Paper 6
TRANSITION TO A POST-CARBON SOCIETY

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Executive Summary

The twin issues of climate change and peak oil point society towards a near future in which we will have to learn to live with far, far fewer fossil fuel resources. This briefing explains why that is the case, and looks at the first steps already being taken in rich and poor countries alike to make the transition to post-carbon societies.

We live in a world confounded by inequality and injustice that extends from North to South, rich to poor, between men and women, and between current and future generations. What equity and justice in a post-carbon society might look like, and how they might be achieved, is the focus of the third and tenth briefing papers in this series. For that reason, this paper addresses them only in passing. There is an increasing awareness that it is now our greatest human endeavour to move towards new systems that allow equitable development, well-being and social justice whilst operating within our planetary limits. More critically still, this transition must occur in a timeframe to avoid catastrophic climate change.

Existing infrastructure and institutions have become a barrier to rapid change. Urban design, energy and transport systems, and buildings, too – once in place tend to 'lock-in' patterns of resource use and consumption that last for decades. Without radical re-engineering, incremental change through substituting with improved alternatives will be too slow, and raise the costs of delivering unavoidable changes later on.

Adaptation should also be seen as part of a long-term mitigation strategy. The way in which new infrastructure is developed has significant implications for the energy intensity of the economy and society. Communities at all levels are already responding to the challenges we have identified. In some cases, the living models are innovative; in others, they are simply remembering skills that have fallen into disuse, or rediscovering past relationships with the natural environment.

Far reaching knowledge transfer will be at the heart of the rapid propagation and replication of these living models. In general, climate negotiations have focused on the flow of knowledge and innovation from the North to the South. But, as we will show, in reality the exchange of knowledge, innovation and experiences should be a two-way flow between both North and South. This would involve a mechanism which facilitates communication from grassroots movements engaged in practise, to governments and civil society whose job it is to facilitate change domestically, and at the international level.

Extensive sharing can occur within the existing international climate change community. Carefully engineered 'coalitions of the willing,' could, however, enhance this process and help to break various deadlocks. For example, the AGCC argue that a long-term, constructive commitment to cooperation via a bilateral climate partnership between India and Europe, or a larger multilateral Global Climate Community would enhance this process.

Introduction: the scale of the challenges

The 'Great Acceleration'
Since the middle of the nineteenth century, the world has experienced a period of explosive economic growth. Over 97 per cent of humanity's financial wealth has been created in just 0.01 per cent of human history.[1] The driver behind this meteoric rise is a complex interaction between abundant cheap energy, the spread of transport and communication technologies, knowledge, science, and population increase coupled with rising consumption.

Defined by some as the 'Great Acceleration', this period of economic growth was detonated by the Industrial Revolution, but really took off after the Second World War in places like Western Europe, North America and Japan, followed soon by other parts of Asia.[2] The great acceleration has had enormous costs, because of a large and, for a long time, poorly understood consequence of the fossil fuels that powered it.

Climate change
In 2007, the concentration of atmospheric carbon dioxide (CO_2) climbed to a new high of 383.6 parts per million (ppm). NASA scientist James Hansen went on the record in early 2008 to say that, rather than deciding on a future, higher level at which to stabilise the amount of CO_2 in the atmosphere, we need to reduce CO_2 concentrations to 350ppm. At present, we are fast heading in the wrong direction. An emerging consensus suggests that, at best, we have less than a decade before potentially irreversible changes to the climate begin to happen.

Peak oil and gas – the end of cheap energy
Strongly coupled to climate change and overlapping in terms of its critical timeframe is the 'peaking' in global production of oil and gas. The so-called 'Hubbert Peak' theory, also known as *peak oil,* or the *topping point*, describes a point in the path of the extraction and depletion of conventional oil and other fossil fuels at which world oil production will soon reach a peak, level-off and then rapidly decline. It is named after the geologist M. King Hubbert who, decades in advance, predicted the peak of US oil production with a high degree of accuracy. The actual global peak year will only be known when it has passed, but most estimates suggest that we are either at, or very close to this point. At most it is one or, less likely, two decades away. Against a background of rising demand, 'peaking' will result in a major shock to the global economy. But, even before then, an opening gap between production and demand is already driving prices up.

Long-distance transport, industrialised food systems, urban and suburban systems and many commodities from cars, plastics and chemicals to pesticides, air conditioning and refrigeration, are all dependent on abundant, cheap energy. The decline in the availability of oil, gas and coal, in chronological order means that unless a systemic transition to a post-carbon society is initiated and planned for now, it is likely to happen without our choosing and with catastrophic impacts on poverty reduction and human development.

Tipping points
One of the most extensive assessments of such climate impacts concluded that society may have been lulled into a false sense of security by the projections of apparently 'smooth' climate change in the most recent Intergovernmental Panel on Climate Change (IPCC) report (AR4).[3] It suggested that that a variety of *tipping elements*[*] could reach their critical point (tipping point) within this century under current climate change dynamics, such as the melting of ice sheets or permafrost.

[*]A tipping element describes sub-systems of the Earth system that are at least sub-continental in scale and can be switched – under certain circumstances – into a qualitatively different state by small perturbations. The tipping point is the corresponding critical point.

Whether or not these highly unpredictable factors are made part of decision-making is a political choice. For example, the most recent IPPC report discusses the implications of dramatic change in the climate system, but does not include their potential impact in future scenarios. The impacts of tipping points were also poorly represented in the *Stern Review*.

