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Low-Carbon Jobs in an Inter-Connected World

Center for American Progress and Global Climate Network December 2009

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The Global Climate Network

The Global Climate Network is a collaboration of independent, influential and progressive research and policy organisations in countries key to tackling climate change. Together, members of the Network are committed to addressing the constraints faced by sovereign governments in agreeing international action.

The Network aims to help governments clear a pathway towards an effective and fair international agreement for avoiding dangerous climate change by proposing bold low-carbon policies and using data and analysis to persuade policymakers that climate change mitigation is in their interest.

The Network is working to:

- Address the political (economic, social and cultural) constraints barring the way to action by bridging the divide between domestic and international policy
- Promote equitable solutions that take into account the huge development, financial and energy challenges countries face
- Champion ideas and innovations to help construct a new political narrative that links action on climate change with enhanced economic and social well-being.

Alone, each Global Climate Network member has significant credibility and influence. By producing joint research, staging events together and seeking to influence policy, the Network can help bridge the dangerous divide that exists and is currently widening between international negotiations and national politics.

The Network's members are:

- Institute for Public Policy Research (ippr), London, also acting as the secretariat for the Network: The UK's leading progressive think tank with a strong track record on research and policy.
- Center for American Progress, USA: Founded by John Podesta, former Chief of Staff to President Clinton.
- Research Centre for Sustainable Development, China: An institute of the Chinese Academy of Social Sciences. Dr Jiahua Pan, its director, is one of 12 members of the Chinese Experts Committee for Climate Change.

- The Energy and Resources Institute, India: The country's leading climate and energy research institute whose director, Dr Rajendra Pachauri, chairs the UN's Intergovernmental Panel on Climate Change and is a close adviser to the Indian government.
- Wuppertal Institute for Climate, Environment and Energy, Germany. The Wuppertal Institute is renowned for its groundbreaking climate change work.
- Vitae Civilis, Brazil. Dr Rubens Born, Vitae Civilis's director, has had significant input into the Brazilian government's recent climate change plan.
- International Centre for Energy, Environment and Development, Nigeria. ICEED has expertise in climate change and energy policy.
- The Climate Institute, Australia. Set up in 2005, the Institute is a leading Australian voice in climate research and advocacy, pioneering clean technology and investment solutions with government and business.
- IMBEWU Sustainability Legal Specialists Pty Ltd, South Africa. An influential Johannesburg-based legal consultancy specialising in sustainability law with a strong climate change focus.

Dr Rajendra Pachauri, John Podesta (see above) and Lord Chris Patten of Barnes, former European Commissioner for External Affairs, are the Network's first patrons.

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Executive summary

Government action on climate change promises economic opportunity. The language of climate change policy has hitherto been largely negative, with wide use of such words as 'limitation', 'constraint' and 'reduction'. However, investing in new technology, stimulating new economic activity around a re-engineering of energy systems and growing new markets – all necessary to avoid climate catastrophe – will stimulate growth and offer new, skilled employment to workers.

This paper focuses on the emerging debate concerning the creation of 'low-carbon' jobs. What perhaps began as rhetoric generated for the purpose of counteracting climate negativity is now developing into an area of study that offers extraordinarily promising benefits. Not only can a low-carbon technology revolution help achieve climate change goals, it can also create new jobs, boost economic growth and help improve the lives of those currently deprived of access to energy.

The Global Climate Network set itself three tasks:

- To review domestic and international work to date on low-carbon job creation
- To assess government policies in member countries that might have an impact on low-carbon jobs
- To provide estimates of the potential for the creation of jobs in important low-carbon energy sectors in member countries.

Our approach is driven by domestic priorities, hence we look at a very wide range of energy-related sectors, from hydro, wind and solar in China to Smart Grid in the United States.

This paper – the product of eight separate national studies conducted over recent months by each of the GCN's member institutes – provides a major fillip for climate optimism and positivism. It shows that:

- Not only will the development and wide use of low-carbon technology create jobs, but globally these will be measured not in thousands but in millions.
- New low-carbon jobs are likely to outnumber job losses in carbon-intensive sectors.
- The jobs created will on the whole attract above-average salaries.

The GCN's exhaustive survey of existing literature on low-carbon jobs and its own estimates – while uncertain in some cases due to a shortage of source data on jobs and low-carbon technology markets – consistently support these conclusions.

Policymakers should aim to fill some of the gaps in data identified in this paper and to come to their own conclusions about precise numbers, but it is the firm, collective view of GCN members that the economic promise from bold, clear and decisive low-carbon policies is very significant indeed.

Low-carbon employment in an interconnected world

In this paper, we define low-carbon jobs as those that are created either directly as a result of the expansion of the low-carbon energy economy or indirectly through supplying sectors within that economy with goods and services. In some of the national studies, we also estimate the likely creation of 'induced' jobs as a result of low-carbon economic development. These include new businesses that are enabled through access to energy they did not have before or as a result of efficiency savings in the economy that are invested in jobs.

The United Nations Environment Programme in a 2008 study estimates that in 2006 2.3 million people were employed in renewable energy industries[1]. The same UNEP study also anticipates a substantial increase in employment in these industries by 2030, by which time it suggests approximately 2.1 million people will be employed in wind energy, 6.3 million in solar PV and 12 million in bio-fuel-related industry and agriculture.

An alternative approach outlined in the literature is to measure the employment opportunities provided by clean energy compared with carbon-intensive industries. This approach suggests renewable-energy programmes will generate more jobs per dollar and more jobs per megawatt of installed power than fossil fuel plants (UNEP/SEF Alliance 2009, Kammen et al 2004).

Job creation will also be shaped by interconnected global markets. There has in recent weeks been much controversy surrounding the creation of jobs in China as a result of investment by the US government in renewable energy. But as this paper shows, this is both threat and opportunity. For while an increased demand for renewable energy in one country will create opportunities for another, so is the reverse true. For instance, our US study shows that the deployment of Smart Grids in Europe, Australia, China and elsewhere could create 138,000 US jobs.

Comparative advantage in the era of globalisation is seemingly neither innate nor fixed. Our German study shows how Germany stands poised to capture a significant global share of the solar thermal market, even though Germany itself is not a good location in which to use the technology. Experiences in others sectors, such as IT, shows that while early

on industrialised countries were the developers and owners of the technology, over time developing countries moved up the value chain (Ernst 2003).

Most studies support the view that active government policy to trigger the wholesale expansion of clean-energy industries is a key driver of low-carbon employment opportunities. Important policies include setting ambitious renewable energy targets, increasing funding for R&D, creating technology testing facilities and centres of excellence, introducing economic support mechanisms such as feed-in tariffs, phasing out subsidies for carbon-intensive industries, and putting a price on carbon emissions (UNEP 2008).

Findings from the Global Climate Network

GCN members have focused explicitly on job creation at the national level in order to generate data that is anchored in national policy objectives. As a result, national rather than GCN-wide assumptions have been used in each study, making jobs numbers hard to compare. Nevertheless, across the wide range of sectors covered in members' studies and taking into account a huge variance in existing national conditions and policies (and availability of data), this paper identifies as many as 19.7 million[2] energy-related job opportunities that could be created in member countries between now and 2020 as a result of policies to reduce carbon emissions.

Each GCN member set out to fulfil four research tasks: to review existing low-carbon employment literature at the national level; review existing government policies and proposals to expand low-carbon energy markets; choose priority low-carbon energy sectors; and make estimates of the number of jobs that might be created as a result. In addition, some GCN members have made estimates of the likely numbers of jobs that could be created from the expansion of low-carbon energy markets in other countries.

Their findings can be summarised as follows:

Australia

Australia has passed legislation mandating that renewable energy account for 20 per cent of national electricity production by 2020. If this renewable energy target were combined with a binding commitment to reduce emissions by 25 per cent, the electricity sector would expand to directly support over 10,000 new jobs annually by 2020. This includes a net increase of close to 3,000 new permanent jobs and more than 7,000 construction jobs, above current levels. According to the government's own analysis, 1.7 million new jobs could be created throughout the economy from 2008 to 2020, with an additional 4.7 million out to 2050, even while national emissions are cut by 60 per cent by 2050.

China

Government wind, solar and hydro power targets could lead to the creation of 6.79 million direct and indirect jobs. The shift in the Chinese economy towards services sectors and away from basic industry could create a further 20 million. The economy is likely to expand at around 8 per cent per year and so while up to 17.38 million fewer jobs might be created if energy efficiency is increased by 60 per cent, the focus on low carbon and services sectors could outstrip these losses by almost 10 million.

Germany

The German government has already adopted emissions and renewable energy targets and, by virtue of being an early mover in renewables, already has a relatively mature industry. Consequently, 278,000 workers are already employed in renewable energy, more than in conventional energy. By 2020, this number could increase to between 353,500 and 400,000. Export markets could add significantly to this, supporting up to 238,600 jobs in the manufacture of solar thermal components alone by 2050.

India

Implementation of the Indian government's National Action Plan on Climate Change could create an additional 10.5 million direct jobs in wind, solar and biofuel energy production. As India is already a world leader in wind technology, ambitious global expansion of wind power could see 288,500 Indian jobs created if Indian firms were able to command 10 per cent of the global market.

Nigeria

The Nigerian government's Renewable Energy Master Plan pinpoints solar, small hydropower, wind and biomass energy. In addition, the government has stated its commitment to using lower carbon natural and associated gas to displace diesel, currently widely used for local power generation. If all untapped small-scale hydro power potential were captured and 37,000 megawatts of gas power were installed, just under 670,000 jobs could be created.

South Africa

The South African government's policy is guided by a range of long-term mitigation scenarios, the most stringent of which, inter alia suggests that around 50 per cent of South Africa's energy would have to come from renewable sources in 2050. Assuming this

equates with a target of 15 per cent of electricity from renewables in 2020, 36,400 new direct jobs and 109,100 indirect jobs could be created. In addition, as many as 700,000 people could be employed in biofuels.

United Kingdom

The UK government has already adopted economy-wide emissions reduction and renewable energy targets and has recently published a Low Carbon Industrial Strategy. Nevertheless, the UK is not in general a leader in low-carbon industries and although offshore wind is a major resource, strong government policy will be needed to attract to the UK the jobs this will create. However, if it is successful in attracting manufacturers and suppliers, this could lead to up to 70,000 UK jobs being created. The UK is also well-placed to capture up to half of all jobs worldwide in offshore wind financial and legal services.

United States

Estimates of the impacts of the recent US stimulus package and the American Clean Energy and Security Act passed last summer suggest that up to 1.7 million net new jobs will be created as a result. Other estimates of the impact of the currently pending Senate legislation is that it would increase that number to 1.9 million jobs. To pick out just one sector of an already allocated revenue stream, the US stimulus focus on Smart Grid could create 278,600 new jobs during installation (of which 139,700 jobs would be ongoing) and establish the US as a leader in Smart Grid technology. If other countries then installed Smart Grid technologies, a further 138,000 US jobs might be created to serve the export market.

