, Nos. 1/2, pp.59–76.

Biographical notes: Emna Omri holds a degree in Finance and Master's in Advanced Studies in Economic and Financial Dynamics from the Faculty of Economics and Management of Sfax. She is currently preparing for her PhD thesis in Economics. Her current research focuses on renewable energy, environmental economy and sustainable development.

Nouri Chtourou holds a degree from the University of Nice Sophia-Antipolis; his doctoral thesis in economics focused on 'Economic analysis of the state in development issues'. He is a Professor at the Faculty of Economics and Management of Sfax and was a Visiting Professor at the University of Nice Sophia-Antipolis. He has served as a Consultant to the World Bank and the African Union. He developed CFAR-m with Professor Rochdi Feki; 'CFAR-m' is an algorithm used a global leader in the field of competitive intelligence (CI). He collaborates with Probus Sigma on CFAR-m with Professor Rochdi Feki. His research focuses on new institutional economics and governance, economics of renewable energy and climate change. He focuses also on models using artificial neural networks on issues such as construction of composite indicators, classification/clustering and ranking/rating.

Damien Bazin received his PhD in Economics and Assistant Professor (Accreditation to Supervise Research) in Economics at the University of Nice Sophia Antipolis, France. After his postdoctoral studies in Canada and missions in China (programme of the European Union), he joined the Research Group on Law, Economics and Management (GREDEG). He conducts research on macroeconomics and sustainable development. His fields of specialisation are many and varied, including ecology, ethical and environmental economy, macroeconomics, corporate ethics, and topics related to socially sustainable development. He develops projects in the Higher Institute of Economics and Management (ISEM) whose direct applications are found within ecological economics and game theory. He provides lectures on company ethics in prestigious Parisian business schools. His latest works are related to the protection of nature and to economic ethics. He regularly collaborates with national daily papers with the aim of popularising fundamental research.

1 Introduction

The world is facing two major crises: one economic and one environmental. The global economic crisis which is the worst since the '30s was triggered by the market of 'subprimes' in the USA. This crisis is characterised by a severe drop in global demand and a leap in unemployment rates. To come out of the crisis, many economists suggest that boosting the global demand is necessary. Although the world situation seems dark,

this crisis can be considered as an opportunity to meet the challenges of climate change. It is therefore recommended that fiscal stimulus give priority to green investments such as energy efficient buildings, sustainable transport and renewable energy.

The green recovery will therefore allow the recovery of the global economy, creation of green jobs and protection of the environment. Given that renewable energy projects require many green jobs and do not emit greenhouse gas (GHG) emissions, they are one of the main components of the green recovery.

The main aim of this paper is to show how the economic crisis is an opportunity to accelerate the spread of renewable energy technologies and what are the achievements made in the renewable energy sector since the use of fiscal stimulus packages.

To answer these questions, this paper will be organised as follows:

- Firstly, we focus on the current context of double crisis.
- Then, we review a selection of responses to the double crisis by international institutions.
- Finally, we explain the forces driving the development of renewable energies.

2 Context of double crisis

The world is facing two serious crises one economic and one environmental. The financial crisis, which had begun in the USA, spread to other countries and finally led to a global economic crisis. The financial crisis has major effects on the global economy, but the need to fight against climate change is also urgent.

2.1 The economic crisis

As it is well known, the USA housing market had a crucial role in the outbreak of the financial crisis, which has been detailed thoroughly elsewhere (Bernanke, 2009; Foster and Magdoff, 2009; Gokhale, 2009). In fact, this crisis was triggered by the market of 'subprimes' in the USA, which consists of mortgages that are granted to clients considered not very solvent. The success of this system depends on two conditions: the steady appreciation of property prices and the stability of interest rates. But the interest rate increased from 1% to 5.25% between 2004 and 2006 and house prices also started to fall. Faced with this situation, households found themselves unable to repay their loans. In response to this situation, banks decided to sell foreclosed homes causing the collapse of property prices and the bubble has burst.

In the summer of 2007, there was the outbreak of the financial crisis. The main driving belt of the subprime crisis was 'hedge funds'. From September 2007 to summer 2008, banks' losses had increased rapidly and reached \$945 billion worldwide (IMF, 2008).

In September 2008, two major bankruptcies have taken place: the collapse of Lehman Brothers (a major US investment bank) and the bailout of American International Group (AIG) (the largest US insurance company). On the heels of these events came similar collapses and rescues of financial institutions in other advanced economies and then in emerging economies. So, what began as a crisis in one sector in one country eventually became "the world's first truly global financial crisis" [Omarova, (2009), p.157].

In autumn 2008, the banking crisis has spread to the real economy and we witnessed the bankruptcy of thousands of small and medium enterprises. For instance, in the USA, the number of businesses declared bankruptcy was rising from 43,546 in 2008 to 60,837 in 2009 (American Bankruptcy Institute, 2010) and in Japan, in 2009, 13,306 businesses declared bankruptcy, representing a 4.9% increase from 2008 (Teikoku Databank, 2010).

Most developed economies were suffering deep recessions with rising unemployment rate and the fall of aggregate demand. According to ILO (2010), the number of unemployed persons is estimated at 212 million in 2009 which means an increase of almost 34 million over the number of unemployed in 2007.

In January 2009, 600,000 people lost their jobs in the USA and it was the worst monthly loss since 1974. Nearly 3.6 million jobs have disappeared between December 2007 and January 2009 (ILO, 2009). As a result, global trade in manufactured goods has fallen with repercussions for East Asian economies. At the same time, the drop of commodity prices has affected countries in Africa, Latin America and the Middle East.

According to the World Bank (2008), each decrease of 1% of growth in developing economies is reflected by an increase of 20 million people who are doomed to poverty.

2.2 *The climate crisis*

While the world economy is facing a temporary global economic crisis, dangerous climate change poses a permanent and serious threat to human being and prosperity. The United Nations Framework Convention on Climate Change (UNFCCC) is an attempt to tackle the problem of climate change and to try to look for strategies to adopt. Climate change is defined by UNFCCC (1992, p.3) as “a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods”.