The cost of climate change
The UK Treasury's *Stern Review* on the economics of climate change, published in 2006, established that early action on global warming was far cheaper than waiting to respond to later, major impacts. But, many climate scientists now believe that the report's recommended emission reduction trajectories and 'acceptable' CO_2 equivalent concentrations were grossly underestimated.

If James Hansen is correct, rather than concentrations rising as high as 550ppm CO_2 as suggested in the *Stern Review*, this implies emissions need to stop rising immediately and begin a long-term decline. Then, there needs to be a global effort to decrease atmospheric concentrations of greenhouse gases from current levels. In this light, the *Stern Review* almost certainly under-estimated both the costs of action, and inaction on climate change.

A report in *Times of India* in September 2007 suggested that Indian development projects reducing the impact of climate change already cost over two per cent of GDP. This figure for 2006/2007 represents almost a four-fold increase since 2000/2001.[4] Whatever the economic price of action, however, the costs of inaction are projected to be far higher. And, there are likely to be major economic and employment benefits in certain courses of action in response to climate change, such as the expansion of the renewable energy sector.

Irreversible damage to the biosphere
Over the past 150 years, humans have had a huge impact on the Earth's biosphere, largely due to the rapidly growing demands for food, freshwater, timber, fibre and fuel. The damage to ecosystems has now resulted in a largely irreversible loss in the diversity of life on Earth. Extinctions driven by human activity are approaching rates associated with the cataclysmic events of the end of the Palaeozoic and Mesozoic eras. In other words, they are the most extreme in the past 65 million years.[5]

Real world delivery
Precisely how we respond to climate change and peak oil will determine whether we make life better or worse for the majority of humankind. For this reason, the rest of this briefing paper looks at the first shoots of transition in both rich and less wealthy countries, to see what we can learn about what might be possible.

Human settlements: Village, town or city?

Today, with a few exceptions, almost everyone lives in a settlement of some kind. The overarching challenge for post-carbon settlements will be to align their consumption patterns of water, food, energy, goods and the generation of waste to a level that does not exceed available biocapacity, and lead to the build-up of ecological debt.

In industrialised countries and among 'high-consuming' classes everywhere, this means a significant contraction of consumption and waste production. It also involves dealing with aging infrastructure, and the legacies of suburban sprawl. For many developing countries, it means reversing the trend of 'slumation' on the margins of high-density settlements, and developing infrastructure that functions sustainably and will be resilient in the face of climate change.

Some low-density settlements, such as villages or rural areas, may be able to achieve a level of fairly comprehensive self-reliance, meeting most of their needs from locally available biocapacity. In contrast, urban settlements, where much future global population growth is expected to occur, are unlikely to achieve significant self-reliance.

The post-carbon city

The industrial revolution stimulated a great migration of people from rural to urban areas. By the end of 2008, the UN predicts that almost 50 per cent of the world's population will live in an urban environment.[6] Today approximately 75 per cent of the European population lives in urban areas, and approximately 78 per cent of all carbon emissions come from urban areas.[7]

- *Living model – banning plastic bags in Dhaka*

Dhaka, the capital city of Bangladesh banned plastic bags in 2002. The ban was motivated by climate adaptation rather than tackling waste, as plastic bags were found to clog drains during monsoon rains worsening the effect of flooding.

The Dhaka example shows how addressing a single issue in a city can lead to other positive outcomes. This is down to the *urban sustainability multiplier* which results from the complex interwoven nature of urban systems. Conversely, however, problems can multiply, too.

Much predicted urban-population growth is set to happen in poor-quality, overcrowded housing – slums – or informal settlements, where approximately one billion urban dwellers already live – almost one in six people on the planet. If current trends continue, there will be 2 billion people living in slums by 2030, and at least 3 billion by 2050 – almost a third of humanity. The UN Human Settlements Programme (UN-HABITAT) revealed that already an astonishing 99.4 per cent of the urban population in Ethiopia lives in slums. Similar figures exist for Chad (also 99.4 per cent), Afghanistan (98.5 per cent), and Nepal (92 per cent).[8]

It is hard to adapt non-existent infrastructure to face either peak oil or climate change. And slum dwellers often have no all-weather roads, no piped water supplies, no drains and no electricity supplies; they live in poor-quality homes on illegally occupied or sub-divided land, which inhibits any investment in more resilient buildings and often prevents the development of infrastructure and provision of services. Making matters worse, a high proportion of such settlements are on sites that risk worsening climate related impacts like flooding and landslides.[9]

- *Living model – Vikas Sagar, Mumbai*

An NGO called Slum/Shack Dwellers International (SDI) mobilised the Vikas Sagar community on the outskirts of Mumbai to create a community savings plan. The plan functions like a small-scale bank, providing loans that are reinvested into the community. With this community reinvestment, single-storey mud huts have been replaced with concrete homes, and walkways are paved with cement and tiles to prevent erosion.

High-density settlements need not be unsustainable, but they will always require a degree of interdependence with surrounding areas. City-dwellers have an ecological footprint consisting of demand for food, water, energy and many other resources that extends far beyond their immediate geographical hinterland.[10] In 2002, estimates put the ecological footprint of Londoners at 49 million global hectares.[†] This is 42 times London's actual biocapacity and 293 times its geographical area (in hectares).[11] However, well-governed large cities can achieve the highest environmental and quality of life standards through

[†] A global hectare is one hectare of biologically productive space with an annual productivity equal to the world average. Currently, the biosphere has approximately 11.2 billion hectares of biologically productive space corresponding to roughly one quarter of the planet's surface. They represent the Earth's natural capital, and their annual yield represents our annual natural capital income.

efficient resource use, low waste volumes and low per capita emissions of greenhouse gases. High-density settlements also have the greatest potential for low carbon travel, such as walking, cycling and mass transit systems.