Conclusions and recommendations

Job creation will result from the expansion of demand for low-carbon energy. But this expansion will not happen accidentally: it will be driven by government policy. The GCN therefore concludes that to create the opportunities identified in this paper, governments must focus on the following four conclusions and recommendations.

1. Clear, consistent and targeted government policy will help boost jobs numbers.

Policy approaches will include economy-wide emissions reduction or efficiency targets, renewable energy targets, feed-in tariffs and other renewable energy market incentives, subsidies – such as recent stimulus packages – regulation and taxes.

GCN recommendation: Develop national, low-carbon industrial strategies.

While many governments are beginning to adopt low-carbon policy frameworks to an encouraging degree, to capitalise on emerging markets in renewable energy and related technologies and establish their place in new global value and supply chains and create jobs they will need a cohesive, multi-dimensional, strategy.

2. Finance is critical to the creation of low-carbon economic opportunities.

The low-carbon economy, and the job opportunities it promises, should not whither due to lack of access to capital. In the current economic climate with finance still constrained, this is a real danger that only governments can address.

GCN recommendation: Governments must pull all available financial levers.

Governments must develop what some contributors to this study have called 'a robust pipeline of financing from government, the financial markets and international institutions' to ensure that low-carbon technologies are not starved of investment.

3. Training is critical to the development of low-carbon sectors.

Each of our national studies concludes that – among other factors – equipping new workforces with the required skills is of high importance. In among the numerical projections, there are also important arguments to be made about the 'quality' of the jobs created.

GCN recommendation: Identify skills gaps and develop a training strategy.

A first step towards a low-carbon skills and training strategy should be the identification by national governments or appropriate agencies of the likely skills gaps that might develop if wider low-carbon industrial strategies are pursued.

4. Adjustment policies should also form part of the strategy.

While the shift to a low-carbon economy promises to create a net job gain, at least in the transition phase, there will be losers and their loss will be costly at the household, economic and political levels.

GCN recommendation: Identify likely job losses and ensure these are minimised.

Retraining staff and helping firms to orientate their business towards greater efficiency will be as essential in low-carbon industrial strategy as enabling the low-carbon economy.

The global picture

The world turns its attention to jobs

According to recent estimates (ILO 2009), global unemployment in 2009 is projected to increase by between 18 and 50 million relative to 2007 levels, totalling between 210 and 239 million people. Thus, employment is at the forefront of policymakers' minds, rich and poor. Whereas they were once a byproduct of a strong economy, jobs have become a 'primary goal', especially of economic recovery efforts (Houser et al 2009: 4).

A central rationale behind recent economic stimulus packages is that public spending, particularly in labour-intensive industries such as infrastructure, construction and manufacturing, will result in job creation as companies expand their capacity to meet increased demand. Measures to generate and foster economic activity with a high labour intensiveness also offer the potential to simultaneously address other issues, such as greenhouse gas emissions. The concept of the 'low-carbon' job has emerged.

Defining low-carbon jobs

There is little consensus over what is meant by 'low-carbon', 'green' or 'clean energy' employment (UNEP/SEF Alliance 2009). 'Green jobs', which have often featured large in political lexicon, traditionally refer to occupations that contribute to preserving or enhancing environmental quality and health, such as protecting ecosystems, controlling pollution, and reducing waste and energy consumption (UNEP 2008).

'Low-carbon jobs' refer to employment in sectors that 'make up the clean energy economy', including energy efficiency, renewables, alternative transport and fuels (White and Walsh 2008a). Defined primarily according to industry rather than occupation, they include a range of medium and high-skilled activities – in R&D, design, production, marketing and retail, transport and distribution, assembly, installation, maintenance and support services including legal, IT and technical consultancy (Pollin et al 2008).

Many of these activities are undertaken by individuals who work in 'indirect' low-carbon jobs, which tend to arise in second-tier supplier industries producing intermediate goods and component parts[3], as well as the service sector. Some studies (Houser et al 2009,

UNEP 2008) also extend the 'low-carbon' tag to include so-called 'induced jobs', jobs that can be gained 'when energy savings are spent elsewhere in the economy'. In this study, we also apply the term 'induced jobs' to those that are created in developing countries as a result of the expansion of energy services through the use of low-carbon technologies, for instance as a result of biofuels cultivation in Indian villages.

Another important conceptual dimension to note in the existing literature is that low-carbon jobs are, or should be, decent jobs. They typically range from entry-level positions to higher-skilled jobs and offer good wages, on-the-job training, opportunities for career advancement, and job security (Cleary and Kopicki 2009, UNEP 2008, White and Walsh 2008a).

In this study there is a variance across the different constituent country papers on which it draws as to the precise definition of a low-carbon job. The Chinese study, for instance, looks both at direct clean energy job creation and at the wider national shift towards a greater proportion of GDP being earned in service sectors. The paper from the US looks very specifically at job creation from the expansion of Smart Grids.

Estimating low-carbon jobs in energy sectors

Policymakers will be concerned primarily about job losses; the expansion of low-carbon technology markets due to public policy measures to reduce emissions will inevitably lead to the contraction of some carbon-intensive sectors (Fankhauser et al 2008, Fredrikkson 1999). However, since the mid-1990s, the number of jobs in the traditional energy sector has declined in the US and Europe anyway, as a result of liberalisation programmes, privatisations and technological progress. In EU member states, it is estimated that between 1997 and 2004 there were 300,000 job losses in the electricity generation sector (EUTC and SDA 2007: 70).[4]

In addition, the energy sector is a relatively small direct employer and in most countries provides a relatively low contribution to overall GDP (Fankhauser et al 2008). Global demand is nevertheless growing. Plus, while job numbers may be low in energy production, the sector has a catalytic effect on the wider economy, creating better prospects for economic development and greater job creation across the economy. Decarbonising the sector is, then, not only a promising means of stimulating additional employment (UNEP 2008), but arguably also the key to wider decarbonisation.

Among the few international surveys to analyse low-carbon job creation, the UN Environment Programme (2008) estimates that in 2006 approximately 2.3 million people were employed in renewable energy industries.[5] The study anticipates a substantial increase in employment in clean-energy industries by 2030, by which time approximately 2.1 million people will be employed in wind energy, 6.3 million in solar PV and 12 million in biofuel-related agriculture and industry (UNEP 2008).[6] Data on jobs numbers in the national studies that follow here suggest this is a gross underestimation.

Other existing studies (regional and country-specific) calculate future potential for job opportunities in relation to anticipated industry growth, as a result of policy initiatives and rising clean-energy investment. For example, a recent European Commission (2009) report estimates the net number of jobs created by reaching the EU's 20 per cent target for the share of renewables in energy use in 2020 at 410,000.

In the US, a study by Roger Bezdek (2007) finds that the US renewable energy industry obtained $39 billion in revenues in 2006 and employed 200,000 people directly and another 246,000 indirectly. Assessing future opportunities under three scenarios, the report suggests that by 2030, 1.3 million direct and indirect jobs could be created under a 'business-as-usual' scenario, 3.1 million under a moderate scenario that leads to a 15 per cent share of renewables in electricity generation, and 7.9 million under an advanced scenario which would see nearly 30 per cent of electricity generated from renewables. The latter scenario 'would require strong national policies, including targets, standards, and invigorated R&D' (UNEP 2008: 100).

Other studies in the US have calculated the number of jobs that could be created as a result of financial stimulus packages for clean energy development and the climate legislation that is making its way through Congress. These are featured in the US summary in Section 2 below.

According to UNEP and the SEF Alliance (2008: 78) renewable-energy programmes will generate, 'per dollar, an order of magnitude more jobs than will expenditures for fossil fuel plants or tax cuts'. A University of Massachusetts and Center for American Progress report (2009), puts a figure on this, estimating that job creation opportunities among less-educated workers would be 'seven times larger than the number of jobs that would be created … by spending the same amount of money within the fossil-fuel industry'.

Further to this, Daniel Kammen, Kamal Kapadia, and Matthias Fripp (2004) claim that renewable energy not only generates more jobs per dollar of investment than fossil fuel energy, but also per megawatt of power manufactured and installed and per unit of energy produced. According to their cumulative analysis of 13 independent reports, solar PV, wind and biomass are all on average more labour-intensive than coal.[7] However, similar analysis carried out by UNEP and the SEF Alliance (2008) points out that mean deviations in such data are too great to enable a firm conclusion to be reached.

In a recent report, Samuel Fankhauser, Friedel Sehlleier and Nicholas Stern suggest that although clean-energy industries may be 'more labour intensive in the short term' especially in the production stages, net job creation may level out or even become negative as and when technologies mature, 'efficiency gains' are made and economies of scale increase (2009: 423).

Houser et al (2009) note a further caveat in that jobs may potentially be lost in other sectors 'as a result of higher tax rates to recoup the fiscal cost of green stimulus programmes' while the initially higher electricity costs of low-carbon alternatives – which ultimately will fall on consumers – may also lead to induced job losses elsewhere in the economy.

Box 1. Carbon Capture and Storage/Sequestration: Cleaning up carbon-intensive jobs

While some job losses appear inevitable, especially as economy-wide policies and targets are implemented, forcing higher costs and adjustment demands on carbon-intensive sectors, developing technologies to clean up certain sectors may help to reduce the numbers of workers affected. The best example of such a technology is Carbon Capture and Storage or Sequestration (CCS).

Many governments and commentators anticipate that CCS will have a leading role in decarbonisation and indeed that without it the necessary emissions reduction will be hard to achieve. But this technology could also potentially safeguard existing jobs in the coal industry and provide additional employment opportunities in sequestration technology and the transportation of gases.

Many of the countries featured in this paper are not only highly dependent on coal for energy supply but also have a large coal mining industry. And while job numbers are often declining due to mechanisation, coal mining remains a labour-intensive activity. For instance, in 2006, 82,595 people were employed in coal mining in the US.6 Thus as a transition technology at least, CCS offers real potential to help preserve jobs in a sector that often has significant political reach.

CCS also offers attractive opportunities for export-orientated job creation to countries that move early and develop the technology. For instance, a recent Center for American Progress report, which focuses on the opportunities for cooperation between the US and China on CCS, estimates that ambitious development of CCS could lead to the creation of almost one million jobs in the US as well as significant numbers of jobs in China (CAP 2009). However, the priority for governments is to move CCS closer to commercialisation more quickly because as long as CCS remains commercially untested and relatively costly, the additional employment benefit relative to capital invested will be minimal (Fankhauser et al 2008).

Global value and supply chains

Creating markets for clean-energy technologies in one location will create employment opportunities not only there, but also in other countries, precisely because supply and value chains are now global.

There is, however, a notable absence in the literature of analysis looking at global supply and value chains for low-carbon industries and products, and their impact on job creation. Existing studies tend to approach the issue of employment potential from a national and/or regional as opposed to an integrated global perspective (see above).[8] Nevertheless, analysis of the wider literature on low-carbon development suggests that countries are likely to capture maximum employment opportunities along the value and supply chains as a result of either of the following scenarios.

