# The Day Technology Saved the Planet
## Transformative Solutions in a Time of Crisis

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**Abstract**
A revolutionary transformation of society based on new technology would allow the UK to take the lead towards a sustainable economy. This transformation would fundamentally change how the economy works and how many resources are used and in what ways, while most of the physical infrastructure would look almost identical to what is around us today.

Such a revolution is required by the "perfect storm" that increased pressure on the planet's resources will create, and enabled by accelerated technological developments. Approached in a strategic way, these converging trends can be directed to spur innovation and creativity on a level that humanity has never seen before.

Instead of trying to identify specific solutions that could provide sustainable solutions, we should look to support clusters that are likely to trigger a multitude of changes. For a sustainable future three ICT clusters are particularly important:

1. Connectivity: ensuring a 21st century communication infrastructure
2. Miniaturisation: enabling ubiquitous computing (ubicomp)
3. Integration: facilitating the emergence of augmented reality (AR)

To ensure that these ICT clusters help transform society towards a sustainable direction (instead of accelerating current unsustainable trends with over consumption and growing income gaps globally) it is important to focus on the areas where change needs to happen. Where change needs to happen and where technology is used today are two different things so a radical shift in priorities is needed. Three areas that need to move beyond incremental improvements towards transformative change are buildings, transport and food. Together these three areas represent up to 75% of the global environmental impact. Services such as those provided by new ICT-based solutions, could help to transform our current centralised, fossil based and inefficient energy system into an integrated, decentralised, renewable and highly efficient energy system.

The policy landscape today lacks a strategic discussion about technological development beyond incremental improvements. With a shift from a risk to an opportunity approach policy makers could increase the support for such transformative solutions.

In order to support an opportunity approach to policy making and ensure that the three emerging clusters of ICT solutions are developed in a way that help contribute towards a sustainable society over the next decades, policy makers should explore six ways forward:

1. A "One planet framework"
2. "Planet positive" companies: From minus to plus
3. Fast track for transformative solutions (reduction of environmental impact > 90%)
4. Disruptive models as base for decision-making
5. Move from national to global approach
6. Move from aggregated quantity to multitude with quality

**Context**

This paper describes a transformation of society which would allow the UK to take the lead towards a sustainable economy. This transformation would fundamentally change how the economy works and how resources are used, while most of the physical infrastructure would look almost identical to that which is around us today.

The reason that such a transformation is required was described earlier this year by Professor John Beddington, the UK's Chief Scientific Advisor. Beddington warned of a "perfect storm" of interconnected food, water and energy shortages that will climax around 2030.[i] A rising global population with a growing proportion consuming on levels similar to that of the UK will lead to an increased demand on these resources that will be difficult to meet – possibly causing destabilisation, rioting, and mass migration. This stress will take place at the same time as the world's population is ageing, causing a pressure on the financial systems that has never before been seen.

During the same time it is likely that technological development will accelerate due to increased connectivity and convergence of key scientific fields, in particular biotechnology, information-technology and nano-technology, possibly also linked to cognitive science.

The combination of the severity of the "perfect storm" of increased pressure on the planet's resources together with accelerated technological development, both requires and enables society to move beyond the incremental improvements towards transformative solutions. Approached in a strategic way, these converging trends can be directed to spur innovation and creativity on a level that humanity has never seen before.

A major challenge when attempting to imagine a sustainable society in 2030 is that its form will depend on a multitude of solutions. It's unlikely that society will look very different (flying cars won't exist and people won't wear space suits) but buildings could become net producers of renewable energy, cars could become storage devices for intermittent energy sources from the net producing buildings, smart solutions in buildings would enable people to avoid commuting to offices (reducing construction), and food could become part of closed systems where it generates local energy before being returned to the soil. For example, virtual meetings already take place using existing technology, and the products involved are unlikely to change much. This lack of aspirational pictures of a sustainable utopia places a responsibility on policy makers – there are no silver bullets, and no one symbolic technology is likely to emerge.[1]

This lack of a futuristic spectacle is probably a key reason why much of the sustainability discussion around climate change is stuck on the supply side. Images of solar panels and wind turbines fight with new coal power plants and nuclear power. Instead, the major challenge is how we use energy rather than how we produce it, but this fact is often lost in the battle over images that policy makers and media seem to be addicted to. Energy should be seen for what it is, the ability to make something happen, and from such a perspective, ICT could be one of the most powerful "energy sources" humanity has ever had.

