Contents

Executive Summary

Acronyms and Abbreviations

1 Introduction........................................................................................................................1

2 Background........................................................................................................................3

3 Sub-Saharan Africa...........................................................................................................13

4 Engineering Capacity Building........................................................................................17
   4.1 Definitions from the Literature..................................................................................17
   4.2 Definitions from Interviews and Emailed Responses................................................24
   4.3 Measuring Engineering Capacity Building...............................................................28
   4.4 Key Issues and Priority Areas Identified in the Literature ........................................31
   4.5 Key Issues and Priority Areas Identified from Interviews and Emailed Responses 35

5 Action by other Organisations..........................................................................................40
   5.1 Initiatives Supporting Capacity Building in Africa...................................................40
   5.2 Measuring the Impact of Initiatives..........................................................................46

6 Possible Action by The Royal Academy of Engineering..................................................47
   6.1 Suggestions from Respondents..............................................................................47
   6.2 Scenarios of Possible Action....................................................................................51

7 Conclusions......................................................................................................................54

Appendix A: Details of Meetings, Telephone Conversations and Email Responses

Appendix B: Interview Guide and Opening Questions to Prompt Discussion

Appendix C: Draft Outline Project Proposal by UNESCO for an International Study on Capacity and Capacity Building in Engineering and Technology

References
Executive Summary

The extreme poverty in Sub-Saharan Africa, the poorest region of the world, has recently been brought to the forefront of international attention. Recognising the need for action, The Royal Academy of Engineering is seeking to establish how it can best contribute to the achievement of the United Nations’ Millennium Development Goals.

By means of a literature review, interviews and correspondence, this pilot study has investigated the concepts of engineering capacity building and Sub-Saharan Africa, identified initiatives being undertaken by other organisations and compiled suggestions as to possible action by The Royal Academy of Engineering.

There are no explicit references to engineering or infrastructure in the Millennium Development Goals, but it is widely acknowledged that both are necessary, although not sufficient, for meeting the goals and for ongoing growth and development. Science and technology have been the focus of several recent initiatives and studies, and definitions of science capacity abound. In contrast there is little written about the role of engineering in poverty alleviation and so a definition of engineering capacity is proposed as follows:

Engineering capacity is the knowledge and experience of people who have access to suitable physical engineering resources to achieve whatever engineered facility is required by their community.

Key issues and priority areas that have been identified as follows: corruption and lack of governance; adopting appropriate standards; ensuring the integration of social, economic and environmental factors in engineering solutions; improving engineering education; encouraging innovation and entrepreneurship; stemming the ‘brain drain’; and ensuring development is sustainable. It is suggested that when discussing engineering capacity building this should not be limited to professional engineers alone. It is also evident that there is a priority, in addressing poverty, for work undertaken by civil engineers; however the work of other branches of engineering is vital for the generation of economic growth and continued development.

Engineering capacity is not currently measured in Africa and there is no consensus on how it could be measured or how the impact of initiatives might be assessed. There is a need for studies to quantify or describe the current situation, and for high-level thinking to establish consensus on how the Millennium Development Goals might be met and to subsequently shape policy.

Several science academies, learned societies and professional institutions are taking action and a number of non-governmental organisations in the UK are engineering-based and committed to work for the alleviation of poverty in the developing world. However it has been suggested that the work is fragmented and lacks leadership.

Suggestions for action by The Royal Academy of Engineering have been compiled into three scenarios described as: low risk, low impact; medium risk, medium impact; and high risk, high impact. To capitalise on the position and resource of the Fellowship of The Royal Academy of Engineering, and to make a measurable contribution to the achievement of the
Millennium Development Goals, it is suggested that an approach corresponding to the scenario described as high risk, high impact will be necessary.
Acronyms and Abbreviations

AAS  African Academy of Sciences
AAU  Association of African Universities
ACU  Association of Commonwealth Universities
ADF  African Development Fund
ADP  Institution of Civil Engineers’ Appropriate Development Panel
AEF  African Engineers Forum
AfDB  African Development Bank
AIMS  The African Institute for Mathematical Sciences
AIST  African Institute of Science and Technology
AU  African Union
CAETS  Council of Academies of Engineering and Technological Science
CCLRC  The Council for the Central Laboratory of the Research Councils
DFID  Department for International Development
EAP  Engineers Against Poverty
EFN  Engineering Forum of Nigerians
ESW  Engineers for a Sustainable World
EVI  Economic Vulnerability Index
EWB  Engineers Without Borders
EU  European Union
FCO  Foreign and Commonwealth Office
G8  Group of Eight Nations
GDP  Gross Domestic Product
GNI  Gross National Income
H&S  Health and Safety
HAI  Human Assets Index
HIPC  Highly Indebted Poor Countries
ICE  Institution of Civil Engineers
IDA  International Development Association
IMF  International Monetary Fund
IStructE  Institution of Structural Engineers
KIST  Kigali Institute of Science, Technology and Management
LDC  Least Developed Countries
LMIC  Lower Middle Income Countries
MDG  Millennium Development Goal
NASAC  The Network of African Science Academies
NEPAD  New Partnership for Africa’s Development
NGO  Non-governmental organisation
NMI  The Nelson Mandela Institute for Knowledge Building and the Advancement
      of Science and Technology in Sub-Saharan Africa
OAU  Organisation of African Unity
ODA  Official Development Assistance
OECD  Organisation for Economic Co-operation and Development
OLIC  Other Low Income Countries
PRSP  Poverty Reduction Strategy Paper
R&D  Research and Development
RedR  Engineers for Disaster Relief
S&T  Science and Technology
SAICE  South African Institution of Civil Engineering
| Acronym | Description |
|---------|-------------|
| SET     | Science, Engineering and Technology |
| TWAS    | Third World Academy of Sciences |
| UMIC    | Upper Middle Income Countries |
| UN      | United Nations |
| UNAIDS  | Joint United Nations Programme on HIV/AIDS |
| UNDP    | United Nations Development Programme |
| UNESCO  | United Nations Educational, Scientific and Cultural Organization |
| UNFPA   | United Nations Population Fund |
| UNICEF  | United Nations Children’s Fund |
| UNIDO   | United Nations Industrial Development Organization |
| USHEPiA | University Science, Humanities and Engineering Partnerships in Africa |
| WFEO    | World Federation of Engineering Organizations |
| WHO     | World Health Organisation |
1 Introduction

As Britain’s national academy for engineering, The Royal Academy of Engineering brings together the UK’s most eminent engineers from all disciplines to promote excellence in the science, art and practice of engineering. The Academy’s leadership role derives from its Royal Charter supported by its peer-elected multidisciplinary engineering Fellowship who come from leading positions in industry, academia and public service.

In line with the fourth of its strategic objectives, namely “To develop the ability of the Academy to make an impact” The Royal Academy of Engineering has undertaken to establish how best it can support capacity building in developing countries by the end 2006; complete consultation and funding case by end 2007; and roll out a pilot programme between 2008 and 2010 (The Royal Academy of Engineering, 2005:12-13). To this end, The Royal Academy of Engineering has commissioned a pilot study to investigate engineering capacity building in Sub-Saharan Africa, with terms of reference as follows:

1. Define what is meant by ‘engineering capacity’ in the context of Sub-Saharan Africa and how any relative increases could be measured.

2. Identify which countries make up Sub-Saharan Africa and assess the current levels of engineering capacity in each of these countries.

3. Establish and review comparable projects which are underway or recently completed by other organisations in the UK and EU. Highlight notable additional studies elsewhere in the world.

4. Review the key issues identified by others (in 3 above), in the context of engineering capacity building. Recommend priority areas for attention by The Royal Academy of Engineering.

5. Draw up proposals for how The Royal Academy of Engineering could practically support the enhancement of engineering capacity in developing countries.

6. Identify which countries in Sub-Saharan Africa would benefit most from these initiatives.

7. Assess how the impact of these initiatives could be measured over suitable time scales.

The aim of the study is to provide an evidence base for decisions by The Royal Academy of Engineering as to what action could best be taken to contribute to poverty reduction and the achievement of the United Nations’ Millennium Development Goals. The study has been undertaken in three stages: a review of the literature and secondary references; qualitative interviews with experts and practitioners; and analysis of interviews and preparation of this project report.

Potential interviewees were selected by means of the literature review, from responses from an initial enquiry email sent to the Fellowship of The Royal Academy of Engineering, and suggestions by Fellows. Some additional names were added to the list as interviews
progressed upon the suggestions of interviewees. Twenty people were contacted by letter requesting an interview (of whom five are Fellows of The Royal Academy of Engineering). Twenty-five people were contacted by email requesting responses to a series of questions either by email or telephone (of whom four are Fellows of The Royal Academy of Engineering). Generally the latter group were based outside the UK. Interviews were held with twenty-four people, telephone interviewees with four people and email responses were received from eight people (who were not also interviewed). This gives an extremely high response rate of 80%\(^1\) reflecting the regard in which The Royal Academy of Engineering is held, and the eagerness of organisations working in the area of science, technology, engineering and development to see The Royal Academy of Engineering take action in this area.

Details of the interviews and emailed responses are set out in Appendix A, and are summarised in Table 1.1. Twelve of the interviewees/correspondents are civil engineers; four are mechanical engineers; one is a mechanical/electrical engineer; one is a materials engineer; one is a chemical engineer; eleven are of other professions; and the profession of six of the interviewees/correspondents is not known.

| Interviews | Telephone Interviews | Email Responses |
|------------|----------------------|-----------------|
| NGO        | British | African | Other | British | African | Other | British | African | Other |
| Government | 7       |         |       |         |         |       |         |         |       |
| Academia   | 5       | 2       | 1     |         |         |       |         |         |       |
| Industry   | 1       | 1       | 1     |         | 1       | 1     |         | 3       | 2     |
| Intergovernmental | 1       |         |       |         |         |       |         |         |       |
| Learned Society | 1       |         |       |         |         |       |         |         |       |
| Total      | 17      | 3       | 3     | 1       | 1       | 1     | 3       | 4       | 1     |

Table 1.1: Summary of the Nationality and Type of Organisation Represented by Respondents

An interview guide was prepared to give structure to the interviewing process (Appendix B). The questions do not comprise a formal survey, but rather a set of themes to explore. A similar list of questions (Appendix B) was sent to those people contacted by email, to prompt discussion. Notes were taken during interviews and telephone calls and summaries prepared immediately afterwards. Analysis of the notes from interviews and emailed responses has been aided by the use of QSR N6 software, which allows the storage and manipulation of non-numeric, textual data.

The study has been undertaken by Dr Helen Bartlett CEng MICE, with guidance from Prof Peter Guthrie OBE FReIng FICE FCGI.

The findings of the pilot study were presented to the International Committee of The Royal Academy of Engineering on 25 April 2006.

\(^1\) The response rate of 80% is calculated, in accordance with standard practice, by dividing the number of people initially contacted by the number of interviews/correspondence generated. There were 30 responses from the 45 people initially contacted, giving a ‘true’ response rate of 67%.
2 Background

As African countries commenced the path to independence in the 1950s and 60s there was great optimism. Meredith (2005:141-2) writes:

African leaders riding the crest of popularity, stepped forward with energy and enthusiasm to tackle the tasks of development and nation building; ambitious plans were launched […]. Expectations were high […]. The circumstances seem auspicious. Independence came in the midst of an economic boom […] public debt was low; foreign currency reserves in many cases were relatively high. Moreover western governments stood ready to provide substantial amounts of aid [and…] given the extent of the vast mineral resources that Africa was known to posses […] the potential for economic development seemed enormous.

However, some fifty years later, Sub-Saharan Africa is the poorest region of the World. Of fifty countries defined as Least Developed Countries (LDCs) by the United Nations (UN), thirty-six are African (Table 2.1). Gross National Income (GNI) per capita ranges from US$90 to US$7,350 in African countries (Table 2.2), averaging just US$860 (including north African countries and South Africa), US$506 (excluding north African countries), and US$342 (excluding north African countries and South Africa). This compares with averages for the developing regions of South Asia and Latin-America and the Caribbean of US$590 and US$ 3,600 respectively (World Bank, 2005b). In their paper How Have the World’s Poor Fared Since the Early 1980s?, Chen and Ravallion (2004) identify that:

Sub-Saharan Africa has emerged as the region with the highest incidence of extreme poverty and the greatest depth of poverty […]. Looking back to 1981, East Asia was the region with the highest incidence of extreme poverty in the world […] South Asia had the next highest poverty rate followed by Sub-Saharan Africa, Latin America, Middle-East and North Africa and lastly Eastern Europe and China. Twenty years later, Sub-Saharan Africa has swapped places with East Asia. […] The number of poor has almost doubled in Sub-Saharan Africa over 1981-2001 from 164 million to 316 million. The share of the world’s poor in Africa has risen from 11% in 1981 to 26% in 2001.

The half-century of independence has been blighted by natural disasters, brutal wars, dictatorships, and the impacts of the Cold War. The causes of ongoing poverty in Africa are often attributed to poor governance, colonial legacy and western political interference (Mistry, 2005). Differences between development in Africa and development in Asia have been attributed to: conflicts in Africa; African infrastructure linking areas of extraction to ports rather than linking regions; division of Africa into countries along inappropriate lines; the emergence of African countries from the colonial era with weaker governance structures than Asia; Africa’s lack of investment in irrigation, rural roads and power; Asia’s diversification away from primary commodities; and the development in Asia of industrial infrastructure, skills and a learning culture (Commission for Africa, 2005:26). Sachs (2005:190-6) writes:
Both the critics of African governance and the critics of western violence and meddling have it wrong. Politics, at the end of the day, simply cannot explain Africa’s prolonged economic crisis […]. The unsolved challenge for development economists is to understand why economic development in Africa has been so hard to achieve, not just in modern times but for centuries, and not in some places but in virtually all of tropical Africa. […] Although predatory government can soundly trounce economic development, good governance and market reforms are not sufficient to guarantee growth if the country is in a poverty trap […]. What then [can] be done for such places where the struggle against poverty and disease [is] more elemental than choices about privatization, budget deficits, or trade policies? To understand […] such crisis, it [is] necessary to unravel the interconnections between extreme poverty, rampant disease, unstable and harsh climate conditions, high transport costs, chronic hunger and inadequate food production.

Easterly (2001) in his book *The Elusive Quest for Growth* describes how investment, education, population control, adjustment lending, and debt forgiveness have all been considered to be panaceas for growth, but all have failed. Easterly attributes the failure to lack of incentive and writes that the “way forward must be to create incentives for growth for the trinity of governments, donors and individuals” (Easterly, 2001:293). Others have attributed the lack of development in Africa to geographical and geological aspects. In a discussion after a meeting of the Parliamentary and Scientific Committee meeting on the importance of Science, Engineering and Technology to a sustainable economy on the African continent, it was noted that “the overall environmental fragility of the African environment is due to the underlying granitic rocks which weather to barren silica sands forming a dustbowl, compared with India which is mainly underlain by basaltic lavas which weather to release essential nutrients to the soil” (Tickell et al., 2006:29).

The approach to development in the 1970s and 1980s has been described as the Washington Consensus, a term coined by Williamson (1999). It focused on trade liberalization, tax reform, privatisation, and deregulation. Chang (2002), amongst others, is highly critical of such approaches and the structural adjustment programmes of the 1970s and 1980s are recognised to have “provided only a partial solution. They prompted reforms that tended to remove serious price distortions, but gave inadequate attention to the provision of social services. Consequently only a few countries managed to achieve sustainable higher growth under these programmes” (NEPAD, 2001:5). The Washington Consensus has now been replaced by what is described by Maxwell (2005) as “the meta-narrative” which:

*emphasises the millennium development goals (MDGs) as an overarching framework, and lays out the link between the MDGs, nationally owned poverty reduction strategies, macro-economic policy (including trade), effective public expenditure management, and harmonised aid in support of good governance and good policies.*

Maxwell (2005:v)

Porteous (2005:282) explains that “although the macroeconomic prescriptions of structural adjustment were not abandoned, the new headlines of the development agenda became poverty reduction, governance reform and debt relief”
At the UN Millennium Assembly in September 2000 a Millennium Declaration was adopted by 189 Member States: “it constituted an unprecedented promise by world leaders to address, as a single package, peace, security, development, human rights and fundamental freedoms” (Annan, 2005). The Declaration included eight Millennium Development Goals (MDGs) to be achieved by 2015 (Box 2.1) and since their launch, the MDGs have formed the focus of most development initiatives.

| Goal 1: Eradicate extreme poverty and hunger |
| Goal 2: Achieve universal primary education |
| Goal 3: Promote gender equality and empower women |
| Goal 4: Reduce child mortality |
| Goal 5: Improve maternal health |
| Goal 6: Combat HIV/AIDS, malaria and other diseases |
| Goal 7: Ensure environmental sustainability |
| Goal 8: Develop a global partnership for development |

*Box 2.1: The United Nations’ Millennium Development Goals (http://www.un.org/millenniumgoals/)*

Targets and Indicators for each goal have been established (Table 2.3) (UN Secretary General, 2001). However, progress towards them has been slow. A review of advancement towards the MDGs by the UN (2005:4-5) states:

Global poverty rates are falling, led by Asia. But millions more people have sunk deep into poverty in Sub-Saharan Africa, where the poor are getting poorer […]. Since 1990, millions more people are chronically hungry in Sub-Saharan Africa and in Southern Asia where half the children under age 5 are malnourished. […] In Sub-Saharan Africa fewer than two thirds of children are enrolled in primary school […] AIDS has become the leading cause of premature death in Sub-Saharan Africa […] ninety percent of malaria deaths occur in Sub-Saharan Africa […]. To achieve the Millennium Development Goals increased aid and debt relief must be accompanied by further opening of trade, accelerated transfer of technology and improved employment opportunities.

To invigorate action to meet the MDGs, the UN launched a new Millennium Project in 2001 “commissioned by UN Secretary-General Kofi Annan to develop a practical plan of action to meet the Millennium Development Goals. As an independent advisory body directed by Professor Jeffrey Sachs, the UN Millennium Project submitted its recommendations to the UN Secretary-General in January 2005” (Juma and Lee, 2005). The work was organised into ten task forces (Box 2.2), “bringing together major thinkers, practitioners, policy experts, and other stakeholders” (Sachs, 2005:223).
Also in 2001, African leaders pledged to commit themselves to eradicate underdevelopment by means of the New Partnership for Africa’s Development (NEPAD): “the strategic framework document arises from a mandate given to the five initiating Heads of State (Algeria, Egypt, Nigeria, Senegal, South Africa) by the Organisation of African Unity (OAU) to develop an integrated socio-economic development framework for Africa” (NEPAD, 2006). NEPAD is “envisaged as a long-term vision of an African-owned and Africa-led development programme” (NEPAD, 2001:13). The document states:

While growth rates are important, they are not by themselves sufficient to enable African countries to achieve the goal of poverty reduction. The challenge for Africa, therefore, is to develop the capacity to sustain growth at levels required to achieve poverty reduction and sustainable development. This in turn, depends on other factors such as infrastructure, capital accumulation, human capital, institutions, structural diversification, competitiveness, health, and good stewardship of the environment […]. The new long term vision will require massive, heavy investment to bridge existing gaps. The challenge ahead for Africa is to be able to raise the required funding under the best conditions possible. We therefore call on our development partners to assist us in this endeavour.

(NEPAD, 2001:13)

The goals of NEPAD are to achieve and sustain an average Gross Domestic Product (GDP) growth rate of over 7% per annum for the next 15 years; and to ensure that the continent achieves agreed international development goals (NEPAD, 2001:14).

