LOW CARBON DEVELOPMENT INDICATORS - **DFID**

Evaluating development outcomes from renewable energy, sustainable transport and energy efficiency aid projects.

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INTRODUCTION

WSP Environment & Energy were commissioned by DFID to conduct a review of the potential indicators that could be utilised to assist in the evaluation of the development outcomes achieved by renewable energy technologies, sustainable transport solutions and energy efficiency measures. This study sets out these proposed indicators and provides the means to benchmark these technologies against one another to maximise the effectiveness of low carbon development aid. This report is an explanatory addition to the low carbon project evaluation tool which represents the practical outputs of this study.

DETERMINING THE ADDITIONALITY OF LOW CARBON ENERGY AND TRANSPORT

Although in some circumstances it still remains difficult to prioritise the key development challenges, to Low and Middle Income Countries (LICs and MICs), a low carbon future represents an imperative rather than an option. Developing countries represent the majority of our future population and economic growth and hence hold a large proportion of the future climate impact.

To limit the impacts of climate change, global agreements on climate change must seek to significantly reduce the emissions of developed countries whilst at the same time limit the emissions growth from LICs and MICs. The most abrasive issue in this deal will be the expectation that all countries should be able to develop by using whatever resources are available to them. It is widely accepted that one of the primary mechanisms for mitigating future emissions from LICs and MICs is technology transfer. It will be necessary to provide evidence that these low carbon solutions are more rather than less attractive as facilitators of development.

Studies identified as part of a literature review have failed to distinguish between the benefits of access to energy and the benefits of making renewable energy improvements. The 'Renewables 2004' conference, held in Bonn in June 2004 was the first dedicated high-level event to fully recognise the role that international actions focused on appropriate applications of renewable energy can have in achieving the MDGs, and to formulate a plan to support this objective.

The Declaration and Action Plan that emerged from the conference presented a joint vision of a sustainable energy future and affirmed a commitment to meeting the first Millennium Development Goal to halve the proportion of people living in extreme poverty by 2015 by extending renewable energy supplies and energy efficiency to one billion people. The conference spawned an important message:

"As energy is to development, renewable energy is to sustainable development."

Bonn Conference, 2004.

How and why is renewable energy associated with sustainable development? Energy is a cornerstone of human development. It cooks, lights, heats and powers our economy, our services and our homes. Access to energy is well understood as an essential component of sustainable development and provides major benefits for the economy, health, education and equality. However, eighty percent of people in sub-Saharan Africa have no electricity. However, the provision of carbon intensive energy is perhaps society's other greatest challenge. To date, cheap energy has been dirty, polluting and exploitative of natural resources. Simply providing access to unsustainable energy sources is building a legacy of high risk issues that will return more suffering than they resolved. Although the MDGs do not mention provision of energy specifically, modern energy services are prerequisites for meeting all of the goals (IEA, 2007).

Additionality of low carbon solutions is defined by the propensity to deliver development outcomes beyond those that viable and functionally comparative substitutes offer (e.g. coal fired power vs solar power; mechanically vs naturally ventilated buildings; or petrol cars vs biofuel cars).

The study hypothesis is therefore that low carbon energy and transport systems are of additional value above and beyond that of fossil fuel based systems; and that logically aid will therefore have greater long term impact when invested in these technologies. According to Renewables 2004¹, Among the benefits that can flow from increased use of renewable energy are: enhanced security of energy supply, reduced threat of climate change, stimulation of economic growth, jobs creation (often in rural areas), higher incomes, poverty reduction, improved social equity, and protection of the environment at all levels. Renewables can also improve access to energy services by providing reliable and affordable energy supply for people in rural and urban areas. Increased utilisation of renewable energy should be seen as a means to such ends, not as an objective *per se* (Renewables 2004). A brief literature review has revealed the following findings regarding the conditions in which development outcomes can be enhanced from renewable energy improvements.

Decentralised systems deliver improved development outcomes in rural areas.

It is argued that in developing countries, centralised energy systems have failed to deliver access to energy to poor and isolated elements of society (ITGD, 2004²). Populations are rising faster than electricity grids are developing. They are also expensive when serving sparsely populated areas, hence the opportunity for the deployment of decentralised technologies to meet the residual need. It is possible of course to provide kerosene or gasoline generators and cooking or lighting equipment however the health issues can be substantial and the lifecycle costs is far greater even than solar power.

Electricity is now more important than heat for maximising development outcomes.

Most domestic and non-domestic energy demand includes a component of electricity and heat. Heat is used for cooking and space heating whilst electricity is more versatile and valuable to development as it provides *inter alia the* ability to supply lighting, refrigeration, vaccine storage and other forms of communications.

Sources of heat are more readily available in rural areas in particular through biomass. Expanding energy choices, particularly electricity, for the poor is therefore an important factor in development and this can be achieved through low capacity rural systems. This is not to say the local sources of heat are sustainable as many carry health and resource constraints. The point is that renewable electricity supplies replace no service at all.

Leapfrog opportunities can be highly cost effective.

Much of the developed world is now looking at decentralisation of their energy networks. Rather than build new centralised fossil fuelled systems, LICs and MICs would do well to direct their efforts into decentralised low carbon systems. This will reduce the cost of transition at a later date and connect rural communities to energy supplies.

Examples of leapfrog technologies include mobile telephones making landlines in many countries an unnecessary infrastructure priority.

In poorer countries, appropriate technologies should prevail.

When implemented with contextual sensitivity, low carbon technologies that are transferred on a south-south rather than a north-south basis can provide a more sustainable solution as they can:

- make efficient use of local energy and human resources
- avoid negative environmental and social impacts of large scale projects
- make use of local manufacturing and skills; and
- be controlled and governed cheaply by local communities to their own benefit.

¹ Renewables 2004 (2004) Conference Report

² Intermediate Technology Development Group (2004) Powering Poverty Reduction; ITGD position paper for renewables.

Sustainable transport and development goals are symbiotic.

A low carbon transport network will either consist of high capacity mass transit systems (in urban areas), or electrified / biofuel based smaller scale systems (in rural areas). In urban settings in particular, the need to efficiently move people and goods drives the development of high capacity infrastructure thus strengthening the case for low carbon solutions. Whilst this can be considered a positive outcome, low carbon fuels such as biofuels are not necessarily without their perverse impacts and should be treated with more caution. Rural transportation is therefore more complex.

Energy efficiency goes straight to the bottom line.

The case for energy efficiency is much clearer as a reduction in energy demand directly translates to environmental benefit and just as importantly to a reduction in household expenditure and therefore fuel poverty, hunger and productivity. The financial returns from energy efficiency projects mean that there is also the potential to support more jobs and commercial organisations that share the rewards of energy efficiency with their customers.

Note: Although not specifically addressed in this report, the authors recognise the importance of the appropriate financial and policy support mechanisms required to support low carbon technological growth.

DFID AND LOW CARBON DEVELOPMENT

DFID's core mission is to ensure that UK development aid is utilised in the most effective way to deliver help and support to the world's poor. The Millennium Development Goals (MDGs) provide an international framework of eight policy goals for progress towards sustainable development from 2000 – 2015. The Millennium Development Goals provide a recognised set of internationally agreed targets with an emphasis on poverty reduction, health and economic development.