Solutions like ICT services can make buildings intelligent, enable an intelligent transport and communication system, as well as allowing society to move from an economy based on owning products to one based on using services. Together such a solution could enable a transformative change in society. Although the technology is almost invisible, it could enable us to dramatically lower our environmental impact and allow nine billion people to live a good

[1] There are obviously a number of disruptive technologies on the horizon that could fundamentally change the way society operates. In particular, atomic-precise manufacturing and biotechnology breakthroughs together with cognitive discoveries could overthrow much of what we take for granted today. Every innovation agenda should therefore leave room for the solutions that are of "high impact, but low/uncertain impact". It is also important to develop filters that can identify media/PR-created hypes around technologies that are quite marginal and/or actually only result in further investments in unsustainable structures.

life without pushing humanity into a war over natural resources. To identify the potential it is however necessary to move from a "vision" based approach to a "service" based approach – looking not at how services look, but at how they are provided.

**Objective**

This paper explores the potential of technology, with focus on Information and Communication Technology (ICT), in providing solutions that can deliver the transformative solutions needed to meet the major challenge of sustainability faced by society. The paper addresses three questions:

1. What will a sustainable society "look like" for people in the UK in 2030?
2. How could technology enable and support the sort of transformational changes that are required?
3. What are the current policies in this area and what changes are required to take advantage of technology's potential?

This paper focuses on environmental sustainability; a society that "meets the needs of the present without compromising the ability of future generations to meet their own needs". [2] For the purposes of this paper, a future sustainable society is defined as one in which citizens (in the UK) use natural resources on a level that makes it possible for everyone on the planet to live at a similar level over time. This paper also includes a definition that is seldom included in sustainability discussions – that the UK exports solutions that contribute to sustainability rather than undermining it. This latter condition is included in the paper for two different reasons:

First, technology is not developed in a vacuum. In a global economy companies are seldom developing and implementing solutions for a domestic market only. So if R&D investments are to pay off in terms of delivering both domestic and global GHG reductions, there is a need for incentives that allow sustainable solutions to be exported to the world. The use of sustainability as a driver for profit and innovation is reasonably new but has entered mainstream discussions in the last few years.[ii]

Second, it is intellectually dishonest to call a country sustainable if its economy is based on an economic structure that makes it hard or impossible to be sustainable. For example, basing an economy solely on the export of extremely energy-inefficient SUVs would not be sustainable – even if the cars were produced using renewable energy and all the employees use smart public transport solutions to arrive at work in the morning.

**A Sustainable Society in 2030**

Projecting twenty years into the future of technology is particularly difficult. For shorter time horizons, linear models can be used, as there is seldom room for any technology breakthroughs with corresponding significant changes. For longer time horizons, the number of variables is so great that even small changes in assumptions deliver fundamentally different outcomes, resulting in a situation where the discussions easily turn into science fiction rather than those based on educated guesses.

Some trends are more robust than others, and it is reasonable to assume that there will be around 8 billion people by 2030, up from 6.5 in 2009. Most of this growth will take place in

[2] The definition and scope of sustainable development has been intensively discussed since the term was established as a political concept. Different groups have emphasised different parts, but almost all agree that the two main pillars are global equity (eradicating poverty) and environmental stewardship (ensuring that humanity lives within the carrying capacity of the planet). See http://www.un-documents.net/wced-ocf.htm. One of the most sophisticated approaches to turn sustainability into a scientific approach is the Natural Step.
http://www.naturalstep.org/en/faq#what-is-sustainability
http://www.naturalstep.org/our-approach#deep-knowledge

cities and between 2000 and 2030 the urban population of the less developed regions is expected to increase by 2.0 billion persons, nearly as much as will be added to the world population of 2.2 billion during the same time.[iii] Goldman Sachs projections for the period from 2011 to 2050 show China growing at 5.2 and India at 6.3. If those figures turn out to be correct, three of the top four economies in the world—China, the US, India and Japan (in that order)—would be Asian within the next two decades. The Asian Century is almost here.[iv] These macro trends however don't help very much when it comes to understand what society will look like.