Climate change includes all changes in climate including temperature, precipitation and wind. But nowadays, we speak much of a change in climate toward warming. Global warming is, in fact, an increase in degrees of temperature due to emissions of GHG attributable mainly to the use of fossil fuels.

Awareness of the dangers of global warming has occurred, during the 1960s and 1970s. In this period, the scientific community demonstrated the fragility of the ecosystem and the dependence of our well being on the climate system. The First World Climate Conference was held in 1979, and brought together foremost scientists conducting research on the risks of climate change. The purpose of the conference was to assess the state of knowledge of climate change and to consider the effects of climate variability on human society.

Due to the creation of the Intergovernmental Panel on Climate Change (IPCC) in 1988, and also with the Second World Climate Conference which was held in 1990, in Geneva, the climate change was gradually extended to the politicians and citizens and has become a political concern.

The first international measure against global warming is the UNFCCC, adopted in 1992 and entered into force in 1994. The Kyoto Protocol, signed in 1997, represents also an important step in the commitment of states against climate change as it sets quantitative and binding targets.

Both climate and economic crises are caused by rich countries but affect much more poor countries (UNEP, 2009a). Indeed, in accordance with IPCC (2007) the poorest of

the world are particularly the most affected by rising sea levels, increased frequency of storms and coastal erosion which are caused by climate change.

Around 14% of the population and 21% of urban dwellers in developing countries live in low-elevation coastal zones that are exposed to these risks (McGranahan et al., 2007).

With rising temperatures, climate change will be very probable unmanageable. This serious global threat can push the Earth's ecology to unknown tipping points, which may fundamentally and irreversibly change the way our planet functions (Lenton et al., 2008).

Research findings from a number of studies indicated that climate change is occurring much more rapidly than previously anticipated. In particular, the Arctic sea ice was shown to be disappearing at a far greater rate than scientists had predicted (UNEP, 2009b). Although there is a global awareness of the dangerousness of climate change, the actions made are not sufficient. In fact, politicians tend to focus on the short term and try to solve the urgent economic and financial problems. The magnitude of the task and the difficulty of putting in place a system to fight against this global problem also help to slow the fight against global warming.

3 A collective response: the green recovery

Many international institutions called for the implementation of a green recovery or a 'green new deal' which consist of strategies for economic recovery and environment protection. To fight against recession and respond to the severe drop in private consumption and investment, budgetary policy is recommended. Indeed, this policy can boost aggregate demand and create new jobs. From this point of view, the economic crisis may appear as a historic opportunity to begin the fight against another great challenge facing humanity: climate change. It would be very wise to devote a considerable part of the global recovery for environmental purposes by investing, for example, in renewable energy and energy efficiency. Furthermore, the OECD (2011a, 2011b), the UNEP (2011), and the World Bank (2012) have all recently adopted the concepts of Green Growth, Global Green New Deal (GGND) and green economy in their reports. Sedlacko and Gjoksi (2009) provide a comprehensive overview of European and international initiatives.

3.1 The global green new deal

The GGND refers to "a set of globally coordinated large scale stimulus packages and policy measures that have the potential to bring about global economic recovery in the short term while laying the foundation for sustained economic growth in the medium and long term" [UNEP, (2009a), p.3]. This idea is inspired by the 'new deal' introduced in the 30s by the USA President Franklin D. Roosevelt as a way to tackle the Great Depression. This 'new deal' has allowed the reduction of unemployment rate, modernisation of infrastructure, and stimulation of the economy.

Several reports (Edenhofer and Stern, 2009; The Green New Deal Group, 2008; UNEP, 2009a) suggested the necessity of adopting a comprehensive strategy that allows the world to get out of the economic recession and follow the path of sustainable

development. All these reports call for the implementation of a set of plans in order to reach the economic recovery while maintaining environment.

The UNEP (2009a, p.4) has described the financial crisis as a ‘unique historical opportunity’: “We believe that there is a unique historical opportunity now to create the basis of a new green economy that is able to allocate natural capital and financial capital in a far more effective and efficient manner into the foreseeable future”. It has insisted on the fact that “we must not miss this chance to fundamentally shift the trajectory of human civilization” [UNEP, (2009a), p.4].

The optimism about the opportunity presented by the financial crisis is derived mainly from the use of fiscal stimulus. Here, the optimists consider this fiscal stimulus as an unprecedented opportunity which permits to direct funds towards crucial green investments.

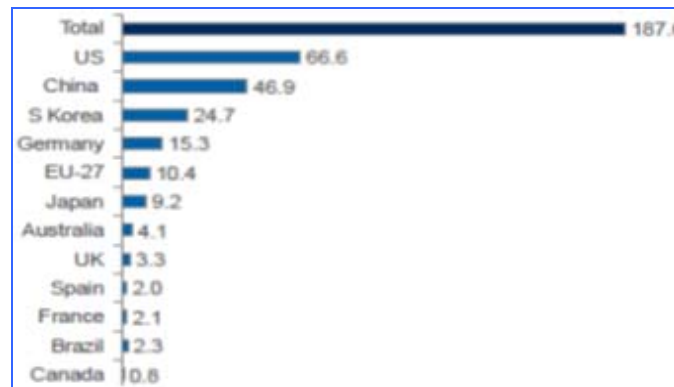
3.2 *Green stimulus in the world*

Green stimulus are defined as: “The share of government economic recovery packages allocated to ‘green’ initiatives such as renewable energy, energy efficiency, smart power grid, transport, and other clean energy technologies” [UNEP et al., (2012), p.79].

Barbier (2009a) showed that using 1% of world wide gross domestic product (GDP) in green investments, during the next two years, provides the infrastructure necessary in the ‘greening’ of the global economy. The recommended volume of these ‘green’ incentives is not difficult to achieve: 1% of global GDP (about 750 billion dollars), which means only a quarter of total fiscal stimulus.