---

2 In 2001 the Organisation of African Unity (OAU) was replaced by the African Union (AU): “whereas the OAU was required by charter to refrain from interference in individual states, the African Union was given the right to ‘restore peace and stability’ to ‘prevent war crimes, genocide and crimes against humanity’; and respond to ‘a serious threat to legitimate order’” (Meredith, 2005:680). The members of the AU have established an African Peer Review Mechanism.
British Prime Minister Tony Blair has a great concern for Africa and has brought the continent to the forefront of international attention: “from 2000 onwards Blair started to promote Africa’s causes at international gatherings, starting with the G8 summit in Genoa in 2001. He appointed a special advisor to deal with Africa in No. 10 and let it be known that Africa would be a priority of his second term” (Porteous, 2005:289). Hilary Benn MP, Secretary of State for International Development, has stated:

There has never been a time, in my political experience, when this debate about Africa, poverty, its causes and what we can do about it has been so much at the centre of our politics. It seems to me that the message that we are being sent by those we represent is very simple: they look to us to act and they want to have faith in the capacity of the political process to deliver real change on behalf of Africa and of development. It is morally unacceptable that this great continent of 54 countries, only a few miles from Europe, should drift away from us and should be the only part of the world to become poorer in the last 25 years.

(Benn, 2005)

In February 2004 Blair launched a Commission for Africa “to respond to positive changes taking place on the continent, such as the leadership shown by the AU and NEPAD, and also seize on the political and symbolic opportunity that 2005 presented to make a difference for Africa” (Commission for Africa, 2006), with five objectives:

1. To generate new ideas and action for a strong and prosperous Africa, using the 2005 British presidencies of the G8 and the European Union as a platform;

2. To support the best of existing work on Africa, in particular the New Partnership for Africa's Development (NEPAD) and the African Union, and help ensure this work achieves its goals;

3. To help deliver implementation of existing international commitments towards Africa;

4. To offer a fresh and positive perspective for Africa and its diverse culture in the 21st century, which challenges unfair perceptions and helps deliver changes; and

5. To understand and help fulfil African aspirations for the future by listening to Africans

(Commission for Africa, 2006)

The title, Our Common Interest, given to the Report reflects the premise on which it is written: that northern nations have more than a moral obligation to act; it is in their interest because there are assumed to be links between poverty and global security. The Commission reported in early 2005, and made recommendations in relation to improving governance, achieving peace and security, investments in health and education, investments in infrastructure and agriculture for economic growth and changes to facilitate trade. The report calls for an additional US$25 billion per year in aid, rising to an additional US$50 billion per
year by 2015 and implores rich nations to commit 0.7% of their annual income to aid (Commission for Africa, 2005). The report notes that the timing of aid increase must be carefully considered because of the lack of capacity in Africa: “to attempt to give extra aid faster [than set out in the report] would not be sensible because [at present] Africa does not have the capacity to handle it effectively” (Commission for Africa, 2005:57).

Blair also placed Africa at the top of the agenda for the UK’s Presidency of the G8 in 2005. In the Gleneagles Communiqué, produced at the end of the G8 summit in July 2005, the leaders of the G8 nations set out a renewed commitment to Africa and “a set of further measures designed to help Africa build the successful future all us want to see” (G8 Leaders, 2005). The measures are aimed at: addressing peace and security; promoting good and responsive government; investing in people and promoting growth. The Communiqué commits to increasing aid, in line with the recommendation of the Commission for Africa, and to cancelling 100% of outstanding debts of the Heavily Indebted Poor Countries to the International Monetary Fund (IMF), International Development Association (IDA) and African Development Fund (ADF) (G8 Leaders, 2005). In April 2006, on a visit to Mozambique, the Chancellor Gordon Brown, committed to spending more than $15bn over ten years to address, as part of the commitments made at Gleneagles, the MDG of primary education for all children by 2015 (Russell, 2006).

The Department for International Development (DFID) is currently preparing a White Paper on international development: “setting out a plan for how the UK government can translate the promises of 2005 into better lives for people in poor countries” (DFID, 2006). Consultation for the White Paper took place during early 2006.

The Make Poverty History campaign has also been instrumental in bringing attention to the problems of poverty. The campaign continues to call for an end to unjust global trade systems, the cancellation of debts for the poorest nations, and for aid to be more sufficient and effective (Make Poverty History, 2006).

It is in the context of the recognition of the need for urgent action for Africa, and the commitments to action by the UK government, that The Royal Academy of Engineering is seeking to establish how it can best contribute to the reduction of poverty, and the achievement of the Millennium Development Goals. The Royal Academy of Engineering has decided to focus on Sub-Saharan Africa and engineering capacity building. These concepts are explored in Sections 3 and 4 of this paper. Section 5 then provides a summary of action by other organisations. Finally suggestions as to how The Royal Academy of Engineering might take action are set out in Section 6.

While the increase in political attention to Sub-Saharan Africa is welcome and timely, and the raised public consciousness hugely beneficial to early actions being taken, political will and public focus have the tendency to shift over time. The engagement of such bodies as The Royal Academy of Engineering provides a structure and mechanism for continued action albeit in a specific area of concern. The Academy should therefore only enter this arena if it can reasonable commit to a long-term involvement.
| Country                              | Population 2002 (millions) | Per Capita Gross National Income (GNI) (US dollars) | Human Assets Index (HAI) | Economic Vulnerability Index (EVI) |
|-------------------------------------|----------------------------|---------------------------------------------------|-------------------------|----------------------------------|
| Afghanistan                         | 23.3                       | 523                                               | 11.6                    | 50.1                             |
| Angola                              | 13.9                       | 447                                               | 23.6                    | 48.5                             |
| Bangladesh                          | 143.4                      | 363                                               | 45.3                    | 22.9                             |
| Benin                               | 6.6                        | 367                                               | 40.2                    | 57.0                             |
| Bhutan                              | 2.2                        | 600                                               | 40.4                    | 40.6                             |
| Burkina Faso                        | 12.2                       | 217                                               | 26.5                    | 49.3                             |
| Burundi                             | 6.7                        | 110                                               | 19.7                    | 53.8                             |
| Cambodia                            | 13.8                       | 263                                               | 44.5                    | 49.7                             |
| Cape Verde                          | 0.4                        | 1323                                              | 72.0                    | 55.5                             |
| Central African Republic            | 3.8                        | 277                                               | 29.9                    | 43.1                             |
| Chad                                | 8.4                        | 203                                               | 26.1                    | 59.2                             |
| Comoros                             | 0.7                        | 387                                               | 38.1                    | 59.1                             |
| Democratic Republic of the Congo    | 53.4                       | 100                                               | 34.3                    | 40.8                             |
| Djibouti                            | 0.7                        | 873                                               | 30.2                    | 48.6                             |
| Equatorial Guinea                   | 0.5                        | 743                                               | 47.2                    | 64.4                             |
| Eritrea                             | 4.0                        | 190                                               | 32.8                    | 51.1                             |
| Ethiopia                            | 66.0                       | 400                                               | 25.2                    | 42.0                             |
| Gambia                              | 1.4                        | 340                                               | 34.0                    | 60.8                             |
| Guinea                              | 8.4                        | 447                                               | 30.3                    | 42.1                             |
| Guinea-Bissau                       | 1.3                        | 170                                               | 31.2                    | 64.6                             |
| Haiti                               | 8.4                        | 493                                               | 35.3                    | 41.7                             |
| Kiribati                            | 0.1                        | 923                                               | 67.5                    | 64.8                             |
| Lao People’s Democratic Republic    | 5.5                        | 297                                               | 46.4                    | 43.9                             |
| Lesotho                             | 2.1                        | 573                                               | 45.4                    | 44.2                             |
| Liberia                             | 3.3                        | 285                                               | 38.7                    | 63.1                             |
| Madagascar                          | 16.9                       | 253                                               | 37.9                    | 21.6                             |
| Malawi                              | 11.8                       | 177                                               | 39.0                    | 49.0                             |
| Maldives                            | 0.3                        | 1983                                              | 65.2                    | 33.6                             |
| Mali                                | 12.0                       | 230                                               | 19.9                    | 47.5                             |
| Mauritania                          | 2.8                        | 377                                               | 38.2                    | 38.9                             |
| Mozambique                          | 19.0                       | 220                                               | 20.0                    | 35.6                             |
| Myanmar                             | 49.0                       | 282                                               | 60.0                    | 45.4                             |
| Nepal                               | 24.2                       | 240                                               | 47.1                    | 29.5                             |
| Niger                               | 11.6                       | 180                                               | 14.2                    | 54.1                             |
| Rwanda                              | 8.1                        | 230                                               | 34.1                    | 63.3                             |
| Samoa                              | 0.2                        | 1447                                              | 88.8                    | 40.9                             |
| Sao Tome and Principe               | 0.1                        | 280                                               | 55.8                    | 41.8                             |
| Senegal                             | 9.9                        | 490                                               | 38.1                    | 38.4                             |
| Sierra Leone                        | 4.8                        | 130                                               | 21.7                    | 47.5                             |
| Solomon Islands                     | 0.5                        | 657                                               | 47.3                    | 46.7                             |
| Somalia                             | 9.6                        | 177                                               | 8.5                     | 55.4                             |
| Sudan                               | 32.6                       | 333                                               | 46.4                    | 45.2                             |
| Tanzania, United Republic of        | 36.8                       | 263                                               | 41.1                    | 28.3                             |
| Timor Leste                         | 0.8                        | 478                                               | 36.4                    | -                                |
| Tuvalu                              | 0.01                       | 1383                                              | 63.7                    | 70.3                             |
| Uganda                              | 24.8                       | 297                                               | 39.8                    | 43.2                             |
| Vanuatu                             | 0.2                        | 1083                                              | 57.4                    | 44.5                             |
| Yemen                               | 19.9                       | 423                                               | 46.8                    | 49.1                             |
| Zambia                              | 10.9                       | 317                                               | 43.4                    | 49.3                             |

Table 2.1: The Current List of Least Developed Countries

(http://www.un.org/esa/policy/devplan/idc03list.pdf)

---

3 Thresholds for inclusion in the list are: population less than 75 million; per capita GNI less than $750; HAI less than 55; and EVI greater than 37. A country must meet all criteria to be included in the list. Thresholds for graduation from the list are: per capita GNI greater than $900; HAI greater than 61; and EVI less than 33. A country must meet at least two criteria to be eligible for graduation from the list.
| Country        | GNI  | Country       | GNI  | Country        | GNI  |
|----------------|------|---------------|------|---------------|------|
| Seychelles     | 7350 | Senegal       | 550  | Uganda        | 250  |
| Mauritius      | 4100 | Sudan         | 460  | Chad          | 240  |
| Botswana       | 3530 | Benin         | 440  | Mozambique    | 210  |
| Gabon          | 3400 | Guinea        | 430  | Niger         | 200  |
| South Africa   | 2920 | Comoros       | 430  | Eritrea       | 190  |
| Tunisia        | 2240 | Kenya         | 400  | Rwanda        | 190  |
| Algeria        | 1930 | Mauritania    | 400  | Malawi        | 160  |
| Namibia        | 1930 | Zambia        | 380  | Sierra Leone  | 160  |
| Cape Verde     | 1440 | Nigeria       | 350  | Guinea-Bissau | 140  |
| Egypt          | 1390 | Sao Tome and Principe | 330 | Liberia | 100 |
| Swaziland      | 1340 | Ghana         | 320  | Congo, Dem Rep | 100 |
| Morocco        | 1330 | Tanzania      | 310  | Burundi       | 90   |
| Djibouti       | 910  | Togo          | 310  | Ethiopia      | 90   |
| Angola         | 760  | Mali          | 300  | Equatorial Guinea | - |
| Cote d’Ivoire, | 660  | Burkina Faso  | 300  | Libya         | -    |
| Congo, Republic| 650  | Madagascar    | 290  | Somalia       | -    |
| Cameroon       | 650  | Gambia        | 270  | Zimbabwe      | -    |
| Lesotho        | 590  | Central African Republic | 270 |            |      |

Table 2.2: Gross National Income per capita, US$, Atlas Method, 2003, African Development Indicators 2005 (World Bank, 2005a).

4 No data available.
| MDG | Goal | Targets | Indicators |
|-----|------|---------|------------|
| 1   | Eradicate extreme poverty and hunger | Halve, between 1990 and 2015, the proportion of people whose income is less than one dollar a day Halve, between 1990 and 2015, the proportion of people who suffer from hunger | Proportion of population below $1 per day Poverty gap ratio (incidence x depth of poverty) Share of poorest quintile in national consumption Prevalence of underweight children (under five years of age) Proportion of population below minimum level of dietary energy consumption |
| 2   | Achieve universal primary education | Ensure that, by 2015, children everywhere, boys and girls alike, will be able to complete a full course of primary schooling | Net enrolment ratio in primary education Proportion of pupils starting grade 1 who reach grade 5 Literacy rate of 15-24-year-olds |
| 3   | Promote gender equality and empower women | Eliminate gender disparity in primary and secondary education, preferably by 2005, and to all levels of education no later than 2015 | Ratio of girls to boys in primary, secondary and tertiary education Ratio of literate females to males of 15-to-24-year-olds Share of women in wage employment in the non-agricultural sector Proportion of seats held by women in national parliament |
| 4   | Reduce child mortality | Reduce by two thirds, between 1990 and 2015, the under-five mortality rate | Under-five mortality rate Infant mortality rate Proportion of 1-year-old children immunized against measles |
| 5   | Improve maternal health | Reduce by three quarters, between 1990 and 2015, the maternal mortality ratio | Maternal mortality ratio Proportion of births attended by skilled health personnel |
| 6   | Combat HIV/AIDS, malaria and other diseases | Have halted by 2015 and begun to reverse the spread of HIV/AIDS Have halted by 2015 and begun to reverse the incidence of malaria and other major diseases | HIV prevalence among 15-to-24-year-old pregnant women Contraceptive prevalence rate Number of children orphaned by HIV/AIDS Prevalence and death rates associated with malaria Proportion of population in malaria risk areas using effective malaria prevention and treatment measures Prevalence and death rates associated with tuberculosis Proportion of tuberculosis cases detected and cured under directly observed treatment short course |
| 7   | Ensure environmental sustainability | Integrate the principles of sustainable development into country policies and programmes and reverse the loss of environmental resources Halve by 2015 the proportion of people without sustainable access to safe drinking water By 2020 to have achieved a significant improvement in the lives of at least 100 million slum dwellers | Proportion of land area covered by forest Land area protected to maintain biological diversity GDP per unit of energy use (as proxy for energy efficiency) Carbon dioxide emissions (per capita) Proportion of population with sustainable access to an improved water source Proportion of people with access to improved sanitation Proportion of people with access to secure tenure |
Develop a global partnership for development

- Develop further an open, rule-based, predictable, non-discriminatory trading and financial system. Includes a commitment to good governance, development, and poverty reduction — both nationally and internationally
- Address the special needs of the least developed countries. Includes: tariff and quota free access for least developed countries’ exports; enhanced programme of debt relief for HIPC countries and cancellation of official bilateral debt; and more generous ODA for countries committed to poverty reduction
- Address the special needs of landlocked countries and small island developing States
- Deal comprehensively with the debt problems of developing countries through national and international measures in order to make debt sustainable in the long term
- In cooperation with developing countries, develop and implement strategies for decent and productive work for youth
- In cooperation with pharmaceutical companies, provide access to affordable essential drugs in developing countries
- In cooperation with the private sector, make available the benefits of new technologies, especially information and communications

| 8 | Table 2.3: Millennium Development Goals, Targets and Indicators (UN Secretary General, 2001) |
|---|---|
| | Net ODA as percentage of OECD/DAC donors’ gross national product (targets of 0.7% in total and 0.15% for LDCs)
| | Proportion of ODA to basic social services (basic education, primary health care, nutrition, safe water and sanitation)
| | Proportion of ODA that is untied
| | Proportion of ODA for environment in small island developing States
| | Proportion of ODA for transport sector in landlocked countries
| | Proportion of exports (by value and excluding arms) admitted free of duties and quotas
| | Average tariffs and quotas on agricultural products and textiles and clothing
| | Domestic and export agricultural subsidies in OECD countries
| | Proportion of ODA provided to help build trade capacity
| | Proportion of official bilateral HIPC debt cancelled
| | Debt service as a percentage of exports of goods and services
| | Proportion of ODA provided as debt relief
| | Number of countries reaching HIPC decision and completion points
| | Unemployment rate of 15-to-24-year-olds
| | Proportion of population with access to affordable essential drugs on a sustainable basis
| | Telephone lines per 1,000 people
| | Personal computers per 1,000 people |
3 Sub-Saharan Africa

Historically Africa was considered, in Europe and the Americas, to be divided into two regions: Arab Africa in the north and Black or Dark Africa in the south (Michigan State University, 2006), terms which are now obsolete and potentially offensive. Nonetheless Africa is still generally considered to be divided into the same two regions, but with names assigned to the regions according to geography rather than culture or race: namely North Africa and Sub-Saharan Africa\(^5\) (or Africa south of the Sahara), although there is no consensus on the suitability of such a division. A writer at Michigan State University (2006) notes:

In the past decade, there has been a growing recognition that the division of Africa into these two regions was created to fit anachronistic cold-war and racialized paradigms of the world that are not viable. While North Africa has a shared Arab heritage which distinguishes it from other regions in Africa, there are social, physical, cultural, and historical connections which unite North Africa with the regions south of the Sahara and makes a stark bifurcation between North and Sub-Saharan Africa untenable. Moreover, a bifurcated regional classification fails to recognize important regional diversity in Africa south of the Sahara.

And Calvocoressi (2001:589) writes

The northern fringe of the African Continent has been made by history a part of the Arab-Islamic civilisation and has been more conscious of affinities with the Middle East than of its ancient economic or current political links with the rest of Africa. Moreover, the European overlordship exercised from Casablanca to Suez through protectorates, unequal treaties, military agreements and direct annexation was different in kind from the colonial empires established by Europeans south of the Sahara. But north Africa is at the same time part of Africa […] Egypt and Morocco have played prominent parts in African affairs and associations; Tunisia had a leading voice in the Congo’s early troubles; Libyan ambitions and arms have troubled not only Central but also West Africa. The desert is no longer the barrier it used to be since the aeroplane and the radio have enable people to transcend it; language is no more a barrier between Arab Africa and Bantu Africa than it is within these two areas; and religion provides points of contact between Muslims and Christians on both sides of the divide. The north, therefore, though still distinct from the rest of the continent in special and enduring ways, will be classed here as more African than Asian, with the sole exception of Egypt.

\(^5\) The Encyclopaedia Britannica (2006) does not include an entry for sub-Saharan Africa, although the term is used in other entries. Instead Africa is divided into five regions: Central (“the region that straddles the equator and is drained largely by the Congo River system”); Eastern (“part of sub-Saharan Africa comprising two traditionally recognized regions: East Africa, made up of Kenya, Tanzania and Uganda; and the Horn of Africa, made up of Somalia, Djibouti, Eritrea, and Ethiopia”); North (“area comprising the modern countries of Morocco, Algeria, Tunisia and Libya”); Southern (“region of the African continent comprising the countries of Angola, Botswana, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, Zambia and Zimbabwe”); and Western (“region lying south of the Sahara and east and north of the Atlantic ocean”).
whose post-war African role has been consistently subordinated to its Asian and not the other way around.

Nonetheless the term Sub-Saharan Africa is widely used in development literature, and generally to specify the poorest nations of the continent. However there are variations in how countries are assigned to the two regions. Table 3.1 identifies, from a list of countries/territories shown in the Times Atlas of the World (The Times, 2004:200) to be a part of the African continent, how various organisation assign countries to Sub-Saharan Africa or non-North Africa.