One example often used to illustrate the difficulties with linear models, and the future of smart solutions in the 20-40 year time span, is the result that McKinsey delivered to AT&T when asked to assess the number of mobile subscribers by the end of the century in the early 80s. McKinsey calculated 900 000[v], which made sense using linear models where the assumption is that the technology will develop in incremental steps. The actual number for the year 2000 was over 100 000 000 subscribers for the US (more than 100 times the estimation from McKinsey). Today, just nine years after the estimation, there are about four billion subscribers worldwide, more than 4000 times the estimation.[vi]

In 1985 mobile phones were still called "shoulder phones"; they weighed 10-20 kilograms, had a 20 minute battery life and a price of more than €100 a month. They were used by a few to make very special calls. The fact that mobile devices could be used as offices twenty years later, as well as social devices that allow people around the world to experience many events in real-time, is not a linear development resulting from incremental improvements in the technology of the early eighties. Rather this represents the convergence of many new technologies that have found their way into the mobile phones of the early 21st century.

The fact that two of the leading companies that provide electric cars, BYD Auto and Tesla motors, were both founded only six years ago in 2003, is not the most striking fact about them. The really interesting point is that both companies developed out of the ICT business, dramatically illustrating the power of converging new technologies. For one company, the convergence of ICT and battery technology, and for the other, a deep understanding of ICT and innovation.[vii]

That linear models can produce numbers over 100 times wrong over a 20 year period is notable, and would not happen in many fields other than ICT. When we look at the role of ICT in relation to current linear models it is important to ask where the current margin of error might be 100 times or more.

It is worth noting that McKinsey is one of the most frequently quoted sources when it comes to low carbon scenarios. Their cost abatement curve is used by policy makers, businesses and NGOs to discuss measures in the 20 year perspective.[viii] The approach used in this model is again a linear model, where improvements of current technologies are the focus, something that can be valuable if policy makers want to know what would happen if everything was going to go on as usual.[3] Technologies like fossil-fuelled cars, the steel industry, cement, and buildings have all demonstrated linear development until now. Some of these will almost certainly also develop along a linear path in the future. Linear models do have an important role to play, especially to illustrate what happens if nothing significant changes.

But the fact that we are facing a "perfect storm" at the same time as accelerated technology development, has rendered linear models that ignore macro-economic effects and new Technology Service Clusters (TSCs) unsuitable to understanding the possibilities of tomorrow.[4]

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[3] There are obviously a number of issues that should be discussed such as those mentioned in this article:
https://blog.pnl.gov/StructuredThinking/index.php/2009/07/mckinsey-substance/

[4] McKinsey is also open about the weakness of the methodology, but many of its users seem unaware aware of these weaknesses which include: (i) static for the selected time frames, (ii)

| **Technology Service Cluster (TSC):** |
| --- |
| A TSC can be described as a group of technologies that provide certain services. ICT infrastructure that provides connectivity is an example of a TSC that allows humans and machines to communicate. It is based on a number of different technologies that operate on different levels and often in parallel; fibre, GSM, 3G, WIFI, Bluetooth etc. They often compete and therefore the rate of innovation and improvement is high. The basic service of connectivity is however independent of any single technology. Similarly the trend of miniaturisation will allow more and more things to process information and the integration of this will allow for an augmented reality that will be developed by a multitude of underlying technologies. |

In order to better understand the possibilities for transformative change in 2030, a first step would be to identify highly plausible major technological changes with far-reaching consequences. The following three TSCs, which could be delivered by a number of technological solutions, could be used as a starting point.[5] Besides opportunities to realise them with different technologies, each of them also has multiple drivers; opportunities for commercialisation which make the realisation of them highly likely over the next decades:

1. Connectivity: creating a 21st century communication infrastructure
2. Miniaturisation: enabling ubiquitous computing (ubicomp) and a service economy
3. Integration: allowing the emergence of augmented reality (AR)

*Connectivity: Creating a 21st Century Communication Infrastructure*

Already today a network of optical fibres, mobile base stations, satellites and WIFI routers cover the whole planet and in most urban areas provide a dense communication web allowing information to move at the speed of light.