On the basis of the results of a system dynamics model, the UNEP (2011) proposes to invest 2% of world GDP over 2010 to 2050 in order to halve energy-related CO₂ emissions and to achieve the UN’s Millennium Development Goals.

Figure 1 Components of green economic stimuli, \$BN (see online version for colours)



Source: Bloomberg New Energy Finance (2010)

Several studies have tried to give the share of green investments in recovery plans such as the series of studies made by HSBC Global Research, in 2009, and the report of

Edenhofer and Stern (2009) which gives a set of recommendations to G20 members. Robins et al. (2009) analysed more than 20 economic recovery plans in order to determine the proportion of the green component. The proportion of green stimulus ranged from 0% for Chile and India to 80.5% for South Korea. Globally, they estimate that the green fiscal stimulus represents approximately 15.6% of total international stimulus packages (about \$436 billion). The study of UNEP et al. (2010) has shown that \$187.6 billion of the 'green stimulus' programme has been announced by major countries since the beginning of the finance crisis in 2008.

The USA accounted for the largest green stimulus programme, at \$66.6 billion. China has devoted \$46.9 billion to green economic stimulus.

At the end of 2009, only 9% of the announced green stimulus packages had been spent (UNEP et al., 2010). At the end of 2011, 141.8 billion of the green stimulus packages had been spent. The USA alone had spent \$42 billion by the end of 2011 while China had spent \$44 billion (UNEP et al., 2012).

3.3 *The UNEP green economy initiative*

The study made by Pearce et al. (1989) in their book *Blueprint for a Green Economy* was one of the first studies interested in the connections between sustainable development and green economy. The authors argued that sustainable development is unachievable because of the intensive use of natural capital to secure growth. So, the adoption of a green economy is necessary in order to ensure the well-being of current and future generations.

UNEP (2011) suggests that the fact of greening economies is not a drag on growth but a new engine of growth. In this report launched in February 2011, UNEP asserts that a green economy is a generator of green jobs and is a vital strategy for the elimination of poverty. This report entitled 'Towards a green economy: pathways to sustainable development and poverty eradication' presents a coherent economic and social strategy for investing 2% of global GDP in greening ten key sectors of the economy which are: agriculture, buildings, energy, fisheries, forestry, industry, tourism, transport, waste, and water.

The green economy initiative is not a replacement for sustainable development but it is a path to its achievement at the national, regional and global levels. This report focus also on the green jobs created in the transition to a green economy and how greening the economy can be a way of reducing persistent poverty. This initiative gives many policies to achieve this shift: eliminate perverse subsidies, stimulate investment in green sectors, and create market-based incentives.

UNEP (2010, p.5) defines a green economy as one that results in "improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities". In its simplest expression, a green economy is "low-carbon, resource efficient and socially inclusive" [UNEP, (2011), p.16]. The UNEP initiative describes also the modelling approach adopted in order to quantify the challenges of moving towards a green economy. The modelling tool used is the Threshold 21 World model (T21-World).

3.4 *The OECD green growth strategy*

The OECD (2011b, p.9) describes green growth as follows: “Green growth means fostering economic growth and development while ensuring that natural assets continue to provide the resources and environmental services on which our well-being relies. To do this it must catalyse investment and innovation which will underpin sustained growth and give rise to new economic opportunities”.

In June 2009, the OECD Ministerial Council Meeting announced the development of a ‘Green growth strategy’. Since then, the OECD has been working with many partners in order to provide a framework for the green growth. So, many reports were launched by OECD in order to explain the need for green growth strategies, to promote the green transition and to measure progress towards green growth.

According to OECD (2011b), green growth has the potential to reveal new sources of growth through many channels such as creation of new markets, boosting investor’s competition, and innovation. In fact, innovation is a key element of the green growth strategy: “Innovation can generate new sources of growth that better reflect the full value of natural capital to society and reduce the cost of addressing environmental risks” [OECD, (2011b), p.12]. So it is necessary that green growth strategies provide incentives to innovation in order to deal with major environmental challenges. In this strategy, it is very important to foster green technologies and eco-innovation.

The green growth strategy is a framework which explains how countries can achieve economic growth and mitigate climate change at the same time. Green growth strategy includes many policy measures such as fiscal reform, research and innovation policies, climate change mitigation instruments, energy efficiency measures, and competition policy in network industries.

According to Hallegatte et al. (2011, p.3), “Green growth is about making growth processes resource-efficient, cleaner and more resilient without necessarily slowing them”. And they consider green growth as a necessary component of sustainable development. In the same line of thought, in the report of World Bank (2012), green growth is considered as necessary, efficient and a pathway to sustainable development. Many papers examine several meanings of the slogan ‘green growth’ and provide a brief overview of responses of international institutions to double crisis (Bina and La Camera, 2011; Jänicke, 2012; Schmalense, 2012; Sterner and Damon, 2011).

According to Schmalense (2012, p.S2) “‘Green Growth’ is a wonderful slogan. After all, everyone agrees that being green is a good thing, and in the current Great Recession economic growth is even more desirable than usual. So ‘green growth’, which combines these two good things, sounds like a truly great thing”.

In his article ‘Sustainable growth: an impossibility theorem’, Daly (1993, p.267) indicates that “The term ‘sustainable growth’ when applied to the economy is a bad oxymoron”. Daly (1993, p.268) indicates that “Even ‘green growth’ is not sustainable”. He explains this by the fact that there is a limit to population of trees the earth can support. Daly (1993) believes that there are limits to economic growth because the world has a finite amount of resources and a fixed flow of energy. So it is an illusion to believe that economy can grow forever even if this growth is green or sustainable: “To delude ourselves into believing that growth is still possible and desirable if only we label it ‘sustainable’ or color it ‘green’ will just delay the inevitable transition and make it more painful” [Daly, (1993), p.268].