It is recognised as part of DFID's aid allocation that it must be supporting development that is environmentally sustainable. Climate change is one of the most important issues for the world's poor and paradoxically, those that are least able to contribute towards carbon emissions, are also least equipped to adapt to the impacts of climate change. Those countries that are highly developed today have achieved this through rapid exploitation of non-renewable fossil fuels for energy and resources. The diagram below shows this relationship with carbon emissions being an interchangeable indicator with ecological footprint.



Figure 1. The correlation between human development and ecological footprint (GFN, 2007³).

³ Global Footprint Network (2007)

High emissions development pathways are challenged by a number of risks including:

- The reduced availability of fossil fuel resources as developed economies exhaust these energy sources;
- the rising costs of purchasing coal, oil and natural gas as continued demand growth accelerates ahead of supply;
- the need to reduce carbon intensity and international agreements to reduce carbon emissions such as carbon taxes or pricing; and
- the economic risks associated with a carbon intensive development trajectory.

Supporting economic development that is achieved with low or zero carbon energy sources for buildings, transport and industry is therefore an essential component of a truly sustainable development aid strategy. In response to the threats that climate change poses, DFID is actively allocating capital to projects that are considered to be low carbon.

THE NEED FOR INDICATORS OF DEVELOPMENT RELATED GAIN?

Provided that that the case for additionality is sound, it is important that the development outcomes from low carbon aid can be measured. A desktop study was unable to produce any results in terms of any current frameworks, methods or indicators that are in use regarding the assessment of the benefits of low carbon technologies.

There is a wide range of evidence that specifically addresses the carbon reduction opportunities and the financial returns from low carbon projects, however the identification and measurement of additional development gain is not considered. There is also a wide base of literature on how to effectively implement low carbon projects in developing and particularly rural settings. This includes proposals for micro finance, community ownership and governmental policy and incentives. These issues are however parallel to this study and not included within its scope.

It has become evident to the best knowledge of this study that no organisation is providing the means or methods with which to measure the additional development outcomes from a low carbon project. Through this study, DFID has started the process of closing this gap.

DFID seeks to increase it's understand of the development benefits achieved by directing aid towards low carbon projects either on a bilateral or multilateral basis. A short preliminary research exercise was conducted to establish whether accepted indicators and metrics existed regarding the accounting of development benefits from renewable energy and sustainable transport improvements. Whilst indicators have been developed for other types of development related infrastructure, their presence for energy or transport projects or investments was uncertain. Most indicators that did exist related to financial performance or carbon emission reductions only. The preliminary study recommended the following next steps:

- In the absence of a quantifiable framework for the assessment of development gain from renewable energy investment, it is suggested that this is developed as a trial model based on the indicators recommended within this study.
- Within carbon and climate change issues being central to this research, it is important that the emissions reduction benefit is not left unaccounted for. This should be included within this analysis tool.
- Furthermore, a decision making framework for investment should be created to analyse investment opportunities and screen them for maximum development impact. This would assist in the prioritisation of aid projects and funding allocation.

This study seeks to progress DFID's aid evaluation processes by establishing a proposed set of indicators that identify the *additional benefits* of low carbon projects towards development objectives. The study also utilises these indicators to establish a project evaluation tool that provides the user with a range of information associated with the performance of various low carbon technologies. For DFID, this enables better judgement regarding the choice of technology within a given context including development status and urbanisation.

INDICATOR DEVELOPMENT

Through literature review, it has not been possible to identify an existing approach to measuring development outcomes from low carbon projects in developing or developed countries. The study is therefore based on the limited availability of existing information and its method sets out to provide a framework within which new information can be collected. It should be noted that as a result, the conclusion of this study (the indicators) will require testing and further refinement including a certain amount of stakeholder engagement.

The method is also driven by an immediate need to evaluate specific projects in the short term. The key product of this study proposes a set of indicators and metrics that can be used as part of flexible system for assessment and evaluation. It evolved that this process can be encapsulated within a dynamic evaluation tool that can be used by DFID to assess the relative impacts of project and link these outcomes to Millennium Development Goals. Figure 2 broadly sets out the approach taken.



Figure 2. Major steps included within the study method.

INDICATOR SELECTION AND VERIFICATION

The process for the selection of indicators is firstly based on a clear association with the Millennium Development Goals i.e. there must be an associated development outcome. The methodology focuses on identifying and exploring the interactions between low carbon projects and the MDGs and then working backwards to indicate what sort of connection can be made. The low carbon projects are divided into three categories. These are:

- 1. Renewable energy technologies (RE);
- 2. Sustainable transport solutions (ST); and
- 3. Energy efficiency programmes (EE).

Renewable Energy: Delivering aid in the form of renewable energy can bear considerable benefits in a range of economic, environmental, and social areas however the primary benefit is increased access to electrical power

brought about by electrification that enables a range of services and improvements in quality of life. That said, renewable energy technologies can be expensive in terms of first cost due to their relative infancy in technology maturity and the lack of specialised support available. This is especially true in poor and emerging economies.

The technologies selected for analysis therefore represent those which have a wide range of application to both gridconnected and off-grid electrical power provision in rural and urban areas. These technologies are location and climate dependent with the potential for use dictated by extant site constraints and resources. A further dimension is that several, but not all, of these technologies permit scalability from building-connected power supplies (for off-grid solutions, say) to utility-scale electrical power provision.

Sustainable Transport: Methods of deploying sustainable transport focus primarily around reducing the number of private vehicle journeys as these contribute significantly to adverse environmental impacts such as carbon emissions and air quality as well as economic impacts such as congestion and indebtedness. That said, private vehicles also enable greater personal mobility and access for trade and commercial purposes. As a result, Sustainable Transport practices are centred around trip reduction through the use of mass transit schemes (although some of these are best suited to urban, suburban and peri-urban areas) as well as the replacement of private petrol/diesel-burning vehicles with cleaner fuel types.

Energy Efficiency: Energy Efficiency pertains to design aspects of buildings and products as well as building and industrial management and behavioural use. Examples of how this could be achieved could either be through retrofit of HVAC systems, increased plant efficiency and improved insulation or the promotion of good practice behaviours. Another aspect deals with the displacement of current products with like products with a lower embodied environmental impact (in production, delivery to market, operation and disposal) such as with lighting and appliances.

Both of these aspects constitute a significant part in reducing the cost and environmental impact of building and product usage. A point to note however, is that economic prosperity increases (and so the propensity of appliances and electrical products), will the importance of Energy Efficiency and replacement by Low Carbon Technology become more significant.

For verification purposes, a number of workshops were set up to test these outcomes against the following criteria:

- a) Is the outcome *direct* or *indirect* from the low carbon project;
- b) Is the outcome additional to the provision of traditional energy supplies (modern fossil fuels or biomass); and
- c) Do the outcomes fall into groups or clusters?