A dramatic increase of connectivity, due to infrastructure that allows humans and machines to communicate, will continue over the coming years. The ICT network could be described as a 21st century low-carbon and resource-efficient infrastructure. This transformation, as well as policy suggestions for how to accelerate the transition has been described in the WWF report *A Five-step-plan For a Low Carbon Urban Development - Understanding and Implementing Low Carbon ICT/Telecom Solutions that Help Economic Development While Reducing Carbon Emissions*.[6]

The first generation of connectivity primarily connected humans, and we have begun to see an exponential uptake of virtual meetings with high quality video conferencing (virtual

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does not capture macro-economic effects, (iii) elasticity not modelled. Also still one of the most quoted reports about ICT and reduced $CO^2$ emissions "Smart 2020" is based on the traditional abatement curve and what part of this that ICT can help to achieve. "Smart 2020" is less a study of ICT's potential and rather an assessment of ICT during a linear development, but is still an important report as it helped to make ICT and $CO^2$ reductions a mainstream topic.

[5] These three clusters were selected based on four criteria: (i) the solution/function the cluster provide can be delivered by many different technologies, (ii) the solution/function from the cluster has use in many areas so many different stakeholders are investing R&D money in it, (iii) the solution/function the cluster provides has a robust market, more than one sector, with customers that can pay, (iv) the solutions/functions the cluster provided are relevant for key needs in society making it important for policy makers and business.

[6] The five main headings are: (i) make ICT a central part of national and city strategies and targets for reducing co2 emissions, (ii) shift focus from a 20th century physical infrastructure to a 21st century low carbon information infrastructure, (iii) encourage cross-sectoral partnerships with a focus on developing new and innovative services, (iv) lead by example and create a level playing field, (v) open innovation for low carbon solutions. For more details please see: http://assets.panda.org/downloads/wwf_ericsson_5_step_plan.pdf

presence). During the American election CNN even used a hologram to enable a discussion between CNN headquarters and a journalist in Chicago.[ix] Less discussed, but of much greater significance towards sustainability is the rapid growth of teleworking.

Teleworking is often misunderstood as a technology that primarily saves resources because of the reduced number of cars used to commute results in lower emissions. While it is true that teleworking reduces emissions from cars, this is only the tip of the iceberg. The major savings are only understood when a full life cycle assessment is used and the system boundaries are extended. By doing this two things happen; first the emissions due to extraction of oil, refineries and transportation as well as the production of the car becomes visible. Second, there are savings from the reduced need for supporting infrastructure in the shape of parking spots, roads, fuelling stations and so forth.[x]

These savings are often 50-150% of the "tail-pipe" emissions and are necessary to address if a sustainable society is the goal.[xi] Savings due to the reduced need for office space are also often ignored. With buildings responsible for about 40% of the world's emissions, the reduced need for space is crucial and teleworking often results in a reduced need for office space.[xii]

*Miniaturisation: Enabling Ubiquitous Computing (Ubicomp) and a Service Economy*

The connectivity that is already taking place will evolve into a different form as miniaturisation creates the basis for ubiquitous computing – the distributed ability to calculate and process information. This Machine to Machine (M2M) connectivity will be made possible with smaller and smaller technology that also becomes cheaper and cheaper. It is estimated that the number of connected devices will reach about 20-50 billion in the next two decades[xiii], allowing for solutions that can fundamentally change how companies operate and how people live and will also spur new business models.

When miniaturisation makes it possible to track the use and position of almost all products in society, it becomes both possible for policy makers to ask for an integrated product responsibility that cover the whole life cycle[xiv] and for companies to change from a linear business model, where the sale of the product is the last step, to a circular model where they have a "cradle to cradle perspective".[xv] The increased and distributed intelligence of ubiquitous computing could therefore support a more transparent economy that is circular and not linear.

The fact that most things will start to "think" around us will also enable a more transformative shift in society. Not only will we be able to track where things are, the things themselves will be able to provide information about their situation, including their environment. This opens up fundamentally new ways to allocate responsibility and create feedback systems when the use of natural resources reaches unsustainable levels in different parts of society. The fact that everything from paper bags and the different components of a mobile phone will be tagged and traceable, as well as the ability to collect information about what the products has "experienced", will allow for a level of transparency never seen before.[7]

The most important opportunity that arrives when the physical world around us becomes intelligent is that, with the right policy framework, this could facilitate a broader shift from an economy based on ownership of physical products to an economy based on access to services. An increasing number of businesses are already moving in this direction. One common example is Xerox; an early adopter in shifting their business model from selling photocopiers to selling the service of copying. This incentivised Xerox to re-use and re-cycle parts, building photocopiers from a lifecycle perspective. An example from another sector,