There is no absolute consensus about the inclusion or otherwise in Sub-Saharan Africa of the following countries, among the sources referenced in Table 3.1:

- Algeria: the WHO includes Algeria in their African region, rather than their Eastern Mediterranean region which includes the other North African countries.
- Djibouti: excluded from Sub-Saharan Africa by the World Bank, UNICEF and the WHO, presumably because of its proximity to the Middle East and the consideration of its ports as Middle Eastern ports.
- Mauritania: included in the Middle East and North Africa region by the Foreign and Commonwealth Office.
- Mauritius: excluded by UNICEF.
- Mayotte: included by the World Bank, the UN and Eldis. Mayotte is geographically part of the Comoros archipelago but is a French Departmental Collectivity, and not part of the Comoros state:” Mayotte […] chose to remain in the French Union when the Comoros became independent in 1976” (Calvocoressi, 2001:757).
- Reunion: included by the UN and Eldis. Reunion is French Overseas Department (The Times, 2004:60).
- Saint Helena: included by the UN. Saint Helena is a United Kingdom Overseas Territory (The Times, 2004:60).
- Somalia: excluded by the WHO.
- Sudan: excluded by the UN and the WHO
- Western Sahara: included by Stanford University. Western Sahara is a disputed region, effectively controlled by Morocco (The Times, 2004:64).

It can be seen, however, that generally the term Sub-Saharan Africa is used to denote all African countries except for the five nations along the northern Mediterranean coast: namely Morocco; Algeria; Tunisia; Libya and Egypt. These countries can be distinguished from the rest of the continent on basis of geography, culture and relative wealth. Since the focus of this study is poverty alleviation the exclusion of these countries on the latter basis seems reasonable.
The other countries/territories it is suggested should be excluded are: Western Sahara on the basis of being a part of Morocco; and Mayotte, St Helena and Reunion on the basis of not being nation states. This gives, for the purposes of this study, a total of forty-eight sub-Saharan countries of which six are island states: Cape Verde; Comoros; Madagascar; Mauritius; Sao Tome and Principe; and Seychelles.

Many respondents affirmed the decision of The Royal Academy of Engineering to focus on Sub-Saharan Africa. Jon Lane wrote: “The vast majority of poor people live in Sub-Saharan Africa and South Asia [and] my feeling is that the engineering institutions and professions in South Asia are light-years ahead of those in Africa.”

The Royal Society have also chosen to focus their capacity building work on Sub-Saharan Africa. Joann Fong explained that this is because there is desperate need in Sub-Saharan Africa, and the science institutions in the region are very weak. Their work may, however, be expanded at some later date to other developing countries. The Royal Society have adopted the definition of Sub-Saharan Africa set out by the Foreign and Commonwealth Office which excludes six North African countries: Egypt, Libya, Algeria, Tunisia, Morocco and Mauritania.

Several respondents pointed out that, realistically, The Royal Academy of Engineering would be able to work most effectively with Anglophone countries. Of the 48 nations designated as Sub-Saharan, five have Arabic as their official language, five are Lusophone countries, 17 are Francophone countries, 18 are Anglophone and three have other languages as their official language (CIA, 2006).

---

6 Email from Philip Githinji of University of Nairobi, 18 February 2006; meeting with Ugochukwu Aduwudike of Cambridge University, 3 March 2006; meeting with Petter Matthews of Engineers Against Poverty, 10 March 2006; meeting with Ian Neal of Engineers Against Poverty, 13 March 2006; meeting with Bobby Lambert of RedR, 15 March 2006; and meeting with Sir Gordon Conway of DFID, 6 April 2006.

7 Email from Jon Lane, Consultant, 11 March 2006.

8 Meeting with Joann Fong of The Royal Society, 22 March 2006.

9 Meeting with Joann Fong of The Royal Society, 22 March 2006.

10 Meeting with Joann Fong of The Royal Society, 22 March 2006.

11 Meeting with Prof Peter Guthrie of Cambridge University, 25 January 2006; and meeting with Prof Tony Ridley of Imperial College and Prof Peter Guthrie of Cambridge University, 13 February 2006.
| Part of the African Continent as Defined in the Times Atlas of the World (The Times, 2004) | Sub-Saharan Africa (World Bank, 2006) | Middle, Western, Eastern and Southern Africa (United Nations, 2006) | Eastern and Southern Africa; and Western and Central Africa (UNICEF, 2006) | African Region (WHO, 2006) | Africa South of the Sahara, (Stanford University, 2006) | Africa South of the Sahara (Eldis, 2006) | Sub-Saharan Africa (FCO, 2006) |
|---|---|---|---|---|---|---|---|
| Algeria | * | * | * | * | * | * | * |
| Angola | * | * | * | * | * | * | * |
| Benin | * | * | * | * | * | * | * |
| Botswana | * | * | * | * | * | * | * |
| Burkina Faso | * | * | * | * | * | * | * |
| Burundi | * | * | * | * | * | * | * |
| Cameroon | * | * | * | * | * | * | * |
| Canary Islands | | | | | | | |
| Cape Verde | * | * | * | * | * | * | * |
| Central African Republic | * | * | * | * | * | * | * |
| Chad | * | * | * | * | * | * | * |
| Comoros | * | * | * | * | * | * | * |
| Congo, Dem. Rep. | * | * | * | * | * | * | * |
| Congo, Rep | * | * | * | * | * | * | * |
| Cote d'Ivoire | * | * | * | * | * | * | * |
| Djibouti | * | * | * | * | * | * | * |
| Egypt | | | | | | | |
| Equatorial Guinea | * | * | * | * | * | * | * |
| Eritrea | * | * | * | * | * | * | * |
| Ethiopia | * | * | * | * | * | * | * |
| Gabon | * | * | * | * | * | * | * |
| Gambia, The | * | * | * | * | * | * | * |
| Ghana | * | * | * | * | * | * | * |
| Guinea | * | * | * | * | * | * | * |
| Guinea-Bissau | * | * | * | * | * | * | * |
| Kenya | * | * | * | * | * | * | * |
| Lesotho | * | * | * | * | * | * | * |
| Liberia | * | * | * | * | * | * | * |
| Libya | | | | | | | |
| Madagascar | * | * | * | * | * | * | * |
| Malawi | * | * | * | * | * | * | * |
| Mali | * | * | * | * | * | * | * |
| Mauritania | * | * | * | * | * | * | * |
| Mauritius | * | * | * | * | * | * | * |
| Mayotte | * | * | * | * | * | * | * |
| Morocco | | | | | | | |
| Mozambique | * | * | * | * | * | * | * |
| Namibia | * | * | * | * | * | * | * |
| Niger | * | * | * | * | * | * | * |
| Nigeria | * | * | * | * | * | * | * |
| Reunion | * | * | * | * | * | * | * |
| Rwanda | * | * | * | * | * | * | * |
| Saint Helena | | | | | | | |
| Sao Tome and Principe | * | * | * | * | * | * | * |
| Senegal | * | * | * | * | * | * | * |
| Seychelles | * | * | * | * | * | * | * |
| Sierra Leone | * | * | * | * | * | * | * |
| Somalia | * | * | * | * | * | * | * |
| South Africa | * | * | * | * | * | * | * |
| Sudan | * | * | * | * | * | * | * |
| Swaziland | * | * | * | * | * | * | * |
| Tanzania | * | * | * | * | * | * | * |
| Togo | * | * | * | * | * | * | * |
| Tunisia | | | | | | | |
| Uganda | * | * | * | * | * | * | * |
| Western Sahara | | | | | | | |
| Zambia | * | * | * | * | * | * | * |
| Zimbabwe | * | * | * | * | * | * | * |

Table 3.1: Countries included in lists of Sub-Saharan African Countries or Non-North African Countries
4 Engineering Capacity Building

4.1 Definitions from the Literature

Capacity building in the context of development is generally understood to mean increasing a country’s capabilities to enable autonomous development. For example:

Capacity building […] includes the capacity of the institutions of a country to manage policy and programme formulation, budgeting and financial management, development planning, implementation, co-ordination and performance monitoring and evaluation of development operations.

(Maconick, 2002:3-4)

The primary goal for aid and assistance should be capacity building in recipient countries, that is to say, the creation and development of human and social capabilities that would foster autonomous development, innovation and change.

(UN Department of Economic and Social Affairs, 2002:2)

Capacity building refers to activities that build or enhance the ability of developing countries to meet their own needs.

(House of Commons Science and Technology Committee, 2004:9)

The capacity of a country is its ability to analyze a situation and formulate and implement the required reforms […] capacity relates to human resources, institutions and procedures. Capacity building aims at creating a critical mass of human skills (talents), quality institutions (including the legislature) and sound procedures […]. It is widely believed that lack of capacity has prevented African governments from formulating and implementing their own macroeconomic poverty-reducing policies.

(IMF, 2005:9)

[Capacity is] the ability to design and deliver policies.

(Commission for Africa, 2005:133)

‘Capacity’ is not well defined, but can be understood as the ability of individuals, organisations or societies to meet their needs.

(Parliamentary Office of Science and Technology, 2004:2)

Capacity building in African countries is all about skills development

(King, 2005:121)

By extension, engineering capacity building could be understood as increasing the ability of nations to carry out engineering and implement policies that relate to engineering. However, the Commission for Africa Report includes building up professional knowledge and skills in engineering within its general definition of capacity building. Capacity and accountability are identified in the report as critical aspects of poverty alleviation and the recommendations for addressing them include: “building up professional skills and knowledge, by revitalising Africa’s higher education, especially in science, engineering and technology”. The report goes on to say “action in three specific areas would build on and enhance existing capacity:
professional skills and leadership; incentives; and equipment and infrastructure, including information and communications technology”. Clearly the Commissioners interpret capacity building as involving both enhancing skills and abilities (human capital) and also enhancing infrastructure (physical capital).

There are no explicit references to engineering, science, technology or the provision of infrastructure in the MDGs. The report of the House of Commons Select Committee on the role of Science in UK International Development policy notes that “since developing countries tend to base their Poverty Reduction Strategy Papers (PRSPs) on the targets emphasised in the MDGs, the absence of headline goals for science and technology and further or higher education may reduce the emphasis placed on these issues by developing countries […] we remain concerned that technologically intensive areas such as infrastructure, energy, water and sanitation are at risk of being neglected by DFID due to their omission from the headline MDGs” (House of Commons Science and Technology Committee, 2004:17). Sir Gordon Conway, Chief Scientific Advisor to DFID, noted that all the MDGs are underlined by energy, infrastructure and water, however as a result of the explicit focus on health and education in the MDGs, donors have moved towards working in these areas and this has resulted in a deficit in investment in infrastructure, energy and water. However, Bobby Lambert of RedR believes that it is right that the MDGs do not make explicit reference to engineering because engineering is not an end in itself; it is a means to an end. He suggested that what attracts people into engineering is not the building of a structure or creation of a product for the sake of that structure or product, but for the impact it can have.

The necessity of one of these elements, namely infrastructure, for growth, development and meeting the MDG is, in fact, widely acknowledged:

At least 3 key factors contributed to the rapid economic transformation of emerging economies […] First […] infrastructure […]. The investments served as a foundation for technological learning […]. Second […] the development of small and medium enterprises […] requires developing local […] expertise […] and […] technicians. […] Third […] higher education institutions, as well as academies […] and associations. […] Poor infrastructure is a critical barrier to accelerating growth and reducing poverty in Africa.

(Juma, 2005b:10-14)

The key to sustainable development in Africa – that is development that does not rely indefinitely on foreign aid – is the creation of infrastructure.

(King, 2005:114)

One of the problems hindering reduction of poverty – and the achievement of other [Millennium Development] Goals – in the developing world is the absence of adequate infrastructure.

(UN Millennium Project Task Force 10, 2005:2)

---

12 Meeting with Sir Gordon Conway and Alistair Wray of DFID, 6 April 2006.
13 Meeting with Bobby Lambert of RedR, 15 March 2006.
However hackneyed the term “Infrastructure” is now perceived to be there can be little real progress towards the Millennium Development Goals without tackling infrastructure problems.

(ICEextra, 2005)

Engineering has a fundamental role to play in addressing all of the Millennium Development Goals especially in providing basic infrastructure services and supporting pro-poor economic activity.\(^\text{14}\)

Infrastructure’s importance for growth, poverty and the Millennium Development Goals has been recognised at several major donor meetings, including the International conference on Financing for Development (Monterrey, 2002) and the World Summit on Sustainable Development (Johannesburg, 2002).\(^\text{15}\)

In the 1980s and 1990s, however, the funding of large scale infrastructure projects in the developing world by donor agencies such as the World Bank became discredited because of, amongst other things, concerns about environmental impacts, a shift to social investments to compensate for the adverse effects of structural adjustment policies, and belief that infrastructure financing should be a private sector activity (Ridley and Lee, 2005:62-3, InfraPoor, 2006:16, DFID, 2002:6-7, Commission for Africa, 2005:87). Singleton and Hahn (2004:38) explain that:

At the […] Rio+10 Sustainability Summit [in 2002] both the United Nations and the World Bank called for alleviation strategies involving ‘no more hardware’, pointing out that major investments over the last 20 to 30 years in water infrastructure schemes had often failed to benefit the people at whom they were aimed. This is because the majority of facilities involving technology are generally abandoned within two years as revenue streams are insufficient to pay for repairs and maintenance and because of the lack of local skill to carry out repairs. […] The summit noted that the emphasis should be on smaller scale solutions suited to local capabilities, understanding and skills.”

However, the Commission for Africa Report notes:

African governments and development partners sharply reduced, over the 1990s, the share of resources allocated to infrastructure – reflecting its lower priority in policy discussions. In retrospect this was a serious policy mistake, driven by the international community, that undermined growth prospects and generated a substantial backlog of investments.

(Commission for Africa, 2005:233-4)

\(^{14}\) A Framework for the Global Dimension within the Engineering Profession, Consultation Document, Development Education Association and Engineers Against Poverty (copy provided by Ian Neal of Engineers Against Poverty in a meeting on 13 March 2006).

\(^{15}\) Development Co-operation Directorate OECD, Task Team on Infrastructure for Poverty Reduction (2006) Guiding Principles on Using Infrastructure to Reduce Poverty (copy provided by Alistair Wray of DFID in a meeting on 6 April 2006).
More recently there has been renewed interest in the provision of infrastructure (DFID, 2002), and Hillary Benn MP, Secretary of State for International Development, has stated that “the Commission for Africa noted that the major part of investments into the roads and railway networks that Africa needs must come primarily from public investment including aid […]. We went through a period when the world deluded itself that this should come from the private sector, but that doesn’t mean that the private sector can’t play a part” (Benn, 2006a:5). However it is not clear whether the provision of, or levels of, infrastructure, however vital, are a part of engineering capacity and engineering capacity building. The literature gives little guidance, but by drawing parallels with general definitions of capacity building, and definitions of science capacity building, it appears that engineering capacity building relates purely to the increase of indigenous engineering skills, and enhancing and supporting engineering institutions and facilities so that nations have the capabilities to provide, maintain and enhance their own infrastructure networks and also generate economic growth through engineering and manufacturing activities.

Furthermore, infrastructure in the sense used in the above references is the product of just one branch of engineering: civil. Less is written about the necessity for development of infrastructure provided and maintained by other types of engineer, for example communications networks. It is useful to consider engineering as described by Prof Calestous Juma as “anything with connectivity”. This clearly demonstrates that while including infrastructure created by civil engineers, such as roads and railways, it also includes other forms of networks created by other branches of engineering.16

Definitions of engineering capacity building are few and far between. King (2003) writes: “capacity building in science, engineering and technology is about ensuring that the whole education system in developing countries can deliver the science and technology capabilities that will be required to deliver a successful and sustainable technological future” and the NEPAD Plan of Action for Science and Technology in Africa, states: “African leaders and the international community have recognized and begun to put emphasis on the urgency of strengthening the continent’s engineering capacity through the revitalization of higher education institutes”. Jones, in papers describing the joint World Federation of Engineering Organisations (WFEO) and UNESCO Engineering for a Better World programme (albeit using the term technical capacity rather than engineering capacity) writes: “the overall objectives of the Engineering for a Better World proposal are to strengthen human and institutional technical capacity in developing countries” (Jones, 2005a); “economic development for developing countries can be effectively stimulated by building the technical capacity of their work force, through quality engineering education programs” (Jones, 2005b); and “education is key to capacity building” (Jones and Oberest, 2003). Clearly the emphasis is on education and educational programmes.

In contrast to the dearth of definitions of engineering capacity, there are many definitions of science capacity and science capacity building presented in the literature. For example:

This study panel defines the S&T capacity of a country as the personnel, infrastructure, investment and the institutional and regulatory framework available to generate activities and acquire scientific knowledge and technological capabilities for addressing with competence and creativity, local, national and international needs.

16 Meeting with Prof Calestous Juma of Harvard University, 16 January 2006.
Science capacity – the infrastructure, investment, institutional and regulatory framework, and personnel available to conduct scientific research and technological development.

(Rand Science and Technology, 2001)

There is a staggering gap in science and technology capabilities between the rich industrialised nations and the poorer developing nations […] without significant scientific infrastructure and expertise within the poorest countries it will be difficult for them to help themselves in finding solutions […] in other words without the capacity embedded in the educational system at school, university and in research laboratories, and without institutions such as academies […] there is little chance that science will be able to be harnessed to address these countries’ needs.

(Lord May of Oxford, 2004)

[There are] many elements that encompass [science] capacity building: individuals, organisations, institutions, and systems of innovation. Furthermore, capacity building encompasses support for many skills and activities, involving elements of the ability to search for, select and use scientific and technological knowledge and products, the ability to develop the means to improve existing scientific and technological knowledge; and the necessary management and governance experience to organise and manage R&D facilities.

(Chataway et al., 2005:5)

Capacity building in this context refers to the creation, improvement and mobilization of human skills, physical infrastructure, financial resources and the necessary policies for science and technology to be produced and used to solve specific African problems.

(NEPAD, 2001:5)

References to science capacity building focus on increasing human skills, and references to infrastructure within science capacity building are to the creation of infrastructure to enable science to be carried out, for example the provision of laboratories. References to science capacity may include engineering, but generally this is only implicit. Occasionally it is stated clearly. For example:

Science and technology, as described in this report, encompass the full range of fields and disciplines, including aeronautics and astronautics; agricultural sciences; anthropology; biology; brain and cognitive sciences; chemical engineering; chemistry; civil and environmental engineering; earth, atmospheric and planetary sciences; economics; electrical engineering and computer science; systems engineering; health sciences and technology; materials science and engineering; mathematics; mechanical engineering; nuclear engineering; physics; political science; psychology; and sociology.

17 In a meeting with Sir Gordon Conway, Chief Scientific Advisor, DFID, 6 April 2006, he noted that he considers engineering to be included in science and technology, but also feels this needs to be more explicit, at moment the inclusion of engineering is only implicit in documents produced by DFID.
The areas of agriculture, engineering and health however loom large in addressing the challenges of developing nations. (InterAcademy Council, 2004:33)

The House of Commons Select Committee Report on the Use of Science in UK International Development Policy distinguishes between Natural Sciences and Development Sciences. The former is defined as “the sciences involved in the study of the physical world and its phenomena. This includes biological, physical, chemical and environmental science, but excludes social science”. The latter is defined as “the full spectrum of social and natural sciences, engineering and technology undertaken with the purpose of informing, supporting, or promoting international development. It should not be confused with the term “development studies” which usually refers to a branch of social science concerned with international development” (House of Commons Science and Technology Committee, 2004:9).

Whether including engineering or not, the importance of science and technology capacity for economic growth and development is widely recognised, both in Africa and in the developing world, and has been the focus of several recent initiatives and studies.

- In 2004 the House of Common Select Committee on Science and Technology undertook an inquiry “to examine how science and technology are informing decisions on the spending of the aid budget, how research is being used to underpin policy making in international development, and how the UK is supporting science and technology in developing countries” (House of Commons Science and Technology Committee, 2004:5). The review focused primarily on the work of DFID and “welcome[d] the fact that the UK Government has now explicitly stated its commitment to the application of science, technology and research to international development” (House of Commons Science and Technology Committee, 2004:11).