1. In instances where low-carbon manufacturing firms move up the value chain and become global leaders in their sector.

2. In instances where there are domestic opportunities for firms to be key links in the supply chain, often as a result of large foreign manufacturers setting up in that country (cf. White and Walsh 2008b).

Both scenarios suggest that in implementing market creation policies in low-carbon technologies, governments must analyse and understand their likely comparative advantage in the global value chain. In this regard, several lessons can be drawn from the electronics industry (see Box 2 below).

Firms and indeed countries may move up the value chain if they can establish themselves as global leaders in a given sector. This is largely dependent in the first instance on a secure and sizeable domestic market, strong political commitment and favourable economic support mechanisms (Bird 2009). These winners, it is argued, are also often the 'first movers' (EUTC and SDA 2007: 72-3).

At the company level, India's Suzlon provides an example of a multi-national firm that has developed comparative global advantage in wind turbine manufacturing and sales by acting early and decisively. In particular, it has set up expansive 'international innovation networks' of subsidiaries which allows it to 'stay abreast of wind technology innovations … maintaining control over intellectual property rights' (Lewis 2007a).

Countries and firms may also develop comparative advantage in the global clean-energy value chain by securing a position at the lower end of the supply spectrum. It may perhaps be easier to gain market access by focusing on specialised secondary activities such as the production and supply of component parts (for example, cells, modules, wafers, and silicon for solar PV) which 'require... less investment and technical know-how' (UNEP 2008: 110).

It is also important to bear in mind the potential contradiction between renewable energy sources 'as a global source of jobs and renewables as part of national competitive economic strategies' (UNEP 2008: 9). Given the importance for countries and firms of cementing their position on the global value chain, it may be the case that 'as renewables industries mature, they will increasingly be marked by difficult issues of competitiveness, trade rules, and wage differentials that are already familiar topics in other industries' (ibid).

Box 2: Gaining comparative advantage in the global electronics industry

The worth of the global electronics market – which involves the manufacturing of components for circuit-boards and microprocessors in telecommunications, medical equipment, optical technologies, photonics and consumer electronics – has been estimated at $2 trillion each year, with semiconductor components accounting alone for $275 billion of worldwide revenue (BIS Business Link 2007).

As with other capital- and technology-intensive value chains, there has been an increasing trend since the 1980s for leading brand-name firms in the electronics industry – such as IBM, Hewlett-Packard, Cisco Systems and Alcatel – to move operations offshore and outsource key activities to contract manufacturers in third countries, notably in the assembly of finished goods and the supply of key intermediate products (Gereffi 2005). In 2001, 90 per cent of consumer electronics sold in the US were produced offshore (USITC 2002).

Asia has become the powerhouse of production for the international market, with China, Korea, Taiwan, Singapore and Malaysia accounting in 2002 for 25 per cent of global electronics production8 (Ernst 2003). China, with its low labour costs and high productivity, has been a priority investment target for global industry leaders, with 85 per cent of China's high-technology exports emanating from foreign-invested enterprises (Gereffi 2005).

Traditionally, activities (and hence jobs) at the high end of the electronics supply chain, in R&D and design, have tended to remain in a smaller number of locations, often where leading firms are based. In the disk drive industry for example, while 80 per cent of the jobs shifted to Southeast Asia from the 1970s onwards, hard disk drive design largely remained based in the US (McKendrick et al 2000). However, comparative advantage is by no means fixed. Certain sectors within the electronics industry have witnessed globalisation of upstream activities, owing to increasing access to and exchange of knowledge, innovation strategies and sophisticated research capabilities (Ernst 2003).

In countries that do not have the manufacturing capabilities or facilities to compete with emerging economies in Asia, governments have attempted to gain comparative advantage and create jobs by targeting certain supply chain activities for role specialisation. The UK for example specialises in software and design innovation for electronic chips 'across a wide spectrum of disciplines, which is recognised globally' (cf. BIS Business Link 2007).

Domestic versus global opportunities

According to much of the literature a significant proportion of low-carbon energy jobs will be created in the country, region or locality for which the end product is intended. This is due in part to high transportation costs (UNEP 2008) for large equipment and component parts and the availability of supporting industrial infrastructure (BSR 2009).

In the US, for instance, it has been estimated that while the majority of wind turbines installed are imported from Europe and Asia, domestic manufacturing of turbine components – primarily towers and blades – has increased from 30 to 50 per cent between 2005 and 2008 (Ayee et al 2009). In this time, 55 new or upgraded domestic manufacturing facilities have been created, resulting in 13,000 new direct jobs. As the US market grows, leading international turbine manufacturers are establishing facilities there and this is likely to generate a large proportion of new jobs, not only in the US, but also – due to international nature of supply chains – in countries overseas (see Box 3).

There is a strong possibility that foreign companies operating abroad may rely on existing supply chains rather than build new ones that support local or regional job creation (cf. for example Gamsca's operations in Ohio [UNEP 2008]). To counteract this, countries such as Spain have introduced local content requirements (Bird 2009, Lewis 2007a), while China has imposed graduated import duties in order to encourage wind industry manufacturers to source locally-produced components (UNEP 2008).

The extent to which specific countries, regions or communities benefit from low-carbon employment therefore depends on the market opportunities available for renewable-energy firms but also on 'whether the necessary industrial and knowledge base, as well as infrastructure exists' (UNEP 2008: 44). Without improving supporting infrastructure and the existing skills base, it will be increasingly difficult for governments to effectively market domestic low-carbon opportunities to foreign firms and investors. As a result, there may be fewer domestic employment opportunities arising across the supply chain.

Policies and drivers for low-carbon employment creation

Much of the literature on low-carbon economic development – and the findings of this GCN study – suggests that creating new and sustainable low-carbon jobs largely depends on the maturity of domestic and international markets and the existence of favourable policy environments to stimulate the growth of clean-energy technologies and industries.

UNEP (2008) suggests that active government policy to trigger the wholesale expansion of clean-energy industries is a key driver of low-carbon employment opportunities. Setting ambitious renewable energy targets, increasing funding for R&D, introducing economic support mechanisms such as feed-in tariffs, phasing out subsidies for carbon-intensive industries, improving the competitiveness of renewables by putting a price on carbon: all these things may help foster low-carbon enterprise, attract private investment and in turn create jobs (Fankhauser et al 2009, UNEP 2008).

Since the implementation of such policies is unlikely to provide a quick fix, many governments faced with the immediate priority of tackling unemployment at a time of recession have opted to allocate a proportion of fiscal stimulus packages to low-carbon measures (Robins et al 2009). Houser et al (2009: 1) suggest, however, that while important, a 'green stimulus is no replacement for a comprehensive climate and energy policy', not only for reducing greenhouse gas emissions and dependence on foreign sources of energy, but also for fostering low-carbon innovation.

Much of the broader literature also emphasises the role of 'active labour market policies' (ALMPs) in safeguarding existing and generating new jobs, many of which may be applicable to low-carbon sectors (Brinkley et al 2008). National and regional governments may intervene by offering financial incentives for clean-energy industries and investors, granting wage subsidies for low-carbon employers and reducing their pay roll taxes.

Box 3: Interconnectedness and job creation: the US wind power market*

The rapid growth of the US wind industry in recent years has attracted a number of large international firms seeking opportunities for investment. Today, leading foreign companies operate, and hence provide domestic jobs, in each stage of the supply chain for US wind power generation. At the same time, US demand for wind products and services generates opportunities for employment beyond its borders.

According to the North Carolina Wind Working Group (cf. Methipara et al 2008), every 100MW of installed power provides per annum 310 full-time-equivalent manufacturing jobs, 67 contracting and installation jobs, and 9.5 jobs in operation and maintenance in the US. In 2008 alone, 35,000 new jobs were created as a result of US market expansion (American Wind Energy Association 2009, Global Wind Energy Council 2008).

Many of the world's leading turbine original equipment manufacturers have established a foothold in the US market. These include Vestas, whose US installations total 1,120MW, Siemens (791MW), Suzlon (763MW) and Gamesca (616MW). However, not all of their manufacturing takes place in the US: for instance, Suzlon only produces rotor blades and nose cones at its US facility, in Pipestone, Minnesota. The company may therefore ship other components (nacelle, nacelle covers, control systems, generators and tubular towers) from its manufacturing facilities in India or China, or source them from external suppliers. As a result, products destined for the US market may well be developed and manufactured by staff in other countries.

The idea that developing the US wind market contributes to employment creation abroad is substantiated if one considers that in 2008 US imports of blades motors and generators were worth $1.8 billion (David 2009). At the same time, US exports of wind turbine components have increased, from $0.7 million in 2003 to $22.1 million in 2008. In some instances, firms have set up manufacturing facilities in the US, in order to supply regional markets in the Americas, especially Canada and Brazil. As a result, US jobs in manufacturing, sales and transportation are likely to be created as a direct result of the growth of the wind power industry in other countries.

While the argument that market growth for renewable technologies in one country creates job opportunities elsewhere appears self-evident, there is very little data that extrapolates precisely in which countries jobs might be based. For the purposes of this study, we carried out a series of in-depth interviews with representatives from leading turbine manufacturers and utilities operating in the US market. Interviewees were either unable or unwilling to provide data on the number of people they employed in different countries, at different stages of the supply chain, and the number of employees providing products and services for the US market.

Nevertheless, our GCN member studies – notably those from the US, India, Germany and the UK – provide insights into the types of domestic employment opportunities that can be created by capturing overseas markets for low-carbon technologies, and also those jobs that will be created abroad as a result of market development in their own countries.

*This box draws heavily on information presented in a study of the US wind power sector by the Center on Globalization, Governance and Competitiveness (see Ayee et al 2009).

In addition to maximising the number of jobs available, it is widely suggested that governments should implement policies to ensure that the workforce is equipped with the necessary skills to exploit low-carbon employment opportunities (Bird 2009). For example, German renewable firms have reported a shortage of qualified workers for knowledge-intensive low-carbon positions, such as designers, engineers and electricians (UNEP 2008). What is needed, it is argued, is a combination of training programmes and effective strategies to attract more people to low-carbon sectors (Bird 2009).

According to the UK government, equipping the workforce with low-carbon skills and know-how will be 'a determining factor in... [its] ability to attract low carbon investment, successfully commercialise low carbon technologies, and innovate within companies' (HM Government 2009: 78). An extensive skills-base will not only be crucial in ensuring the growth of low-carbon industries domestically, but will also play a role in determining the extent to which they can secure a stake of and be competitive in the global market for clean energy products and services, a conclusion reached in many of the national contributions underscoring this study.

Findings from the national studies

Methodology and approach

The primary aim of this study is to examine the prospects for the creation of jobs in low-carbon energy sectors in the nine countries in which the Global Climate Network's members are based. This synthesis paper is based on eight national studies that are, in several cases, the first of their kind; in Nigeria, for instance, the GCN's member institute found almost no literature on job creation and less still on low-carbon employment.