[7] Privacy is a key issue and collection of date that is not linked to individuals as well as avoidance of storage of personal data will be key to ensure support and a robust system. Education regarding what data is recorded, and how, is important.
http://ec.europa.eu/information_society/policy/rfid/about_rfid/helping_me/index_en.htm
http://www.epa.gov/waste/hazard/transportation/manifest/present/eman-rfid.pdf
http://ieeexplore.ieee.org/xpl/freeabs_all.jsp?arnumber=1407743

Interface shifted from selling carpets to providing high quality floor space, again resulting in a number of resource savings – including changing only those parts of the carpet that are in need of change, and recycling more material.[xvi]

Such examples show how a service approach can already be implemented today, but with the emergence of ubiquitous computing, much more economic activity can move from physical ownership to renting of services. This shift fundamentally depends on the ability of companies to measure use and the possibility for consumers to get access to the services when needed. The miniaturisation of communication and process capacity results in the creation of intelligent things that can communicate, thereby enabling a shift to a service based economy.

*Integration: Allowing the Emergence of Augmented Reality (AR)*

The integration of technology into almost every aspect of our life, and the tools that can interpret this information will enable Augmented Reality (AR)[xvii] to emerge. AR allows the hidden environmental and social effects of life to be seen in real-time, at the point when decision are taken. This could enable society to deal with one of the major challenges that the market economy of today has not been able to deal with; the consequences of our behaviours projected years into the future, or across spatial boundaries to other places on the planet.

Today it is possible for many people to follow their energy consumption in real-time and a number of solutions already exist that help companies and individuals to optimise their energy use.[xviii] However this is only the beginning, as the information available combined with the increasing processing power of the devices we carry with us will open up totally new opportunities. When looking at a car it will be possible to see the infrastructure needed to use it and how much more energy (in)efficient it is than the average car and so forth. When we look at food we will be able to see those who have produced the food throughout the supply chain, and we will be able to see how our body will change if we consistently eat that food. For almost all of the products in society, such augmented reality will allow citizens to make choices based on much more than just the price and information, currently provided through advertising commercials.

Already today a number of applications exist that give an indication of the kind of services that will be developed. Driven by technological advances and increased access to information and citizens' interest in the world around them, *Wikitude.me* for Google's Android mobile phone software is a platform that allow users to develop applications that bring geo-information, Points of Interest (POIs) and embedded media to the world around the user.[xix] For Apple's iPhone, *Yelp* and *BionicEye* were among the first AR applications launched.[xx]

These visualisations will allow for dramatic changes both on the consumer level, and help policy makers and business leaders make decisions. Such visualisations could support an economy that also includes long-term concerns – the legacy of decisions could be easily be made visible for everyone to see.

**Focus Where it Matters**

A number of studies have discussed the opportunity for ICT to contribute to reduced carbon emissions, and some also more generally the contributions to environmental sustainability.[xxi]

Often such studies describe the contribution of ICT within the existing systems of society. Policy makers so far have been reluctant to include ICT and other innovative technologies in the discussions about reduced CO2 emissions, so this is a natural reaction. By discussing the role of ICT as field of its own, two things are achieved; first the media, policy makers and others can see that ICT can play a role in the areas that they focus on in a way that they are not used to being discussed. Second innovative solutions that are disruptive to the companies responsible for much of the environmental destruction can be discussed without these companies having to be "blamed".

To support a significant and necessary contribution of technology towards environmental sustainability, it is important to focus on those areas which currently have a major impact on sustainability. For example, while the environmental impact of music downloads is interesting, it has never been the music industry that challenged the environmental sustainability of the planet.[xxii] From an perspective of maximising the impact of ICT solutions, three areas are of particular interest: buildings, transport and food.[xxiii]

Instead of approaching the companies and sectors in these three areas as problems, resulting in a situation when the focus is on incremental improvements, these areas can instead be approached from a service perspective.[xxiv]

Today buildings represent approximately 40% of global emissions of CO2.[xxv] A lot can be done to improve the efficiency but the potential for new technological solutions is easier to see when the services involved; light, comfortable temperature and so forth are clearly in focus. This perspective would provide room for smart ICT solutions like fibre optic cable reflecting lights and self-heating buildings.

The full potential is not realised until the problem is turned into an opportunity however, and it is here where ICT and a new generation of technologies can play a crucial role. There is no reason that buildings should be major users of energy, or why they should have a goal of zero emissions, instead buildings can be seen as net providers of renewable energy. This is not possible to do in a meaningful way unless there are intelligent energy systems where production and consumption can be balanced.