- *Living model – Vauban near Freiburg, Germany*[12]

In 1992, a disused barracks complex in Vauban was redeveloped into a sustainable community of about 4000 people. The community is characterised by low-energy-consuming 'passive houses' where no active system is needed to maintain comfortable temperatures. CO_2 emissions have been reduced by 80–90 per cent due to good design and a woodchip-powered combined heat and power plant and district heating grid. Other exemplary achievements include:

a) 45 per cent of households have agreed to live without owning a car. There are only 150 cars per 1000 inhabitants, compared to 270 in 'a similar district' and an average of 430 for Freiburg.
b) Rainwater is collected separately to be used in houses or filtered into the ground.
c) One building project has pioneered the use of vacuum toilets, which minimises flush water. The sewerage is also used to generate biogas.

- *Living model – sustainable communities, the transition town initiative*[13]

The first transition town initiative was set up in 2005 in Kinsale, Co. Cork, Ireland. This was closely followed by Totnes, in Dorset, England. There are now 41 official transition towns in the UK and internationally, with an additional 600 communities who are considering becoming transition towns. Transition towns include settlements ranging in size from neighbourhoods, to villages, towns and cities. Their aim is to reduce oil dependence, and lower the ecological impact of their economies by localising the way they meet their needs for food, energy and other goods and services.

The first stages of the transition initiative include the development of an 'Energy Descent Plan' – a road map to low carbon energy independence. By 2021, Kinsale Transition Initiative plans to source the majority of its energy from sources within a ten-mile radius. Their distributed energy system will include wind, biomass from short-rotation coppice and anaerobic digesters for a combined heat and power plant, and solar.

- *Aspirational model – One Planet Living in Masdar City, Abu Dhabi*

Masdar City aims to become the world's first zero-carbon, zero-waste, car-free city through the One Planet Living programme - a global initiative launched by the World Wide Fund for Nature (WWF) and environmental consultancy BioRegional. Plans include:

a) Electricity for the six square kilometre city will be generated by photovoltaic panels, while cooling will be provided via concentrated solar power.
b) Water will be provided through a solar-powered desalination plant.
c) Landscaping within the city and crops grown outside the city will be irrigated with grey water and treated wastewater produced by the city's water treatment plant.[14]

High-density settlements are often heralded as optimally efficient living spaces (or at least potentially so), because of their often highly integrated systems and population density. Given this, opportunities for energy efficiency and recycling are high.

- *Living model – 'zero waste' cities* [15]

Since 1999, 70 per cent of Local Authorities in New Zealand have adopted a 'zero waste' policy – most are aiming for zero waste by 2015.

Zero waste, like 'carbon neutral,' is a slightly misleading term because the notion of perfect energy conservation contradicts physical laws. Used here, though, it refers to a zero-waste-to-landfill strategy, and is being implemented by a number of countries, cities and firms. The strategy involves the redesign of products and production processes using, for example, a

'cradle-to-cradle' approach, and backed by laws governing extended producer responsibility, that require companies to take back their worn products or packaging.

- *Living model – Goa's RUrbanism*

RUrbanism is a city growth plan that aims to turn Goa into a 'neobiological' mix of humans and nature. The model will weave high-density living with rural living encouraging a symbiotic relationship with the environment. The settlement will be surrounded by forests, and integrated with rice paddies, fishponds and vegetable gardens. The programme plans not only to substantially reduce the city's ecological footprint, but also to encourage a better relationship with time. Time has been viewed as an additional resource and the city design will aim to allow for more personal, leisure, household and community time.

- *Living model – Dongtan, China*

Dongtan – China's first ecocity – provides insights on how to integrate sustainable transport into business development, road infrastructure development, and local community development. The city will be designed to be self-sufficient in energy, water and most food. Buildings will be built to high efficiency standards; and public transit will be commonplace. The engineering firm ARUP has agreed to work with the Chinese Government to extend the ecocity model to a further four Chinese cities. But, Dongtan – to be built on the third-largest island in China - also reveals the limits of green designs as the new city is vulnerable to sea level rise and storm surges are likely to increase with global warming.

Transport

Transport, and its promise of freedom through hyper-mobility, creates social aspirations. But increases in private transport are associated with a particular type of development - sprawl. In the North, the built environment is dominated by the needs of the car. Motorised transport is over 95 per cent dependent on oil and accounts for almost half of the world's use of oil. Against a backdrop of soaring oil prices and climate change, encouraging modal shifts to public or active transport is common sense and a key objective for sustainability.

Avoiding sprawl

The US-based Sierra Club defines suburban sprawl as, 'low-density development beyond the edge of service and employment, which separates where people live from where they shop, work, recreate and educate – thus requiring cars to move between zones'. In the long term, sprawling settlements can reduce social capital and increase social segregation.[16] Studies show sprawl also influences levels of physical activity and health outcomes. One study in the United States found that residents of sprawling areas were likely to walk less in leisure time, weigh more and have a greater prevalence of hypertension.[17]

Sprawling occurred in North America in the period between the wars, and in Europe in the two decades after the Second World War. A comparable pattern emerged in Latin America in the 1960s in, for example, Mexico City and Greater Saõ Paulo.[18] As urban areas extended into metropolitan zones, inner city populations declined, often accompanied by the dereliction of the original city core.