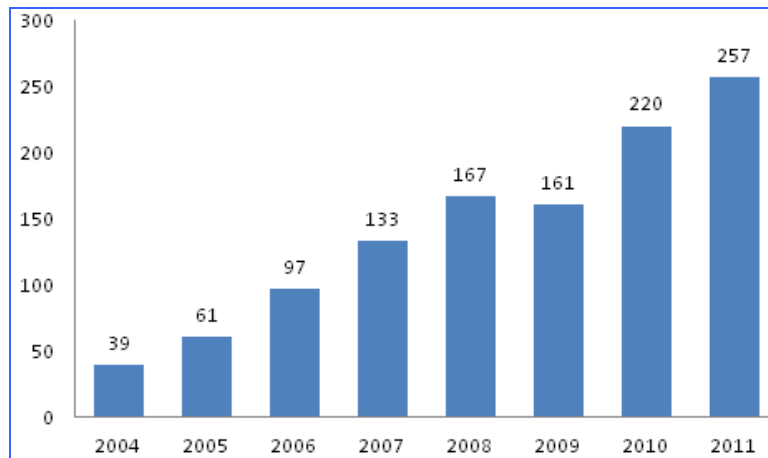
4 The expansion of the renewable energy sector

The rising wave of investment in renewable energy sector is the most visible aspect of the transition to a green economy [UNEP et al., (2012), p.38].

The following definition of renewable energy is setting down by IEA (2008, p.7): “Renewable energy is derived from natural processes that are replenished constantly. In its various forms, it derives directly or indirectly from the sun, or from heat generated deep within the earth. Included in the definition is energy generated from solar, wind, biomass, geothermal, hydropower and ocean resources, and biofuels and hydrogen derived from renewable resources”.

At the beginning, the expansion of the renewable energy sector needs support from the government such as investment subsidies, low-interest loans and tax deductions. It is necessary also to reduce perverse subsidies to fossil fuels and increase research and development spending in the renewable energy sector. Pushing down the price of renewable energy sources and removing the barriers to their adoption will accelerate the process of industrial expansion. Then, the increase of growth rates in production will reduce costs and then prices which makes renewable energy sources more competitive. At the end, we will reach a point where subsidies for renewable energy are no longer necessary.

Figure 2 Global new investment in renewable energy, 2004–2011, \$BN



Source: UNEP et al. (2012)

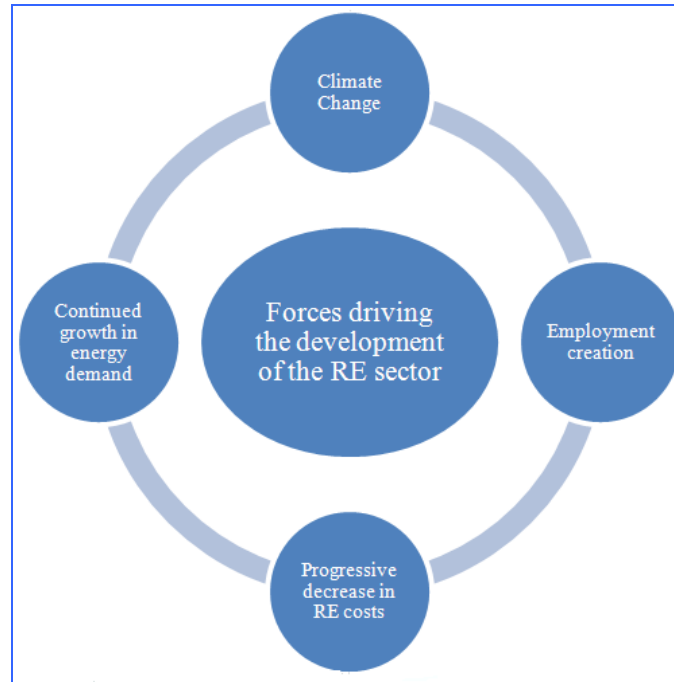
During the last two years, there was a rebound in renewable energy investment due to the green stimulus programmes. Figure 2 shows the continuous growth of renewable energy investment since 2004, with expansion continuing in spite of the crisis of 2008 to 2009. New global investment in the renewable energy sector hit a record in 2011 and reached \$257 billion.

5 Forces driving development of the renewable energy market

Edenhofer and Stern (2009, p.6) suggest that if no action is taken to reduce reliance on fossil fuels 'the next economic crisis is pre-programmed'. The use of renewable energy sources is essential in this current context characterised by: the continuous growth in energy demand, the increase of oil price, the climate change, the high unemployment rate, and the progressive decrease in renewable energy costs. Thus renewable energy is the energy of the future.

The most important forces driving the rapid growth in renewable energy sector (see Figure 3) are: increased attention given to climate change, strong potential of employment creation, notable decrease in renewable energy costs, and continued growth in energy demand.

Figure 3 Forces driving development of the renewable energy market (see online version for colours)



5.1 The climate change

The decrease in activity due to the economic crisis has reduced global GHG emissions. However, climate change does not result from the flow of emissions, but from the stock. Thus, even a sharp decline in short term emissions decrease slightly damages expected from climate change. For this reason, all countries must engage in a comprehensive strategy for promoting renewable energy sources in order to reduce the stock of GHG.

According to UN/DESA (2009), energy is essential to economic development and renewable energy is essential to a future without dangerous climate change. So, a rapid

conversion from fossil fuels to sun, wind, and water-based energy technologies is no more a choice but an obligation to attempt the climate stability.

5.2 Job creation

At the OECD green growth strategy and the UNEP green economy initiative, it is clearly shown that it is possible to tackle climate change, grow the economy, and create green jobs at the same time. This is called a ‘double dividend’.