Using an opportunity based approach allows for new synergies to be explored where most existing problems can be turned into opportunities. The problem of uncertainty over renewable energy, and the need to charge electric cars where they are standing for a long time, all of a sudden provide an opportunity for a sustainable system that is robust. The better the decentralised energy production becomes, the more energy the system will create, and the better the battery (or other energy storage system) becomes, the more robust the system will become.

The multiple uses of ICT are important to understand. ICT can help to design and simulate new situations and the connectivity will allow new solutions to be connected and work together as system solutions. ICT solutions like telework, m-health and smart appliances will make up the different parts. These levels exist in parallel and will strengthen each other.

**From Problem to Opportunity**

To a large extent, the current policy landscape lacks a discussion about technological development beyond the incremental improvements that can help deliver sustainable outcomes. It is also a problem-based agenda where the focus is on the major emitters and how they can reduce their emissions within their current business models.

For deep reductions and solutions that nine billion people can use, a different approach is needed. For example, supporting net producing buildings will require policy makers to challenge much of the existing advice that come from the power companies and those with a strong focus on how to extract energy.

One of the hurdles to overcome in order to tap into technology is to leave the current models of energy production, transportation development and food production in favour of integrated solutions that link companies which so far have not been involved as solution providers. Linking up farmers, construction companies, architects, providers of electric vehicles and ICT companies could trigger a new generation of innovative solutions.

Special attention should be given to solutions that use the three clusters presented above. If policy makers promoted solutions that shift the dependence from a resource-intensive 20th century infrastructure to a 21st Century low carbon and resource-efficient infrastructure they would encourage solutions that help drive further reductions. Policies that encourage a “cradle

to cradle" approach and focus on service will open opportunities for new companies and entrepreneurs. Finally, encouraging the use of ICT to measure and visualise different effects can help more sophisticated strategies to be developed.

**Possible Ways Forward**

The following six strategic measures would support an accelerated uptake of transformative technologies and support sustainable applications based on the three ICT clusters written about above.

1. *Apply a "one planet framework"*

Use the sustainable natural resource use and $CO^2$ emissions that UK citizens would have access to if 9 billion people were living at the same level as a baseline for the products and services required by 2030. This would provide all major policies, R&D, trade, industry, infrastructure planning and so forth with an objective framework, showing how sustainable different existing solutions are. Such a framework also shows what kind of solutions are really delivering sustainability rather than slightly less unsustainable solutions. Ensuring that ICT innovations are developed in this direction is important, and the 9 billion challenge should be presented as the bases for all major R&D projects and strategies for industrial development.

2. *Promote "planet positive" companies: from minus to plus*

In order to support solutions it is important to move the focus from the big emitters to those companies and solutions providing the solutions needed. Policy makers should identify winners and solution providers, and also include these solution providers as advisers. The shift to the solution providers also opens up a focus on the positive impacts on employment, export, etc as sustainable solutions are supported.

The negative impacts of ICT itself should not be ignored, but it is important for policy makers to understand that the major environmental impact of the ICT industry is due to toxic materials rather than the energy required and effect on the climate perspective.

The ICT sector could be asked to take the lead by policy makers in developing a framework for reporting their positive impacts.

3. *Promote transformative solutions (reduction of environmental impact > 90%)*

For research and commercialisation, a particular focus should be given to transformative solutions that reduce emissions and resource use by 90-99%. Today most of the focus is on solutions that often deliver improvements in the 10-20% range.

Projects, including those related to the three sustainability clusters of ICT, should be designed to deliver strategies that result in implementations of transformative solutions.

4. *Develop disruptive models for decision-making*

Policy makers and business leaders need models and tools that help guide them in situations where disruptive change is likely (or necessary). All major policy decisions should include the possible role of disruptive technologies. The models that policy makers use today often exclude uncertainty in order to get inaccurate exact numbers, instead of including uncertainty to get approximate results that are of the right magnitude. ICT solutions can both help to create visual representations of different choices as well as provide examples of solutions that are disruptive.