- *Living model – urban planning to prevent suburban sprawl*

There are many examples where strict planning regulations have been implemented to prevent the city sprawl into rural areas. One estimate by North American think tank 'Sightline' suggested that Vancouver would have sprawled out by an additional 650 km^2 if high-density living had not been encouraged. For the past 20 years urban development in Vancouver prioritised pedestrians and access to public transport. For example, in 1995 Vancouver City council adopted the Vancouver CityPlan and prioritised walking, biking, and mass-transit over car use. The city continues to develop policies that encourage more sustainable modes of transport.

Active transport
Active transport is human-powered mobility like walking and cycling. Designing settlements to maximise active transport produces several win-wins, including improved equity in access to services, reduced noise and congestion, greater energy security, and benefits from alternative uses of the considerable resource costs of road transport. From a public health and well-being perspective, active transport offers the greatest opportunity for benefit – especially for increasingly sedentary urban populations.

Fast forward or gridlock?
Large parts of the world stand at an important crossroads in the future of their transport systems. For example, Tata, the Indian car maker, unveiled the Nano car in Delhi in January 2008 – introducing the prospect of mass-market motoring to India. The 'world's cheapest car' will retail at £1,250 (100,000 rupees). Tata has billed Nano as *The Peoples' Car*, but Dr Pachauri, head of the Indian NGO TERI and chairman of the Nobel-prize winning IPCC, is less optimistic, 'This is not the transport option for the country of a billion people, many of whom cannot afford to buy even a bus ticket.' He added that it would be wrong to think that the Nano could substitute for bicycles and would only add to the already chaotic traffic conditions in urban centres. Pachauri suggested that Delhi should follow London's example and introduce congestion charges.

Road building accounts for most transport-related international aid.[19] But the benefits for the poorest are unclear. Regardless of the Nano, most of the world's population will never own a car. And, surveys show that road building often fails to meet the needs of the poorest, for whom many trips are off-road, by foot, and over short distances, carrying small loads for subsistence needs.[20]

- *Living model – Rickshaw Bank*[21]

Rickshaw Bank is the flagship program of the Centre of Rural Development (CRD) in India. There are currently 8 million rickshaw pullers in India, making it a highly significant means of transport. However, it is common for pullers to rent their rickshaws daily, with little or no scope for long-term ownership. The Rickshaw Bank provides communities with an income-generating asset – the rickshaw – and allied services which act to promote micro-entrepreneurship among urban poor and rural migrants. One rickshaw bank in Assam has enabled over 390 Rickshaw pullers to buy their rickshaws in full, and there are a further 510 Rickshaw pullers who will soon join their ranks. 1474 rickshaws had been disbursed by the programme by the 30th Oct 2007.

While these Velorickshaws (non-motorised) provide a clean solution to transport within urban areas, the motorised 'Autorickshaw' has been responsible for deteriorating air quality in cities such as Delhi, Bangalore, and Chennai. In 1998, under direction of the Supreme Court, Delhi was forced to take remedial action on the high level of local air pollution. One of the measures introduced was the mandatory conversion of all public transport vehicles, including Autorickshaws in the city to CNG fuelled vehicles. Within a few months of the programme's implementation, a perceptible change was evident in Delhi's air quality.

- *Living model – City of cyclists*

Known as the *City of Cyclists*, one-third of commuting within the city of Copenhagen is by bicycle, and 90 per cent of residents own bicycles. This is in part due to 323 km of cycle tracks. Copenhagen has also launched a free *City Bikes* scheme with hubs strategically located around the city centre. Copenhagen's comprehensive cycle policy, drawn up in 2002, extended the cycle network, increased supply of bicycle parking space, introduced traffic lights that turn green for cyclists before cars, and reduced on-street car parking to free up road space for cyclists.

- *Living model – London's cycle superhighways and congestion charging*

London aims to increase the number of cyclist in the city by 400 per cent by 2025. A £400 million investment in a network of *cycle superhighways* within the city is designed to make cycling safer and more efficient. In the city centre there will be a bike-hire scheme similar initiative to Copenhagen's *City Bikes*. Hire bikes will be based at various stations in the centre of London and will be free to use for short journeys.

London has also pioneered congestion charging. Vehicles are charged for entering the congestion zone during peak hours. More recently, the congestion zone has been extended, and less efficient vehicles will be required to pay more to enter the zone.

- *Living model – Philly Car Share*[22]

Philly Car Share is one of the most successful car-sharing schemes in North America, with over 30,000 members. Car sharing is a popular commuting solution, particularly in the short term where public transport availability is low. Evidence suggests that incentivising car sharing typically doubles uptake (up to 30 per cent of commuter trips).[23] Examples of incentives include: special highway lanes reserved for high-occupancy vehicles; parking spaces reserved for car-sharing vehicle; and subsidised car insurance for car sharers.

- *Living model – Bogotá, Colombia*[24]

In the 1990s, Bogotá implemented a programme which simultaneously restrained vehicle ownership, improved conditions for walking and biking, and enhanced bus transit. To deliver this ambitious scheme, the Government opened two lines of a planned bus rapid transit system, built 200 km of a planned 300 km network of bike lanes, expanded numerous sidewalks, added a 17 km pedestrian zone, and implemented a number of demand-management measures. These measures included banning a large proportion of cars from the city during peak hours, doubling parking fees, and increasing fuel taxes by 20 per cent. These measures were boosted by car-free Sundays and other promotional efforts.

Aviation

Although global CO_2 emissions grew by 13 per cent from 1990 to 2000, CO_2 emissions from aviation and road transport both grew by 25 per cent.[25] Globally, aviation officially contributes approximately 2 per cent of emissions. However, the overall effect on climate change is much greater. Aircraft not only release CO_2 from the combustion of kerosene, there are also non-CO_2 effects (such as nitrogen oxides (NO_x) and condensation trails) which also have climate effects. When these non-CO_2 effects are considered, aviation's share of anthropogenic climate impact is much greater.