The current crisis has generated a very high unemployment rate in the world. Thus, creating new jobs is an emergency in the current context. Many reports indicate that renewable energy sector is an opportunity to create new jobs. Actually, renewable energy technology is more labour-intensive than fossil fuel technology which means that more jobs are required for each megawatt (MW) of energy generated from renewable sources than from fossil fuels. So, the diffusion of renewable energy sources in both developed and developing countries can afford millions of ‘green jobs’. The renewable energy sector is more labour intensive than conventional energy industries. As Van Jones (2009, p.9) remarks: “Solar panels do not install themselves. Wind turbines don’t manufacture themselves. Buildings do not weatherise and retrofit themselves. Urban trees, green roofs and community gardens do not plant themselves. All these activities require human labour. Recognising this simple fact helps to undermine the myth that ecological restoration must always be at odds with economic performance”.

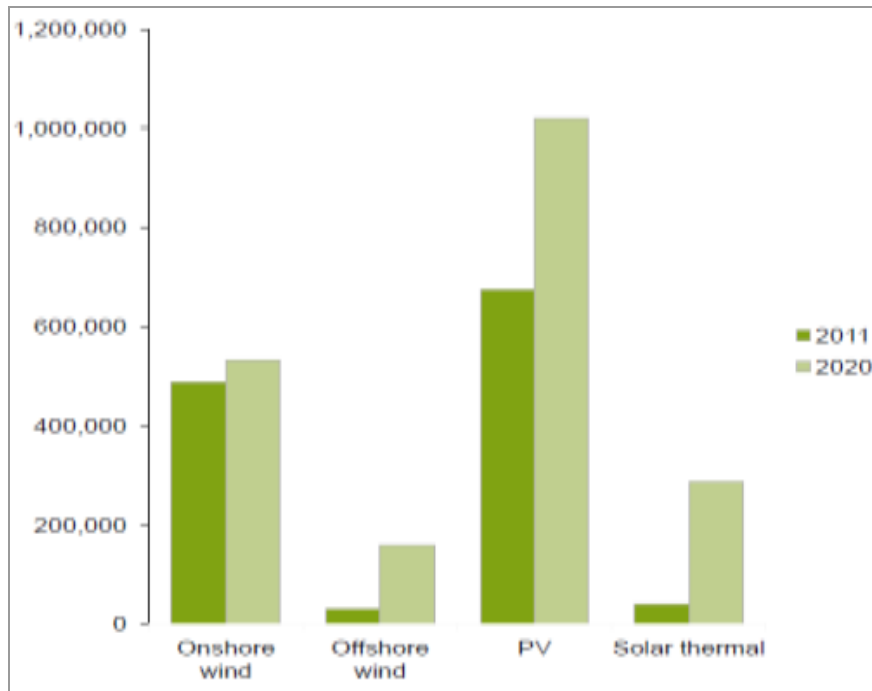
In recent years, about 2.3 million people found new work in this sector, while these energies provide only 2% of global primary energy. In comparison, total employment in the oil, gas and refining industries in oil just exceeded 2 million in 1999. The technology which offers the highest employment generation is solar photovoltaics (PV) with 7 to 11 jobs per MW of average capacity (UNEP et al., 2008). The report ‘Green jobs: towards decent work in a sustainable low-carbon world’ (UNEP et al., 2008) gives a detailed analysis on the emergence of the concept of green economy and its impact on the creation of green jobs. This report indicated that global employment in the wind energy sector would grow from 300,000 in 2006 to 2.1 million in 2030. Giving the enormous expansion in the PV sector, the number of jobs in this sector would rise from 170,000 in 2006 to 6.3 million in 2030.

Cai et al. (2011) found that, in 2010, for every 1% increase in the share of solar PV generation, in China, there could be a 0.68% increase in total employment. In 2012, Bloomberg New Energy Finance conducted a green jobs analysis on the wind and solar sectors. This study predicted that overall employment in wind and solar would grow from 1.2 million in 2011 to two million in 2020, because of the continuous growth in demand for these technologies. Figure 4 shows that in 2011, the onshore wind sector and its sub-contractors employed 488,000 people, while the PV sector employed 675,000. The offshore wind sector and solar thermal employed respectively 29,000 and 41,000 (UNEP et al., 2012).

There are many ways of measuring jobs created in the renewable energy sector such as jobs per annual MW installed and jobs per cumulative MW installed. So there are many studies that try to measure job creation by renewable energy technologies (Böhringer et al., 2013; Cai et al, 2011; Dalton and Lewis, 2011; Lehr et al., 2012; Yi, 2013). While measuring the number of jobs created is possible using job ratios, determining the quality of jobs created is much more complicated. Sastresa et al. (2010)

introduced a quality factor (QF) for each renewable energy technology, in Aragon (Spain), in order to describe the quality of jobs created. The results of this study reveal that wind energy generated higher quality jobs than solar thermal and PV. According to UNEP et al. (2008, p.38), “Green jobs span a wide array of skills, educational backgrounds, and occupational profiles”.

Figure 4 Full-time equivalent employment in wind and solar in 2011 and 2020 (see online version for colours)



In his book, *The Third Industrial Revolution: How Lateral Power is Transforming Energy, the Economy, and the World*, Rifkin (2011) links the two technologies of the 21st century which are internet and renewable energies. This link will change the way power is distributed and will create new types of jobs. According to Rifkin (2011), the workforce of the ‘Third Industrial Revolution’ will need to be skilled in new technical fields such as digital power grid management, hybrid electric and hydrogen-powered transport, etc.

5.3 The progressive decrease in renewable energy costs

In 2008, the PV industry production attained a world-wide production volume of 7.3 GWp of PV modules. In fact, PV industry is one of the fastest growing industries in the world. Business analysts predict lower costs and then lower prices for consumers. With these important increases in capacity have come equally important decreases in cost (European Commission Joint Research Centre, Renewable Energy Unit, 2009).

So, renewable energy prices are falling rapidly, driven by increasing demand, economies of scale, and technology improvement. For example, in Europe, every time the

amount of wind generation capacity doubles, the price of electricity produced by wind turbines falls by 9% to 17% (Krohn et al., 2009). With each increase in wind energy generation, the industry learns how to make wind turbines more efficient, which drives down the costs. This effect is called a ‘learning curve’: the more renewable energy production capacity increases, the more we learn about renewable energy industry and the less expensive it becomes.