- Also in 2004 the InterAcademy Council, created by fifteen national academies of science to provide advice to international bodies such as the UN and World Bank, published a strategy for building worldwide capacities in science and technology (InterAcademy Council, 2004). The report concluded that “the Study Panel is […] convinced that all nations, particularly the developing ones, require an increased level of S&T capacity to enhance their ability to adopt new technologies – as in those related to the new life sciences – and adopt them to local needs” (InterAcademy Council, 2004:xii).

- Task Force 10 of the UN Millennium Project investigated the role of science, technology and innovation in meeting the MDGs. The report of the Task Force argues that “meeting the MDGs will require a substantial reorientation of development policies to focus on key sources of economic growth, particularly the use of scientific and technological knowledge and related institutional adjustments. It outlines key areas for policy action – focusing on platform or generic technologies, defining infrastructure services as a foundation for technology, improving higher education in science and placing universities at the centre of local development, spurring entrepreneurial activities, improving the policy environment and focussing on areas of under funded research for development.” (UN Millennium Project Task Force 10, 2005).
In 2005 the independent think-tank, The Smith Institute, produced a series of essays entitled *Going for Growth: Science, Technology and Innovation in Africa*. “One of the central messages of the report is its emphasis on building Africa’s capacity to solve its own problems. This focus is reflected in the stress placed on economic growth as a critical basis for addressing poverty. This collection of essays seeks to elaborate on this theme by underscoring the role of science, technology and innovation in development in general, and in international co-operation in particular. The different chapters signal the growing interest in making the transition from short-term, relief-based activities to long-term development, based on building competence at all levels of science.” (Juma, 2005a:6).

African Ministerial Conferences on Science and Technology were held in Johannesburg in 2003 and Dakar in 2005, and were attended by African science ministers and representatives from western governments. At the latter conference a *Plan of Action for Science and Technology*, produced by the African Union and NEPAD was adopted. The plan “articulates Africa’s common objectives and commitment to collective actions to develop and use science and technology for the socio-economic transformation of the continent and it integration into the world economy” (NEPAD, 2001:5).

Again, the emphasis in most of the reports is on technical education, but also includes training in entrepreneurship. The conclusion that can be drawn from the literature is that engineering capacity building is understood as the creation or enhancement of human knowledge and skills, and the supporting institutions and organisations that are required to identify needs and implement engineering solutions.

Although the provision of infrastructure is not considered a part of engineering capacity building, several authors identify that there can, and advocate that there should be, a technological learning process through civil engineering infrastructure projects. For example:

African countries also need to enhance their own ability to develop, operate and maintain infrastructure services. Foreign construction and engineering firms will continue to be the main sources of technological, organisational and institutional knowledge for infrastructure development. But governments in African countries should devise policies to encourage technology transfer and build local capabilities in infrastructure projects.

(Ridley and Lee, 2005:68)

Infrastructure development [...] serves as a technological learning process, which provides individuals, firms and governments with opportunities to acquire and diffuse new skill and knowledge

(Ridley and Lee, 2005)

Because of its fundamental role, the learning process in infrastructure development is a crucial element of a country’s overall technological learning process. [...] Africa should therefore structure the design and construction of railways, airports [... etc] in ways that promote technological, organisational and institutional learning.
Governments have traditionally viewed infrastructure projects from a static perspective. Although they recognize the fundamental importance of infrastructure, they seldom consider infrastructure projects as part of a technological learning process. In fact, infrastructure development provides a foundation for technological learning, because it involves the use of a wide range of technologies and complex institutional arrangements. Policymakers need to recognize the dynamic role infrastructure development can play in economic growth and take the initiative in acquiring the technical knowledge available through international and indigenous construction and engineering firms.”

(UN Millennium Project Task Force 10, 2005:2)

However, claims that infrastructure development projects automatically enhance technological learning are not substantiated by evidence from historic projects. Exotic technology applied to a project in a country where there is little or no technological awareness will not generally lead to an enhancement of knowledge. It seems concerted effort and action will be needed to harness the learning potential. Furthermore, continued reliance on western expertise and western approaches predetermines the solutions adopted and takes little or no account of particular prevailing conditions in relation to, for example, labour costs, need for employment, climatic differences, affordability and maintainability. There is a need for the countries of Africa to develop their own solutions to engineering needs. Continued reliance on western firms and western approaches reinforces dependency and actively prevents the development of more relevant and enduring solutions. New paradigms are needed for delivering solutions in developing countries, changing attitudes towards design approaches and design standards.

Following the example of definitions of science capacity building, engineering capacity should, it is suggested, be defined in terms of a nation’s ability to undertake the engineering process, as opposed to being measured in terms of its stock of engineering products. A tentative definition was set out, prior to interviews, as follows: Engineering capacity building is the creation or enhancement of human knowledge and skills, and the supporting institutions and organisations that are required to identify needs and implement engineering solutions.

4.2 Definitions from Interviews and Emailed Responses

Speaking about capacity building in general, Andrew Scott of Practical Action described it as the ability for communities to identify their own needs, plan, engage with others and implement solutions. Similarly Ian Neal of Engineers Against Poverty stated that capacity is the ability to understand context, to influence it, to influence others and to adapt; and Alistair Wray explained that there are five areas in which DFID seek to support capacity in relation to infrastructure: capacity to identify and prioritise action; capacity of institutions; capacity to procure (this is tied into good governance and transparency); capacity of the private sector to...

18 Meeting with Prof Peter Guthrie of Cambridge University and Prof Tony Ridley of Imperial College, 13 February 2006.
meet infrastructure needs; and capacity to operate and maintain infrastructure. Marie-Odile Zanders of Buro Happold wrote that:

A useful definition of capacity development [set out] by UNDP (1997) is that it is “the process by which individuals, groups, organisations, institutions and societies increase their abilities to 1. perform core functions, solve problems, define and achieve objectives and 2. understand and deal with their development needs in a broad context and in a sustainable manner”. Clearly the emphasis in all the above is on the ability to identify problems and take action.

Ron Watermeyer describes the desired outcome of capacity building as “indigenous science and technology capacity which ensures that public funds are utilized effectively – for initial project implementation, for long-term operation and maintenance, and for the development of capacity to do future projects”. Taking his guide from the protocol of the African Engineers Forum, Watermeyer describes four areas of capacity building:

- Individual capacity: individuals educated, trained, equipped, informed and networked
- Institutional capacity: professional organizations and societies, statutory boards, councils, foundations and other structures fully functioning
- Technical capacity: appropriate technologies (including indigenous technologies and materials), systems, processes, procedures, methods, standards, guidance materials, software and hardware and research papers
- Decision making capacity: decision makers including clients understand/aware of issues.

Similarly, Dawie Botha of SAICE has identified what he terms ‘pillars’ of engineering capacity: individual; institutional; technical; decision making; business; and resources and supplies. Definitions of the first four are as set out by Watermeyer. The fifth pillar is described as “the availability of a commercial infrastructure to support engineering […] and] the main elements concerning this issue would include factories, quarries, timber mills, distribution networks”. Pillar six includes “resources to underpin built environment activities […] including raw materials, manufactured and finished products maintenance and management of facilities and infrastructure as well as funding frameworks and sources of income”. The distinction between pillars 5 and 6 is not clear.

A succinct definition of engineering capacity building was provided by Jeff Smith of Wardell Armstrong who stated that engineering capacity is the:

knowledge and experience of people who also have access to suitable physical engineering resources to achieve whatever ‘engineered’ facility is needed by their community. In the context of developing countries, ‘engineering capacity

---

19 Meeting with Sir Gordon Conway and Alistair Wray of DFID, 6 April 2006. Alistair Wray was speaking about civil engineering projects: DFID work only in the least developed countries where the primary need is for basic infrastructure created by civil engineers.
20 Email from Marie-Odile Zanders of Buro Happold, 17 March 2006.
21 PowerPoint presentation sent by email from Ron Watermeyer of SAICE, 28 February 2006.
22 PowerPoint presentation sent by email from Ron Watermeyer of SAICE, 28 February 2006.
23 PowerPoint presentation sent by email from Dawie Botha of SAICE, 12 March 2006.
building’ requires suitable: Education and training; Practical experience; Materials/resources; Machinery and tools; and an appropriate (locally tailored) approach to technology, H & S [and] environmental controls.  

Smith’s definition implies the capability to identify what engineered facilities are needed and plan accordingly. It also includes a need for practical experience and opportunities that was identified by several respondents. Prof Richard Carter of Cranfield University suggested that there are high levels of capacity in Africa if measured in terms of educated and trained engineers; therefore the issue is not training more engineers. What does not exist in Africa is the opportunity for trained engineers to find employment and gain practical experience. Engineers may be well qualified and able intellectually but have not had the opportunity to practice professionally. This was reiterated by Ugochukwu Akuwudike of Cambridge University who said that engineers in Africa do not have opportunities to be inventive or innovative. However, in contrast, Prof Awadhi Mawenya of Tanzania identified a lack of ‘critical mass’ in terms of the number of educated and trained engineers as the first of four key issues for capacity building in Africa. He went to say that this ‘critical mass’ has not been quantified and it was suggested that studies may be needed to identify requirements.

Several respondents suggested that engineering should not be limited to professional engineers, and therefore engineering capacity building must address other ‘levels’ in the industry (trades-people, craftspeople, technicians and the like) and also skills provided by other professions, such as social scientists. Consequently, the focus in engineering capacity must not be limited to tertiary education and academic research, vital as these are. The Kigali Institute of Science and Technology in Rwanda is often held up as an example of capacity building at technician level.

It was also suggested that the training of professional engineers needs to include areas not traditionally covered in engineering curricula: for example social, cultural and environmental issues; the ability to interact with other organisations and with people for whom solutions are developed; and the implementation of projects including both project management and other ‘softer’ skills. Bobby Lambert of RedR noted that environmental issues are now seen as central to all that engineers do and he suggested that, in the same way, development issues should become a part of standard mainstream professional issues. Engineers Against Poverty, in partnership with the Development Education Association, have prepared a

24 Email from Jeff Smith of Wardell Armstrong, 27 February 2006.
25 Telephone conversation with Prof Richard Carter of Cranfield University, 28 February 2006.
26 Meeting with Ugochukwu Akuwudike of Cambridge University, 3 March 2006.
27 Meeting with Prof Awadhi Mawenya of Design Partnership Ltd, Tanzania, 6 April 2006.
28 Telephone conversation with Dr Tony Marjoram of UNESCO, 2 March 2006; meeting with Prof John Wood of CCLRC, 8 March 2006; meeting with Tony Roche of RedR, 22 March 2006; meeting with Prof Christopher Clayton of Southampton University, 22 March 2006; and meeting with Stephen Hunt, Andrew Scott and Dr Lucy Stephens of Practical Action, 24 March 2006.
29 Meeting with Peter Matthews of Engineers Against Poverty, 10 March 2006.
30 Sir David King, Chief Scientific Advisor to HM Government noted that the conversion of a military barracks into the KIST, soon after the genocides in Rwanda ended, was highly symbolic; 30 March 2006.
31 Telephone conversation with Prof Richard Carter of Cranfield University, 28 February 2006; meeting with Ian Neal of Engineers Against Poverty, 13 March 2006; email from Marie-Odile Zanders of Buro Happold, 17 March 2006; meeting with Tony Roche of RedR, 22 March 2006; and meeting with Stephen Hunt, Andrew Scott and Dr Lucy Stevens of Practical Action, 24 March 2006.
32 Meeting with Bobby Lambert of RedR, 15 March 2006.
consultation document for a framework for building global perspectives into the professional development of engineers. The framework is to be aimed at UK based learning providers.

It was repeatedly emphasised by respondents that civil engineering should be a priority in engineering capacity building because it meets basic needs and is therefore at the beginning of a sequence of requirements for poverty reduction and wealth creation through economic growth. Alistair Wray pointed out that DFID works mostly with the lowest income countries and with fragile states, where the needs are for basic infrastructure of the type provided by civil engineers. The needs which are met by other branches of engineering are mostly, but not exclusively, related to the generation of economic growth as countries develop. However the need for reliable, affordable and renewable energy supplies is also recognised to be vital if the MDGs are to be met (Benn, 2006c:5).

Respondents were asked for their opinion on the differences between science and engineering capacity building. Some respondents thought there was no difference. Generally, however, the delivery of practical solutions was identified as the difference. Prof Philip Githinji wrote “engineering capacity building differs from science capacity building by its objectives, applications and expected achievements. The former is more practically oriented, compared to pushing the frontiers of knowledge and will most probably have more specific time deadlines”; Prof Christopher Clayton paraphrased a quote from Rankine which explains that science deals with the question of what are we to think, whereas engineering deals the question of what are we to do, and explained that the end product in science is knowledge, whereas the end product in engineering is practical application; Tony Roche considers science to be conceptual whereas engineering adapts scientific knowledge to produce and maintain products and services; and Marie Odile-Zanders wrote:

It is different as engineers are expected to apply their knowledge to deliver tangible outputs [...]. It is therefore not only very important for people to learn how to solve theoretical problems, but also how to deliver any of the proposed solutions. This requires, among others, capacity to lead, project management skills and the ability to work with a wide variety of partners from both public and private sector.

The difference seems to be in outputs and impacts which must have implications for measurement.

Generally there is an assumption, agreed with by most respondents, that engineering capacity leads to economic growth, wealth creation and poverty alleviation. David Ball, however, questions this assumption, on the basis that other conditions also need to be in place, including the rule of law, effective and neutral judiciary, effective government and
administration and the elimination of corruption. Andrew Scott of Practical Action also questioned the assumption made in most texts on science, technology and development, that science and technology are essential for economic growth, and economic growth leads to poverty reduction for all (his colleague Steven Hunt described this as the ‘rising tide lifts all boats’ argument). Practical Action tries to consider those people and communities who will be the last to benefit from increased economic growth. Petter Matthews suggested that engineering capacity building that results in pro-poor growth should be pursued, and the OECD’s Guiding Principles on Using Infrastructure to Reduce Poverty begins with the statement that “to achieve sustained poverty reduction, developing countries must attain higher, durable growth that involves and benefits poor people. Pro-poor growth is […] crucial to meeting the Millennium Development Goals”.

The report sets out four principles to guide efforts to promote pro-poor growth in partner countries through infrastructure: 1) use partner country led frameworks as the basis for co-ordinated donor support; 2) enhance infrastructure’s impact on people; 3) improve management of infrastructure investment, to achieve sustainable outcomes; and 4) increase infrastructure financing and use all financial resources efficiently.

Sir David King distinguished between poverty eradication and wealth creation. He suggested that the former implies a need for ‘handouts’ which creates dependency and the continuation of poverty.

4.3 Measuring Engineering Capacity Building

The Commission for Africa Report states “what is measured and monitored usually gets results. Establishment of an explicit framework for monitoring results of well defined activities will be crucial for enhancing effectiveness of capacity development” (Commission for Africa, 2005:140). However, difficulties in measuring capacity are frequently acknowledged:

There are few widely accepted theories of capacity development. There also remain wide disparities in the meanings that participants attribute to terms such as ‘capacity’, ‘capacity building’ and ‘performance’ […] few programmes or projects collect data on process issues to do with capacity building. Almost none have any baseline data […] there is little agreement on the time factor ie what is a reasonable period within which to assess progress on capacity issues, especially when dealing with complex organizational systems … three years, five years, twenty years? And what is to be seen as a reasonable connection between the improvement to capacity and its subsequent effects on outcomes such as poverty eradication […] most public and non-public organizations are focused on programme issues and assess their effectiveness in terms of actual services or products delivered.

(Morgan, 2002:17-8)

41 Email from David Ball, 17 March 2006.
42 Meeting with Steven Hunt, Andrew Scott and Dr Lucy Stevens of Practical Action, 24 March 2006.
43 Meeting with Petter Matthews of Engineers Against Poverty, 10 March 2006.
44 Development Co-operation Directorate OECD, Task Team on Infrastructure for Poverty Reduction (2006) Guiding Principles on Using Infrastructure to Reduce Poverty (copy provided by Alistair Wray of DFID at meeting on 6 April 2006).
45 Meeting with Sir David King, Gary Cass and Dr Tracey Elliott of OST, 30 March 2006.
Much of what capacity building strives to achieve cannot be measured.
(Maconick, 2002)

It is not a straightforward matter to quantify national science and technology capacity, but by any measure there is a vast gap between the North and South.
(House of Commons Science and Technology Committee, 2004:43)

Akin Adubifa (2004) and Khalil-Timamy (2002) both set out to make an assessment of science and technological capacity in Sub-Saharan Africa. Both reports acknowledge the incompleteness of statistics:

Government departments in charge of collecting, compiling and classifying statistical information, have not identified the most basic indicators, let alone prepared formats for their institutionalization. In fact data for most S&T indicators are neither gathered nor compiled […] however some data is still collected and made available to international institutions such as the World Bank, UNESCO and UNDP. Data for this report rely heavily on published material from these sources.
(Khalil-Timamy, 2002:12)

It has been necessary to describe the science and technology systems of the countries through subjective interpretation of scattered, incomplete, and sometimes inaccurate or totally missing data on performance indicators. […] There is a chronic lack of statistical data to describe the characteristics and performance of Sub-Saharan Africa’ science and technology sub-sector.
(Akin Adubifa, 2004:2, 14)

Khalil-Timamy presents data on: student populations in primary, secondary and tertiary education; R&D scientists and technicians per 100 people; established domains of research (and notes that, in general, scientific and technological research in Sub-Saharan Africa has demonstrated a pronounced bias towards agriculture); production capabilities (in terms of product); small firm industrial clusters; and migration. The author suggests that countries should collect data on: human resources (engineers, technicians and craftspeople); technical resources (machines, equipment, tools); and institutional resources (departments, industrial units, public agencies and enterprises).

Akin Adubifa refers to data on: scientific publications; patents; number of African scientists and engineers in professional practice, and presents case studies of science and technology capacity building initiatives and anecdotal lessons from such initiatives.

In preparing their report, the House of Commons Select Committee asked DFID “what formal mechanisms it used to help developing countries identify their science and technology requirements and incorporate these into their PRSPs”. The response from DFID is described as “disappointing”. DFID rely on dialogue between their country offices and governments. However as the report notes “we have reservations about the levels of expertise in science and technology within the country offices, and therefore about the effectiveness of this approach” (House of Commons Science and Technology Committee, 2004:14).
The NEPAD Consolidated Plan of Action for Science and Technology in Africa identifies that there is a need to assess engineering infrastructure and curriculum of higher engineering education institutions because adequate and reliable data and information on the nature and quality of existing capabilities and content of training is not available. The Plan suggests “commissioning a competent agency or network to […] gather data and provide a comprehensive assessment of capacities” (NEPAD, 2005).

The report of the Task Team on Infrastructure for Poverty Reduction, discusses how the effects of infrastructure on pro-poor growth might be measured and notes:

Available data on infrastructure are unreliable, incomplete and out of date. Most partner countries have limited central, local and sector capacity to generate and manage such data. More sector datasets are needed – ideally recognising the link between infrastructure, growth and poverty reduction – to allow international comparisons and support linkages between sector programming, country outcomes and global MDGs.

(InfraPoor, 2006)

The general consensus among respondents was that engineering capacity in Africa is not currently measured. Several respondents did however suggest parameters that could be used to measure engineering capacity. These included: the size and effectiveness of local firms; the number of engineering graduates; the monetary value of infrastructure projects completed each year; membership of accredited institutions; the number of graduates finding in-country employment; the number of professional engineers engaged; ratios of local to ex-pat engineers on projects; levels of available labour; the number of material suppliers; the number of artisans associations and their interests; the number of contractors; and amounts of equipment and plant.

Clearly the suggestions reinforce the opinion expressed by many respondents that discussions of engineering capacity building should not be limited to professional engineers. Furthermore, as Petter Matthews explained, headcounts of engineers and technicians do not demonstrate engineering capacity. Bobby Lambert used the analogy of a battery, explaining that a battery has capacity once it is charged but it is only a means to an end and doesn’t actually do anything until it drives the motor, and Prof Ernest Shannon stated that capacity must be measured in terms of output because the number of engineering graduates is irrelevant, what is important is the economic output resulting from their work. Sir Gordon Conway suggested that engineering capacity should be measured in terms of progress towards the MDGs, however a headcount of engineers in any nation would be useful to demonstrate the low number of engineers even if it is not in itself a measure of capacity. A need for both quantitative and qualitative measures was emphasised by three respondents.