While the direct contribution of aviation to climate change at present may seem small relative to other sectors; its growth presents a significant challenge. The tourism and aviation industry is quick to identify the economic importance of tourism to developing nations. The statistics, however, reveal that the vast majority of tourism occurs within regions such as Europe. This means that a large proportion of flights taken within Europe are short-haul flights, making up approximately two-thirds of the overall market. Additionally, intra-regional tourism is where the UN World Tourism Organisation forecasts the greatest level of growth. Therefore, since intra-regional tourism is expected to grow more than *inter*-regional tourism – dependent on long-haul flights – there is a real case for developing efficient, equitable, and effective methods of limiting air travel use, such as good networks of high-speed rail links.

From a development perspective, the significant role of international actors in the tourism sector – means that a large proportion of income generated through tourism is repatriated, 'leaking' out of the national economy. This means that tourism's contribution to GNP is often significantly overestimated. In some cases, leakage rates of up to 60 per cent have been reported. In an age of imminent peak oil, developing countries depending on tourism as a means of development will be particularly vulnerable to rising oil prices (discussed in more

detail in paper three). It would be prudent to assess whether tourism-based development (also a highly contended development pathway) is realistic in a post-carbon society.

Energy

Over 80 per cent of the CO_2 released into the atmosphere from human activity is due to the burning of fossil fuels, mainly used to produce electricity, heat or for transport. Yet around 2.4 billion people still do not have access to clean fuels for cooking or heating, and 1.6 billion do not have access to electricity. Though largely disregarded in the UN Millennium Development Goals, access to good, clean energy is essential for their attainment.[26]

Economic and population growth mean that global energy demand is accelerating, and climate change and peak oil point to the need for renewables to replace fossil fuels as far as possible. But, demand reduction among 'over-consumers' is equally important. For example, the richest populations use up to 20 times more energy per person than those from the poorest countries.[27] The differential between per capita carbon emissions in the USA and Tanzania is around 200:1.[28]

The renewable revolution
The development of renewable energy resources is constrained by the current availability of appropriate technologies, poor institutional mechanisms, and the challenges of developing systems for small remote markets at reasonable prices. Yet technologies such as solar, wind and mini-hydro are clean, affordable and often better suited to the local environment than imported fossil fuels; they are also cheaper than connecting to national grids. The costs of all renewable energy technologies look set to fall as they are scaled up. Solar energy, in particular, has immense potential. While it is currently one of the more expensive clean technologies, the European Photovoltaic Industry Association estimates photovoltaics (PV) will be competitive with peak electricity generation by 2012 – assuming a doubling in production reduces its price by around 20 per cent.

- *Living model – the potential of solar PV*

In theory, power generated from solar PV could provide thousands of times more energy than the world currently uses. In 2005, Germany had over 600 MWp (peak megawatts) of installed solar photovoltaic capacity – an increase of 100 MW from 2004. And, Japan was the first country to install over a gigawatt (one thousand megawatts) of solar PV.

- *Living model – China's Brightness Programme*

China's rural electrification scheme –The Brightness Programme –aims to bring electricity to over 23 million homes by 2010. PV is used most extensively in the programme because it is cheap to install off-grid. In troubled Tibet alone, around 400 village PV systems produce 2.4 MW and 100,000 home systems produce 7.7 MW. More recently, Shanghai announced a programme to install 70 MW. Additionally, both solar-water heating and building-integrated PV will feature in China's first ecocity, Dongtan.

- *Living model – providing 100 per cent renewable energy to high-density settlements*

The University of Kassel has shown that through the integrated control of small and decentralised plants it is possible to provide reliable electricity in accordance with needs. The energy system included a mix of biomass/biogas, solar PV, wind and storage (hydro-pumped storage, compressed-air reservoirs, and batteries).This German study shows that, technically, there is nothing preventing a 100 per cent renewable energy system.

Green collar jobs
Renewable energy can create new jobs and investment. And if supported by the international community in the short term, local renewable energy resources can be healthier, cheaper, more secure, and more reliable than fossil fuels in the long term. Lower fuel bills would allow

regional governments and rural communities to invest resources elsewhere. Renewable energy could improve water, sanitation and living conditions, provide better health services, elevate the status of women and create an environment that encourages learning.[29]

- *Living model - solar PV enabling local businesses to develop in South India*[30]

SELCO is a private business based in Bangalore which provides PV battery charging systems which supply single lamps for street vendors and poor homes. One of the benefits of lighting is extended hours for income generation. While viewed as an expensive source of energy compared to grid electricity, for the 57 per cent of the population who do not have access to mains electricity, PV systems are far cheaper than expensive kerosene or dry cell batteries. These systems reduce carbon dioxide emissions. And, by providing lighting, they allow extended hours for income generation. The increased income can quickly cover the cost of the system. SELCO's innovation department has also provided other affordable PV-powered systems, for example, power for sewing machines to increase the productivity of sewing businesses; power for soldering irons for television repair; and small PV powered silk looms.

- *Living model: Sustainable energy for rural progress, India*[31]

Desi Power's Employment and Power (EmPP) Partnership Programme, integrates decentralised electrification and energy services with employment generation in rural India. It will supply 10 clusters of 10 villages each with a 50 kW biomass plant. Total power generation will be 500 kW per cluster and 5 MW for 100 villages. Energy services will be promoted and micro-enterprises built simultaneously with the power plant.