We began with an international literature review, a summary of which is included above. Each GCN member then attempted to complete three research tasks at the national level:

1. Conduct a thorough review of the national literature on low-carbon and green job creation, where such data was available.

2. Assess the government policies or proposals to reduce emissions, emissions intensity or energy intensity and/or to expand use of renewable energy.

3. Provide estimates of the potential for job creation in priority low-carbon energy sectors (that is, those sectors identified in government literature and in the GCN's previous study [Global Climate Network 2009] as being of high national importance).

In addition, members attempted to make further estimates of jobs in sectors that might be created as a result of a country or firm's share of future export markets. Where economy-wide policies already exist or have been proposed, GCN members – in China and the US, for instance – have not only looked at the gross number of low-carbon jobs that might result, but have also attempted to arrive at net numbers by using assessments of likely losses in carbon-intensive sectors as a result.

At the national level, GCN members have worked to a variety of methodologies to arrive at the estimates of job numbers. This is part due to time and financial constraints, which prevented the creation of full models or regression analyses and also due to the lack of source data, which in some cases has made the estimation of job numbers very difficult indeed. It is also of high importance to the GCN – as an international alliance of domestic organisations rather than an international organisation – that we adequately reflect the different national circumstances and so necessarily the national studies are not directly comparable.

There are, however, clear parallels, important common findings and strongly shared conclusions. There is also a set of nine, standalone national studies that are likely to be of interest and importance at the domestic level precisely because they address national concerns and interests. These are published separately but are available through the Global Climate Network's website (globalclimatenetwork.info).

The findings of these national studies are summarised below, country by country, in alphabetical order. For the purposes of this synthesis paper – in particular to allow the international reader to establish a clearer impression of the context in which national assessments of low-carbon job creation are being made – we have also included some basic data about national labour markets and levels of unemployment.

Australia: Clean energy jobs in the electricity generation sector

Background

Australia has withstood the worst impacts of the global economic downturn better than most advanced economies. GDP grew by 0.60 per cent during the last four quarters (Trading Economics 2009), enabled in part by government stimulus measures to drive infrastructure development and consumer spending.

One of the biggest climate-related challenges for Australia will be in the electricity generation sector, which accounts for around 37 per cent of Australia's total emissions, making it the single biggest source of carbon pollution.[9] Changes in the way Australia produces and uses electricity will have implications for employment. In October 2009, total unemployment rose to 670,100 or 5.8 per cent of the working-age population (Australian Bureau of Statistics 2009).

Expanding renewable energy generation capacity will offer the potential to create new jobs, including in construction, operation and maintenance. Growth in demand for renewable energy and energy efficiency services will also have spin-off benefits for supporting industries, leading to indirect employment benefits.

Policy assumptions

The Australian Parliament has recently passed legislation mandating that renewable energy account for 20 per cent of national electricity production by 2020. The Federal Government has also introduced a AUS$4.5 billion Clean Energy Initiative to support low-emission and renewable energy technologies, including funding to deploy a combined 2000MW of solar and carbon capture and storage (CCS) technologies.

Assuming it passes through the Senate and comes into effect in 2011, the Carbon Pollution Reduction Scheme (CPRS) will improve the cost-competivenees of low-carbon technologies and, as a result, is likely to increase their uptake. In capping 75 per cent of Australian emissions, it is likely to result in slower rates of growth in emissions intensive sectors. Yet even if Australia were to adopt an emissions reduction target of 25 per cent below 2000 levels by 2020 alongside the CPRS, all but two industries—oil and aluminium —will continue to epand by 2050 (Commonwealth of Australia 2009a).

Findings

Existing studies suggest that Australia's economy and workforce will continue to grow strongly even as carbon emissions are sharply reduced. According to the government's own analysis, 1.7 million new jobs could be created throughout the economy from 2008 to 2020, with an additional 4.7 million out to 2050, even while national emissions are cut by 60 per cent by 2050. Under the same scenario, average annual incomes are also expected to rise by AUS$4,300 by 2020 (Gilliard 2009).

Previous work by the Climate Institute (2009) looking at the renewable energy sector as a whole estimates around 26,200 new direct and indirect jobs could be created if all planned and committed clean energy projects go ahead. This new paper – conducted alongside leading Australian energy sector consultants, McLennan Magasanik Associates (MMA) and IT Power (Australia)[10] – specifically analyses the direct employment impacts of a transition to a low-carbon electricity sector.[11] It finds that if, by 2020, 20 per cent of electricity is derived from renewable sources and emissions are reduced by 25 per cent below 1990 levels[12]:

- 10,000 new jobs will be created in Australia's electricity sector. This includes a net increase of approximately 3,000 new permanent jobs and more than 7,000 construction jobs, above current levels.
- In addition, on average around 2,300 local manufacturing jobs are likely to be supported each year between now and 2030, with spikes in years of high installation of almost 7,000 manufacturing jobs.
- Total full-time equivalent employment in the electricity generation sector will increase by 17 per cent between 2010 and 2020, totalling 20,000 in 2020.
- In the period 2010–2020, a significant proportion of employment will be supported as a result of increased reliance on wind, bio-energy and gas.
- In later years, it is projected that solar thermal and geothermal will make up an increasing portion of the generation mix, resulting in increased employment in these sectors.

Conclusions

These findings are highly significant as they should put to rest claims that taking strong action on climate will cost jobs. However, government policy will be essential to ensure employment opportunities in the electricity sector are created over the coming decades. This will include policies to support investments in new, low-carbon, energy sources, such as the emissions trading scheme and renewable energy targets and a suite of other policies, including those designed to support regional development.

Among the policies that will be on the government's priority list to achieve job creation through decarbonisation include: innovation policy, a skills strategy and adjustment policies to ensure affected workers have access to retraining and support. In a carbon-intensive country such as Australia, the latter will be essential to ensure a 'just transition' to low carbon.

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China: Reducing energy intensity, increasing supply from renewables

Background

The job market in China has to provide opportunities for around 775 million people. In 2008, the unemployment rate was 4.2 per cent (National Bureau of Statistics of China 2009). The recent global recession reportedly caused short-term unemployment for some additional 20 million people (see for example Hogg 2009).

China is accustomed to large-scale economic transformations affecting working patterns. In the five years from 1997 to 2002, around 50 million people lost their jobs as a result of government policies that reduced the numbers of workers employed in state- and group-

owned companies – part of the structural adjustments to take China from planned to market economy. In the same period, the numbers of employees in private firms quadrupled (see for example Meng JianJun 2002).

Against this backdrop, policies to reduce the energy and emissions intensity of China's future growth – assumed to be around 8 per cent per annum between now and 2020 – appear to have relatively modest, if structurally profound, implications. These changes will also occur against a backdrop of a further, significant structural shift in the Chinese labour market as the government attempts to shift the economy higher up the value chain. It is envisaged that the service sector will increase its share of GDP from 40.1 per cent in 2008 to 50 per cent in 2020.[13]

Policy assumptions

The government's well-publicised plans to establish a target for reducing the emissions intensity of industrial production will result from a decoupling of energy use from growth and a greater use of renewables, nuclear and clean coal in its energy mix. This paper examines the jobs impact in 2020 of two possible outcomes of such a policy against a business-as-usual (BAU) case:

- A low level 40 per cent reduction in the use of energy per unit of GDP
- A high level 60 per cent reduction in the use of energy per unit of GDP
- A BAU case of a 1.91 per cent per annum reduction.[14]

The government has also set targets for the deployment of renewable energy. This paper estimates the likely job creation that might result from an increase in:

- Hydro power from 170GW in 2008 to 300GW in 2020
- Wind power from 12GW in 2008 to either 100GW or 150GW in 2020
- Solar PV from 0.4GW in 2008 to 20GW in 2020.

In addition, this paper estimates the number of construction and related jobs that might be created as a result of the recently announced economic stimulus, of which trillion Yuan (circa $440 billion) will be invested by 2020 in new energy infrastructure.

Findings

The employment market in China is expanding rapidly as a result of its economic growth. This study looked at manufacturing, construction and transportation jobs in the wider economy and found that:

- A reduction in energy intensity of 40 per cent by 2020 led to a net loss in jobs created of 11.49 million compared to the numbers of jobs created under BAU.
- A reduction in energy intensity of 60 per cent by 2020 led to a net loss in jobs created of 17.38 million compared to the numbers of jobs created under BAU.
- Manufacturing was the sector in which numbers of jobs created were lower, with construction and transportation sectors gaining.

In three renewable energy sectors, modest gains in research, manufacturing, installation, operation and maintenance job numbers were possible if government targets are achieved by 2020:

- In hydro power, an additional 1 million jobs could be created
- In wind power an additional 670,000 to 1 million jobs could be created
- In solar PV an additional 860,000 to 880,000 jobs could be created.

In addition, by 2020:

- A further 4 million jobs might be created as a result of stimulus expenditure
- The gradual shift towards services sectors – for which energy intensity is much lower than primary or secondary sectors – could create up to 20 million new jobs.

Conclusions

In 2020, while China's macro-shift towards lower energy use per unit of GDP will lead to between 11.49 and 17.38 million fewer jobs being created in traditional sectors, the combination of targets and investment in renewable and new energy sectors (6.46 to 6.78 million jobs created) and the macro-shift towards services sectors (up to 20 million jobs created) appear likely to bring about a net gain in jobs overall. Clearly not all of these jobs are low carbon, although these trends are likely to lead to a decoupling of emissions from economic growth and perhaps (if the deployment of renewable energy is deep enough) to an absolute reduction in emissions.

Aside from sustained government policies to achieve energy efficiency and renewable energy deployment and the investment of China's stimulus money as planned, the government will need to prioritise investment in skills to ensure that workers are equipped to take advantage of new energy and service sector jobs. In addition, new social insurance schemes will be even more necessary to support those unskilled workers who will struggle to find employment in a higher skilled economy.

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Germany: Jobs from capturing global solar thermal markets

Background

Germany's recent recession has been deep but more short-lived than in other industrialised countries. By November 2009, it had posted its second successive quarter of economic growth, with GDP expanding by 0.7 per cent. After reaching a high in April 2009 of 8.3 per cent, unemployment levels have now fallen to 7.7 per cent, in part because of the German government's policy of kurzarbeit, under which firms cut working hours rather than jobs and the government pays 60 per cent of workers' lost salaries.

Nevertheless, news of potential low-carbon job creation in a country still committed to significant heavy industry is likely to be welcome. Germany's relatively long history of renewable energy policy has already demonstrated that declining numbers of jobs in conventional energy[15] – a trend attributable to the maturity of technology as much as the growth of competing sectors – have been more than matched by rising renewable energy jobs.

Policy assumptions

According to the German government, policy, such as its feed-in tariff and direct incentives to support the development of manufacturing of specific technologies, has helped create markets for renewable technologies that may not otherwise have existed. However, as the government observes, 'the net employment increase [in forthcoming years] will not happen by itself' and will require continued government intervention (BMU 2006).