46 For example: email from Jeff Smith of Wardell Armstrong, 27 February 2006; meeting with Ugochukwu Akuwudike of Cambridge University, 3 March 2006; email from Jon Lane, Consultant, Malawi, 11 March 2006; email from Marie-Odile Zanders of Buro Happold, 17 March 2006; and meeting with Stephen Hunt, Andrew Scott and Dr Lucy Stevens of Practical Action, 24 March 2006.
47 Meeting with Petter Matthews of Engineers Against Poverty, 10 March 2006.
48 Meeting with Prof Ernest Shannon of UK Commission to UNESCO, 28 March 2006.
49 Meeting with Sir Gordon Conway and Alistair Wray of DFID, 6 April 2006.
50 Telephone conversation with Prof Richard Carter of Cranfield University, 28 February 2006; meeting with Petter Mathews of Engineers Against Poverty, 10 March 2006; meeting with Ian Neal of Engineers Against Poverty, 13 March 2006.
and Prof Richard Carter noted the inappropriateness of using citation analysis, a common measure of science capacity, to measure engineering capacity.51

Sir David King suggested that the of capacity of a country can be measured using the approach set out by Partha Dasgupta, Professor of Economics at Cambridge University.52 Dasgupta suggests the wealth of a nation be measured in terms of its built infrastructure, its human skills, its environmental and natural resources, and its institutional and cultural resources.

Three respondents53 identified a recent study titled Numbers and Needs undertaken by Allyson Lawless, a past-president of the South African Institution of Civil Engineering (SAICE), with support from a group of researchers, to quantify the capacity of the civil engineering profession in South Africa (Lawless, 2006). The study was prompted by recognition that the civil engineering profession in South Africa faces unprecedented challenges in attracting, recruiting and retaining staff to meet the country’s infrastructure needs. The study provides evidence of shortages and also makes recommendations for action (SAICE, 2006). Watermeyer states that the study “attempt[s] to quantify the technological challenge facing developing countries and countries with dual economies by providing an indication of the ratio of engineer to population of a number of developed and developing countries.”54 A proposal for collaboration between The Royal Academy of Engineering and UNESCO on similar studies in other African nations, and expanded to address all branches of engineering, has been set out by Dr Tony Marjoram of UNESCO (Appendix C).

4.4 Key Issues and Priority Areas Identified in the Literature

Key issues relating to engineering capacity building in Africa, identified through the literature review, are: addressing corruption and lack of governance; improving infrastructure; appropriate standards; including social, economic and environmental factors when developing engineering solutions; improving education in engineering; encouraging entrepreneurship and innovation; stemming the “brain drain”; engaging the African Diaspora; attracting women into engineering; and ensuring that Africa’s environment is protected and development is sustainable.

Mistry’s (2005) thesis in his paper Reasons for Sub-Saharan Africa’s Development Deficit that the Commission for Africa did not Consider, is that Africa does not need more financial aid, which in the past has been wasted through corruption. Instead, he believes Africa needs increased human, social and institutional capital and suggests that this capital should come from immigration. The author presents Botswana as an example: “it found ways of importing and embedding the foreign human, social and institutional capital it needed”. Many other authors identify a need to improve governance in African nations. The ICE’s Engineering Without Frontiers Commission identifies “reasonable governance structures […] a functioning civil society; and freedom from persecution, conflict and corruption” as “prerequisites for development” (ICE Presidential Commission, 2005:6). The Commission

51 Telephone conversation with Prof Richard Carter of Cranfield University, 28 February 2006.
52 Meeting with Sir David King, Gary Cass and Dr Tracey Elliott of OST, 30 March 2006.
53 Telephone conversation with Dr Tony Marjoram of UNESCO, 2 March 2006; meeting with Petter Matthews of Engineers Against Poverty, 10 March 2006; and meeting with Prof Christopher Clayton of Southampton University, 22 March 2006.
54 Watermeyer, R (2005) Poverty Reduction Responses to the Millennium Development Goals (advance copy of a paper to be presented at IStructE meeting on 11 May 2006, emailed by Ron Watermeyer, 15 March 2006)
for Africa’s report identifies governance, accountability and transparency as foundations for development (Commission for Africa, 2005:33-7). Jones and Oberest (2003), in a paper describing WFEO initiatives for capacity building, note that “one caveat that must be mentioned in any discussion of foreign aid […] endemic corruption must be identified and systematically weeded out. Finally, the House of Commons Select Committee Report states “we regard scientific and technological capability as part of good governance” and the report suggest that scientific and technological capacity should be a condition of budgetary support (House of Commons Science and Technology Committee, 2004).

The need for improved infrastructure to enable industrial development and access to trade, especially for the land-locked countries of Sub-Saharan Africa, has been identified as essential (UNIDO, 2004:2, DFID, 2002:6-13, King, 2005:114, Juma, 2005b:13-14). Ridley and Lee (2005:66) state that “infrastructure […] is one of the most important factors in attracting foreign direct investment” and the Report of the Commission for Africa (2005:236) states: “for their part, African governments must re-prioritise the importance of infrastructure in their poverty reduction strategies”.

The ICE’s Engineering Without Frontiers Commission identified “appropriate standards” as a key theme. Referring to civil engineering works, the Commission considers that standards currently required to attract project funding, and, by implication standards taught in engineering education, may not be appropriate for all projects (ICE Presidential Commission, 2005). In contrast, Ridley and Lee (2005:70) state “the design, manufacture, supply and delivery of infrastructure hardware, software and systems are now global. This globalisation would not have been possible without internationally agreed standards. In order for infrastructure services in African countries to become more effective and extensible, countries need to create and enforce national standards that conform to international benchmarks”. Perhaps the contrasting opinions arise because the authors are considering different types of infrastructure and engineering. Jerome (1997:51) identifies “casual factors in the inadequate provision of infrastructure and delivery of infrastructure services in Africa” as including “investment decisions and tariff policies primarily driven by political considerations. […] It is not uncommon for the political element, for reasons of prestige or with unjustified claims to insist on an over-designed capacity”. The author advocates the private provision of infrastructure.

In relation to including factors such as economic, political and social when developing engineering solutions, Singleton and Hahn (2004:39) write:

Engineering solutions are integral to the mitigation of poverty. However engineering is not the sole contributor to successful poverty alleviation programmes. Sustained alleviation of poverty also entails attention to social, economic and political influence. Sustainable engineering will be achieved when the engineering solutions adopted take into account their utilisation of natural resources […]. Life-cycle engineering takes into account the operational and maintenance cost of the engineering solution proposed […]. Empowered engineering will take into account the capabilities of the local community, particularly its engineering and technical professions […]. Appropriate engineering will consider various options […] and may adopt labour-based construction techniques […].
The NEPAD Consolidated Plan of Action for Science and Technology in Africa notes that “Africa’s low investment in science and technology is [...] manifested in declining quality of science and engineering education at all levels of educational systems” (NEPAD, 2005:7) and “ensuring [higher education] institutions are able to recruit and retain quality staff is therefore vital to Africa’s future supply of highly skilled scientists and engineers”. The Commission for Africa’s report (Commission for Africa, 2005:34) states that “the shortage of skilled professionals in Africa is a critical issue. It has its roots in a tertiary education system that is in a state of crisis”. The Joint Science Academies statement to the G8 Conference calls on the governments to “help revitalise African universities and support the development of centres of excellence in science, engineering and technology” and points to the fact that “the Commission for Africa report [...] stressed the need for investment in higher education and centres of excellence, particularly in science and technology” (National Science Academies of the G8 Nations and NASAC, 2005). In 1995 the UNESCO Nairobi office convened a meeting of nineteen African experts involved in the planning, development and implementation of engineering programmes to deliberate the problems facing engineering education in Africa (UNESCO Expert Group, 1995:v). The group identified the following issues and problems of engineering education in Africa: “inadequacy of financial resources; unprogressive management structure of universities; staff problems; quality of enrolments; relevance of the curriculum, lack of cooperation with local industry; and the society’s perception of the engineer” (UNESCO Expert Group, 1995:6). Carter notes “the specialised western curriculum adopted in most African countries puts artificial walls between natural science and social science, technology and its utilisation (Tickell et al., 2006:27).

Juma (2005b:12) notes that considerable efforts are underway to include entrepreneurial skills in the curriculum of higher education institutions, and to encourage students to transform research into enterprises. King (2005:119) writes “much of the focus on improving educational standards in Africa has been directed at primary education, with good reason. But that will not produce the doctors, nurses and engineers needed” and “universities are not just a breeding ground for skilled personnel; [...] they can foster entrepreneurial activities [...] particularly if the relevant business skills are taught in the academic curriculum”. The Report of the UNESCO Working Group on Strategic Issues in Engineering Education in Africa (1995:16) states: “the issue is [...] what sort of training [the engineer] should receive in order to make him an ‘employment creator’ and not an ‘employment seeker’. The background to this is the big unemployment among engineering graduates on the continent”. The working group suggests “the introduction of courses in entrepreneurship and management [...] and the adoption of national policy on the provision of grants for the commercialization of ideas” (UNESCO Expert Group, 1995:16).

In references addressing science and technology capacity building in Africa, the issue of the “brain drain”, that is skilled African professionals leaving the continent to work in Europe and North America, is a common theme. The Report of the UN Millennium Project Task Force 10 notes (2005:91): “to meet the shortage of engineers and scientists, developed countries recruit from developing nations. Ironically, developing countries are putting their scarce resources into education and training that benefits then developed world”. The Report of the InterAcademy Council (2004:48-50) notes that “the brain-drain issue is a serious impediment to building and sustaining indigenous human resources” and suggests was to address the problem. Referring to shortage of university staff, the UNESCO Working Group notes that “there are several reasons for this external and internal brain drain. One every obvious one is the low remuneration [...] and the other equally important reason is the poor
infrastructure which is not conducive to academic activity” (UNESCO Expert Group, 1995:15).

Closely related to the issue of needing to stem the flow of the brain drain, are the common calls to identify ways to engage the highly skilled African Diaspora in development (UN Millennium Project Task Force 10, 2005:137, Commission for Africa, 2005:137). The Engineering Forum of Nigerians (EFN) has a vision “to provide a forum for Nigerian engineers based in the UK for the purpose of promoting engineering development in all its ramifications in Nigeria”.  

Attracting women into careers in science and engineering is also highlighted as an essential issue (UN Millennium Project Task Force 10, 2005:90, InterAcademy Council, 2004:50). Juma (2005b:11-12) notes “the urgency of investing in higher technical education is compounded by the impact of HIV/AIDS and other infectious diseases on Africa’s labour force. The challenges include building human capacity and transmitting technical skills to succeeding generations, which underscores the urgency to expand women’s access to higher technical education”. The UNESCO Expert Group (1995:17) states that “an analysis of the problem of gender distribution in enrolment in engineering schools showed that it originates from the secondary school level. Hence the solution of the gender equity problem would have to be at that level”.

Finally, the need for development to be sustainable is emphasised in several reports and papers (Commission for Africa, 2005:248-50, Jerome, 1997:45, DFID, 2002:18-9). Ron Watermeyer has, however, noted the difference between the ‘green agenda’ of the north and the ‘brown agenda’ of the south when considering sustainable development. The key issue in the former is ecosystem well being; in the latter it is human well being. The former considers an eternal timeframe, whereas the latter focuses on the immediate. The scale of the green agenda is local to global; the scale of the brown agenda is local only. The former is concerned about future generations, the latter about low income groups. And finally, and perhaps most significantly, the green agenda aims to use less services to reduce consumption, whereas the brown agenda desires the provision of more services. Sustainable development, in reality, seeks to address both agendas in parallel.

The African Engineers Forum (AEF) aims to provide technical leadership in support of “wealth creation; sustainable development as a prerequisite for development; quality of life; and holistic education and training for capacity building”. The AEF has identified the key issues and influences which account for underdevelopment in Africa as: political and social instability; environmental challenges caused by natural disasters and human interventions; large scale illiteracy and lack of skills and technological expertise; large scale illness including malaria and HIV AIDS; globalization issues that marginalise Africa; and ill advised aid programmes (African Engineers Forum, 2004).

Sir Crispin Tickell identifies the “main global problems” as: population growth; land degradation; climate change; water pollution and shortage; loss of biodiversity; and risks from new technology (Tickell et al., 2006:22). He writes “no where do these global problems have more effect than in Africa” and goes on to state “so far efforts to cope with this alarming rate of interconnected problems have had little success. They tend to be associated with

---

55 Flyer for EFN event Engineering Opportunities and Professional Development held 16 April 2005 in London, provided by Ugochukwu Aduwudike of Cambridge University at a meeting on 3 March 2006.
56 PowerPoint presentation by Ron Watermeyer of SAICE, sent by email 28 February 2006.
problems of government, governance generally, poor infrastructure, local conflicts and corruption” (Tickell et al., 2006:23).

4.5 Key Issues and Priority Areas Identified from Interviews and Emailed Responses

The key issues identified in the literature were generally reinforced by the findings from interviews and emailed responses. Several respondents identified corruption and instability as key issues. Petter Matthews noted that because of low engineering capacity in African nations, and the lack of large infrastructure projects over the last decade, there is a risk that additional resources channelled into infrastructure will lead to corruption and not end up being used as intended. The theme that technologies cannot be introduced effectively without consideration of other factors such as corruption and lawlessness is a common one. Dr Ian Gibson MP writes: “my point is not that introducing new technologies is pointless in this environment, but that its application cannot be isolated from a proper consideration of many other, often basic and overlooked, factors” (Gibson, 2004:30). David Ball suggested that The Royal Academy of Engineering should work only with countries where there is good governance and Claire Curtis-Thomas MP suggested that it is unrealistic for The Royal Academy of Engineering to consider working in fragile states, which she stated make up the majority of Sub-Saharan African nations. However Prof Tony Ridley expressed an opinion that there wasn’t time to wait for African countries to be ‘clean’ before taking action. In relation to this difficulty, Hillary Benn MP has said “the biggest challenge we as donors face and governments face in applying these principles [on which aid is given including respect for human rights, and lack of corruption] in the poorest countries where governance is weak and corruption can be a major problem. Now some would argue that we should refuse to work in such countries […] I think that view is wholly mistaken” (Benn, 2006b:2).

Several respondents also described the brain drain as a key issue. Poor facilities in African universities, lack of opportunities, and poor pay were identified as factors exacerbating the brain drain.

David Ball believes a key issue to be attracting foreign investment to unlock potential. Infrastructure, a skilled workforce and markets were suggested to be essential elements of attracting foreign investment. Petter Matthews also identified the huge potential of the private sector and explained that Engineers Against Poverty are working in this area; for example it is highly likely that huge investment will occur over the next few years to exploit

57 Meeting with Petter Matthews of Engineers Against Poverty, 10 March 2006; email from David Ball, 17 March 2006; meeting with Keith Bachelor of Foster Wheeler Energy Ltd, 21 March 2006; telephone conversation with Dermot Knight of Scott Wilson, 3 April 2006; and telephone conversation with Claire Curtis-Thomas MP, 21 April 2006.
58 Meeting with Petter Matthews of Engineers Against Poverty, 10 March 2006.
59 Email from David Ball, 17 March 2006.
60 Telephone conversation with Claire Curtis-Thomas MP, 21 April 2006.
61 Meeting with Prof Tony Ridley of Imperial College and Prof Peter Guthrie of Cambridge University, 13 February 2006.
62 Telephone conversation with Dr Tony Marjoram of UNESCO, 2 March 2006; meeting with Dr Ian Gibson MP, 8 March 2006; email from David Ball, 17 March 2006; and email from Marie-Odile Zanders of Buro Happold, 17 March 2006.
63 Email from David Ball, 17 March 2006.
64 Meeting with Prof Calestous Juma of Harvard University, 16 January 2006; and email from David Ball, 17 March 2006.
hydrocarbons in Africa. What is not certain is whether the development opportunities that exist through the foreign investment in hydrocarbons will be realised. EAP, together with the ICE made a submission to International Development Select Committee inquiry on private sector development. The executive summary states: “Attracting foreign investment is a necessary though not sufficient condition for reducing poverty.”

Ironically, anti-globalisation protesters campaign against multi-nationals working in developing countries. In response Sachs (2005:356-7) writes: “Africa’s problems, I have noted repeatedly, are not caused by exploitation by global investors but rather by its economic isolation, its status as a continent largely bypassed by the forces of globalization […] Following the end of colonial rule after World War II, some countries chose open trade policies, whereas most developing countries chose protectionism. The open economies decisively outpaced the closed economies”. Hillary Benn, speaking about campaigns to end poverty, notes “many of these campaigns say little explicitly about the creation of more and better jobs for poor people. I think there is little real debate about growth. Amongst some there is even hostility to the idea of international integration into the global economy. Some argue that globalisation is a race to the bottom. And amongst others there is a mistrust of the private sector […]. This is not in the interests of poor people” (Benn, 2006a:3).

The key role of infrastructure in development was mentioned or assumed by most respondents: Dermot Knights suggested that the biggest problem facing Africa is the lack of mature infrastructure; and Prof Calestous Juma stated that the most important contribution to reshaping the debate on international development is highlighting infrastructure as the foundation for technical innovation. The need for regional integration of infrastructure in Africa was also noted by two respondents, and concern over Chinese contractors working in infrastructure provision in Africa was expressed by three respondents: Prof Tony Ridley advised that Nigerian engineers have, through the Institution of Civil Engineers, expressed their deep suspicion of Chinese contractors working in Africa; Sir Gordon Conway expressed concern that Chinese contractors are not addressing anything beyond the provision of hard infrastructure, and that the infrastructure being provided is not necessarily in the best interest of Africa’s development; and Ian Neal noted that a key concern in Africa is the current role of Chinese companies which are winning the majority of contracts because they are very competitive on price, but don’t necessarily have high standards. The suggestion is that large projects funded by the Chinese are ignoring social and environmental impacts. Giles (2006:394) quotes an expert from WWF who states that “few African countries, such as Zambia and South Africa, have the political will and infrastructure to ensure hydropower is implemented responsibly. Elsewhere […] funders with low environmental standards such as China and the Arab banks […] can operate almost unchecked.”

Appropriate standards and appropriate technologies were also identified to be key issues. Ron Watermeyer wrote:

65 Meeting with Petter Matthews of Engineers Against Poverty, 10 March 2006.
66 The Submission of the Institution of Civil Engineers and related parties to the International Development Select Committee on Private Sector Development (copy of the document provided by Ian Neal of Engineers Against Poverty in a meeting on 28 February 2006).
67 Telephone conversation with Dermot Knight of Scott Wilson, 3 April 2006.
68 Meeting with Prof Calestous Juma of Harvard University, 16 January 2006.
69 Meeting with Prof Calestous Juma of Harvard University, 16 January 2006; and meeting with Petter Matthews of Engineers Against Poverty, 10 March 2006.
70 Meeting with Prof Tony Ridley, 13 February 2006; meeting with Ian Neal of Engineers Against Poverty, 13 March 2006; and meeting with Sir Gordon Conway and Alistair Wray of DFID, 6 April 2006.
Commitment to the Millennium Development Goals relating to poverty reduction demands innovative responses from the engineering community. Significant changes in procurement systems and appropriate standards and technologies have been made in post-apartheid South Africa. These also address the “brown” (underdevelopment) agenda and provide a platform for capacity building in developing countries.  

And Jeff Smith wrote:

in developing countries [...] neither cutting edge university research or hi-tech industries will exist, or be needed. Much of the existing ‘engineering capacity’ may be basic and possibly may depend on old (but robust) technology which may be regarded as obsolete and useless by someone used to life at the other (more sophisticated) end of the engineering spectrum!