INDICATOR CLUSTERING

Research into the wide range of benefits from low carbon projects led the team to a conclusion that it was appropriate to cluster and segment the indicator analysis. A series of grouped indicators are therefore available for multivariate analysis that can either be simple or complex but will always allow for drilling down to pertinent contextual issues.

Thematic clustering: The indicator identification process revealed that the benefits of low carbon technologies were easy to cluster into groups representing the three main pillars of sustainable development (economic, social, environmental), but also revealed a fourth enabling pillar which is referred to as transformational change – or the ability to adapt, build capacity and establish new markets. This final cluster was considered of specific importance to low carbon project development. This clustering would be important in the grouping of technology comparisons in the context of local project circumstances.

Contextual clustering: As each technology and project has particular circumstances which directly impact the effectiveness and scale of a particular outcome, it was deemed appropriate to cluster the analysis of indicators by their context. The two contextual criteria are development status (LIC / MIC) and geographical setting (Urban / Rural).

A total of <u>39 indicators with metrics</u> are put forward divided by each of the three sets of low carbon sectors identified. The following section justifies the inclusion of each of the indicators selected for inclusion within the study.

THE INDICATORS

The indicators taken forward from the initial workshops are presented below in their appropriate clusters and low carbon categories. The following section justifies and briefly explains the reasoning behind the indicators' selection.

			Economic	Environmental	Social	Transformational Change	Millennium Development Goal target
	RE01	Total job creation: Number of jobs created / MW	x				1a, 1b, 1c, 2a, 3a, 7d, 8a, 8b, 8d, 8f
	RE02	High value job creation: % jobs created with a salary >40% GDP per capita	x				1a, 1b, 7a, 7d, 8a, 8b, 8d, 8f
	RE03	Employment sector development: % of total energy sector employment working in renewable energy				x	7a, 8a, 8b
\geq	RE04	Household expenditure: cost of electricity delivered £/MWh	x				5a, 7c, 7d, 8b, 8d, 8f
<u>c</u>	RE05	Gender equality: % new jobs occupied by women			X		1b, 5a, 5b, 6a, 6b, 6c, 7d, 8b
e	RE06	Gender equality: % decrease in time spent sourcing fuel			х		1b, 2a, 3a, 4a, 5a, 5b, 6a, 6b, 6c, 8b
<u> </u>	RE07	Greenhouse gas emissions: tCO2e/MWh		X			7a, 8c
	RE08	Greehouse gas emissions: tCO2e/£m		X			7a
e	RE09	Fresh water consumption: m3/MWh		x			4a, 7a, 7b, 7c, 8b, 8c
å	RE10	Total land take: ha/MW		х			1c, 7a, 7b, 7c, 8b, 8c
2 N	RE11	Productive land take: productive land area used ha/MW (including forest)		х			1c, 7a, 7b, 8b
S	RE12	Air quality: Particulates and SOx emissions (kg/MWh)		X			7a
ž	RE13	Indoor Air quality: % of dwellings meeting WHO indoor air quality guidelines			X		4a, 5a, 7d, 8b
ě	RE14	Access to energy: % change in rural electrification			X		4a, 5a, 7b, 7c, 7d, 8b, 8c, 8d, 8e, 8f
ш.	RE15	Security of supply: change in annual hours of electricity supply interruptions			X		8a, 8b, 8c, 8d, 8e, 8f
	RE16	Access to communication: % of remote households with access to mobile communications			х		4a, 5a, 6b, 7d, 8b, 8c, 8e, 8f
	RE17	Market development: No. of new local enterprises established within three years serving the project's operation				X	1a, 1b, 7d, 8b, 8d
	RE18	Supply chain development: value of procurement orders placed within national supply chain				X	1a, 1b, 7a, 7d, 8b, 8d
	ST01	Job creation: Total number of jobs created / £m	x				1a, 1b, 1c, 2a, 3a, 7d, 8a, 8b, 8d, 8e, 8f
()	ST02	High value job creation: % jobs created with a salary >40% GDP per capita	x				1a, 1b, 7a, 7d, 8a, 8b, 8d, 8f
	ST03	Access to employment: % working population within catchment using project to serve new employment			X		1a, 1b, 2a, 3a, 5b, 6a, 6b, 6c, 7d, 8b, 8c, 8d, 8e, 8f
음 o	ST04	Gender equality: % change in proportion of female public transport ridership			х		1b, 5b, 6a, 6b, 6c, 7d, 8b, 8f
r d	ST05	Carbon dioxide emissions: % change in gCO2/passenger km		X			7a, 8b
ai JS	ST06	Lifecycle GHG impact: tCO2e/£m		X			7a, 8b
alst	ST07	Land take: ha/km new infrastructure / service planned		X			1c, 7a, 7b, 8b, 8c
зг	ST08	Air quality: % change in modelled ambient PM10 and NOx concentrations		x			4a, 5a, 7a, 7d
0 '	ST09	Access to public transport: % population with access to public transport within 2km	_		X		2a, 3a, 5b, 6a, 6b, 6c, 7d, 8b, 8d, 8e, 8f
	ST10	Market development: No. of new local enterprises established within three years that serve the project's operation				X	1a, 1b, 7d, 8b, 8d
	ST11	Supply chain development: No. of new enterprises established as component of project supply chain				Х	1a, 1b, 7a, 7d, 8b, 8d
cy ^	EE01	Total job creation: Total number of jobs created / £m	x				1a, 1b, 1c, 2a, 3a, 7d, 8a, 8b, 8d, 8e, 8f
	EE02	High value job creation: % jobs created with a salary >40% GDP per capita	x				1a, 1b, 7a, 7d, 8a, 8b, 8d, 8f
	EE03	Energy poverty: % change in energy spend per household	x				1a, /a, /d, 8b, 8d, 8f
ם ים	EE04	Household income: % reduction in energy spend as proportion of household income	x				1a, 1c, 3a, 5a, 7a, 7d, 8b, 8d, 8f
ie er	EE05	Energy security: % reduction in energy demand MWh/£m	x				1a, 4a, 7a, 7d, 8b, 8c, 8f
<u>i</u> i	EE06	Gender equality: % new jobs occupied by women			X		1b, 5a, 5b, 6a, 6b, 6c, 8b
ШШ	EE07	Greenhouse gas emissions: reduction in tCO2e/£m	-	X			
ш	EE08	Energy intensity: % reduction in kWh/m2 of projects served		X			/a, /b, /c, 8b
	EE09	Market development: No. of new local enterprises established within three years that serve the project's operation				x	1a, 1b, /d, 8b, 8d
	EE10	Supply chain development: No. of new enterprises established as component of project supply chain				X	1a, 1b, 7a, 7d, 8a, 8b, 8d

THE INDICATORS - RENEWABLE ENERGY

The first low carbon project category is renewable energy technologies. The following indicators and metrics were developed for assessing the additional development impact of renewable energy technology projects. There are 18 renewable energy indicators numbered RE01 – RE18.