As well as the creation of jobs, total CO2 emissions avoided through the use of renewable energy sources in Germany amounted to about 112 million tonnes of CO2 (74.4 million t CO2 in electricity generation, 25.2 million t CO2 in heat generation and 12.0 million t CO2 in fuels) (BMU 2009). Between 2000 and 2007, it is reported that the share of renewables in Germany's final energy consumption increased from 3.8 to 9.8 per cent. Yet, further expansion of renewable energy will be necessary if the government's 18 per cent target share by 2020 is to be met (cf. BMU 2009).

Findings: Jobs in renewable energy

In 2007, the number of workers employed in renewable energy sectors – principally in wind, biomass and solar energy – was for the first time greater than the number of workers employed in conventional energy sectors.

- In 2008, 278,000 people were employed in renewable energy sectors compared with 238,171 in conventional energy sectors. Between 2007 and 2008, renewable energy jobs increased by 12 per cent (BMWi 2009, BMU 2009).

- By 2020, the government estimates that employment in the renewable energy sector will increase to between 353,500 and 400,000, including at least 162,093 in wind, 29,159 in solar PV and 54,240 in biomass/biogas (BMU 2006).

According to existing employment projection scenarios, it is anticipated that a large proportion of jobs in Germany will be generated as a result of expanding export markets. In 2004, exports accounted for approximately 35 per cent of renewable energy technology production and services (BMU 2006). Jochen et al (2002) estimate Germany's renewable technology exports at €350 million in 2000 and project that Germany will share 4–5 per cent of the world market by 2010.

Findings: Solar thermal

German leadership in solar technologies is well documented and growth in both domestic and export solar thermal markets offers the potential for substantial job creation in Germany. In 2008, German manufacturers of solar thermal facilities reported an estimated combined turnover of €1160 million, which accounted for 7.9 per cent of the total annual revenue of German renewable energy manufacturers (BMU 2009).

This paper analyses the impact of policies and measures promoting solar thermal technology on job creation and market development in Germany. It combines new analysis with existing studies and finds that:

- In 2008, 17,400 people were employed in German solar thermal industries, primarily in heat production[16]. Of that total, 15,000 jobs were in manufacturing and 1,900 jobs were in operation and maintenance. This represents a 44 per cent increase in the number of people employed in this sector compared with 2007 figures (BMU 2009).

- In 2050, between 36,000 and 238,600 people could be employed by German companies in the concentrated solar thermal power (CSP) industry alone. This range estimate, from a previous study by Wuppertal Institute (Vallentin and Viebahn 2009), is based on different percentage scenarios (between 10 and 34 per cent) of the world CSP market

share for German companies[17]. It is likely to be conservative since it only accounts for jobs in component manufacturing, such as the fabrication of parabolic troughs, towers and mirrors.

- Given that there is little potential for solar thermal power production in Germany, almost all CSP products and services will be destined for export, primarily to Mediterranean and North African countries. Thus, many employment opportunities in German companies will not necessarily be based in Germany, but instead located close to plant sites. This is particularly true of installation, operation and maintenance jobs.

Conclusions

Government policy frameworks and carefully designed support mechanisms have been crucial for the expansion of renewable energy technologies in Germany[18], particularly as these technologies remain relatively expensive compared with conventional energy sources. The solar thermal industry, heavily reliant on government subsidies, is a case in point: when state support for investors and end-users was temporarily withdrawn in 2004, the market slumped.

Yet, with steady, targeted government support and a concomitant upsurge in the number of German solar thermal manufacturers, Germany is well placed to gain jobs from the expansion of the solar thermal market, both at home and abroad. However, employment generated in the solar thermal sector is unlikely to compensate wholly for job losses in conventional German energy sectors. As with other country studies in this paper, skills development programmes and measures to support the redeployment of workers to clean-energy industries will be necessary if Germany is to make maximum use of the opportunities brought about by international low-carbon development.

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India: Job creation through the development of wind, solar PV and biofuel markets

Background

Despite being the world's 10th largest economy and with a services sector that now accounts for almost one-third of India's GDP, 25 per cent of its population remains extremely poor. India's labour force is around 520 million with an official unemployment rate of around 7 per cent, but because of its levels of poverty, many people are engaged in informal employment or as casual agricultural workers and so the accuracy of this figure is hard to judge.[19]

In 2008, India's economy grew by 7.4 per cent in spite of weaker demand for its products and services from many troubled industrialised economies. This level of growth is leading to increased demand for energy. The International Energy Agency estimates that to meet its future energy needs, India will need to expand its gross capacity to exceed 400GW in 2030. This will include extending electricity supply to the 56 per cent or so of rural households who currently have none.

Policy assumptions

The government of India published its National Action Plan on Climate Change (NAPCC) in 2008. At the heart of the NAPCC is an overarching goal to reach a renewable energy target of 10 per cent by 2012 and eight 'missions' that include ambitious targets for the deployment of solar energy as well as enhanced energy efficiency (Government of India 2008).

This paper uses assumptions about the potential of renewable energy in India from the NAPCC and other sources and makes projections of job creation potential in three sectors: wind, solar PV and biofuels.

Findings: Wind

The Government of India plans to increase wind capacity by 2GW per year to a 2008 baseline of 9.6GW already installed. According to The Energy and Resources Institute (TERI, the GCN's Indian member institute), wind power in India creates 37.5 jobs per mega-watt (MW) during construction and installation (including manufacture) and five jobs per MW in operation and maintenance. This study therefore estimates that:

- If 2GW were installed per year to 2020, a total of 243,225 jobs would be created.
- If only 1GW were installed per year to 2020, a total of 145,725 jobs would be created
- If wind power expands globally to 352 GW by 2020[20] and India's share of the global market increases from 7 per cent to 10 per cent:
- Up to an additional 288,500 Indian jobs could be created, largely in manufacturing.

Findings: Solar

The Government of India plans to increase installed solar photo-voltaic (PV) capacity from 100MW in 2008 to 20GW in 2020. Using Greenpeace & EPIA (2006) assumptions about the creation of jobs per peak MW installed, this study estimates that:

- Up to 234,350 jobs could be created by 2020 if government targets are met.
- Up to 117,175 jobs could be created by 2020 if government targets are only half met.

These estimates only take into account Indian manufacturing, installation, operation and maintenance to supply the Indian market. If solar PV expands globally and India expands its manufacturing capacity, then clearly these numbers could be significantly greater.

Findings: Biofuels

The Government of India plans to raise 3 million biofuel hectares 'substantially on waste-lands'[21] in 200,000 villages and to raise a further 4 million hectares of plantation to cover 100,000 industries. According to government projections, this could lead to the creation of one direct job per hectare in establishing and managing plantations and a further 15 jobs per village both directly from processing the crops and indirectly through increased commercial activity and availability of cheaper energy supply.

This study therefore finds that:

- Up to 5 million jobs could be created as a result of village coverage.
- Up to 5 million further jobs could result from industrial biofuel production.

Biofuels are not without controversy, of course. The danger that they may displace food crops, perpetuate poorly paid, rural labour and lead to uncertain outcomes in terms of the control of greenhouse gas emissions are all factors that must be weighed against the likely high numbers of jobs the government's plans could create.

Conclusions

Renewable energy production offers significant job creation prospects: in wind, solar PV and biofuels combined, using the most optimistic assumptions about labour intensity and expansion within these sectors, a total of almost 10.5 million new jobs could be created. However, the vast majority of these jobs are likely to be created in India's push to increase the use of biofuels in rural communities and small and medium-sized industry.

The remaining new jobs – in wind power and solar PV – are nevertheless worth creating because they will not only add to India's high-waged-high-quality jobs portfolio, but also because they will help position India to take advantage of growing export markets in these sectors. For instance, in wind energy, if there is ambitious global installation then more than a quarter of a million Indian jobs may result.

As with other countries in this study, to realise the higher numbers suggested here, India will have to pursue the creation of new energy markets aggressively to ensure its aspirations are met. It will also need to invest in training to ensure an adequate number of workers are able to fill highly skilled renewable energy jobs.

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Nigeria: Creating jobs in small hydropower and natural gas

Background

Since the early 2000s, Nigeria has registered steady, incremental annual GDP growth thanks largely to increased oil exports and high international crude prices. However, growth contracted from 6.4 per cent in 2007 to 5.3 per cent at the end of 2008 (CIA 2009), following the onset of the global recession and a slow-down in demand for oil.

Despite government reform efforts, the country continues to be hampered by acute infrastructure problems and a situation in which 70 per cent of the population live below the poverty line (ibid).

Economic output has been seriously constrained by the ongoing power sector crisis, which has plunged total generating capacity of conventional power down to under 2000MW from a total installed capacity of about 8000MW.[22] As a result of poor power supply, industries, especially in the manufacturing sector, have witnessed a gradual decline in operational capacity and in many cases production has moved to neighbouring West African countries. This has resulted in substantial job losses throughout the Nigerian economy. Today, approximately 40 million people are in unemployment (allafrica.com 2009).

Nigeria's hunger for energy continues to grow. In 2006, a government study projected a medium to long term electricity demand of 30,000MW and 192,000MW respectively. This paper focuses on the prospects of small-scale hydropower and natural gas technologies to help overcome Nigeria's energy crisis, provide increased energy supply, reduce emissions and create new job opportunities.

Policy assumptions

The 2005 Renewable Energy Master Plan (REMP) sets out a road map for increasing the role of clean-energy sources in Nigeria's power generation mix. The Plan envisages 15,903MW of electricity from renewable energy by 2015 and pinpoints solar, small hydropower, wind and biomass energy generating systems as integral technologies to this process.[23]

The Nigerian government has indicated that natural gas[24] will continue to play an important role in power generation.[25] So too will associated gas from crude oil production, which – despite government efforts to prevent this – continues to be flared into the atmosphere.[26] The 2008 National Gas Master plan sets out the government's plans to develop the domestic gas market and modernise gas transmission and utilisation infrastructure. In line with the 2005 Electricity Power Sector Reform Act, it also envisages a transition towards private sector and decentralised ownership of electricity generating gas plants from the erstwhile public sector vertically integrated power utility.

Findings: Small hydropower

The REMP targets an increase in small and micro hydropower usage from the 37MW currently installed to approximately 2000MW by 2025. This would account for over 10 per cent of Nigeria's total electricity production and 66 per cent of its renewable energy contribution.

According to a UNIDO-RC-SHP Africa study[27], a typical micro hydro plant of 75.1KW generates 120 direct energy infrastructure jobs in construction, installation and operation and maintenance. Using existing data from two additional studies (Zarma 2006 and

Energy Commission of Nigeria and UNDP (2005) into SHP development in Nigeria, verified by interviews with industry experts and government officials, the present study finds that:

- Approximately 14,800MW gross potential hydro capacity remains untapped across Nigeria and offers strong potential for rural SHP developments.[28]
- If the SHP sites/schemes identified in existing studies were to be developed, this could create as many as 88,000 direct jobs (as above).
- An additional 281,200 indirect jobs could be created in supplier industries including agro-processing, saw milling and local craft enterprises.