Designing for failure, and adopting different standards from those used in developed countries, may initially be more appropriate in developing nations. Ron Watermeyer notes that building regulations in South Africa are applicable to less than half of the country’s housing. He advocates developing building codes for all types of housing with different performance levels, and in a paper to be presented at Institution of Structural Engineers (IStructE) in May 2006, describes how, in response to South Africa’s first democratically elected government’s commitment to built 300,000 low income homes every year, the SAICE and the IStructE have developed innovative codes of practice.

Prof Peter Guthrie also noted that engineering degrees in Africa are modelled on international courses which enables African students to continue onto higher degrees in Northern countries, but is not necessarily teaching skills which are relevant to Africa including designing for failure, appropriate standards and appropriate technology. The need for appropriate content of engineering courses was identified as a key issues in addition to the suggestion, already discussed in reference to definitions of engineering capacity building, that engineering curricula need to cover areas not traditional included.

Prof Awadhi Mawenya believes that there is a need to address the ‘relevance’ of engineering education in Africa. He noted that even in close proximity to well-established, prestigious universities there is huge poverty. Yet the work going on in these institutions is not addressing the problems of poverty. He described a dilemma facing universities: how to include technical content but also address relevance and make solving the problems of poverty a focus of engineering education.

A problems based approach to teaching was advocated by Dr Tony Marjoram.
Three African academics identified weaknesses in African universities as key issues in engineering capacity building. Prof Calestous Juma suggested that in African countries, university engineering departments are consistently non-existent or weak, unlike plants sciences and agriculture which have strong departments. Prof Philip Githinji stated that “the key issues are: the quality and sufficiency of physical facilities (buildings, laboratories and computers); further development of senior academic staff; provision of financial resources; maintenance and continuity of high standards.” Prof Awadhi Mawenya identified modernization and relevance of engineering education in Africa as two of four key issues. Linking engineering to business development and enterprise creation has also been identified as vital for development. Three other African academics emphasised the shortage of books and equipment at African Universities:

The first thing that comes to mind is the renewal of laboratory equipment, machinery and instrumentation for Faculties of Engineering in African Universities and in the Polytechnics. Our governments have not been providing adequate funding for this important component of capacity building, to the extent that most of the items in use are several decades old and obsolete.

Equipment, machinery and computers are in great need and can contribute significantly to the quality of engineering education.

Equipment, machinery and computers (including software) are in great need […] as are] books and journals. For new institutions like ours we need funds to support training of local staff and development of infrastructure (like library, laboratories, classrooms, etc) plus hostels, especially if we have to get girls to universities.

A lack of engineering capacity in local governments and municipalities was identified by some respondents: this problem in South Africa, albeit for civil engineering alone, is highlighted by the Needs and Numbers study which identified that of the 231 local municipalities in South Africa 79 have no civil engineers, 42 have only one civil technician, and 38 employ only technologists and technicians under the age of 35 (SAICE, 2006). Andrew Scott and Dr Lucy Stevens of Practical Action believe that engineers at district engineer level in local municipalities are, in Africa, in very influential positions and suggested that a vital part of engineering capacity building is developing and equipping those engineers with the skills to make sure their work has a positive impact on poverty. Kobus van Kyl, writing about South Africa, stated:

---

80 Meeting with Prof Calestous Juma of Harvard University, 16 January 2006.
81 Email from Prof Philip Githinji of the University of Nairobi, 18 February 2006.
82 Meeting with Prof Awadhi Mawenya of Design Partnership Ltd, Tanzania 6 April 2006.
83 Meeting with Prof Calestous Juma of Harvard University, 16 January 2006; and meeting with Ugochukwu Aduwudike of Cambridge University, 3 March 2006.
84 Email from Philip Githinji of the University of Nairobi, forwarded by Derek Bradley FREng, 2005.
85 Email from Silas Lwakabamba of Kigali Institute of Science and Technology (KIST), forwarded by Derek Bradley FREng, 2005.
86 Email from Colleague of Silas Lwakabamba of KIST, forwarded by Derek Bradley FREng, 2005.
87 Meeting with Prof Christopher Clayton of Southampton University, 22 March 2006.
88 Meeting with Steven Hunt, Andrew Scott and Dr Lucy Stevens of Practical Action, 24 March 2006.
Many engineers have left local government with the result that there a significant number of municipalities without any engineer or with technical people who have limited experience and training. While our government functions well on national and provincial level, this is not the case at local level. If you consider that service delivery is done at local government level, this lack represents a serious obstacle to development.\footnote{Email from Kobus van Kyl of Johannesburg University to Prof Christopher Clayton of Southampton University. Copy provide at meeting with Prof Clayton, 22 March 2006.}
5 Action by other Organisations

5.1 Initiatives Supporting Capacity Building in Africa

No initiatives have been identified as being undertaken by members of the Council of Academies of Engineering and Technological Science (CAETS), although research has been limited to a review of each academy’s website. However, initiatives by two science academies have been identified:

- The US National Academy of Science has a programme called *The African Science Development Initiative* which “directly engages African academies of science in building their capacity to provide independent, evidence-based advice to their governments on health-related matters” (The National Academies, 2006a). The initiative is supported by a US$20m grant from the Bill and Melinda Gates Foundation. Efforts are initially focussing on Uganda, Nigeria and South Africa (Alberts, 2004; Alberts, 2005).

- The Royal Society has had a concern for Africa for many years, and in the past has generally focussed its attention on South Africa. However in 2005 “the Society consulted widely [...] with partner organisations and scientists in Africa on three key initiatives: providing input to the Commission for Africa instigated by the Prime Minister; inputting to the Department for International Development's consultation exercise on its science, technology and innovation policy; and developing the Society's extended programme of work in Sub-Saharan Africa in future years” (The Royal Society, 2005). As part of the third initiative, The Royal Society has appointed a manager, capacity building and are exploring how they might take action. At present The Royal Society are working with NEPAD and with science academies in two countries (Ghana and Tanzania) as well as funding research exchange programmes. The work in Ghana and Tanzania is building upon work to strengthen science academies which was started with grants from the US National Academy of Science’s *African Science Development Initiative*.

Initiatives that have been identified that are being undertaken by groups of academies include:

- A programme called *Capacity Building for Young Academies* being undertaken by the InterAcademy Panel on International Issues, led by the Third World Academy of Sciences (TWAS). The InterAcademy Panel is a collaboration of ninety science academies based in Trieste, Italy. The TWAS is an organization of science academies from more than seventy countries, formed in the mid-1990s, which is concerned with building up science institutions in Africa (Alberts, 2001). The *Capacity Building for Young Academies* programme “helps build the capacities of young academies, particularly those in developing countries, to strengthen their role in providing independent advice to governments on issues of national and global concern. The programme has led to the creation of regional networks of science academies in

---

90 Meeting with Prof Peter Guthrie of Cambridge University and Prof Tony Ridley of Imperial College, 13 February 2006.
91 Meeting with Joann Fong of The Royal Society, 22 March 2006.
92 Meeting with Joann Fong of The Royal Society, 22 March 2006.
Africa, the Americas and among member states of the Organization of the Islamic Conference.” (The National Academies, 2006b).

- The Network of African Science Academies (NASAC) is “an autonomous scientific organization, established at the initiative of the African Academy of Sciences (AAS), by academies of science in Africa as a non-governmental, non-political and non-profit scientific organization, in Nairobi in December 2001. […] The general objective of the Network is to act as an independent African forum that brings together academies of science in the continent to discuss the scientific aspects of problems of common concern, to make common statements on major issues relevant to Africa and to provide mutual support to Member Academies. In pursuing this objective the Network collaborates with other Academies inside and outside the continent as well as with regional and international organizations concerned with African problems” (The National Academies, 2006b). Together with the academies of the G8 nations (The Royal Society in the UK), NASAC made a statement to the G8 summit in 2005 (National Science Academies of the G8 Nations and NASAC, 2005).

Of the professional engineering institutions in the UK, it appears that only the Institution of Civil Engineers (ICE) is undertaking initiatives in this area, although the ICE, the Institution of Structural Engineers, the Institution of Mechanical Engineers and the Institution of Electrical Engineers all have branches in African countries. The ICE also has agreements of co-operation with: the Ghana Institution of Engineers; the Institution of Engineers Kenya; and the Zimbabwe Institution of Engineers.

The ICE has had since 1980 an Appropriate Development Panel (ADP) which “discusses wide ranging appropriate technical solutions which are capable of making a valuable contribution towards the improvement of life for millions of people world wide, particularly those in the South.” (ICE, 2006). The ADP was praised by Tony McWalter MP, in a Westminster Hall debate about international development, for the high quality of the evidence it submitted during consultation by the House of Commons Select Committee on Science and Technology for their report on the use of science in UK international development policy (ICEextra, 2005). On 28 March 2006 Peter Cameron of the ICE ADP and Petter Matthews of Engineers Against Poverty gave oral evidence before the House of Commons International Development Select Committee Inquiry into private sector development (The United Kingdom Parliament, 2006).

In 2004 the ICE established a Presidential Commission *Engineering without Frontiers* to consider the role of engineering in addressing poverty and the MDGs (ICE Presidential Commission, 2005). The report recommends that the ICE should do more to raise the awareness of developmental and societal issues; continue its work to change the membership profile; support the work of organisation such as Transparency International in the field of business and ethics; work to empower indigenous professional organisations in LDCs; work to change the way engineers are educated; help LDCs establish undergraduate courses and post-graduate research to meet their development challenges themselves; address the problems of the imposition of inappropriate standards, allowing design for failure; contribute to capacity building in LDCs by providing advice to local engineers and contribute to training programmes; and increase calls for a Chief Engineer to advise government.

The ICE is also a member (the only UK member) of the World Federation of Engineering Organisations (WFEO). WFEO are undertaking a project jointly with UNESCO, *Engineering
for a Better World, “to promote capacity building in engineering and technology for poverty eradication, secure and sustainable social and economic development” (Jones, 2005a). Several interviewees were aware of this initiative.93 “Programme activities will include advocacy and advisory services, information gathering and publication, curricula development and delivery, continuing education, distance and virtual learning and associated expert meetings, workshops, conferences and institutional cooperation in partnership with the public and private sectors, professional bodies and NGOs. The proposed programme is for a period of six years, with possible extension. The programme will require at least three core professional and support staff, complemented by seconded professional staff, consultants, fellows and interns. The Programme budget is estimated at $2.5million per year - $15 million over 6 years.” (WFEO, 2006). Ron Watermeyer advised that the South African Institution of Civil Engineering (SAICE) is participating in the WFEO Capacity Building project.94

The UK National Commission to UNESCO has a Natural Sciences Committee. Prof Shannon FREng sits on this committee, representing the Institution of Mechanical Engineers. He explained that the four biggest engineering institutions were invited to have a representative on the committee, but only two of those four attend meetings. Of the Committee’s budget of £580m Prof Shannon estimates that 99% is spent on scientific work, and less than 1% on engineering. He has worked hard to produce an evidence base to demonstrate that UNESCO’s use of their budget is not contributing to engineering capacity building.95

The Royal Society for Chemistry launched a programme Archives for Africa on 28 February 200696 making “its historical research archives that contain 1.5 million pages and 250,000 articles available free of charge electronically [to developing nations] as part of its commitment to help build science and technology capacity.” The Royal Society for Chemistry is “the first Learned and Professional organisation to provide developing countries with free access to science journal archives” (The Royal Society of Chemistry, 2006).

The recent establishment of several technical and engineering educational institutions and networks in Africa has also been identified:

- The Kigali Institute of Science, Technology and Management (KIST) is widely held up as a success in technical and engineering education (UN Millennium Project Task Force 10, 2005:94, Commission for Africa, 2005:138). “The Kigali Institute of Science, Technology and Management (KIST) is the first public technological institute of higher learning in Rwanda. It came into existence as a UNDP project on November 1st, 1997 with a clear mandate to produce technical, scientific, administrative and managerial expertise of high calibre […]. The establishment of KIST was part of Rwanda Government's mission to build a strong post-genocide human resource base that was so desperately needed then, and is still needed now” (KIST, 2006).

93 Meeting with Prof Peter Guthrie of Cambridge University and Prof Tony Ridley of Imperial College, 13 February 2006; email from Ron Watermeyer of Soderlund and Schutte, South Africa, 28 February 2006; telephone conversation with Dr Tony Marjoram of UNESCO, 2 March 2006; meeting with Petter Matthews of Engineers Against Poverty, 10 March 2006; and meeting with Ian Neal of Engineers Against Poverty, 13 March 2006.
94 Email from Ron Watermeyer of Soderlund and Schutte, South Africa, 28 February 2006.
95 Meeting with Prof Ernest Shannon, 28 March 2006.
96 Meeting with Joann Fong of The Royal Society, 22 March 2006.
• “The Nelson Mandela Institution for Knowledge Building and the Advancement of Science and Technology in Sub-Saharan Africa (NMI) is a private and independent organization established to provide the leadership needed to address the growing knowledge gap between Sub-Saharan Africa and the rest of the world. It will play both a direct and catalytic role in improving learning and the application of science and technology to the development needs of Sub-Saharan Africa. To achieve its objectives, the NMI is establishing the African Institute of Science and Technology (AIST). AIST will be a world-class learning, teaching, and research institution and will produce young entrepreneurs and leaders committed to creating and adapting knowledge to transform local communities and improve the human condition across the African continent. NMI will also develop the Sub-Saharan African Learning Network to promote continuing education and learning across the continent.” (Nelson Mandela Institute, 2006). NMI is supported by the World Bank Institute, Diaspora of African Scientists and Engineers, Indian Institute of Technology-Bombay (IIT), and the International Finance Corporation (IFC).

• University Science, Humanities & Engineering Partnerships in Africa (USHEPiA) is a programme which has developed a network between a number of partner Universities in East and Southern Africa. “USHEPiA is a "south-south" initiative with the aim of human resource development through sustainable capacity-building in the general areas of science, engineering and the humanities. Working through an International Steering Committee, USHEPiA has awarded 39 fellowships since its formal inception in 1995. Thirty-six of the fellowships have allowed staff development Fellows at the participating universities to work for higher degrees” (West and Shackleton, 1999:2). “Major funding for Fellowships in Science and Engineering initially came from the Rockefeller Foundation and the Carnegie Corporation, with some financial support also contributed by the Ridgefield Foundation and the Coca Cola Foundation. Significant funding was later obtained from the Andrew W. Mellon Foundation for the addition of fellowships in the Humanities.” (West and Shackleton, 1999:4). The Report of the InterAcademy Council (2004:53) states “USHEPiA’s success has been attributed to thorough advance consultation among stakeholders, carefully defined and agreed objectives, and especially high level cooperative management backed by local management and support. The program is also recognized for the enthusiasm it generates and for its impact beyond the individual fellows, two hallmarks of effective capacity-building initiatives”.

• The African Institute for Mathematical Sciences (AIMS), in Cape Town, South Africa was established jointly by the University of Stellenbosch and the University of Cambridge. The Institute teaches a nine-month postgraduate diploma to students from all over Africa. Teaching is provided by three south African universities, the University of Cambridge and the University of Oxford. “The goals of AIMS are: to promote mathematics and science in Africa; to recruit and train talented students and teachers; and to build capacity for African initiatives in education, research, and technology. […] The AIMS project is a concrete attempt to implement the New Partnership for Africa’s Development (NEPAD).” Sir David King believes AIMS to be a powerful North-South model.97

---

97 Meeting with Sir David King, Gary Cass and Dr Tracey Elliott of OST, 30 March 2006.
With the exception of AIMS, the above are all South-South initiatives. Other South-only initiatives include the African Engineers Forum, which was identified by several respondents.\(^98\) In 1995 the SAICE together with Engineering Societies located in Zimbabwe, Ghana, Kenya, Namibia and Tanzania established an Africa Forum (AF) to facilitate liaison within Africa. In 2000 the African Engineers Forum was established, to build on the earlier work of the AF, with the aim of promoting and fostering sustainable development within an African context. The AEF Protocol of Understanding was signed by eight Institutions of Engineers in 2001, and a further four in 2004. The AEF is working towards the following goals: “excellence in engineering technology in Africa; informed and intelligent decision making about built-environment infrastructure by all government structures and private sector entities […]; a sufficient pool of competent professionals […]; sustainable professional frameworks and organizational structures in Africa; an awareness relating to AEF activities in order to prepare the countries, its people and its decision makers for the challenges of the future […]; and support the development of entrepreneurship in the engineering environment.”(African Engineers Forum, 2004).

Joann Fong of The Royal Society advised that the Association of Commonwealth Universities (ACU) is working closely with the Association of African Universities (AAU) to support and revitalise science and technology education in Africa.\(^99\) John Rowett when taking on the position of Secretary General of ACU, secured support for his wish to use ACU in support of the G8 initiative on Africa, during UK Presidency of the G8 in 2005.\(^100\)

Several non-governmental organisations in the UK are engineering-based and committed to work for the alleviation of poverty in the developing world. These include:

- **Engineers Against Poverty (EAP)** (formerly the Telford Challenge) who work “through brokering and supporting multi-sector partnerships between the state, private and civil society sectors and by developing other innovative pro-poor engineering initiatives […] have special expertise in improving the corporate social responsibility programmes of engineering services companies.” (Engineers Against Poverty, 2006). Petter Matthews explained that EAP see their role as very broad, addressing and shaping both corporate and public policy. He went to say that most commercial organisations’ experience of NGOs is limited to what he described as the “campaigning NGOs”, such as Friends of the Earth and Greenpeace, who use approaches such as protesting outside launches of company accounts and the like. Consequently, commerce/industry tends to see NGOs as trouble makers. EAP see themselves at the other end of a spectrum of NGOs, together with organisations like Transparency International. However Matthews noted that all NGOs are complementary parts, regardless of their position in the spectrum, and EAP are not in conflict with the campaigning NGOs; in fact Matthews stated that the campaigning approach of Friends of the Earth and the like can give rise to companies turning to work with NGOs like EAP and Transparency International.\(^101\)

- **RedR - Engineers for Disaster Relief**, founded in 1980, is an organisation with a mission to: “to relieve suffering caused by disasters by selecting, training and

---

\(^98\) Email from Ron Watermeyer, 28 February 2006; meeting with Petter Matthews of Engineers Against Poverty, 10 March 2006; and meeting with Prof Christopher Clayton of Southampton University, 22 March 2006.

\(^99\) Meeting with Joann Fong of The Royal Society, 22 March 2006.

\(^100\) Meeting with John Rowett of Association of Commonwealth Universities, 10 January 2006.

\(^101\) Meeting with Petter Matthews of Engineers Against Poverty, 10 March 2006.
providing competent and committed personnel to humanitarian programmes worldwide” (RedR, 2006). “The original concept of RedR was to create a register of carefully selected engineers who could be called on at short notice to work for up to three months with front-line relief agencies on secondment from their regular employer. This concept remains to this day but it has been supplemented by widening the skill base on the Register, increasing the period of assignments and by including professional aid workers” (RedR, 2006). RedR is also a major provider of training courses in humanitarian assistance and disaster response. In 2003 RedR merged with the International Health exchange to become RedR-IHE (Roche, 2005).

- **Practical Action** (formerly known as the Intermediate Technology Group, or ITDG) was founded in 1966 by economist E Schumacher to “prove that his philosophy of ‘Small is Beautiful’ could bring real and sustainable improvements to people’s lives” (Practical Action, 2006). “Practical Action works with poor communities to help them choose and use technology to improve their lives for today and generations to come”. The organisation focuses on four areas: reducing the vulnerability of poor people; helping poor people make a living; helping poor communities gain access to basic services; and helping poor communities respond to new technologies. The NGO works in four regions of the world: Latin America, East Africa; Southern Africa and South Asia. In Africa their work is concentrated in Kenya, Sudan and Zimbabwe.