RE01 - Total job creation: Number of jobs created / MW

Each form of energy generation has a specific potential for job creation. It is felt that when compared to fossil fuel based energy systems, renewable source generation, and particularly that which is decentralised, is capable of creating more jobs both at a local level and throughout the supply chain. A key economic benefit with therefore be greater employment at the local level and the opportunity to form new enterprises. For example a new maintenance company could be established offering skilled maintenance services to domestic and community installations of PV. Basic research is available on the number of jobs created by a range of technologies. This metric is simply the number of jobs created per megawatt of installed capacity. This will often be a decimal for centralised systems.

RE02 - High value job creation: % jobs created with a salary >40% GDP per capita

A secondary but important economic indicator is the number of high value or 'white collar' jobs created by a particular renewable energy technology. This is an important indicator of the ability of a given technology to advance the income of a proportion of the population beyond unskilled labour employment. The most important dynamic of this indicator is the ratio of skilled to unskilled jobs which has in this case been defined as being above the 40th percentile of GDP/capita referenced at national level.

RE03 - Employment sector development: % of total energy sector employment working in renewable energy

A further indicator associated with employment is the proportion of the overall energy sector related employment attributable to renewable energy generation and distribution. This is an indicator of transformational change in that it is a proxy for the scale of development of the renewable energy sector at large.

RE04 - Household expenditure: cost of electricity delivered £/MWh

The cost of electricity to households is a primary function of energy poverty. This means that even when electricity is available; it may be too expensive for a household to purchase, thus excluding them from its benefits. Traditionally fossil fuel based energy supplies have been cheap, however increasingly there is upward pressure upon these prices which has made the economics of various renewable energy sources viable or even attractive. As renewable energy supplies are established, their success will be partially determined by the cost of electricity delivered.

RE05 - Gender equality: % new jobs occupied by women

In some geographies there is an acute disparity between the share of employment occupied by women. It is possible that new jobs created within the renewable energy sector are able to be equally fulfilled by women and the nature of those roles could break down some of the stigma and tradition regarding women and work. Jobs that are more local to the household and are more independent for example including less manual labour may help initially to provide a firmer basis for change. The collection of biomass is one example of a task that is already largely undertaken by women however it does not have entirely positive outcomes (see RE06); there may be opportunities for

community roles and organisational development across a range of technologies. The cleaning of PV panels for example could be undertaken by either gender.

RE06 - Gender equality: % decrease in time spent sourcing fuel

This related indicator attempts to focus on the reduction in time spent collecting fuel. Where biomass is the incumbent fuel source, women often spend significant amounts of daylight hours gathering wood for cooking and heating. This activity prevents them from a range of social opportunities and perhaps most importantly, access to education and employment. The issue with domestic biomass is although it is generally considered renewable when harvested sustainably; it also has health impacts and consumes productive time.

RE07 - Greenhouse gas emissions: tCO2e/MWh

Recognised as one of the two primary drivers for moving to sustainable energy sources, the limitation of greenhouse gas or carbon emissions is a development imperative. The indicator for low carbon energy supplies is simple and allows for easy comparison. This forms an important element of the environmental contribution towards the MDG.

RE08 - Greenhouse gas emissions: tCO2e/£m

RE08 provides an alternative efficiency indicator for greenhouse gas emissions based on the carbon reduction potential per unit of spend. This is a very transparent method of comparing technologies and cross-sector projects in terms of environmental performance.

RE09 - Fresh water consumption: m³/MWh

Many energy technologies impact water resources through abstraction for process cooling. This environmental indicator is particularly important for future proofing communities against future water shortages for important water uses such as drinking, washing and irrigation. This indicator will be less important in coastal areas where salt water is utilised for cooling however the will still be an environmental impact from elevated temperature discharges. The focus on freshwater is appropriate due to the risks and dis-benefits of groundwater exploitation and river diversion.

RE10 - Total land take: ha/MW

This indicator will be most important in countries those that are densely populated. One of the perceived benefits of low carbon technologies is that they are more flexible in terms of land take. Wind turbines can be integrated with pasture and solar thermal collectors can be put on roof space. Less land taken by large power facilities and distribution means more space for agriculture, carbon reforestation and enterprise.

RE11 - Productive land take: productive land area used ha/MW

Perhaps a more incisive and focused indicator with an emphasis on land that is proven to be capable of sustaining productive crops including foodstuffs, biomass and biofuels for example. Whereas land take in lower density countries may be less of an issue, productive land always carries an opportunity cost. The lower the land-take for the energy or transport system, the more preferable the solution.

RE12 - Air quality: Particulates and SOx emissions (kg/MWh)

Air quality issues are a major environmental issue associated with domestic biomass, kerosene and larger scale energy technologies and vehicles. Non combustion technologies such as wind generation or solar energy contribute zero emissions at a local level. This represents significant air quality improvement particularly with regard to the key air quality parameters of PM_{10} and oxides of sulphur.

RE13 - Indoor Air quality: % of dwellings meeting WHO indoor air quality guidelines

Indoor air quality is a major health issue in low income countries in particular due to the burning of wood and kerosene for cooking, heating and lighting. Improved indoor air quality is attainable by the transfer of fuels to clean and renewable sources.

RE14 - Access to energy: % change in rural electrification

Centralised electricity grids do not reach everybody. Distributed electricity sources have been proven to increase access to electricity in rural areas in particular where it is not economically viable to distribute from a network. Renewable energy sources provide independent or community based access to electricity.

RE15 - Security of supply: change in annual hours of electricity supply interruption

This affects domestic property, industry and social infrastructure alike. If an island state is isolated and suffers from unreliable sources / deliveries of fuel, local renewable energy development will revolutionise the stability of the energy systems. In developing countries electricity grids are often unstable and are prone to regular interruptions to supply.

RE16 - Access to communications: % of remote households with access to mobile communications

Renewable energy, because of its ability to reach remote and isolated locations is able to transform communications by providing access to mobile phones and the internet. By measuring the increase in access to mobile communications before and after project implementation, the additionality of renewable energy can be evaluated.

RE17 - Market development: No. of new local enterprises established within three years serving the project's operation

As an indicator of the level of transformational change enabled by a project, this metric measures the ability of a project to generate new opportunities for sector growth in renewable energy support and maintenance. All organisations included within the procurement remit of the project will be considered to quality as long as they are established between 0 and 3 years following practical completion.

RE18 - Supply chain development: Value of procurement orders placed within national supply chain

Upstream of the project are the suppliers of equipment, expertise and manpower to deliver new renewable energy projects. Measurement of the volume of orders received by national companies as a result of the project will inform the level of transformational change, capacity and economic activity generated by the project.

THE INDICATORS - SUSTAINABLE TRANSPORT

The second low carbon category is sustainable transport. The following indicators and metrics were developed for assessing the additional development impact of sustainable transport projects. There are 12 sustainable transport indicators numbered ST01 – ST12.

ST01 - Job creation: Total number of jobs created / £m

Sustainable transport systems can be simple or complex. Some schemes will develop a variable volume of jobs based on a total spend to jobs ratio. If a base case is considered to be roads for gasoline vehicles then light rail or rapid bus systems are likely to require greater employment opportunities due to their more complex nature. It is accepted that some sustainable transport alternatives may therefore have a higher initial capital cost.