One of the dominant characteristics of the renewable energy industry, in 2011, was declining technology costs. In fact, PV module prices decreased dramatically by close to 50% and onshore wind turbine prices by between 5% and 10%. This decrease in costs has made these two leading renewable energy technologies more competitive (UNEP et al., 2012).

The IPCC (2012) review of renewable energy technologies also analysed the speed at which costs have decreased for some specific renewable technologies. The results showed that average global PV module prices dropped from about \$22 per watt in 1980 to less than \$1.5 per watt in 2010. This huge reduction in costs is due mainly to economies of scale and learning effects.

5.4 Continued growth in energy demand

World primary energy demand is expected to continue growing at a high speed. The IEA (2010) forecasted a growth rate in energy demand of 1.4% per year up to 2035. The fastest growth is expected in non-OECD countries with a projected rate of 2.2% per year, particularly in China and India.

6 The example of China

There is not one path to green the economy. In fact, the green transition strategy is specific for each country and it depends on many characteristics mainly the natural and human capital and also the level of development. Both developed and developing countries have experienced an increase in renewable energies investment. This investment increased, in 2011, in developed economies by 21% to \$168 billion, and in developing economies by 11% to \$89 billion (UNEP et al., 2012).

The efforts made by the Chinese Government in order to green the economy are ambitious and needs to be detailed. As China is the largest carbon-emitting nation, its decision to achieve sustainability is very important not just for the Chinese people but for the rest of the world. The Chinese Government’s 11th Five-Year Plan (2006–2010) allocated an important part of investments to renewable energy sector and energy efficiency. In fact, according to Nesbitt et al. (2011), during the 11th Five Year Plan, the equivalent of between US\$700 million and US\$1.4 billion was invested in clean energy with 50% spent on Research and Development for renewable energy. Efforts have continued with the 12th Five Year Plan to boost the green transition and promote good environmental practices. Investment in new energy-related sectors alone is to increase substantially to about US\$770 billion from 2011 to 2020, including an estimated US\$231 billion for wind power (Pan et al., 2011).

Increasing renewable energy use is the core of China’s plan to make the transition from ‘brown’ economy to a ‘green’ one. In fact, the Chinese Government has committed

itself to producing 16% of its primary energy from renewable sources by 2020 (UNEP, 2010). For total investment in renewable energy sector, China became the first in 2011, with \$52 billion. For capacity installed, close to 20 GW of wind capacity was added in China in 2011 (UNEP et al., 2012).

7 Conclusions

The economic recession coupled with the gravity of climate change has pushed the international community to adopt a green recovery. In this case, the economic recovery becomes an opportunity to guide the global economy toward green growth with low carbon content. Several countries have shown a great willingness to invest in green industries such as South Korea. Even China, which is one of the most polluting countries in the world, devoted 40% of its economic recovery to green infrastructure such as renewable energy. Indeed, the renewable energy sector is a key component of the economic recovery given its many advantages at the social, economic and environmental levels. But to integrate the renewable energy sector into the green recovery we need a global and coherent strategy which takes into account the characteristics of developed and developing countries.

The GGND presents a coherent programme in order to remove major barriers to renewable energy expansion and accelerate the process of technology diffusion. The renewable energy sector can be an engine of true green growth by improving per-capita incomes and employment in all countries around the world.

There are no purely virtuous aspects of the green recovery. In fact, greening the economy is very expensive and it faces some barriers. According to the UNEP (2011) report, the annual investment needed to green the global economy was estimated to be in the range US\$1.05 to US\$2.59 trillion. The green transition needs also policy support for many years, in order to put the economy on a green path. The sovereign debt crisis in Europe in late 2011 and the austerity pressures in many countries pose a threat to continued investment in the green sectors. There is also another reason which makes some politicians less motivated about greening the economy. In fact, for example, renewable power projects can create many jobs, but those in manufacturing, may be in another country. So the benefits of the green transition are not spread evenly.

References

- American Bankruptcy Institute (2010) [online]
<http://www.abiworld.org/AM/AMTemplate.cfm?Section=Home&TEMPLATE=/CM/ContentDisplay.cfm&CONTENTID=66471> (accessed 20 May 2013).
- Barbier, E.B. (2009a) 'Rethinking the economic recovery: a global green new deal', Report prepared for the Economics and Trade Branch, Division of Technology, Industry and Economics, United Nations Environment Programme [online] <http://www.sustainable-innovations.org/GE/UNEP%20%5B2009%5D%20A%20global%20green%20new%20deal.pdf> (accessed 18 September 2012)
- Barbier, E.B. (2009b) 'A global green new deal', Report prepared for the Green Economy Initiative and the Division of Technology, Industry and Economics, United Nations Environment Programme.