Findings: Natural gas

Projections of jobs in the gas power generation sector in this paper take into consideration existing policies to drive gas plant investment, in addition to employment data from the national utility, the Power Holding Company of Nigeria (PHCN). The paper estimates that:

- On average seven jobs per MW power produced can be created in the installation, operation and maintenance of a typical gas power plant, as well as in upstream gas gathering and processing, and downstream pipeline transmission and distribution.
- Approximately 37,000MW of new installed electricity generation capacity could create 260,000 direct jobs (as above).
- An additional indirect 40,700 jobs could be created in specific areas of the supply chain, including component manufacturing of compressors and gas meters, and lube oil production for compressor stations and transportation systems.

Under the Petroleum Industry Bill (PIB 2007), a local content requirement has been introduced which mandates the use of Nigerian labour in the oil and gas industries[29]. Consequently, this paper anticipates that the majority of job opportunities identified will be filled by Nigerian workers.

Conclusions

The Nigerian Federal Government's Seven-Point Agenda makes power production a central priority that will improve livelihoods, tackle unemployment and stimulate economic growth. Increased electricity generation through cleaner sources of power will also contribute significantly to reducing Nigeria's greenhouse gas emissions.

This paper calls for stronger government policy frameworks to spur growth in both sectors and, therefore, maximise their job creation potential. This includes a supportive fiscal regime to incentivise private sector investments in low-carbon sectors[30] and

stronger regulatory frameworks to attract financing from carbon markets and the Clean Development Mechanism (CDM). Upfront public finance will also need to be mobilised to support the capital costs of SHP projects and infrastructure development, particularly in the gas power sector.

As Nigeria moves towards a liberalised and cleaner power sector, the government will also need to ensure that potential job losses are, where possible, minimised, and that programmes are in place to support the re-employment of workers, particularly those currently working in diesel generator importing firms and other carbon-intensive energy industries.

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South Africa: Creating jobs by investing in renewable energy

Background

After a period of stable economic growth since the turn of the century, South Africa's real GDP growth slowed to 3.1 per cent in 2008 and is expected to shrink further by the end of 2009, as a result of the economic downturn. Of an active workforce of 17.79 million, 22.9 per cent were unemployed in 2008 (CIA 2009). In the first half of 2009, nearly half a million people lost their jobs with a further 300,000 job losses expected by the end of the year (The Economist 2009).

The economic stimulus package introduced by the South African government in February 2009 is geared primarily towards a ZAR 787 billion (approximately US$105 billion) three-year infrastructure roll-out. The package contains several priority programmes to tackle unemployment, including an Expanded Public Works Programme and plans to restructure macro-economic policy in favour of employment-generating exports, which could also help reduce South Africa's ZAR 64.5 billion trade deficit (Southafrica.info 2009).

Although not specifically earmarked for funding in the stimulus package,[31] the renewable energy sector has been identified by the government as an effective means to generate employment as well as reduce emissions[32]. This is despite substantial job cuts in the electricity generation sector as a whole over the last 25. During this time, 70,000 jobs have been lost despite electricity generation increasing by over 60 per cent between 1980 and 2000 (Energy and Development Research Centre 2003)[33].

Policy assumptions and economy-wide estimates

The South African government's 2004 National Climate Change Response Strategy states that decarbonisation is consistent with the country's key social and economic objectives, including poverty alleviation, job creation and sustainable development. To help inform policy responses to climate change, the government has commissioned the Long Term Mitigation Scenarios (LTMS 2007). The most ambitious scenario identified in this document, the 'required by science scenario', envisages stabilisation of domestic emissions at 30-40 per cent of 2003 levels by 2050[34] and suggests that:

- Short-term efficiency to reduce emissions by 9,000 tonnes in 2050 (thus achieving 43 per cent of the scenario's goal) will lead to net job losses of around 0.3 per cent in 2015.
- However, medium-term efficiency to reduce emissions by 13,800 tonnes in 2050 (64 per cent of scenario goal) will lead to a net increase in both GDP and employment of approximately 1 per cent in 2015. This would require a strong policy response to achieve, inter alia, 50 per cent of electricity generated by renewable sources in 2050.

Findings: Renewables

Beyond the economy-wide projections of the LTMS, this paper draws on findings from an earlier study (AGAMA 2003) to make assumptions about the potential of renewable energy for job creation in South Africa. The government's 2003 White Paper on Renewable Energy sets a short-term target of generating 10,000GwH of final energy consumption from renewable sources by 2014, which equates to approximately 4 per cent of total electricity supply.

This study estimates that if South Africa were to instead generate 15 per cent of its electricity from renewable energy technologies in 2020, this could create as many as 36,400 new direct jobs and 109,100 indirect jobs, without any additional cost to the economy[35]. This figure excludes bio-fuels which alone could create 700,000 direct and indirect jobs by 2020.

Findings: Wind

In the wind power sector, the paper estimates – conservatively, by the authors' admission – that a typical 37.5MW wind farm could generate 3.7 direct jobs per MW in manufacturing and installation, and a further 1.0 jobs per MW in operation and maintenance (see AGAMA 2003). Based on varying assumptions pertaining to the installed capacity potential and degree of local manufacture involved, the study calculates that:

- If renewables were to account for 15 per cent of total installed electricity capacity in 2020 and wind power contributed 50 per cent of this total, 22,400 new direct jobs could be created.
- If however, renewables were only to account for 7.6 per cent of total installed electricity capacity and wind contributed 50 per cent, approximately 9,000 new direct jobs could be created.

Importantly, the study suggests that not all jobs generated will necessarily be domestically based. Wind technologies are likely to be imported from, and hence manufacturing jobs located in, other countries. Instead, it is estimated that the majority of local jobs in wind power generation will be in professional and management services.

Findings: Solar PV

The paper estimates that the construction, transportation and installation of a 2-KWp photovoltaic array could generate a total of 35.5 jobs per megawatt installed. Using the same assumptions as above, it suggests that:

- If renewables were to account for 15 per cent of total installed electricity capacity in 2020 and solar PV contributed 0.5 per cent of this total, 2,475 new direct jobs could be created.
- If renewables were to account for 7.6 per cent of total installed electricity capacity and solar PV contributed 0.5 per cent, approximately 1,000 new direct jobs could be created.

Although job estimates tend to be lower in the solar sector, this paper argues that South Africa possesses the necessary technical skills base to fill jobs in PV manufacture and installation. Thus, with the right policy tools and incentives to attract investment, the industry offers substantial domestic job creation potential. It also notes that South Africa is at the forefront of commercialising super-thin solar technology, which could be manufactured for regional export and lead to further job creation.

Conclusions

Significant opportunities for employment lie in clean-energy sectors and can be harnessed if the South African government scales up its renewable energy ambitions[36]. Targeted government policies to increase local demand for priority renewable technologies – such as solar PV – and measures to encourage investment in the domestic market will be necessary to ensure job opportunities are maximised.

Like in other countries in this study, the South African government will need to determine future human capacity needs in renewable energy sectors and prioritise skills development accordingly, through public training programmes and sectoral initiatives.

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United Kingdom: Jobs and the low-carbon transition

Background

The UK government has targeted the development of low-carbon sectors and industries as a means to spur job creation and revitalise the economy. In July 2009, it published its Low-Carbon Industrial Strategy (LCIS), setting out how the UK can capitalise on economic opportunities in low-carbon and environmental goods and services, remove barriers to market for clean-energy technologies, and provide decent job opportunities.

This new activist approach for transitioning to a low-carbon economy is set against a backdrop of rising unemployment following the onset of the global economic recession.

By June 2009, 2.4 million people were unemployed in the UK, up from 1.7 million at the same point in 2008 (ONS 2009). Unemployment is expected to peak at around 3 million by the middle of 2010.

It is unclear whether those areas of the economy that have provided large-scale employment in the past – such as the financial services and real estate sectors – are likely to recover fully any time soon. In the longer term, employment in some sectors may be substantially reduced.[37] As a result, other areas of the economy will need to expand if employment is to return to pre-recession levels, which is forecast to happen in 2016 (Clifton et al 2009).

Policy assumptions and estimates

The future growth of clean-energy industries is central to the government's plans to reduce emissions by 34 per cent by 2020 and 80 per cent by 2050, compared with 1990 levels. Rapid and sustained deployment of renewable technologies will also be necessary if the UK is to comply with its obligation under the EU to provide 15 per cent of its electricity through renewable sources by 2020[38].

The UK paper notes that existing job forecasts for renewable sectors vary widely and are based on a set of different assumptions and variables. A recent study commissioned by the government (Douglas Westwood 2008) estimates that if the UK meets the target, proposed by the Renewables Advisory Board (RAB), of 38.5GW of installed renewable energy capacity by 2020, as many as 133,000 new jobs could be created[39].

Offshore wind, which forms the focus of an earlier ippr study (Bird 2009), is one industry in which a large proportion of future clean-energy jobs might fall. The UK currently has the world's largest installed capacity for offshore wind and government has set out ambitious plans for expansion[40]. However, few studies offer estimates of the number of jobs that could be created in the industry. A recent report by the Carbon Trust (2008) provides an exception: it suggests that if 29GW of offshore wind capacity is installed in 2020, this would create between 40,000 and 70,000 jobs along the supply chain.

An additional study commissioned by the British Wind Energy Association (Boettcher et al 2009) looks at jobs created in the wind power industry as a whole, according to three alternative scenarios, and finds that:

- 22GW total wind capacity (offshore and onshore) could create 23,000 jobs by 2020.
- 27GW total wind capacity (offshore and onshore) could create 36,000 jobs by 2020.
- 34GW total wind capacity (offshore and onshore) could create 57,000 jobs by 2020.

Douglas Westwood (2008) adopts an alternative approach by forecasting jobs created in the wind sector according to the government's ability to attract turbine manufacturers to the UK. It anticipates the creation of:

- 5,000 new jobs by 2020 under a low-scale scenario (one manufacturer and 10 per cent of installed capacity manufactured in the UK).
- 14,000 new jobs by 2020 under a mid-scale scenario (two manufacturers and 25 per cent of installed capacity manufactured in the UK).
- 34,000 new jobs by 2020 under a high-scale scenario (three manufacturers and 50 per cent of installed capacity manufactured in the UK).

Although these studies differ substantially in their assumptions and findings, it is generally agreed that the majority of jobs in the combined wind industry are likely to arise in two stages of the supply chain: manufacturing and installation. However, not all jobs will necessarily be local.[41] Given the UK's lack of manufacturing base for renewable energy technologies, wind turbines are likely to be imported from oversees (Carbon Trust 2008). Instead, the UK might be better positioned to generate domestic jobs in component manufacturing, such as the manufacture of towers and foundations which could draw on existing skills and knowledge bases in the offshore oil and gas sectors.[42]

Given its relatively mature service sector, the UK may also capture jobs in financial and legal services for domestic and international markets for offshore wind. Indeed, the Carbon Trust (2008) estimates that the UK can accrue half of all service jobs in the global offshore wind industry by 2020.