ST02 - High value job creation: % jobs created with a salary >40% GDP per capita

Due to the varied and more complex nature of sustainable transport system technology, it is likely that some forms of infrastructure or low emissions vehicles are going to create a jobs market for skilled and highly skilled individuals. This applies to the design, manufacture and operation of public transit and localised mobility solutions.

ST03 - Access to employment: % working population within catchment using project to serve new employment

One of the key benefits of low carbon public transport in particular is the access that is created to centres of employment opportunity. Individuals who could not previous afford to travel by private means to a place of work may now be able to participate in a more cost effective public transit system. The wider benefits to the economy are substantial. The ability to assist poverty reduction is the primary outcome as a result of the increased income from the newly accessible jobs.

ST04 - Household expenditure: % change in cost of travel/passenger km

Having cost effective transport is a major development factor. Physical access to infrastructure must be complemented by an affordable travel option. Private vehicle ownership for example is not an option for many. Whilst rural areas can be served by minibus routes relatively effectively, urban areas require more structured movement of people and goods. Large scale, low carbon infrastructure reduces the cost of travel to the individual and provides a more structured environment for subsidies if required.

ST05 - Gender equality: % change in proportion of female public transport ridership

Although the evidence is difficult attain, this indicator searches for a relationship between low carbon transport options and increased female ridership. Whilst this ridership will also be demand-led as a result of increasing employment and education opportunities for women, it will also indicate whether the travel environment is more appropriate for mixed gender travel. It is also possible to provide segregation on public transport systems whereas minibus transport modes are less flexible. There is evidence of segregated models of transport in Mexico and Saudi Arabia for example.

ST06 - Carbon dioxide emissions: % change in gCO2/passenger km

A very clear environmental indicator for sustainable transport is the operational emissions of carbon dioxide per passenger kilometre. This intensity indicator is useful for demonstrating the relative carbon performance of different modes of transport.

Emissions can range from zero g/km for cycling and walking to 100-250 g/km for private vehicles. Bus a rail travel range from 10-60 g/km on average.

ST07 - Lifecycle GHG impact: tCO2e/£m

A more in depth environmental indicator for low carbon transport is the embodied carbon cost of the infrastructure. Embodied carbon is a sum of the upstream production of the physical hardware of the transport system. Large infrastructure project will tend to have higher embodied carbon but often lower operating emissions. A rapid bus transport system is a good balance between initial impact and operating impact. This indicator will be useful for distinguishing between technologies in detailed analyses.

ST08 - Land take: ha/km new infrastructure / service planned

Whether in urban or rural areas, the land take for a transport project will have an impact. In rural areas the issue is more focused on agricultural productivity whereas in the urban areas the size of the infrastructure above ground determines the density and connectivity of a town or city. This has a significant impact upon the emissions of a city's operations as more journeys are required by alternative forms of transport – often cars and taxis. Efficient cities have excellent public infrastructure but are walkable and concentrated.

ST09 - Air quality: % change in modelled ambient PM_{10} and NO_x concentrations

Any major transport project should perform an environmental and social impact assessment. For transport projects, air quality modelling to forecast pollutant concentrations and contours is necessary. This indicator attempts to demonstrate the variability in health impacts from low carbon transport options over combustion based options. Measurements of particulates and nitrous oxides should be taken from an appropriate point along the transit line and not at any point away from it.

ST10 - Access to public transport: % population with access to public transport within 2km

Sustainable transport systems are characterised by ease of access resulting in improved ridership and model shift. The issue with some low carbon public transport infrastructure projects is that they can only serve dense populations well in urban areas. This indicators gives recognition to a solution which increases access to rural and isolated communities in particular, even if there is a small rise in emissions as a result.

ST11 - Market development: No. of new local enterprises established within three years that serve the project's operation

As an indicator of the level of transformational change enabled by a project, this metric measures the ability of a project to generate new opportunities for sector growth in sustainable transport operations and maintenance. All organisations included within the procurement remit of the project will be considered to quality as long as they are established between 0 and 3 years following practical completion.

ST12 - Supply chain development: No. of new enterprises established as component of project supply chain

Upstream of the project are the suppliers of equipment, expertise and manpower to deliver new sustainable transport projects. Measurement of the volume of orders received by national companies as a result of the project will inform the level of transformational change, capacity and economic activity generated by the project.

THE INDICATORS - ENERGY EFFICIENCY

The third low carbon category is energy efficiency. The following indicators and metrics were developed for assessing the additional development impacts of energy efficiency projects. There are 9 energy efficiency indicators numbered EE01 – EE09.

EE01 - Total job creation: Total number of jobs created / £m

Some energy efficiency measures generate new jobs as well as produce economic and environmental benefit to the owner of an asset and the local population. All EE measures deliver environmental and economic benefits. When distinguishing between energy efficiency projects, one for the key indicators will be the ability of that solution to generate jobs. For example, the improvement of insulation in buildings requires a number of unskilled and semi skilled employees thus creating a good foundation of employment funded by the energy cost reductions achieved. Developed economies are now very focused on energy efficiency for these reasons and have calculated the number of jobs created from loft insulation programmes for example.

EE02 - High value job creation: % jobs created with a salary >40% GDP per capita

Some solutions will generate a more preferable mix of skilled to unskilled jobs as for example the focus may be on the design of energy efficient buildings or energy reduction technologies. This indicator delimitates those jobs that are created that have salaries above the 40th percentile.

EE03 - Energy poverty: % change in energy spend per household

By reducing demand for energy through efficiency projects, some of the technologies have the potential to lift people out of energy poverty by reducing the amount of income that needs to be allocated to energy related uses including fuels. This indicator is measured by establishing the catchment for an energy efficiency programme (e.g. 1000 homes moving to LED lighting resulting in a 13% reduction in energy spend per household).

EE04 - Energy security: % reduction in energy demand MWh/£m

This macro-level core indicator deals with the effectiveness of the aid spend in terms of reducing energy demand. This provides a technical return on the investment but importantly indicates the level or volume of development outcomes achieved as a result of the reduced cost of energy and its role in poverty reduction. Energy supplies that are in place will be more robust as a result of this spend.

EE05 - Gender equality: % new jobs occupied by women

Some energy efficiency programmes are suited to incorporating more women into the workforce. This indicator may have specific reference to behavioural or appliance / lighting replacement programmes for example.

EE06 - Greenhouse gas emissions: reduction in $tCO_2e/\pounds m$

Linked to the effectiveness on efficiency per £m, this indicator provides the equivalent environmental response choosing greenhouse gas emissions as the indicator.

EE07 - Energy intensity: % reduction in kWh/m² of projects served (electricity + heating)

This indicator represents an intensity benchmark that takes into account the preexisting conditions that prevailed prior to the project's implementation. Energy demand benchmarks are often expressed in kWh/m^2 which can then be expressed as a % change. This is another indicator grouped around the effectiveness of the measure deployed.

EE08 - Market development: No. of new local enterprises established within three years that serve the project's operation

As an indicator of the level of transformational change enabled by a project, this metric measures the ability of a project to generate new opportunities for sector growth in energy efficiency operations and maintenance. All organisations included within the procurement remit of the project will be considered to qualify as long as they are established between 0 and 3 years following practical completion.