The power debate: distributed versus centralised energy

Centralised energy infrastructures can be extremely inefficient.[32] In the UK, Greenpeace estimates that up to two-thirds of potential energy is lost between generator and consumer.[33] Converting heat energy to electricity is at best 50 per cent efficient – a further 5 to 7 per cent is lost in transmission. The large majority of renewables function far more efficiently and practically if they are integrated into a decentralised energy system where power is generated at or near to the point of use. Developing a renewable, distributed energy (DE) and food system is likely to have a significant impact on an economy's resilience to future energy and food price shocks, either as a result of climate change or peak oil. But the benefits of such a system go further than simply providing a buffer against price shocks. There are many local economic benefits that can contribute to poverty reduction, and improved community self-confidence through greater self-reliance.

The World Alliance for Decentralised Energy (WADE) economic model has been used extensively to calculate the economic and environmental impacts of a DE system. The model has recently been used by the UK Foreign Office to project China's energy future; by the Federal Government of Canada to look at the country's energy system; and by the European Commission to investigate the options for the EU. The Chinese analysis confirms the view that DE can meet demand growth at lower cost due to its reduced requirements for transmission and distribution (T&D). This is notably beneficial in China, where T&D costs are high due to the country's size. Combining this factor with DE generation's far lower fuel consumption offers the prospect of cost effectively reducing CO_2 emissions in China.[34]

- *Living model – DE brings social equity and income to rural areas in Wales*

Apart from the efficiency gains, DE systems can contribute to social equity and bring income to rural areas. A number of small projects have been developed by individuals or cooperatives. A scheme Cwmni Gwynt Teg in Wales has enabled individuals to secure financial stake in wind farms. Participants tend to be relatively well off due to the cost of shares, but some schemes have reinvested part of their income into energy efficiency to benefit the whole community. The energy provided has lower running costs, because of efficiency gains, and is also buffered against fluctuations in energy markets.

- *Living model – 100 per cent renewable energy*[35]

In 2004, the world's smallest nation, Niue in the South Pacific had 70 per cent of its infrastructure destroyed by Cyclone Heta. Once the immediate needs of the population were met, Greenpeace began helping the Government to make Niue the first nation on Earth to meet all its energy requirements from renewable sources. With one of the highest wind-energy intensities in the South Pacific and ample solar resources, Niue is more than able to meet all its energy needs. The project will reduce Niue's dependence on imported fossil fuels, while creating employment because people are trained to maintain and operate the cleaner technologies. The project will also draw new investment into the economy, and help promote local businesses.

- *Living model – the solar island*

Sagar an island in the Sunderbans Delta, 6 km off the mainland in West Bengal is home to just under 200,000 people living in 43 villages. Sagar is making innovative use of medium-scale solar power to meet the needs of thousands of people unable to access energy from a national grid. The West Bengal Renewable Energy Development Agency has provided grid-quality electricity in this way since 1996. The Agency works in cooperation with rural energy development cooperatives formed by the recipients of the power supply. Over 1,600 families benefit from solar-powered home-lighting systems and 58 shops and businesses can access stable power supplies. Before solar power arrived, the island's population depended on expensive and inadequate diesel generators. The Agency now has plans for the whole island to switch to renewable energy.

- *Living model – waste produces biogas for cooking and electricity generation*[36]

Biogas is produced from the decomposition of organic material in anaerobic conditions. The gas can be used directly for cooking, as a safer alternative to liquefied petroleum gas (biogas cannot be lit accidentally by a spark). Burning biogas as a fuel also prevents the release of methane from unmanaged decomposition of organic matter. As a greenhouse gas, methane is 23 times more damaging than carbon dioxide.

Biogas systems also improve waste management. In rural areas, food waste can be used as food for animals, but in urban environments this is not usually feasible. Urban and areas with poor waste-disposal schemes can benefit from improved waste management, and residue from the biogas plant can also be sold as a fertiliser, due to its high nitrogen, phosphorous and potassium content.

Urban – BIOTECH in urban Kerala has developed biogas digesters for managing food waste and other organic wastes in 12,000 households, 220 institutions and 19 municipal sites. These avoid the emission of around 37,000 tonnes of carbon dioxide or its equivalent per year by replacing liquefied petroleum gas for cooking and diesel for electricity generation.

Rural – SKG Sangha in Karnathaka supplies biogas plants to households in rural areas of South India. So far, SKG Sangha has installed plants that benefit over 210,000 people. Each plant also saves around four tonnes of carbon dioxide or its equivalent by replacing the unsustainable use of wood. In this region, biogas stoves save women on average two to three hours a day from collecting wood and cooking. The fuel switch from wood to biogas also has many health and welfare benefits as biogas abates respiratory or eye problems associated with wood fires. Additionally, kitchens and cooking equipment are cleaner.

Food

Growing global interdependence has for some come hand in hand with declining food self-sufficiency. But climate change and peak oil are now leading many to question the efficiency of the global food system, either in economic or environmental terms, or in its ability to feed hungry people.

Climate change is expected to have profound impacts on global agriculture. While some nations may benefit from milder weather and increased crop yield, others will suffer from more erratic rainfall patterns and higher temperatures. The most recent report of the IPCC states that crop yields could decrease by up to 30 per cent in South Asia by the middle of the twenty-first century.[37] Intensive farming practices, led by new technologies during the 'Green Revolution' in the late twentieth century have resulted in significant soil erosion, water shortages, and deforestation. These technologies included pesticides, irrigation projects, and synthetic nitrogen fertilizer – all of which are heavily dependent on fossil fuel energy.