Conclusions

In order to foster the growth of, and maximise job opportunities in, renewable energy sectors, the paper calls for targeted government intervention that prioritises areas of strategic interest for the UK. In the offshore wind industry, greater government support for RD&D, better incentives for developers under the Renewables Obligation (RO), and removal of barriers to delivery (including delays in the planning system, problems accessing the grid and inadequate port infrastructure) will all be necessary if the industry's potential for growth is adequately harnessed.

A proactive government skills policy is needed to address shortages in technical, job-specific and generic 'green' skills among the British workforce[43]. The paper also suggests that plans to stimulate clean-energy industries should contribute to reducing inequalities in the labour market. Although low-carbon jobs are relatively well-paid and offer good career prospects, the government should consider linking the Low-Carbon Industrial Strategy with its welfare reform agenda to assist the long-term unemployed back into work, and introduce programmes that promote female employment in low-carbon sectors.

Finally, the paper calls for the government to identify jobs – in coal, gas and other carbon-intensive sectors – at risk from the low-carbon transition and develop strategies with employees, trade unions and Regional Development Agencies to protect jobs

where possible and support employees in finding new work. This will not only minimise the political risk associated with decarbonisation, but more importantly ensure that the transition is fair.

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United States: Building smart grids and comparative advantage

Background

In October 2009, unemployment in the U.S. rose from 9.8 percent to 10.2 percent, its highest level since 1983 (US Bureau of Labor Statistics 2009). It is not surprising, therefore, that the Obama administration has made the creation of jobs in new sectors, including low carbon, a centrepiece of its agenda in Congress and a focus of its economic recovery package.

Groups such as the Apollo Alliance have also brought the opportunity for job creation through investment in low-carbon energy to greater public attention. However, a backlash has begun recently as it became clear that US stimulus energy investments were supporting the creation of jobs in other countries, most notably in China (see, for instance, Pasternak 2009). While the accuracy of such claims cannot easily be verified, as this study shows, the creation of markets in one country can lead to new jobs both in that country and elsewhere.

Policy assumptions

The $787 billion American Recovery and Reinvestment Act (ARRA), signed into law in February 2009, contains almost $100 billion to support clean energy and 'green collar' job programmes. In June 2009, the US House of Representatives passed the American Clean Energy and Security Act (ACESA). A similar bill is now being reviewed in the Senate.

Analysis of ARRA and ACESA concluded that the two pieces of legislation could stimulate $150 billion in clean-energy investments annually over the next decade. Studies suggest:

- ARRA and ACESA could generate a net 1.7 million new jobs in energy efficiency, renewable energy, and other green job sectors (PERI and Center for American Progress 2009).
- ACESA could generate 425,000 new efficiency-related jobs by 2030; increasing the level of investment could swell this number to one million new jobs (Laitner 2009).
- Up to 1.9 million jobs in efficiency and renewable energy by 2020 could result from ACESA (Environmental Entrepreneurs 2009).
- These studies vary in assumptions and findings but unanimously conclude not only that investment in a low-carbon economy can produce thousands of jobs in the US, but also that bolder investments result in higher job creation.[44]

Findings: Smart Grid

The term 'Smart Grid' refers to a group of digital technologies and systems with the ability to transform electricity generation, transmission, distribution, storage, metering and grid maintenance. They are an imprimatur of the low-carbon economy, allowing for greater efficiency and control of power usage and for an eclectic range of power sources to be connected.

While upgrading the U.S. grid – smart or otherwise – over the next two decades may require an estimated $1.5 trillion of investment, implementing Smart Grid technology could, according to government estimates, save the United States $638 to $802 billion over 20 years (U.S. Department of Energy 2009a). The 2007 American Recovery and Reinvestment Act provides $4.5 billion for deploying Smart Grid technologies (U.S. Department of Energy 2009b).

The smart meter – the most mature in the group of technologies required for creating the Smart Grid – provides a proxy for Smart Grid projects from which jobs impacts can be extrapolated. Using data from a 2009 study (KEMA 2009), verified through a series of in-depth interviews with companies involved in Smart Grid deployment in the US and based on the installation of 128 million smart meters – smart meters for virtually every US consumer – this study finds that:

- Around 2,000 jobs per one million smart meters – a total of 278,600 jobs – can be created during the installation phase, notionally from now until 2012.
- Post 2012, a 'steady state' from 2012 until 2018 would provide 139,700 jobs.
- While there would be job losses of 26,200 in the steady state period, mostly in meter reading, which would be rendered obsolete, there would be a net gain, mostly in manufacturing.

The installation of Smart Grid technologies in the European Union (as a result of the 20-20-20 package), Canada, Australia, China and elsewhere will result in a rapid global expansion in demand, especially for manufactured technologies. Assuming that this creates 250 projects (that is, 250 million meters) by 2015 (see for instance Pike Research 2009) and the US can capture 60 per cent of the manufacturing market, this study finds that:

- Around 920 jobs per global million meter project might be created in the US.
- This could result in up to 138,000 additional US jobs from global investment in smart grids.

Conclusions

The potential for US job creation through new smart grid projects in both the US and overseas is an important rejoinder to claims that US investment in low-carbon technology is creating jobs overseas. However, the American Recovery and Reinvestment Act has a 'Buy American' clause, which may help stimulate US jobs as the US market expands, but may also encourage other countries to introduce similar clauses and lock US manufacturers out of their markets.

There is clearly a need to retrain the tens of thousands of meter readers whose jobs may be threatened as smart grids are introduced, but the benefits of investing in smart grid technology appear to outweigh the risks. However, fast deployment – both in the US and elsewhere – at the scale envisaged in this study will require coordination on technology and standards between governments.

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Conclusions and recommendations

The creation of jobs is likely to be secondary to GDP growth in many policymakers' minds and to productivity in the minds of industry leaders. Their assumption will be that combined in the right measure, growth and productivity will create new jobs. However, big economic changes, such as the recent finance and economic crises, bring employment into sharper focus. The emergence of a global, low-carbon economy may represent another such change.

Recent job losses in the US, which some commentators are now suggesting may even endanger the Democrats' majority in one house of Congress if the trend is not reversed come the 2010 elections, could have a profound political cost. Similarly, in China, the short-term loss of tens of millions of jobs in late 2008 due to the weakening of demand in export markets was, according to some officials, a potentially destabilising trend (South Asia Analysis Group 2008).

The promise of a swathe of new jobs – and the strong suggestion that these may outnumber job losses – should serve as a significant political and economic enticement to governments to move more stridently towards low-carbon economic development. However, as the Global Climate Network notes in its previous Breaking Through on Technology paper (GCN 2009), the shift – including the creation of new jobs, the development of new technologies and the avoidance of dangerous climate change – will not happen by accident. It must be driven by government policy.

In time, some of the necessary policy signals may well come from the international level. However, it is hard to escape the importance of national policy to ensure demand for important technologies is created in the first place and that the politics of job creation can be given a fillip by the resulting employment boom. With this in mind, our conclusions and recommendations are as follows:

1. Clear, consistent and targeted government policy will help boost jobs numbers

As many of the national papers that underscore this study demonstrate, markets for low-carbon technology – and therefore jobs numbers – expand as a result of government

policy. Policy approaches taken include economy-wide emissions reduction or efficiency targets, renewable energy targets, feed-in tariffs and other renewable energy market incentives, subsidies – such as recent stimulus packages, regulation and taxes.

The GCN's national papers also summarise the policies and proposals of governments to develop low-carbon technology markets; the projections and estimates of jobs numbers are made using these assumptions. From this it would be fair to deduce that an increasing number of policymakers not only see the low-carbon economy as possible but also inevitable. If this is the case, early movers (Germany might be argued to be one example in this report) and those that drive new technology markets most aggressively will reap the economic benefits, including job creation.

One further conclusion in this area, which is evident from China, the US and other national papers and from some of the international literature, is that more aggressive and ambitious government policies seem likely to create higher net numbers of jobs. While this is a tentative conclusion, it also stands to reason; if the economic, fiscal and regulatory signals from government strongly support low-carbon technology, then businesses will be more likely to make the required investments.

GCN recommendation: Develop national, low-carbon industrial strategies

While government intervention in markets should always be handled with care, it is difficult to conceive of an economic transformation on the scale required to avoid dangerous climate change that takes place in the free market alone. While many governments are beginning to adopt low-carbon policy frameworks to an encouraging degree, to capitalise on emerging markets in renewable energy and related technologies and establish their place in new global value and supply chains and create jobs they will need a cohesive, multi-dimensional, strategy.

National low-carbon industrial strategies are likely to differ significantly from country to country, depending on national resources, skills bases and existing infrastructure. As well as low-carbon policy frameworks and sector- or economy-wide incentives to create sustained demand, strategies may include: finance; support for research and development; a training and skills strategy; investment in infrastructure; adjustment policies for workers and industries that are carbon-intensive.

The GCN is not arguing that governments should be active in their economies to the extent that they pick winning technologies. However, it is our view that government needs to define clearly the national low-carbon policy framework, develop a vision for where in the global market a nation's low-carbon comparative advantage will lie, help ensure national infrastructure and the nation's skills base is up to the job and provide finance. Markets will in the end determine which technologies succeed, but in the meantime it is government's proper role to ensure low-carbon wins out over carbon-intensive.

2. Finance is critical to the creation of low-carbon economic opportunities

The low-carbon economy, and the job opportunities it promises, should not wither due to a lack of access to capital. In the current economic climate with finance still constrained, this is a real danger that only governments can address. Public funds have a role to play, but they too are hugely constrained: finance capital markets are where the bulk of the world's wealth is still located but currently the economic signals to direct this money towards low-carbon investment are not strong enough.

The financing of some of the policies and measures the GCN has identified in this paper is the subject of the Network's next study, due for publication during COP 15 in Copenhagen.

GCN recommendation: Governments must pull all available financial levers

While carbon markets might establish long-term price signals to steer investment towards low-carbon, this is unlikely to be strong enough soon enough. Significant, up-front capital expenditure is also required to ensure many of the job opportunities identified in this report are realised. Governments must therefore do everything in their power – from the wise use of limited public funds, to the creation of low-carbon capital market regulation, tax incentives and new financial channels – to shift investment from high to low carbon.

Governments must develop what some contributors to this study have called 'a robust pipeline of financing from government, the financial markets and international institutions' to ensure that low-carbon technologies are not starved of investment.

3. Training is critical to the development of low-carbon sectors

Each national paper that supports this study concludes that – among other factors – equipping new workforces with the required skills is of high importance. Whether or not a workforce is ready to supply new, low-carbon industries with labour will make or break low-carbon industrial strategy. In among the numerical projections, there are also important arguments to be made about the 'quality' of the jobs created.