### 5. *From a national to a global approach*

Even though the world is connected, many administrative structures focus on national borders, even when those are of decreasing importance. The opportunity to support global research clusters, identify markets at the global bottom of the pyramid, and deliver cost efficient solutions based on existing competitive advantages around the world seldom happens in the field of sustainability. It is a fallacy that global approaches are inherently unsustainable, and that national, or even local small-scale approaches are sustainable. Initiatives that connect citizens over national boarders and formulate priorities based on a global perspective should be supported.

### 6. *From quantity to quality*

The possibility to collect and process data allows society to formulate targets and evaluate measures in a way that will challenge the current focus on aggregate measures like GDP, unemployment, health and so forth.[xxvi] The need to move beyond a simple GDP focus has been increasingly discussed, and a robust summary of the current state of knowledge was recently presented in the report by the Commission on the Measurement of Economic Performance and Social Progress, by Professor Joseph E. Stiglitz, Amartya Sen and Jean-Paul Fitoussi.[xxvii]

Macroeconomics, simulation models and marketing are three fields of particular interest where sustainability needs to be integrated and the consequences of emerging technologies included. It is also important to support MBA education programmes that integrate sustainability and innovation as part of the education to obtain a new generation of business leaders that understand how innovation can support a sustainable development.[8]

*Brief Policy Review*

A review of relevant policies in the field of sustainable, and/or low carbon ICT, is difficult. It is a very new field where only during 2008/2009 did Europe acknowledge the importance of ICT for a low carbon development.[9] It was only with the ICT4EE (ICT for Energy Efficiency) in 2009 that Europe firmly put ICT at the centre of the climate discussions.[xxviii] Second, and linked to the first, there is still no agreement on how to approach sustainable/low carbon ICT. The work in Europe, both by the commission and member countries, is spread among different initiatives and projects. Many of these projects have been going on for a long time and are producing interesting results, such as work on smart buildings.[xxix]

There is now an agreement that ICT can play an important role, and in almost all major documents ICT is now mentioned, including in the UK.[xxx] On the EU and global level a similar pattern can be seen, where both basic research[xxxi] and corporate initiatives include ICT.[xxxii]

Even the traditional ICT agenda, which used to focus on the ICT infrastructure itself, now include a distinct sustainability element where the use of ICT is becoming the main focus. This is true both at the EU level[xxxiii] and at the international level. For example, at ITU Telecom World 2009 one of three thematic streams was ICT and climate change.[xxxiv] In contrast to this, in 2002 during the preparations for the World Summit on the Information Society, only a handful of organisations were engaged in the work to promote the use of ICT for sustainable development.[xxxv]

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[8] An interesting example is the competition: *Sustainable Innovation: Creating Value from the shift to a low carbon economy*, a competition arranged by Ashridge, in association with the European Academy of Business and Society (EABIS) and with the support of HP and WWF. The aim was to find the best ideas from management and other post-graduate students about how organisations can innovate to create value from the shift to a low carbon economy http://www.ashridge.org.uk/sustainableinnovation

[9] Japan was a few years ahead and US is still struggling to get a coherent policy in place. On a company level Japanese and US companies are however often ahead of EU companies.

Investors are also looking at ICT from a solution perspective and for the first time, in 2009 a question that allows ICT companies to present their solutions in a structured way was included in the Carbon Disclosure Project's questionnaire.[xxxvi]

While the UK has many innovative initiatives and has been leading the field in many aspects of the climate agenda, most of the leadership has been linked to political rhetoric rather than actual strategies, with even less implementation.[10]

A challenge for the UK and most other countries (with the possible exception of Japan[xxxvii]) is that current targets and strategies are not supporting a transformative agenda. A transformative UK strategy should include specific targets for solutions that deliver minimum 90% reductions. The "UK Low Carbon Transition Plan" is a well-intended strategy, but it is based on a 20th century approach of incremental improvements within an existing system. Individual strategic investments that could be part of a transformative agenda already exist, and transformative results could be achieved by linking such initiatives together.[xxxviii] It is also important to establish filters in order to differentiate between the different kind of innovations, which range from lobbying material to keep old industries, to truly innovative ideas.[xxxix]

A focus on the three Technology Service Clusters (TSCs) presented in this paper, with action in the six areas above could move UK and UK companies, as well as the countries and companies that will collaborate in these initiatives, to the forefront of the innovation driven sustainability work in the 21st Century.

[10] Tony Blair's achievements in bringing climate change into the G8 and the UN has provided the UK with a legacy as a leader in the international climate work.

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