A problem of carbon intensive agriculture

Despite currently using, on average, 2.2 kilocalories of fossil fuel energy to extract 1 kilocalorie of plant-based food, global food production is declining.[38] In the case of meat, the average amount of kcal fossil energy used per kcal of meat is much greater; with an input/output ratio of 25.[39] Growing populations put pressure on food systems, but the rapid increase in the consumption of meat worldwide and growing demands for cereal grain for biofuels pressurises the system still further.

The key problems relating to current industrialised agriculture systems include:

a) *Dependence on fossil fuels* - Agriculture is hugely dependent on the fossil fuel, oil, both for transport, machinery and the manufacture of fertilisers and pesticides.
a) *Agriculture contributes to climate change* - Greenhouse gases from the agriculture sector accounts for about 22 per cent of global total greenhouse emissions, this is similar to industry and greater than transport.[40]
b) *Livestock production* – Livestock production accounts for around 18 per cent of all greenhouse gas emissions (in CO_2e) – this figure also includes transportation of livestock and production of feed. Increasingly meat-based diets stand to worsen this problem.[41]
c) *Declining agricultural biodiversity* - up to 75 per cent of agriculture biodiversity is estimated to have been lost in the past century, mainly due to large-scale monocultures. Three-quarters of the world's food is generated from only 12 plant types and 5 animal species.[42]

The rise in demand for biofuels is creating competition for land and water between crops grown for food, and those grown to make biofuels. 'Tortilla Riots' in Mexico in 2007 followed the rise in price of corn as more land was given over for biofuel production.[43] While the food versus fuel debate continues, 13 per cent of the world's population (850 million people) are still undernourished in terms of energy intake.[44]

Cuba's experience following the collapse of the Soviet Union, upon whose cheap oil it was heavily dependent, throws light on the challenges of the rapid transition to a post-carbon future. Cuba's eventual transition to a more self-sufficient food system wasn't smooth, but by embracing more traditional, labour-intensive and organic methods of farming and through an expansion of urban farming, the Cuban experience demonstrated, first what is possible in the face of a sudden and unpredictable shock, and second that feeding people with very little or even no fossil fuel inputs is possible.

- *Living model – Cuba: increasing food security through urban farming*

Following the imposition of the US trade-embargo in the aftermath of the Cuban revolution, the Soviet Union became Cuba's primary trade partner. Sugar and tobacco were exported to the Soviet Union at above-average prices, and in return Cuba received oil – some of which was re-exported to earn convertible currency. The favourable terms of trade for exports meant that a disproportionate amount of land was designated to export crops grown in a highly industrialised monocrop agricultural system. By 1989, three times as much land was dedicated to sugar cane as food. This dependency meant that trade relations mean that when the Soviet Union collapsed, Cuba's situation became desperate. In what become

known as the 'Special Period in Peacetime', oil imports dropped by more than 50 per cent, with a significant impact on fuel available for the economy, and foreign exchange earnings from oil fell to zero. Wheat and grains for human consumption decreased by 50 per cent, as did other foodstuffs. And, Cubans' calorific intake fell by as much as 30 per cent below 1980 levels. A 80 per cent drop in fertilisers and pesticides, and a further decline in oil-derived energy meant that its highly industrial agricultural system was simply unsustainable.

The loss of oil resulted in a rapid shift to biofertilisers and biopesticides and a return to animal traction. However, the large-scale state farms were not compatible with these alternative farming methods, whereas small-scale farms were able to respond quickly and boost production above previous levels. Recognising this, the State acknowledged that small-scale management systems were essential for organic farming. In 1993, it issued a decree that terminated state farms and turned them into Basic Units of Cooperative Production –worker-owned enterprises or cooperatives. Over 80 per cent of state-owned farms were redistributed in this way.

The huge food shortage that Cuba faced in the early years of the 'Special Period in Peacetime' was overcome within five years due to small-scale and urban farms. Food shortages and the rise in food prices made urban agriculture very profitable. With State backing, there was an explosion in the growth of urban farming. Lots and backyards in Cuban cities now support food crops and farm animals – relying almost exclusively on organic techniques. The Cuban experience illustrates that a nation's population can become virtually self-reliant in food production with small- and medium-scale farms and cooperatives, and using ecologically sound practices. It suggests that globally, in developed and developing nations, there is a vast untapped potential for urban farming. In Havana alone, there are more than 26,000 food gardens, spreading across 2400 hectares of land and producing around 25,000 tonnes of food.[45]

The benefits of urban farming
Reintegrating agriculture in urban areas has been identified as a key element of the 'sustainable city': providing jobs and food for rising urban populations, and bringing ecological balance through green spaces and increased biodiversity. Urban farming helps feed city residents and protect the environment by reducing the need to bring in food.

The UN Development Programme has estimated that about 800 million urban and peri-urban farmers produce over 15 per cent of the world's food. If city governments adopted explicit policies and incentives to encourage urban agriculture, the number of urban farmers would probably increase substantially. There are already many urban farms within Asian cities. Of these, 200 million produce food primarily for the market, but the great majority raise food for their own families.[46]

- *Living model – urban farming in Middlesbrough, UK*

To raise awareness of food miles, improve health and aid regeneration of Middlesbrough, the local council's regeneration team joined forces with environmental regeneration charity Groundwork. The project turned over parkland, town-centre planters and other landholdings for fruit and vegetable growing involving approximately 1000 residents. The eight-month project culminated in a town meal where over 8000 people shared some of the food that had been grown. Middlesbrough's regeneration team hope to start up a social enterprise restaurant, supplied by community-run food cooperatives.