- **Engineers Without Borders-UK**, aims to “facilitate human development through engineering. This is achieved through: UK and overseas placements with development organisations for students and young graduates; Presentations and seminars surrounding development at university branches; Practical and theoretical training courses around the UK; and UK-based research projects on aspects of development, run at universities.” (Engineers Without Borders - UK, 2006). Ian Neal noted that EWB is working at campus level and is proving to be key in engaging students and influencing curricula.102 Engineers Without Borders-UK is not a part of the Engineers Without Borders International Network. There are tensions between the various EWB organisations and differences in opinion over the value of short term trips.104 Dr Tony Marjoram is sympathetic to this view, but thinks such programmes can be useful if done within a good framework and the philosophy of EWB is attractive to young people, making engineering seem relevant by demonstrating how engineering can address ‘big issues’.105 Several countries in Africa have Engineering Without Borders organisations which are provisional members of the Network.

Petter Matthews pointed out the differences in emphasis of the work of RedR, Engineers Against Poverty and EWB. He explained that RedR’s emphasis is primarily on humanitarian assistance; EWB mobilise undergraduates and work locally at a small scale applying appropriate technology; and EAP are working at corporate and government policy level.

102 Meeting with Ian Neal of Engineers Against Poverty, 13 March 2006.
103 Telephone conversation with Dr Tony Marjoram of UNESCO, 2 March 2006; meeting with Petter Matthews of Engineers Against Poverty, 10 March 2006; and meeting with Ian Neal of Engineers Against Poverty, 13 March 2006.
104 Telephone conversation with Dr Tony Marjoram of UNESCO, 2 March 2006.
105 Telephone conversation with Dr Tony Marjoram of UNESCO, 2 March 2006.
There is a complementary set of skills between the three and Matthews feels it is important that there is coordination between the activities of the organisations.106

In the US, Engineering without Frontiers-USA has recently been renamed Engineers for a Sustainable World (ESW). It is “a non-profit organization with a network of professionals and students working to reduce poverty and improve global sustainability […]. Through domestic and international development work, education, and public outreach, ESW mobilizes engineers to address the challenges of global poverty and sustainability. […] Members and volunteers are building a better future by developing innovative technologies, shaping policy, and fostering small-scale enterprise, improving lives and building a more sustainable world.” (ESW, 2006). The organisation has projects in South Africa, Nigeria and Senegal; chapters on campuses; and summer placements for US students.

5.2 Measuring the Impact of Initiatives

The difficulty of measuring capacity and changes in capacity has been noted in Section 4.3 of this report. The literature gives little guidance on how the impact of initiatives on capacity may be measured and no additional information was obtained from respondents as to how the impact of initiatives might be measured. Two respondents did however note that the time scale for assessing impact should be long-term. Prof Tony Ridley suggested that perhaps a twenty five year horizon might be reasonable to allow for real change as a result of any initiative;107 and Prof Peter Guthrie, in discussing the appropriateness of extending existing Royal Academy of Engineering schemes to Africa, suggested that schemes of fifteen years, rather than five years might be more appropriate.108

106 Meeting with Petter Matthews of Engineers Against Poverty, 10 March 2006
107 Meeting with Prof Tony Ridley of Imperial College and Prof Peter Guthrie of Cambridge University, 13 February 2006.
108 Meeting with Prof Peter Guthrie of Cambridge University, 24 January 2006.
6 Possible Action by The Royal Academy of Engineering

6.1 Suggestions from Respondents

Several respondents\textsuperscript{109} identified the need for quantification of the situation before decisions are made as to what action to take: Philip Githinji identified an initial task to be “on-the-ground assessment of current status” and wrote that “The Royal Academy of Engineering would be in a unique position to assess the needs in the region in collaboration with engineering professionals and academics in Africa, and together formulate action programmes and projects, with follow through to implementation”;\textsuperscript{110} Dr Ian Gibson MP stated that a pilot study, or a task force, is needed to establish what should be done and such a body should go to Africa, make local contacts and ask what is needed;\textsuperscript{111} Prof Awadhi Mawenya explained that he believes a ‘critical mass’ of engineers is needed to enable industrial development in Africa and that a study is needed to quantify this critical mass;\textsuperscript{112} and Prof Richard Carter emphasised that a study should be undertaken, to give a baseline assessment and suggested that there may be existing studies that could contribute, but there probably is not anything comprehensive already done. Carter described such a study as a ‘good, solid review’ and suggested it would be best undertaken by a consultant who knows the country,\textsuperscript{113} although there may be a place for a balance of experience and a fresh look.\textsuperscript{114}

As already noted Dr Tony Marjoram of UNESCO has set out a proposal for collaboration on studies of a similar form to the \textit{Numbers and Needs} study undertaken by Lawless for the SAICE. Dr Marjoram suggested that studies of capacity could be used as an evidence base to demonstrate to policy makers the need for action, given the implications on poverty reduction of having fewer and fewer engineers.\textsuperscript{115} Implying that undertaking surveys and studies to inform policy makers was an ongoing rather than one-off undertaking, Bobby Lambert of RedR suggested that The Royal Academy of Engineering prepare an annual ‘State of Africa Report’, akin to the ICE’s annual ‘State of the Nation Report’.\textsuperscript{116} Claire Curtis-Thomas MP has suggested that a representative from The Royal Academy of Engineering accompany her on a four day trip to Sierra Leone at the end of May 2006 as a fact-finding trip. Claire Curtis-Thomas is raising money for, and arranging construction of, a 100,000 library in Sierra Leone.\textsuperscript{117}

The need for studies is important because it is apparent that as yet there is no consensus on how the problems of poverty in Africa might be addressed, and how the MDGs may be reached. However, even when studies have produced evidence to describe the problems and the current situations, decisions will have to be made as to the best way to progress. Dermot Knight suggested that The Royal Academy of Engineering would be in a strong position to direct the development of ideas as to how the aims set out in the Commission for Africa report could be implemented, and then use their influence to ensure momentum is maintained.

\textsuperscript{109} Including Steven Hunt of Practical Action; Keith Batchelor of Foster Wheeler Energy Ltd; and Tony Roche of RedR.
\textsuperscript{110} Email from Philip Githinji of the University of Nairobi, 18 February 2006.
\textsuperscript{111} Meeting with Dr Ian Gibson MP, 8 March 2006.
\textsuperscript{112} Meeting with Prof Awadhi Mawenya of Design Partnership Ltd, Tanzania, 6 April 2006.
\textsuperscript{113} Telephone conversation with Prof Richard Carter of Cranfield University, 28 February 2006.
\textsuperscript{114} Correspondence from Prof Peter Guthrie of Cambridge University, 21 April 2006.
\textsuperscript{115} Telephone conversation with Dr Tony Marjoram of UNESCO, 2 March 2006.
\textsuperscript{116} Meeting with Bobby Lambert of RedR, 15 March 2006.
\textsuperscript{117} Telephone conversation with Claire Curtis-Thomas MP, 21 April 2006.
and action taken. He described this as taking the Commission for Africa Report to the next level: formulation of policy.\footnote{Telephone conversation with Dermot Knight of Scott Wilson, South Africa, 3 April 2006.}

Several other respondents suggested that The Royal Academy of Engineering is in a strong position to influence high level thinking: Bobby Lambert suggested that The Royal Academy of Engineering should consider itself a ‘think-tank’ and aim to influence in the way that think-tanks do;\footnote{Meeting with Bobby Lambert of RedR, 15 March 2006.} Prof Ernest Shannon suggested that the collective-wisdom of the Fellowship could be used to shape government policy;\footnote{Meeting with Prof Ernest Shannon of UK National Commission for UNESCO, 28 March 2006.} Keith Batchelor suggested that The Royal Academy of Engineering could be in a position to influence governments to recognise the importance of indigenous engineering capacity;\footnote{Meeting with Keith Batchelor of Foster Wheeler Energy Ltd, 21 March 2006.} and John Rowett suggested that The Royal Academy of Engineering join an Africa Steering group.\footnote{Meeting Dr John Rowett of Association of Commonwealth Universities, 10 January 2006.} Two other respondents also suggested that The Royal Academy of Engineering should develop a role in advising government, both in the UK and in Africa, in relation to engineering and poverty reduction.\footnote{Meeting with Ugochukwu Aduwudike of Cambridge University, 3 March 2006; and meeting with Ian Neal of Engineers Against Poverty, 13 March 2006.}

Petter Matthews suggested that the legitimacy of The Royal Academy of Engineering, both in the eyes of government and of engineering institutions would enable it to coordinate work. Matthews suggested that in the UK there are a large number of engineering institutions but their influence is limited to their discipline.\footnote{Meeting with Petter Matthews of Engineers Against Poverty, 10 March 2006.} Ian Neal suggested that The Royal Academy of Engineering could take on the role of ‘honest broker’ between the three sectors of civil society, government and business/industry.\footnote{Meeting with Petter Matthews of Engineers Against Poverty, 10 March 2006.} Petter Matthews noted that there are barriers to the three sectors working together because they have different organisational cultures. The Royal Academy of Engineering is, he feels, in a strong position to lead cross-sectoral working given that it does not fit neatly into any one of these three sectors. Matthews suggested The Royal Academy of Engineering could work through publications, convening conferences or establishing networks.\footnote{Meeting with Ian Neal of Engineers Against Poverty, 13 March 2006.} Dermot Knight and Tony Roche also noted that there are many organisations taking action in this area but the work is fragmented and lacks leadership.\footnote{Meeting with Tony Roche of RedR, 22 March 2006; and telephone conversation with Dermot Knight of Scott Wilson, South Africa, 3 April 2006.}

A concrete suggestion for action to influence high level thinking and develop solutions for meeting the MDGs was put forward by Bobby Lambert of RedR who suggested that The Royal Academy of Engineering convene a meeting similar to the ‘Copenhagen Consensus’ meetings, but comprising a panel of engineers rather than economists. The Copenhagen Consensus Centre at Copenhagen Business School carries out research to “improve the foundation for prioritizing between various efforts to mitigate the consequences of the World's biggest challenges. In particular […] how to do this in the most cost efficient manner” (Copenhagen Consensus Center, 2006). In 2004, at the instigation of economist Bjorn Lomborg, a Copenhagen Consensus conference was convened, in which eight of the world’s leading economists came together and produced a prioritised list of opportunities for
the world's future. The panel were asked to set priorities for confronting ten great global challenges: civil conflicts; climate change; communicable diseases; education; financial stability; governance; hunger and malnutrition; migration; trade reform; and water and sanitation. In addressing the challenges the panel were asked the question: “What would be the best ways of advancing global welfare, and particularly the welfare of developing countries, supposing that an additional $50 billion of resources were at governments’ disposal?”

Dermot Knight advised that it is recognised that huge amounts of aid to Africa have been ineffectual and there is a current opportunity to ‘revamp’ the whole system of aid, and the way money is used. Knight thinks The Royal Academy of Engineering would be in a strong position to put views and ideas forward, and create networks to influence implementation. For example, the economists of the Copenhagen Consensus, identified water and sanitation as projects 4, 5 and 6 in their list of prioritised projects, but it is not clear that the actual implementation of water and sanitation projects was discussed. Clearly this is an engineering problem. Prof Peter Guthrie has noted that economists set policy, while engineers deliver policy. Therefore it would be most appropriate for a group of engineers to take the work of others and operationalise it, or perhaps involve other disciplines if policy suggestions are to be developed.

The Experts’ Panel of the Copenhagen Consensus was shadowed by a Copenhagen Consensus Youth Forum. Prof Peter Guthrie has suggested, along the same lines, that in considering the issues of poverty alleviation, and developing thinking on how the problems might best be addressed, a shadow Royal Academy of young engineers should be convened which would perhaps also provide an opportunity for a greater number of engineers with real experience in Africa to contribute to the debate.

The need to work with African led initiatives, to work to strengthen existing African institutions and to have strong local partners was emphasised by several respondents. Jon Lane stated “it's a good idea for The Royal Academy of Engineering to become involved in poverty reduction and the MDGs, and it should do so by supporting institutions in developing countries, not by trying to do its own work there directly”. There were several reasons given for working with, and supporting, African institutions, including the principle of African self-determination and the belief that such an approach will be more effective. However, Claire Curtis-Thomas MP questions how The Royal Academy of Engineering would identify they people and organisations it could work with, and suggested that the lack of stability in most Sub-Saharan countries would render partnerships ineffectual.

---

128 Telephone conversation with Dermot Knight of Scott Wilson, South Africa, 3 April 2006.
129 Correspondence from Prof Peter Guthrie of Cambridge University, 21 April 2006.
130 Meeting with Prof Peter Guthrie of Cambridge University and Prof Tony Ridley of Imperial College, 13 February 2006.
131 Email from Philip Githinji of the University of Nairobi, 28 February 2006; telephone conversation with Prof Richard Carter of Cranfield University, 28 February 2006; email from Jon Lane, Consultant, Malawi, 11 March 2006; meeting with Prof Christopher Clayton of Southampton University, 22 March 2006; meeting with Practical Action, 24 March 2006; meeting with Sir David King, Gary Cass and Dr Tracey Elliott of OST, 30 March 2006; meeting with Sir Gordon Conway and Alistair Wray of DFID, 6 April 2006; and meeting with Prof Awadh Mawenya of Design Partnership Ltd, Tanzania, 6 April 2006.
132 Email from Jon Lane, Consultant, Malawi, 11 March 2006.
133 Telephone conversation with Claire Curtis-Thomas MP, 21 April 2006.
In relation to the African self-determination, Prof Peter Guthrie used the analogy of a supermarket and a craft fair: supermarkets identify what the customer wants and respond to the demand; craft fair stall holders make what they want to make, and hope it will sell. Joann Fong also explained that The Royal Society is keen to work with NEPAD because it is African led and Keith Batchelor noted that there has been 100% sign-up to NEPAD amongst African countries and suggested The Royal Academy of Engineering should consider working with NEPAD. However Claire Curtis-Thomas MP stated that if The Academy wanted to take action in Sub-Saharan Africa then it would not be appropriate to work with NEPAD because in pan-African organisations the non-fragile states are likely to “run away with any initiative”.

Sir David King stated that the UK government now pursues partnership under Africa, rather than partnership with Africa as previously advocated, and also suggested that despite a recognised need for scientific centres of excellence in Africa, the initial priority must be to work with existing scientific institutions so as not to draw staff and expertise away from them. Sir David King would like to see aid given in such a way that an agreement is made with a country as to how much is to be given and over what timescale, it is then handed over for the nation to use as it sees best, and the UK government’s role would be only to audit periodically.

In relation to increased effectiveness from working with African institutions, Prof Philip Githinji wrote “The Royal Academy of Engineering might find easier connectivity with training institutions, professional engineering bodies, etc. In Kenya, for example, I would suggest Faculties of Engineering, the Polytechnics, Engineering Registration Board, and the Association of Consulting Engineers” and Prof Richard Carter suggested that the key institutions in Africa are the professional institutions and there are obvious linkages for meeting up with or getting involved with such organisations.

To address the problem of lack of mentors in African engineering companies, Prof Christopher Clayton suggested the forming of web based networks to allow mentoring from overseas. He suggested that companies that have offices in several countries are able to share their knowledge and expertise virtually within their organisations and perhaps a similar model could be followed to enable Fellows of The Royal Academy of Engineering to mentor young African engineers. Obviously the ideal would be for engineers to work directly with more experienced engineers who would mentor them, but a web-based scheme would provide some mentoring where conventional approaches are not possible. Prof Clayton also suggested that older UK engineers might be more familiar with operating in the lower technology way that African engineering professionals operate.

Providing opportunities for industrial placements in the UK was another suggestion by Prof Clayton and also by Keith Batchelor. Batchelor suggested that The Royal Academy of

---

134 Meeting with Prof Peter Guthrie of Cambridge University and Prof Tony Ridley of Imperial College, 13 February 2006.
135 Meeting with Joann Fong of The Royal Society, 22 March 2006.
136 Meeting with Keith Batchelor of Foster Wheeler Energy Ltd, 21 March 2006.
137 Telephone conversation with Claire Curtis-Thomas MP, 21 April 2006.
138 Meeting with Sir David King, Gary Cass and Dr Tracey Elliott of OST, 30 March 2006.
139 Telephone conversation with Prof Richard Carter of Cranfield University, 28 February 2006.
140 Email from Philip Githinji of the University of Nairobi, 18 February 2006.
141 Telephone conversation with Prof Richard Carter of Cranfield University, 28 February 2006.
142 Meeting with Prof Christopher Clayton of Southampton University, 22 March 2006.
Engineering could tailor their existing industrial secondment scheme to enable African engineers to work in UK companies for periods of six to twelve months to increase their engineering experience.\(^{143}\) Prof Peter Guthrie suggested that the Visiting Professor Scheme could work well, with senior engineers from UK industry spending time at African Universities, and African academics spending time at UK Universities.\(^{144}\) Sir David King also suggested a programme for post-doctoral researchers modelled on the Humboldt Foundation Fellowship programme, which is a programme for post-doctoral scientists of all nationalities to undertake long-term research stays in Germany with special fellowships for post-doctoral scientists from developing nations. It is prestigious programme and a network exists amongst the past and present Fellows. Sir David King believes there are great possibilities for a network formed between Northern scientists and engineers and Southern scientists and engineers and that The Royal Academy of Engineering would be in a good position to demonstrate the evidence and political imperative for such a scheme.\(^{145}\) Claire Curtis-Thomas MP is currently working to have the British Council Chevening Awards Scheme, which provides funds for students to do post-graduate degrees in the UK, to include engineering in addition to arts and humanities courses.\(^{146}\)

Prof Guthrie suggested that schemes should involve both Universities and Technical Colleges and Marie-Odile Zanders suggested that The Royal Academy of Engineering should concentrate on improving the capacity of workers, rather than professional engineers, through training materials and identifying and distributing best practice.\(^{147}\) To address the problem of lack of books and study materials, Prof Christopher Clayton suggested that Fellows could donate and pay for shipping of their unwanted books and journals to African Universities.\(^{148}\)

### 6.2 Scenarios of Possible Action

Suggestions made by interviewees have been compiled into three scenarios describing possible action by The Royal Academy of Engineering. The scenarios are set out in Boxes 6.1, 6.2 and 6.3. The first scenario, described as low risk, low impact, will be the easiest to implement, requiring nominal funding to be raised to support the work. It would serve to satisfy the requirement to take some action, but in reality will have little impact on the achievement of the MDGs. The next scenario, described as medium risk, medium impact, will need more co-ordinated effort and greater funding, but consequently is likely to have greater impact. However, to genuinely make the most of the position and resources of the Fellowship of The Royal Academy of Engineering, and to make a measurable contribution towards the achievement of the Millennium Development Goals, it is suggested that an approach corresponding to the scenario described as high risk, high impact will be necessary. Clearly this will require considerable commitment and significant funding and most likely require a staff appointment to co-ordinate the work. But the opportunity to have the greatest impact should not be missed.

\(^{143}\) Meeting with Keith Batchelor of Foster Wheeler Energy Ltd, 21 March 2006.  
\(^{144}\) Meeting with Prof Peter Guthrie of Cambridge University, 24 January 2006; and meeting with Prof Peter Guthrie of Cambridge University and Prof Tony Ridley of Imperial College, 13 February 2006.  
\(^{145}\) Meeting with Sir David King, Gary Cass and Dr Tracey Elliott of OST, 30 March 2006.  
\(^{146}\) Telephone conversation with Claire Curtis-Thomas MP, 21 April 2006.  
\(^{147}\) Email from Marie-Odile Zanders of Buro Happold, 17 March 2006.  
\(^{148}\) Meeting with Prof Christopher Clayton of Southampton University, 22 March 2006.
The Royal Academy of Engineering supports the work of NGOs such as Engineers Against Poverty and Engineers Against Borders. Adding the name of The Royal Academy of Engineering to proposals brings credibility to the work of the NGOs. In addition a simple scheme is established whereby Fellows send their spare books and journals to African Universities to enhance the engineering libraries of those institutions.