EE09 - Supply chain development: No. of new enterprises established as component of project supply chain

Upstream of the project are the suppliers of equipment, expertise and manpower to deliver new energy efficiency projects. Measurement of the volume of orders received by national companies as a result of the project will inform the level of transformational change, capacity and economic activity generated by the project.

PROJECT EVALUATION TOOL

With this study, DFID's goal is to be able to assess the relative merits of a variety of low carbon project proposals. With the indicator categories and themes framed, the next logical step is to apply this to a range of project assessment scenarios. Due to the multivariate nature of the data behind the construction of scenarios, it was decided that the best method of conveying marginal benefit against other types of aid as well as how this satisfied the Millennium Development Goals (MDGs) was to construct an interactive tool for project evaluation.

INPUTS AND OUTPUTS

The tool is operated simply by selecting only three inputs. These are low carbon project type e.g. bus rapid transport, electric vehicles, heavy rail (to be input individually input by category for RE, ST and EE), the national development status of the host country (low or middle income / urban or rural) and the indicator theme that it most important to the project's context. A typical query would have the following inputs:

Select indicator set for display	> Environmental
Select country development status	> LIC-RURAL
Select Renewable Energy Technology	>Wind

The tool automatically updates revealing a set of graphs and the same analysis for each project category. See figure 3 below:





Two main outputs are available:

- Firstly, to assess the level of alignment and impact that a specific project type has on development outcomes; and
- Secondly, to compare the various technology types with one another in the context of a set of economic, environmental, social or transformational change indicators

These two sets of analysis are conveyed by two graphs in each of the three (RE, ST and EE) categories. To the left of the screen is a wheel graph displaying the emphasis of the project and the strength of impact against the MDGs. An

example from the query above is shown below in Figure 4. It demonstrates a high impact upon MDGs 7a and b and 8 b and c.



Figure 4. Example of an indicator alignment graph

DEVELOPMENT OF OPTION BENCHMARKS

Having devised a suitable set of indicators and corresponding metrics and how a tool should communicate this data, benchmarking of how aid types performed against the metrics was required (ranked, compared to other aid types). This exercise was carried out based on expert judgement from past project experience.

The performance of each aid type in satisfying each of the metrics (RE01-18, ST01-12, EE01-09) was scored relative to each of the other aid types within the aid category. Numbers close to 1 represented a poor satisfaction of the metric, whereas numbers close to 8, 9 or 10 (for each category) represented a good satisfaction of the metric. So if Concentrated Solar Power (CSP) scored a value of 1 for RE02 High-value job creation, and Geothermal scored a value of 8, then Geothermal would be the optimum type of aid in order to satisfy the RE02 metric, and CSP the least optimum.

To the right of the screen, a bar chart offers data regarding the comparison of alternative technology types to the one which you have selected. These are benchmarked against a business as usual scenario which acts as a reference point (even if it does not accurately represent the in-country situation. An example of the output from the same query is captured in Figure 5 below where it can be shown that wind performs well (in fact the best overall) with the environmental component making a significant contribution towards its ranking. So the tool tells us that if environmental issues are the main development issue, then geothermal options may also warrant investigation.



Figure 5. Example of a technology benchmarking output graph.

INTERPRETING TOOL OUTPUTS

This section illustrated the tool outputs with a little more resolution. For more detailed instructions on how to use the tool, please refer to the corresponding user guide.

The graph on the right hand side of each category indicates a comparison with other aid types within the aid categories (RE, ST and EE). The graph on the left hand side of each category indicates the intensity with which the technology selected for sub-analysis affects the Millennium Development Goals.



In the example shown above, several conclusions can be deducted from the data:

- Insulation delivers the greatest overall impact in MIC-URBAN areas, as shown by the tallest grey and red bar in the graph on the right hand side. This is highly contextual and does not permit the suspension of user judgment; in this example, aid in the form of better insulation would be more applicable in Tashkent than Tripoli
- Insulation delivers the greatest economic impact in MIC-URBAN areas, as shown by the tallest red bar in the graph on the right hand side
- Significant low carbon technologies (CHP, District Infrastructure) yield similar economic impacts, as shown by the similarity in size of the red bars. This would be because of concentration of skilled labour into a relatively small pool (spatially and demographically) of workers.
- The economic impact is the largest driver for delivering aid in the form of District Infrastructure as it accounts for nearly two thirds of its overall impact (shown by the red bar being a majority of the grey bar)
- The Business As Usual (BAU) aid type is shown to have little overall impact in the economic, environmental, social and transformational change indicator sets. This is shown by the grey bar corresponding to BAU as being the lowest in height
- The Business As Usual (BAU) aid type is shown to have little economic impact as shown by the red bar corresponding to BAU as being the lowest in height
- The deployment of aid in the form of (building capacity for) Passive Design has the greatest impact on the Global Partnership Millennium Development Goal as shown by the darker colours of the MDG Impact Assessment wheel on the left hand side. This indicates that addressing the special needs of least developed countries is Passive Design's greatest impact area. However, this does not necessarily mean that Passive Design has a significant impact on the Global Partnership goal, merely that it is its strongest impact area compared to the other MDGs
- Passive Design has some impact on Environmental Sustainability (as shown by the two red shaded MDGs 7a and 7d). It is possible to discern from this that impacts pertaining to resource conservation and urban improvement are affected, but not a loss in biodiversity nor access to drinking water, as would logically be inferred
- Passive Design has a small impact on Universal Education (as shown by the light yellow shaded MDG 2a) through the metrics used that pertain to economic improvement and fuel poverty alleviation, the inference being that schooling will be more accessible and operable
- Passive Design has no impact in Combating HIV/AIDS (as shown by the unshaded MDG 6). This means that through the metrics specified under the indicator set (economic, environmental, social and transformational change), Passive Design does not directly impact upon Combating HIV/AIDS.

From the analysis above it is possible to see that not only the headline graphics are useful, but that it is also possible to drill down into the specific performance of individual indicators. This allows the tool to be used flexibly and in specific circumstances where a single development goal is of paramount importance.

TOOL LIMITATIONS

The tool was created in order to disseminate and analyse data based on a database of 'floating' benchmarks. These benchmarks take the form of ranking specific types of aid against each other in order to create a self-reinforced dataset upon which to make aid decisions. Measurable benchmark data could have been constructed but would have several limitations:

- Metrics are difficult to measure in isolation (such as ST11 "Market development: No. of new local enterprises established within three years that serve the project's operation") and independently of other direct/indirect factors
- Research into measuring the metrics for each aid type in each development status (LIC-URBAN/LIC-RURAL/MIC-URBAN/MIC-RURAL) would be extensive
- Even if robust data could be obtained for each scenario, the database would still not resolutely reflect every scenario such as country- and region-specific peculiarities

The tool is therefore designed to not be fully comprehensive in determining a precise value in job creation or energy poverty alleviation (for example) when an aid type is applied to a place with a certain development status. Rather, the tool is capable of indicating the relative benefit of one type of aid against another in a location with a generalised economic, demographic and fuel mix (among others) composition.