Many workers employed in new, low-carbon technologies will require a high level of skill and are therefore likely to attract salaries above national averages. This too is good news, not just for governments seeking to orientate their economies higher up the value chain, but also for those concerned about the structural flaws in the global economy caused, in part, by an oversupply of low-waged labour.

GCN recommendation: Identify skills gaps and develop a training strategy

A first step towards a low-carbon skills and training strategy should be the identification by national governments or appropriate agencies of the likely skills gaps that might develop if wider low-carbon industrial strategies are pursued.[45] These gaps will need to be filled with a range of innovative, public-academic-private training and apprenticeships partnerships, which are likely to require financial and technical support from governments.

4. Adjustment policies should also form part of the strategy

The politics and economics of unemployment are currently playing out as a result of the recent economic crisis that has beset developed countries in particular. While the shift to a low-carbon economy promises to create a net job gain, at least in the transition phase, there will be losers and their loss will be costly at the household, economic and political levels.

The national studies from China and the US illustrate this point very clearly. Plans to reduce the carbon intensiveness of China's economic growth will lead to plant closures and job losses. The US report spells this out at an industry-specific level. As America develops its Smart Grid, it will no longer require workers to read domestic and industrial meters; tens of thousands of low-skilled jobs will be lost, although those losses will be more than adequately offset by job gains.

GCN recommendation: Identify likely job losses and ensure these are minimised

Retraining staff and helping firms to orientate their business towards greater efficiency will be as essential in low-carbon industrial strategy as enabling the low-carbon economy. Schemes that have minimised the impact on workers of the recent recession, such as Germany's kurzarbeit[46], are important examples of how a worker-focused approach can help limit wider economic damage. It is possible to imagine how a low-carbon kurzarbeit might serve both the aim of reducing job losses and of helping transform existing business.

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Endnotes

1 Although, by the authors' own admission this is a conservative estimate, since it does not take into account a number of countries for which there is lack of systematic data (UNEP 2008).

2 This figure is the Sum of the *gross* direct, Indirect and– in the Case of India and Nigeria – induced job creation estimates in each of the national studies. Australia10,000; China 6.79 million; Germany 360,600; India 10.5 million; Nigeria 670,000; South Africa 845,500; UK 70,000; US 416,600.

3 For instance, a wind turbine typically contains over 8,000 component parts, not all of which are uniquely destined for turbines or other low carbon products (Gereffi *et al* 2008).

4 EUTC *et al* 2007 does not suggest that post-Kyoto Protocol policymaking was a factor in this decline even though their data set begins in 1997.

5 Although, by the authors' own admission this is a conservative estimate, since it does not take into account a number of countries for which there is lack of systematic data (UNEP 2008).

6 In a separate report with the SEF Alliance (2008: 78), UNEP claims that renewable energy programmes generate between about 16,000 and 22,000 jobs per billion dollars of spending.

7 This is measured in terms of average employment over the life of a production facility (jobs/MW average).

8 Duke University's enter n Globalization, Governance and Competitiveness (2008) provides a notable exception in its analysis of prospects for job creation along the value chains of several low carbon technologies and products in the US. Gary Gereffi and Kristian Dubay map the value chain for concentrating solar power (CSP) technologies and estimate that at the component production stage, companies (and hence jobs) that provide parts for CSP plants in the US are located in at least six countries. This includes Solar Millennium AG in Germany (parabolic trough collectors), Cristaleria Espanola SA in Spain (mirror and reflectors) and Luz/ Solel in Israel (linear receivers and heat storage technology). See also Box 3 below on the US wind market.

9 Emissions from this source have risen sharply since 1990. While national emissions have increased by around 8 per cent since 1990, emissions from electricity generation have sky rocketed by 55 per cent (cf. Commonwealth of Australia 2009b).

10 MMA's modelling provided detailed results on total generation of electricity and total installed capacity for each year of the study and for each technology. The modeling assumes a shift towards less emissions-intensive electricity generation, which sees emissions from this sector reduced to 9% below 2009 levels by 2020 and 13% below 2009 levels by 2030. This data was used by IT Power (Australia) to assess the impacts on employment, by applying assumed employment factors for each technology. A 'decline factor' was also applied to account for likely improvements in labour productivity over time.

11 The results from this study differ from The Climate Institute's earlier report. First, only direct jobs were assessed in this study, while the previous study also assessed indirect employment impacts. Second, the construction jobs for this report were assessed for each year of the study period, whereas the previous study estimated the total number of construction jobs created over the entire study period.

12 Modelling assumes that carbon capture and storage technologies are available but do not become commercially viable until 2025.

13 According to the Chinese State Council's Directive on Accelerating the Development of Services Industries.

14 Between 1985 and 2004, this was the average improvement in energy intensity.

15 The German government estimates that 20,622 jobs were lost in conventional energy sectors between 2004 and 2008 (BMWi 2009, BMU 2009a).

16 The paper anticipates that *domestic* market opportunities for solar thermal will almost exclusively lie in heat production, as opposed to electricity generation.

17 The authors suggest that German manufacturers will face competition from US and Spanish counterparts to capture concentrated solar power export markets. However, German manufacturers possess a highly specialised knowledge and skillsbase with regard to the manufacturing of specific plant components, such as receivers, mirrors and heat storage facilities, and are therefore likely to accrue substantial job numbers in this stage of the value chain

18 The German experience highlights the need for policies and measures that are designed to take into account the different features and purpose of developed and diffused technologies. For instance, while feed-in tariffs have been effective in promoting renewable electricity generation, they are less relevant to renewable heat generation. In the case of solar thermal heat production, mandated renewable heat use supported by direct subsidies for businesses and homeowners are important. The newly introduced 2009 Renewable Energy Heating Act is a step forward: it sets a target of 14 per cent of heat production from renewable sources by 2020 and provides financial incentives to renewable heat endusers, in the range of "50 million per annum by 2012.

19 For more Information on the structure of India's economy, see the CIA factbook https://www.cia.gov/library/publications/the-world-factbook/geos/in.html

20 The International Energy Agency (2007) assumes a growth rate of 27% for 2008, which decreases to 10% by 2010, and then falls to 4% by 2030. By 2035, the growth rate stabilizes at 1%.

21 Much of the area planted would therefore not displace other crops and would, in theory, lead to additional employment in villages (Government of India 2006).

22 Generating capacity in October had increased to about 2600MW, but is still far off the 6000MW promised by the Federal Government by December 2009 (PHCN daily operation report).

23 A new proposed Clean Energy Bill will be debated in early 2010.

24 Natural gas reserves currently stand at about 5.30 trillion m3, placing Nigeria the seventh largest natural gas reserves in the world. (Cf.!end of 2007 data from EIA World Energy Outlook to 2030; Shell Global Scenarios 2025; EC World Energy Technical & Climate Outlook 2030.)

25 Natural gas produces fewer emissions than other conventional energy sources.

26 Nigeria is still rated as the world's biggest flarer of associated natural gas. The World Bank (ESMAP 2004) estimates that Nigeria loses about US$2.5 billion annually as a result of flaring.

27 Personal Communication to Prof. R. 'Layi Fagbenle from Dr. A. A. Esan, Technical Director/ CEO, UNIDO–Regional Centre for Small Hydropower in Africa, Abuja, Nigeria (2009).

28 SHP is a relatively low-cost renewable energy, ideal for rural electrification, particularly in areas where there is no national electrical distribution network. SHP projects are considered to have a relatively low environmental impact compared to large hydro schemes. http://unidorc.org/nigeria/n_shp.htm

29 Nigerian labour is compulsory for 95 per cent of all local construction jobs, and 75 per cent of managerial and supervisory jobs. Any new gas power project will require 80 per cent of jobs to be reserved for Nigerian citizens.

30 In 2008, the Nigerian government introduced a Multi-Year Tariff order which offers a subsidy for companies investing in new plants, including renewable power sources. However, this programme has yet to be fully implemented.

31 Section 3.6 of the Stimulus Package Framework recognises the opportunities in industries that combat the negative effects of climate change !and calls for South Africa to develop strong capacity in these green technologies and industries'.

32 For instance, the 2003 White Paper on Renewable! Energy recognizes the job creation potential of low-carbon technologies and that they are more labourintensive than conventional energy technologies.

33 Estimates of current jobs in the electricity sector range from between 30,000-65,000. This data is based on AGAMA (2003) and informal interviews with senior representatives in the coal industry and electricity sector and climate change experts.

34 Against a BAU scenario, this target would require emissions reductions of 1300Mt CO2-eq per year until 2050.

35 While there is likely to be a decline in employment in conventional energy sector, the study finds that this will not be a result of an increased uptake of RETs. In 2020, it estimates that there will be 15,600 people employed in the coal industry.

36 The South African Department of Energy and the World Bank have recently issued a call for consultants in the energy sector to help undertake a revision of the 2003 White Paper on the Renewable Energy. This is likely to include a new target for renewable energy generation in the region of 10-15 per cent by 2020.

37 For instance, the government and opposition parties have each indicated that in order to reduce the UK's fiscal deficit, public spending will need to be cut, which will have a serious impact on the scale of public sector employment.

38 However, with only 5.6GW of electricity from renewable sources installed in 2006, it is questionable whether this target is achievable.

39 In a separate analysis commissioned by the government (2009), Innovas estimates a total of 400,000 jobs by 2015 in low-carbon and environmental goods and services as a whole, including renewable energy sectors.

40 Under the RAB scenario (above), offshore wind accounts for 47 per cent of the 2020 target for renewable electricity generation capacity.

41 Only jobs in operation and maintenance (O&M) will necessarily be located in the UK, owing to the need for them to be in close proximity to wind farms.

42 Despite this, there are still hopes that the UK will be able to develop full offshore wind manufacturing (as opposed to selected component manufacturing). For instance, Clipper Wind has a research centre in Blyth, North East England and Mitsubishi may also set up factories in the region.

43 In the wind industry, BWEA point to a ahortage in qualified electrical engineers, turbine technicians and project managers among the workforce (Boettcher!et!al 2009).

44 In addition, the American Solar Energy Society found that aggressive deployment of energy efficiency and renewable energy technology could create 4.5 million new jobs by 2030. Further reports have analysed job impacts on specific industries or states (see, for example, Duke University Center on Globalization, Governance and Competitiveness 2009).

45 We might add that this GCN study has identified a significant lack of data on lowcarbon employment in general, on potential for job creation and on skills gaps and that governments will need a better understanding of the employment impacts of policy if they are to ensure low carbon industrial strategy attracts strong domestic support.

46 See national summary section.

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About the Global Climate Network

The Global Climate Network is a collaboration of independent, influential and progressive research and policy organisations in countries key to tackling climate change. Together, members of the Network are committed to addressing the constraints faced by sovereign governments in agreeing international action.

The Network aims to help governments clear a pathway towards an effective and fair international agreement for avoiding dangerous climate change by proposing bold low-carbon policies and using data and analysis to persuade policymakers that climate change mitigation is in their interest.

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