- Barbier, E.B. (2010) 'Global governance: the G20 and a global green new deal', *Economics: The Open-Access, Open Assessment E-Journal*, Vol. 4, No. 2, pp.1–35 [online] <http://www.economics-ejournal.org/economics/journalarticles/2010-2> (accessed 22 April 2012).
- Bernanke, B. (2009) *Four Questions about the Financial Crisis*, Speech by Federal Reserve Chairman at the Morehouse College, Atlanta, Georgia.
- Bina, O. and La Camera, F. (2011) 'Promise and shortcomings of a green turn in recent policy responses to the 'double crisis'', *Ecological Economics*, Vol. 70, No. 12, pp.2308–2316.
- Böhringer, C., Keller, A. and Werf, E. (2013) 'Are green hopes too rosy? Employment and welfare impacts of renewable energy promotion', *Energy Economics*, March, Vol. 36, pp.277–285.
- Cai, W., Wang, C., Chen, J. and Wang, S. (2011) 'Green economy and green jobs: myth or reality? The case of China's power generation sector', *Energy*, Vol. 36, No. 10, pp.5994–6003.
- Dalton, G.J. and Lewis, T. (2011) 'Metrics for measuring job creation by renewable energy technologies, using Ireland as a case study', *Renewable and Sustainable Energy Reviews*, Vol. 15, No. 4, pp.2123–2133.
- Daly, H.E. (1993) 'Sustainable growth: an impossibility theorem', in Daly, H.E. and Townsend, K.N. (Eds.): *Valuing the Earth: Economics, Ecology, Ethics*, pp.267–274, The MIT Press, Cambridge.
- Edenhofer, O. and Stern, N. (2009) 'Towards a global green recovery. Recommendations for Immediate G20 Action', Potsdam Institute for Climate Impact Research and Grantham Research Institute On Climate Change And The Environment, Report for the German Foreign Office, Submitted to the G20 London Summit-2 April 2009 [online] http://www.pik-potsdam.de/members/edenh/publications-1/global-green-recovery_pik_lse (accessed 20 December 2012).
- European Commission Joint Research Centre, Renewable Energy Unit (2009) 'PV Status Report 2009' [online] <http://publications.jrc.ec.europa.eu/repository/bitstream/111111111/6017/1/pv%20report%202009.pdf> (accessed 15 November 2012).
- Foster, J.B. and Magdoff, F. (2009) *The Great Financial Crisis: Causes and Consequences*, Monthly Review Press, New York.
- Gokhale, J. (2009) 'Financial crisis and public policy', *Policy Analysis*, No. 634, Cato Institute, Washington, DC [online] <http://object.cato.org/sites/cato.org/files/pubs/pdf/pa634.pdf> (accessed 17 November 2012).
- Hallegatte, S., Heal, G., Fay, M. and Treguer, D. (2011) *From Growth to Green Growth*, The World Bank, Policy Research Working Paper 5872 [online] <http://elibrary.worldbank.org/docserver/download/5872.pdf?expires=1379695217&id=id&accname=guest&checksum=4187B6CB9611E0BA72C7C440D8587BB6> (accessed 11 November 2012).
- IEA (2008) *Renewables Information*, 2008 ed., International Energy Agency, OECD Publishing, Paris.
- IEA (2010) *World Energy Outlook 2010*, International Energy Agency, OECD Publishing, Paris.
- IMF (2008) *Global Financial Stability Report Containing Systemic Risks and Restoring Financial Soundness*, International Monetary Fund, Washington DC.
- Intergovernmental Panel on Climate Change (IPCC) (2007) edited by M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, *Climate Change 2007: Impacts, Adaptation and Vulnerability*, Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, UK.
- Intergovernmental Panel on Climate Change (IPCC) (2012) 'Renewable energy sources and climate change mitigation' [online] http://srren.ipcc-wg3.de/report/IPCC_SRREN_Full_Report.pdf (accessed 7 December 2012).

- International Labour Organization (ILO) (2009) *Global Employment Trends January 2009*, International Labour Office, Geneva.
- International Labour Organization (ILO) (2010) *Global Employment Trends January 2010*, International Labour Office, Geneva.
- Jänicke, M. (2012) ‘Green growth’: from a growing eco-industry to economic sustainability’, *Energy Policy*, September, Vol. 48, pp.13–21.
- Krohn, S., Morthorst, P.E. and Awerbuch, S. (2009) *The Economics of Wind Energy*, European Wind Energy Association [online]
http://www.ewea.org/fileadmin/ewea_documents/documents/00_POLICY_document/Economics_of_Wind_Energy_March_2009_.pdf (accessed 5 June 2013).
- Lehr, U., Lutz, C. and Edler, D. (2012) ‘Green jobs? Economic impacts of renewable energy in Germany’, *Energy Policy*, August, Vol. 47, pp.358–364.
- Lenton, T.M., Held, H. et al. (2008) ‘Tipping elements in the Earth’s climate system’, *Proceedings of the National Academy of Sciences of the United States of America*, Vol. 105, No. 6, pp.1786–1793.
- McGranahan, G., Balk, D. and Anderson, B. (2007) ‘The rising tide: assessing the risks of climate change and human settlements in low elevation coastal zones’, *Environment and Urbanization*, Vol. 19, No. 1, pp.17–37.
- Nesbitt, E.R. et al. (2011) ‘China’s vision for renewable energy: the status of bioenergy and bioproduct research and commercialization’, *Journal of International Commerce and Economics*, August, pp.1–33 [online] <http://ssrn.com/abstract=1927503> (accessed 16 May 2013).
- OECD (2011a) *Towards Green Growth: A Summary for Policy Makers*, OECD, Paris [online]
<http://www.oecd.org/greengrowth/48012345.pdf> (accessed 14 December 2012).
- OECD (2011b) *Towards Green Growth*, OECD, Paris [online]
<http://www.oecd.org/greengrowth/48224539.pdf> (accessed 13 April 2013).
- Omarova, S.T. (2009) ‘The new crisis for the new century: some observations on the ‘big-picture’ lessons of the global financial crisis of 2008’, North Carolina Banking Institute, Vol. 13, pp.157–165 [online] http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1905800 (accessed 22 April 2013).
- Pan, J., Ma, H. and Zhang, Y. (2011) *Green Economy and Green Jobs in China: current status and Potentials for 2020*, Worldwatch Report 185 [online]
<http://www.worldwatch.org/system/files/185%20Green%20China.pdf>
 (accessed 15 April 2013)
- Pearce, D.W., Markandya A. and Barbier, E.B. (1989) *Blueprint for a Green Economy*, Earthscan Publications, London.
- Rifkin, J. (2011) *The Third Industrial Revolution: How Lateral Power Is Transforming Energy, the Economy, and the World*, Palgrave Macmillan, New York.
- Robins, N., Clover, R. and Singh, C. (2009) *A Climate for Recovery: The Colour of Stimulus Goes Green*, HSBC Global Research, London [online]
http://www.euractiv.de/fileadmin/images/HSBC_Green_New_Deal.pdf
 (accessed 22 October 2012)
- Sastresa, E.L., Usón, A.A., Bribian, I.Z. and Scarpellini, S. (2010) ‘Local impact of renewables on employment: assessment methodology and case study’, *Renewable and Sustainable Energy Reviews*, Vol. 14, No. 2, pp.679–690.
- Schmalense, R. (2012) ‘From ‘green growth’ to sound policies: an overview’, *Energy Economics*, November, Vol. 34, Supplement 1, pp.S2–S6.
- Sedlacko, M. and Gjoksi, N. (2009) *Sustainable Development and Economic Growth: Overview and Reflections on Initiatives in Europe and Beyond*, European Sustainable Development Network, ESDN Quarterly Report, December [online] http://www.sd-network.eu/quarterly%20reports/report%20files/pdf/2009-December-Sustainable_development_and_economic_growth.pdf (accessed 4 April 2012).