NEXT STEPS

Some important next steps include:

- 1. Further testing, verification and stakeholder engagement regarding the indicators and the facilitation of a common approach amongst donor agencies.
- 2. A detailed data review and referencing exercise explore possibility of using measured data
- 3. The establishment of a set of key indicators
 - a. Thematic issues: i.e. selecting a single key social, environmental and economic indicator for low carbon projects.
 - b. Policy issues: Establish a set of policy indicators for assessing the strength of enabling circumstances within a give country.
- 4. The preparation of a best practice guide for the funding of renewable energy projects including an assessment of the most appropriate technologies and their best methods of deployment.
- 5. Development of a transformational change strategy for sector development.
- 6. A carbon analysis what is low carbon, what are the tradeoffs between aid and emissions?
- 7. Preparation of a climate adaptation toolkit to operate alongside this one.

Appendix A Evaluation Tool User Guide

INDICATORS TOOL USER GUIDE

The DFID Sustainable Aid Indicators Tool (hereafter referred to simply as 'the tool') is designed to inform the operator of the broad impact of delivering aid in the form of either renewable energy, sustainable transport and energy efficient/low carbon technologies (hereafter referred to as RE, ST and EE/LCT, respectively). It is a spreadsheet- and VBA-based tool created in Excel 2003. Macros should be enabled when running the tool.

INPUTS

The tool is essentially broken down into three key areas on the Interface sheet around which the user can select which a single, or combination of aid types, to be assessed, in the categories of renewable energy, sustainable transport and energy efficient/low carbon technologies. The very top of the Interface sheet contains two inputs (**Indicator Set** and **Country Development Status**).

Microsoft Excel - DFID Sustainable Aid Indicators Tool v9.xls	
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The Indicator Sets available for selection are:

- Economic
- Environmental
- Social
- Transformational Change

When an Indicator Set is selected, the set/cluster of metrics pertaining to that Set (for each of the aid categories, RE, ST, EE/LCT) are listed in their respective areas within the Interface worksheet. The Country Development Statuses available for selection are:

- LIC-URBAN
- LIC-RURAL
- MIC-URBAN
- MIC-RURAL

When a Country Development Status is selected, the metric data for each aid type is extracted for the Indicator Set that is selected. So for example, the metrics for Social indicators will be the same for MIC-RURAL as LIC-URBAN although the values for each aid type will be different.

The technology Type Sub-Analysis input exists for each of the aid categories (RE, ST, EE/LCT). The options available for selection are the aid types within each aid category (so, PV, Wind, Biomass etc for RE, Cycle Schemes and Metro for ST etc.).

A change in the value of any of these five input cells will run a macro that will update all graphs in the Interface sheet.

OUTPUTS

The outputs are presented within each aid category on the Interface sheet, with data presented depending on the three inputs (Indicator Set, Country Development Status and Aid Type).



The metrics presented (depending on the Indicator Set) will generate values for each Aid Type (depending on the Country Development Status) in the array of yellow-shaded cells. Each value represents a ranking of that particular aid type, compared to other aid types within that aid category on an escalating scale between 1 and the number of aid types (8 for RE, 9 for ST, and 10 for EE/LCT). Lower numbers indicate that the aid type will perform poorly compared to other aid types (within the aid category) for that particular metric. For example, in the screenshot below, a local bus network is ranked 9 (best) in the number of jobs created / £m invested compared to other aid types. A cycle scheme by comparison is ranked 1 (worst) in the metric of job creation. (This is in the context of MIC-URBAN development statuses).

A row of total scores is then used to sum each aid type's rankings in the development status context when a particular indicator set is used. These are represented graphically in the bar chart below shown as the Indicator Set Value (the coloured series). A grey series above this represents the total score of the aid type across all indicator sets (Economic, Environmental, Social and Transformational Change).

The 'wheel' graph on the left hand side indicates how the Aid Type specified in the Aid Type Sub-Analysis input impacts contributing to the Millennium Development Goals. This is calculated by multiplying the rankings for all metrics by those metrics which correspond to an MDG. For example, Job creation: Total number of jobs created/£m metric overlaps with MDG targets 1a and 1b (among others), which are to do with poverty reduction. Heavy rail, in this example, scores mid-range (4) in that metric so that contributes to the MDG Impact Assessment for the End Poverty

and Hunger goals. The fact that is coloured a middle-ranged colour on the MDG Impact Assessment wheel, indicates that Heavy Rail has a larger impact in other MDG goals than in ending poverty and hunger.

The colours on the MDG Impact Assessment wheel are determined as follows. The individual scores for each MDG target (1a, 1b, 1c etc) are ranked against each other, with a corresponding percentile given according to the figure below.



Appendix B Technology Summaries

RENEWABLE ENERGY TECHNOLOGIES

(BAU)

The Business As Usual (BAU) scenario in the context of Renewable Energy aid is assumed to be the electrification of an area using the least-cost (fossil fuel) option specific to that particular region. This is likely to be a diesel generator for off-grid applications and connection with a 'brown' (fossil fuel majority) mix for grid-connected applications.

P۷

Photovoltaics (PVs) are semiconductors that convert sunlight into electricity. They work optimally in direct sunlight at efficiencies of around 13% although they bear significant costs. PVs can be used on standalone, off-grid applications or can be grid-connected which may include provision for export of excess solar electricity to the grid at a premium, if such a tariff structure exists. Grid-connected solutions tend to off better energy security (with the back up being the grid) but do not lend themselves to reducing fuel poverty in rural areas where the grid may not extend.

In the context of aid delivery within the tool, PV is assumed to be a range of sizes applicable at the small- (building), medium- (community), and large- (utility) scale.

CSP

Concentrating Solar Power (CSP) uses mirrors to reflect sunlight to a working fluid that heats up to produce steam which can be used to drive a turbine for electricity generation. CSP is typically deployed at the utility- and multimegawatt scale only, usually in locations of adequate land area. Being grid-connected, CSP systems aid in the renewable electrification of a grid and therefore is not biased towards either rural or urban areas.

Wind

Wind turbines generate electricity by harnessing wind to drive an alternator that produces electricity. They can be deployed in a range of scales, from building-mounted turbines (generally less than 15kW in size) to mid-sized turbines (200kw, 24m diameter) to large-scale multi-megawatt turbines (<5MW), the latter of which are usually situated offshore. In the context of aid delivery within the tool, Wind is assumed to be a range of sizes for either building or community-scale use.

Biomass

Biomass in the context of aid delivery is taken to pertain to using a renewable feedstock of wood-based fuels for combustion in order to generate electricity. These are typically scalable in size but most practicable for building- and community-sized applications.

Geothermal

Geothermal energy occurs due to the radioactive decay of particles within the earth's core. This releases heat that can be extracted in the form of hot water through sub-surface aquifers. The hot water, when reaching the surface, reduces in pressure to produce steam which can be used to drive a turbine for electricity generation. Geothermal wells can be either naturally occurring or be stimulated by pumping water down.

In the context of aid delivery within the tool, Geothermal is assumed to be employed at the utility-scale.