- *Living model – Cornwall Food Programme*

The Cornwall Food Programme, run by the Royal Cornwall Hospitals Trust in partnership with the Soil Association, shows what sustainable food procurement can achieve. Since 2001 the menus in three Cornish hospitals have been transformed by serving increasing amounts of fresh, locally produced and organic food to patients, visitors and staff. Over 80 per cent of

the Trust's food budget is now spent with Cornish companies, and over 40 per cent goes on Cornish produce; the annual 'food miles' travelled by delivery vehicles and the carbon emissions associated with them have been cut by two-thirds.[47]

- *Living model – Growing Communities*[48]

The inner city London Borough of Hackney is an unlikely location for a local food scheme. However, its urban market gardens supplies fresh seasonal produce to over 300 local households through a weekly organic vegetable box scheme that, is so successful there is a waiting list to join in some areas. *Growing Communities* also runs an all-organic weekly farmers market. It draws its produce from farmers within a 100-mile radius, who follow environmentally sustainable practices. The scheme also encourages the local community to evolve from passive consumers into active producers by encouraging them to 'make, bake, grow or pick good food throughout the year', and to reconnect with the flows of resources in and out of their community.

- *Living model – Community Supported Agriculture (CSA)* [49]

CSA is a model for partnership between farmers and consumers that shares the responsibilities and rewards of farming. With roots in Switzerland, Germany and Japan, CSA schemes aim to create a community around the issues of food, land and nature. Consumers share risks undertaken by farmers, similar to investors in a financial market. Producers have a ready market for their produce, and consumers have access to fresh, local produce which supports environmentally sound agricultural practices and land use.

- *Historical model – Digging for victory*[50]

During the Second World War, Americans set up 20 million home and community gardens, which provided 40 per cent of civilians' fresh vegetables. Today, most of the estimated 10 million hectares of lawns in the USA are maintained by chemical fertilizers and herbicides.

- *Living model – organic farming in Ethiopia – increasing resilience*[51]

Until recently, coffee made up 87 per cent of Ethiopia's total agricultural exports. However, following the crash of world market prices for coffee in 2003, triggered primarily by a World Bank Investment programme in the Vietnamese coffee industry which resulted in saturation of the market - export earnings halved from $400 million to $200 million. Ethiopia's 40 million predominately small-scale, subsistence farmers are now developing sustainable, organic food systems, utilising traditional knowledge married with improved techniques such as composting.

- *Living model – Navdanya organic farming organisation*[52]

Indian activist Vandana Shiva has criticised policies which have marginalised India's small farmers and made them more vulnerable to climate change. 'Policies driven by corporate globalisation are pushing farmers off the land, and peasants out of agriculture,' she said in April 2007. In her view, 'this is not a natural evolutionary process; it is a violent and imposed process and the 150,000 farmer suicides are one aspect of this violence.' Navdanya – an organic farming organisation she founded in 1991 – has shown how small farms are more productive than larger ones and promote biodiversity. In West Uttar Pradesh, for example, farmers have achieved yields of 62.5 quintal per hectare using a native wheat variety for organic production compared to 50 quintal per hectare for chemically produced wheat.

- *Living model – conservation farming raises yields ten-fold in Zambia*[53]

The Evangelical Fellowship of Zambia (EFZ), is training people to use a technique known as 'conservation farming', which has helped communities in the Monze East area to deal with changing rainfall patterns and boost self-sufficiency in the face of drought. This is vital in an area that has recorded the lowest river water levels in 12 years and in a country where 17 per cent of the population is HIV+ and which has more than 1.5 million orphans.

Conservation farming is a minimum-tillage method that traps moisture, improves the quality of the soil, minimises soil erosion, and creates growing conditions that exhibit a high drought tolerance which typically achieves a ten-fold yield increase. Conservation farming requires sustained periods of moderate activity on the farmers' part rather than short periods of intense activity. This has enabled many to continue to farm who would otherwise be too frail to cope with the traditional ways of working the land. It is also particularly beneficial for women who are increasingly responsible for agriculture. By encouraging farmers to diversify, EFZ helps to ensure that yields remain high even in times of low rainfall. In some years, conservation farming of maize alone isn't enough to ensure adequate food for people. When this happens, diversification is a vital coping mechanism. Cash crops can be grown and then sold to purchase food. The yield mean that farmers are can create community grain stores to provide for the most vulnerable.

Conclusion

Climate change and peak oil suggest that for countries, rich and poor alike, the future is going to look very different from the present. The picture of how we grow our food, design our homes, move around and power our economies will alter radically. Science also suggests that we need to be making this transition now. More positively this briefing paper suggests that already, from Europe to India, many of the solutions we need are already with us.

Innovation is the ability to adapt to constraints. A bilateral climate partnership between India and Europe, or a more extensive Global Climate Community could catalyse this process. Finding a way to directly exchange knowledge between communities, civil society groups, research institutions and governments will be central to accelerating development and installation of post-carbon solutions.

Working in partnership will also overcome some of the fundamental problems of intellectual property rights, which have in part, been responsible for delays in the widespread transfer of green technology to the global South. Furthermore, a long-term partnership would have a multiplier effect. Not only will it foster social and economic resilience to climate change and facilitate the reduction of emissions, it could also stimulate investment into human capital by generating the demand for skilled labour. This will be necessary to increase the absorptive capacity for some of the post-carbon innovations described in this briefing paper. The challenge will then be whether we can make the necessary changes fast enough, on a big enough scale, and in such a way that the needs of the world's people are met.

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