- Stern, T. and Damon, M. (2011) 'Green growth in the post-Copenhagen climate', *Energy Policy*, Vol. 39, No. 11, pp.7165–7173.
- Teikoku Databank (2010) [online] http://www.tdb.co.jp/english/news_reports/backnumber/brr09nen.html (accessed 20 May 2013).
- The Green New Deal Group (2008) *A Green New Deal, Joined-Up Policies to Solve the Triple Crunch of the Credit Crisis, Climate Change and High Oil Prices*, New Economics Foundation, London, UK [online] http://www.i-r-e.org/bdf/docs/a008_a-green-new-deal.pdf (accessed 24 September 2012).
- United Nations Environment Programme (UNEP) (2009a) *Global Green New Deal: Policy Brief* [online] <http://www.unep.ch/etb/publications/Green%20Economy/UNEP%20Policy%20Brief%20Eng.pdf> (accessed 12 November 2012).
- United Nations Environment Programme (UNEP) (2009b) *UNEP Year Book 2009: New Science and Developments in our Changing Environment* [online] http://www.unep.org/yearbook/2009/PDF/UNEP_Year_Book_2008_EN_Full.pdf (accessed 12 November 2012).
- United Nations Environment Programme (UNEP) (2010) *Green Economy: Developing Countries Success Stories* [online] http://www.unep.org/pdf/greeneconomy_successstories.pdf (accessed 25 March 2013).
- United Nations Environment Programme (UNEP) (2011) *Towards a Green Economy: Pathways to Sustainable Development and Poverty Eradication – A Synthesis for Policy Makers* [online] http://www.unep.org/greeneconomy/Portals/88/documents/ger/GER_synthesis_en.pdf (accessed 4 December 2012).
- United Nations Environment Programme (UNEP), Frankfurt School of Finance and Management and Bloomberg New Energy Finance (2011) *Global Trends in Renewable Energy Investment 2011 – Analysis of Trends and Issues in the Financing of Renewable Energy* [online] http://www.unep.org/pdf/BNEF_global_trends_in_renewable_energy_investment_2011_report.pdf (accessed 12 November 2012).
- United Nations Environment Programme (UNEP), Frankfurt School of Finance and Management and Bloomberg New Energy Finance (2012) *Global Trends in Renewable Energy Investment 2012* [online] <http://fs-unep-centre.org/sites/default/files/publications/globaltrendsreport2012.pdf> (accessed 12 November 2012).
- United Nations Environment Programme (UNEP), ILO, IOE and ITUC (2008) 'Green jobs: towards decent work in a sustainable low carbon world' [online] http://www.ilo.org/wcmsp5/groups/public/---ed_emp/---emp_ent/documents/publication/wcms_158727.pdf (accessed 7 November 2012).
- United Nations Environment Programme (UNEP), SEFI and Bloomberg New Energy Finance (2010) *Global Trends in Renewable Energy Investment 2010 – Analysis of Trends and Issues in the Financing of Renewable Energy and Energy Efficiency* [online] http://www.rona.unep.org/documents/news/GlobalTrendsInSustainableEnergyInvestment2010_en_full.pdf (accessed 12 November 2012).
- United Nations Environment Programme (UNEP), SEFI and New Energy Finance (2009) *Global Trends in Sustainable Energy Investment 2009 – Analysis of Trends and Issues in the Financing of Renewable Energy and Energy Efficiency* [online] http://www.unep.org/pdf/Global_trends_report_2009.pdf (accessed 12 December 2012).
- United Nations Framework Convention on Climate Change (UNFCCC) (1992) *United Nations Framework Convention on Climate Change*, United Nations [online] <http://unfccc.int/resource/docs/convkp/conveng.pdf> (accessed 18 December 2012).
- United Nations Department of Economic and Social Affairs (UN/DESA) (2009) *A Global Green New Deal for Climate, Energy and Development* [online] http://sustainabledevelopment.un.org/content/documents/cc_global_green_new_deal.pdf (accessed 16 December 2012).

- Van Jones, A. (2009) *Green Collar Jobs*, Our Planet, February [online]
<http://www.unep.org/PDF/ourplanet/2009/feb/en/OP-2009-02-en-ARTICLE3.pdf>
(accessed 17 October 2012).
- World Bank (2008) *Global Financial Crisis and Implications for Developing Countries*, Paper for G20 Finance Ministers' Meeting, Brazil [online]
<http://www.worldbank.org/financialcrisis/pdf/G20FinBackgroundpaper.pdf> (accessed 5 December 2012).
- World Bank (2012) *Inclusive Green Growth, the Pathway to Sustainable Development* [online]
http://siteresources.worldbank.org/EXTSDNET/Resources/Inclusive_Green_Growth_May_2012.pdf (accessed 3 December 2012).
- Yi, H. (2013) 'Clean energy policies and green jobs: an evaluation of green jobs in U.S. metropolitan areas', *Energy Policy*, May, Vol. 56, pp.644–652.