Hydro

Hydropower can be employed at both the small-scale as well as very large-scale for electricity generation. The natural flow of running water is harnessed in order to turn turbines for electricity generation.

In the context of aid delivery within the tool, hydropower can be assumed to be either employed at the small or large scales. However, it should be considered that when utilised on a large scale, the environmental impacts can be inflated due to the volume that may be required for a large reservoir, to name one example.

B CHP

Biomass Combined Heat and Power (B CHP) uses a renewable feedstock of wood-based fuel for combustion to both generate electricity and utilise waste heat that is generated. The best application of this typically tends to be in urban areas where heat can be shared with minimal losses.

SUSTAINABLE TRANSPORT SOLUTIONS

BAU

The Business As Usual scenario for Sustainable Transport refers to the least-cost option for provision of transportation to a region; usually through use of private vehicles.

Heavy Rail

In the context of aid delivery, Heavy Rail refers to the deployment of standard-gauge rail infrastructure for both freight and passenger movements. This can be used in connecting ind

LRT

Light Rapid Transport (LRT) is typically seen in urban and suburban areas in cities with a reasonable transport infrastructure in place.

Metro

Aid in the form of contribution to the development of a Metro/Subway/Underground system is assumed to increase the provision for public transport ridership and would be most applicable in dense urban areas.

BRT

Bus rapid transit systems are designed as a low cost mass transit system popularised in the cities of Bogota and Curitiba in particular. Raised platforms provide access to express bus ways which are networked across the city. Capacity is not quite as high as a subway system however the cost of infrastructure is much more affordable and therefore the service is more accessible to the poor.

Local Bus

Local Bus services can displace many journeys through the informed design of transport routes, linking nodes and hubs of commercial and residential activity. In addition, Local Bus services disproportionately improve access for poorer and more rural populations. As a result, the provision of Local Bus services is a common feature of both aid delivery for the purposes of economic uplift as well as curtailment of environmental impacts.

Electric/FC Vehicles

Although many private vehicle journeys can be displaced through aid in the form of mass transit schemes, those journeys for which private vehicle use is still desired/required can be mitigated through delivering aid that results in the increased uptake of Electric or Fuel Cell (FC) Vehicles. Electric Vehicles are an emerging technology which charges a battery when connected to a power supply. Limitations in battery storage general requires that the provision of electric charging points must be dense which implies better utility for urban and suburban areas. Fuel Cell Vehicles are also an emerging technology and requires considerable logistical support. As such, both types of vehicles currently only share a significant market penetration in developed countries. Both types of technology aid should not be viewed in isolation but as part of a transformational change in the transport infrastructure such as the logistical chain required to support a fleet of Electric/FC Vehicles.

LEVs

Low emitting vehicles (LEVs) can displace conventional petrol and diesel vehicles to a greater degree than electric and fuel cell vehicles can because of the simpler technology. That said, the availability of LEVs in low and middle income countries can be inadequate to create a self-sustaining sector of the automotive industry. Furthermore, lax

vehicle performance regulations as well as lack of affordable spare parts (resulting in the cannibalisation of other vehicle components) may compound the struggles of LEVs at diverting a significant section of the private vehicle sector from conventional petrol and diesel vehicles.

Cycle Schemes

Delivering aid in the form of cycle schemes in the tool is assumed to encompass a range of measures such as capital for cycle purchase or aiding in cycle infrastructure, for example. Aid in the form of cycle schemes tend to have a spatially limited impact, given that journeys will almost exclusively be for short distance use. This can be useful in certain rural applications but would have a greater impact in dense urban areas where other forms of transport could be avoided for local journeys.

ENERGY EFFICIENCY

(BAU)

The Business As Usual scenario in the context of Energy Efficiency and Low Carbon Technology is assumed to be the policies adopted, if any, by local, provincial or national legislation pertaining to energy use for a specific technology.

Passive Design

Passive Design pertains to maximising the use of natural resources (light, heat and cooling) for the conditioning of healthy and comfortable buildings. Some of the features, for example would be glazing elements such as louvers to reduce solar insolation (for overheating), use of heavy materials (to provide internal cooling through absorption of heat), optimised glazing to maximise sunlight yet prevent excessive heat gains. These measures are typically incorporated at the design stage, requiring the skills of architects and engineers and, depending on site context, may reduce energy demands by upto 30%. As a region sought to develop housing and infrastructure as a result of economic prosperity, the incorporation of passive design measures would become more important as a new building stock was brought online.

Insulation

Insulation in the context of the tool refers to optimisation of a building's external walls, floors and roof. In a hot climate, this would be to prevent the penetration of warmth from the outside in, and in a cold climate, prevent the conduction of heat from the inside out. In certain countries which have access to affordable natural gas, such as certain Central Asian states, the provision of aid in the form of insulation may not compare with the availability of a cheap source of fuel, so site consideration is necessary when using the tool for project evaluation.

Lighting

Lighting accounts for a approximately 15% of a building's energy consumption yet aid delivery in the form of alternative Low Carbon Technology (such as LEDs) and Energy Efficient measures (such as daylighting) could reduce this significantly.

HVAC

Heating, Ventilation and Air Conditioning (HVAC) refers to the units and systems that provide these conditioning services for buildings. HVAC systems are often over-sized for the particular requirements of a building and so environmental and cost savings can be made by reducing these in size or through the purchase of more efficient or alternative systems. Delivering aid in the form upgrading HVAC equipment can have significant impacts on environmental and economic metrics.

Plant efficiency

As with HVAC, plant efficiency refers to to the units and systems that provide conditioning services for buildings but specifically refers to the behaviour in operating and managing the use of such equipment. The tool represents the

changes made to plant efficiency in order to operate at parameters close to maximum efficiency or with intelligent usage.

Appliances

Delivering aid in the form of Energy Efficient and Low Carbon appliances can reduce domestic and commercial energy consumption through items such as microwaves, televisions, computers etc. As economic prosperity improves, an increase in the availability of electronic and electrical goods will benefit disproportionately from aid that is designed to drive energy efficiency in these products.

Behavioural

Behaviour can have a significant impact on the usage of energy and natural resources but in middle- and low-income countries, scope for much further improvement may be tempered by the fact that efficient behaviour usually bears least cost for fuel consumption and so will be in practice anyway.

In the tool, delivering aid through the promotion of efficient practices can be applied to an educational context (which would affect curriculum in urban and local areas equally) or a localised programme focusing on a particular energy use scenario.

District Infrastructure

District Infrastructure as defined in the tool refers to the engineering equipment, design and support services required for the sharing of heat and electricity in a localised context. This enables users who do not require to electricity or heat during particular times (domestic users during the day, say) to redistribute electricity and heat to users which would require it (such as commercial users).

Gas CHP

Delivering aid in the form of Gas-fired Combined Heat and Power (CHP) refers to the infrastructure necessary to support such a power plant to utilise heat from gas combustion for electricity and deliver that locally. This can be a very efficient way of recovering energy from an otherwise inefficient process but depends on the demand for heat close to a gas generator. Siting of the generator should also be considered; if it is far away from users of waste heat then there may be little scope for the implementation of Gas CHP.