Box 6.1: Low Risk, Low Impact Scenario

The Royal Academy of Engineering selects several African institutions (professional engineering organisations and educational institutions, both universities and technical colleges) which it undertakes to support and strengthen. Schemes are established for, inter alia: placements in engineering companies for professional development; visiting professorships; and exchange programmes. The Royal Academy of Engineering also works with The Royal Society to establish a programme modelled on the German Humboldt Foundation Fellowship programme, but for several levels, not just post-doctoral researchers.

Box 6.2: Medium Risk, Medium Impact Scenario
The Royal Academy of Engineering extends its strategic priorities to address Africa as well as the UK. The Royal Academy of Engineering sets out to understand the problem of development in Africa, the role of engineering in development, and to influence high-level thinking. To begin, the Royal Academy of Engineering carries out studies, undertaken in collaboration with African partners, to assess needs, existing capabilities and constraints and commits to producing an annual “State of the African Continent” report. The Royal Academy of Engineering then convenes a “Copenhagen-Consensus” type meeting where leading engineers from academia, industry and government meet to identify how problems might be addressed and to formulate action plans. This is the first of many conferences which aim to advance thinking and understanding of engineering capacity building in Africa. The Royal Academy of Engineering takes on the role of ‘honest broker’ acting between the three sectors of industry, government and civil society and uses the studies of needs, capacities and constraints, and the findings of the Copenhagen-Consensus type meetings to shape government policy (both in the UK and Africa) while working with the African-led NEPAD. The Royal Academy of Engineering is recognised for its leadership and its coordinating role, overcoming previously fragmented action.

Box 6.3: High Risk, High Impact Scenario
7 Conclusions

A pilot study has been undertaken to investigate engineering capacity building in sub-Saharan Africa. A literature review, interviews and correspondence with experts and practitioners have been conducted. The study has investigated the concept of engineering capacity building; considered how Sub-Saharan Africa is defined; investigated how and if engineering capacity is measured in African nations; and looked at initiatives being undertaken by other organisations. Finally suggestions have been compiled as how The Royal Academy of Engineering might take action to contribute to poverty reduction and the achievement of the United Nations’ Millennium Development Goals.

The following conclusions have been drawn from the study:

Background and Context:

- As African countries commenced the path to independence in the 1950s and 60s there was great optimism. However, some fifty years later, Sub-Saharan Africa is the poorest region of the World. Of fifty countries defined as Least Developed Countries by the United Nations, thirty-six are African.

- The causes of ongoing poverty in Africa are often attributed to poor governance, colonial legacy, western political interference, poor incentives and geographical and geological factors.

- The approach to development in the 1970s and 80s, described as the Washington-consensus, has been replaced by a focus on the UN Millennium Development Goals (MDGs), agreed in 2000, and nationally owned Poverty Reduction Strategy Papers (PRSPs). Progress towards the MDGs has been slow.

- In 2001 African leaders pledged to commit themselves to eradicate underdevelopment by means of the New Partnership for Africa’s Development (NEPAD). The goals of NEPAD are to achieve and sustain an average Gross Domestic Product growth rate of over 7% per annum for the next 15 years and to ensure that the continent achieves agreed international development goals.

- In 2004, PM Blair launched a Commission for Africa which made recommendations in relation to improving governance, achieving peace and security, investments in health and education, investments in infrastructure and agriculture for economic growth and changes to facilitate trade. The report called for an additional US$25 billion per year in aid, rising to an additional US$50 billion per year by 2015 and implored rich nations to commit 0.7% of their annual income to aid.

Definitions of Sub-Saharan Africa:

- The term Sub-Saharan Africa is widely used in development literature, generally to specify the poorest nations of the continent. However there is no absolute consensus on which countries are included in Sub-Saharan Africa. Generally the term is used to denote all African countries except for the five nations along the northern Mediterranean coast: namely Morocco; Algeria; Tunisia; Libya and Egypt. These
countries can be distinguished from the rest of the continent on basis of geography, culture and relative wealth. Adopting such a definition gives a total of 48 Sub-Saharan countries of which 6 are island states.

- Realistically, The Royal Academy of Engineering would be able to work most effectively with Anglophone countries.

- Some respondents suggested The Royal Academy of Engineering should work only in countries where there is good governance. Other suggested that there is not time to wait for countries to be ‘clean’ before taking action.

**Definitions of Engineering Capacity Building:**

- Capacity building in the context of development is generally understood to mean increasing a country’s capabilities to enable autonomous development.

- The Commission for Africa Report included building up professional knowledge and skills in engineering within its general definition of capacity building.

- There are no explicit references to engineering, science or technology in the MDGs and there is concern that areas such as infrastructure, energy, water and sanitation are at risk of being neglected, while there is an emphasis on health and primary education.

- The necessity of infrastructure for growth and development is, however, widely acknowledged, although in the 1980s and 1990s the funding of large scale infrastructure projects became discredited. More recently there has been renewed interest in the provision of infrastructure.

- Definitions of engineering capacity building are few and far between. Definitions that are set out focus solely on higher education. In contrast, there are many definitions of science capacity presented in the literature. These too focus on increasing human skills and references to infrastructure are to the creation of infrastructure to enable science to be carried out, for example the provision of laboratories.

- References to science capacity may include engineering, but generally this is only implicit.

- Following the example of definitions of science capacity building, engineering capacity should be defined in terms of a nation’s ability to undertake the engineering process, as opposed to being measured in terms of its stock of engineering products.

- A succinct definition of engineering capacity building was provided by A J Smith FREng who stated that engineering capacity is the:

  Knowledge and experience of people who also have access to suitable physical engineering resources to achieve whatever ‘engineered’ facility is needed by their community. In the context of developing countries, ‘engineering capacity building’ requires suitable: Education and training; Practical experience; Materials/resources; Machinery and
tools; and an appropriate (locally tailored) approach to technology, H & S [and] environmental controls.

Smith’s definition implies the capability to identify what engineered facilities are needed and plan accordingly. It also includes a need for practical experience and opportunities.

- Engineering should not be limited to professional engineers.
- There is a priority, in addressing poverty, for work undertaken by civil engineers; however the work of other branches of engineering is vital for the generation of economic growth and continued development.
- The training of professional engineers needs to include areas not traditional covered in engineering curricula: for example social, cultural and environmental issues; the ability to interact with other organisations and with people for whom solutions are developed; and the implementation of projects including both project management and other ‘softer’ skills.
- The assumption that engineering capacity leads to economic growth, wealth creation and poverty alleviation has been questioned, on the basis that other conditions also need to be in place. The assumption that economic growth leads to poverty reduction for all has also been questioned and engineering capacity building that results in pro-poor growth should be pursued.

Measuring Capacity:

- There is a consensus that engineering capacity in Africa is not currently measured.
- Parameters suggested for measuring capacity often include ‘headcounts’ of engineers. However, this does not demonstrate engineering capacity. Capacity should be measured in terms of output, however ‘headcounts’ of engineers could be useful to demonstrate the low number of engineers even if it is not in itself a measure of capacity. Using citation analysis, a common measure of science capacity, is inappropriate.
- There is little guidance on how the impact of initiatives on capacity may be measured however the time scale for assessing impact should be long-term.

Key issues and Priority Areas:

- Key issues and priority areas that have been identified are: corruption and lack of governance; improving infrastructure; adopting appropriate standards; ensuring the inclusion of social, economic and environmental factors in engineering solutions; improving engineering education; encouraging innovation and entrepreneurship; stemming the ‘brain drain’; and ensuring development is sustainable.
Initiatives by Other Organisations:

- No initiatives have been identified as being undertaken by members of the Council of Academies of Engineering and Technological Science (CAETS).

- Initiatives by two science academies have been identified: The US National Academy of Science has a programme called *The African Science Development Initiative*; and The Royal Society has appointed a manager, capacity building, are working with NEPAD and with science academies in two African countries and funding research exchange programmes.

- A programme called *Capacity Building for Young Academies* is being undertaken by the InterAcademy Panel on International Issues, led by the Third World Academy of Sciences (TWAS); and The Network of African Science Academies (NASAC) is an independent African forum that brings together academies of science in the continent to discuss the scientific aspects of problems of common concern. Together with the academies of the G8 nations (The Royal Society in the UK), NASAC made a statement to the G8 summit in 2005.

- Of the professional engineering institutions in the UK, it appears that only the Institution of Civil Engineers (ICE) is undertaking initiatives in this area. In 2004 the ICE established a Presidential Commission *Engineering without Frontiers* to consider the role of engineering in addressing poverty and the MDGs.

- The ICE is also a member (the only UK member) of the World Federation of Engineering Organisations (WFEO). WFEO are undertaking a project jointly with UNESCO, *Engineering for a Better World*. The South African Institution of Civil Engineering (SAICE) is participating in the project.

- The Royal Society for Chemistry launched a programme *Archives for Africa* making its historical research archives available free to developing nations.

- Several technical and engineering educational institutions and networks in Africa have been established recently, including: the Kigali Institute for Science and Technology (KIST) which is often held up as a success in technical and engineering education; The Nelson Mandela Institution for Knowledge Building and the Advancement of Science and Technology in Sub-Saharan Africa; University Science, Humanities & Engineering Partnerships in Africa (USHEPiA), a network between a number of partner Universities in East and Southern Africa; and the African Institute for Mathematical Sciences (AIMS), in Cape Town, South Africa, established jointly by the University of Stellenbosch and the University of Cambridge.

- In 2000 the African Engineers Forum was established with the aim of promoting and fostering sustainable development within an African context. The AEF Protocol of Understanding was signed by eight African Institutions of Engineers in 2001, and a further four in 2004.

- The Association of Commonwealth Universities (ACU) is working closely with the Association of African Universities (AAU) to support and revitalise science and technology education in Africa.
Several non-governmental organisations in the UK are engineering-based and committed to work for the alleviation of poverty in the developing world, including Engineers Against Poverty, Engineers Without Borders, Practical Action and RedR.

**Possible Action by The Royal Academy of Engineering:**

- It is suggested that there is a need for quantification of the situation before decisions are made as to what action to take. UNESCO has set out a proposal for collaboration on studies, of a similar form to a study undertaken by the South African Institution of Civil Engineering, to demonstrate to policy makers the need for action.

- There is no consensus on how the problems of poverty in Africa might be addressed, and how the MDGs may be reached. It is suggested that The Royal Academy of Engineering is in a strong position to influence high level thinking and to direct the development of ideas as to how the aims set out in the Commission for Africa report could be implemented.

- There are many organisations taking action in this area but the work is fragmented and lacks leadership. The legitimacy of The Royal Academy of Engineering, both in the eyes of government and of engineering institutions, would enable it to coordinate work and it is suggested that The Royal Academy of Engineering could take on the role of ‘honest broker’ between the three sectors of civil society, government and business/industry.

- In order to influence high level thinking and develop solutions for meeting the MDGs, The Royal Academy of Engineering could convene a meeting similar to the ‘Copenhagen Consensus’ meetings, but comprising a panel of engineers rather than economists.

- The Experts’ Panel of the Copenhagen Consensus was shadowed by a Copenhagen Consensus Youth Forum. In considering the issues of poverty alleviation, and developing thinking on how the problems might best be addressed, a shadow Royal Academy of young engineers could be convened which would also provide an opportunity for a greater number of engineers with real experience in Africa to contribute to the debate.

- There is a need to work with African-led initiatives, to work to strengthen existing African institutions and to have strong local partners. The UK government now advocates partnership under Africa, rather than partnership with Africa.

- Mentoring networks, placement schemes for African engineers to work for short periods in UK engineering companies, a Visiting Professors Scheme and a programme for post-doctoral researchers modelled on the Humboldt Foundation Fellowship programme have been suggested.

- Suggestions for action have been compiled into three scenarios.
The first scenario, described as low risk, low impact, will be the easiest to implement, requiring nominal funding. It would serve to satisfy the requirement to take some action, but in reality will have little impact on the achievement of the MDGs.

The next scenario, described as medium risk, medium impact, will need more co-ordinated effort and greater funding, but consequently is likely to have greater impact.

To genuinely make the most of the position and resources of the Fellowship of The Royal Academy of Engineering, and to make a measurable contribution towards the achievement of the MDGs, it is suggested that an approach corresponding to the scenario described as high risk, high impact will be necessary. Clearly this will require considerable commitment and significant funding and most likely require a staff appointment to co-ordinate the work. But the opportunity to have the greatest impact should not be missed.
Appendix A: Details of Meetings, Telephone Conversations and Email Responses

Meetings:

10 January 2006:
Keith Davis, Head of Engineers Affairs RAEng met with Dr John Rowett, Secretary General, Association of Commonwealth Universities (ACU).

16 January 2006:
Philip Greenish, Chief Executive RAEng, Keith Davis Head of Engineering Affairs RAEng, Peter Saraga FREng, Chair of the International Committee RAEng and Helen Bartlett met with Prof Calestous Juma, Professor for the Practice of International Development, Harvard University.

24 January 2006:
Helen Bartlett met with Prof Peter Guthrie FREng, Professor in Engineering for Sustainable Development, Cambridge University.

13 February 2006:
Keith Davis, Head of Engineers Affairs RAEng, Alan Walker, Policy Advisor Engineering Policy RAEng and Helen Bartlett met with Prof Tony Ridley FREng, Emeritus Professor of Transport Engineering, Imperial College and Prof Peter Guthrie FREng, Professor in Engineering for Sustainable Development, Cambridge University.

3 March 2006:
Helen Bartlett met with Ugochukwu Akuwudike, PhD student, Cambridge University.

8 March 2006:
Helen Bartlett met with Dr Ian Gibson MP, former Chairman of the House of Commons Science and Technology Committee.

8 March 2006:
Helen Bartlett met with Prof John Wood FREng, Chief Executive Officer, Council for the Central Laboratory of the Research Councils (CCLRC).

10 March 2006:
Helen Bartlett met with Petter Matthews, Director, Engineers Against Poverty (EAP).

13 March 2006:
Helen Bartlett met with Ian Neal, Programme Officer, Engineers Against Poverty (EAP).

13 March 2006:
Keith Davis, Head of Engineers Affairs RAEng, Alan Walker, Policy Advisor Engineering Policy RAEng and Helen Bartlett met with Dr Tony Marjoram, Senior Programme Specialist, Division of Basic and Engineering Sciences, Natural Sciences Sector, United Nations’ Educational, Scientific and Cultural Organisation (UNESCO).
15 March 2006:
Helen Bartlett met with Bobby Lambert, Chief Executive, Engineers for Disaster Relief (RedR).

21 March 2006:
Helen Bartlett met with Keith Batchelor FREng, Director, Foster Wheeler Energy Ltd.

22 March 2006:
Helen Bartlett met with Tony Roche FREng, Vice President, Engineers for Disaster Relief (RedR).

22 March 2006:
Helen Bartlett met with Prof Christopher Clayton, Professor, Department of Civil and Environmental Engineering, Southampton University.

22 March 2006:
Helen Bartlett met with Joann Fong, Manager, Capacity Building, The Royal Society.

24 March 2006:
Helen Bartlett met with Steven Hunt, Consultant, Andrew Scott, Policy and Programmes Director, and Dr Lucy Stevens, International Co-ordinator, Access to Services Programme, Practical Action.

28 March 2006:
Helen Bartlett met with Prof Ernest Shannon FREng, Past-President of the Institution of Mechanical Engineers and Member of the Natural Sciences Committee, UK National Commission for UNESCO.

30 March 2006:
Keith Davis and Helen Bartlett met with Sir David King, Chief Scientific Advisor to HM Government, Gary Cass, Office of Science and Technology, and Dr Tracey Elliott, Assistant Director, Global Policy, Office of Science and Technology.

6 April 2006:
Helen Bartlett met with Sir Gordon Conway, Chief Scientific Advisor, Department for International Development (DFID) and Alistair Wray, Head of Profession, Infrastructure Group, DFID.

6 April 2006:
Helen Bartlett met with Prof Awadhi Maweyna, Director, Design Partnership Ltd, Consulting Engineers, Tanzania.
Telephone Conversations:

28 February 2006:
Helen Bartlett spoke with Prof Richard Carter, Professor of International Water Development, Cranfield University.

2 March 2006:
Helen Bartlett spoke with Dr Tony Marjoram, Senior Programme Specialist, Division of Basic and Engineering Sciences, Natural Sciences Sector, UNESCO.

3 April 2006:
Helen Bartlett spoke with Dermot Knight, Scott Wilson, South Africa.

21 April 2006
Helen Bartlett spoke with Claire Curtis-Thomas MP, a Fellow of the IMechE and the IEE.

Email Correspondence:

18 February 2006:
Email from Prof Philip Githinji, retired, formerly of the University of Nairobi.

27 February 2006:
Email from Jeff Smith FREng, Managing Director, Wardell Armstrong.

28 February 2006 and 15 March 2006:
Emails from Ron Watermeyer, Director, Soderlund and Schutte, Consulting Engineers, South Africa and Past-President of the South African Institution of Civil Engineering (SAICE).

10 March 2006 and 17 March 2006:
Emails from David Ball FREng.

11 March 2006:
Email from Jon Lane, Consultant in Water and Sanitation for Developing Countries, Malawi.

12 March 2006 and 23 March 2006:
Emails from Dawie Botha, Executive Director, South African Institution of Civil Engineering (SAICE).

13 March 2006:
Email from Robert Reith FREng, formerly of FIDIC Executive Committee.

17 March 2006:
Email from Marie-Odile Zanders, International Development Consultant, Buro Happold.

20 March 2006:
Email from Dr Tony Marjoram Senior Programme Specialist, Division of Basic and Engineering Sciences, Natural Sciences Sector, UNESCO.

23 March 2006:
Email from Keith Batchelor FREng, Director, Foster Wheeler Energy Ltd.
## Appendix B: Interview Guide and Opening Questions to Prompt Discussion

### Opening questions
- Could you tell me a little about your background and experience/expertise in poverty reduction/capacity building?
- Do you think engineering capacity is important for poverty reduction?
- Which countries make up Sub-Saharan Africa?
- For the purposes of this study do you think the RAEng should consider all of Africa or just SSA?
- Do you think the division of Africa into two regions is useful?
- Which countries do you think might benefit most from action by the RAEng?
- What is engineering capacity?
- What is meant by engineering capacity in the context of developing countries/Africa?
- How is engineering capacity different from science capacity or other types of capacity?
- How is it (or changes in it) measured?
- How might one go about assessing the levels in each country?
- Is the engineering capacity of African countries currently quantified?
- Ongoing initiatives?
- Are you aware of any existing projects where organisations like the RAEng are supporting engineering capacity building in Africa?
- How, practically, are the projects undertaken?
- How is the impact of initiatives measured?
- Potential initiatives?
- How might the RAEng support the enhancement of engineering capacity in Africa?
- Are there needs that the RAEng would be in a unique position to meet?
- Should action be at a regional or country level?
- Priority areas?
- What do you think are the priority areas?
- What are the key issues in engineering capacity building?
- What are the difficulties or challenges of engineering capacity building?
- Other Interviewees?
- Is there anyone else you think I should speak to?
- Any references you recommend I look at?
Opening Questions to Prompt Discussion:

1. What is meant by engineering capacity building in the context of developing countries?

2. How is engineering capacity building different from science capacity building or other forms of capacity building?

3. How might engineering capacity building be assessed, and changes in it measured?

4. How is the engineering capacity of African countries currently quantified?

5. How might The Royal Academy of Engineering support the enhancement of engineering capacity?

6. What initiatives are being undertaken by other organisations?

7. Are there needs that The Royal Academy of Engineering would be in a unique position to meet?

8. What are the key issues in engineering capacity building?

9. What are the priority areas?

10. Should the study consider only Sub-Saharan African countries?
Appendix C: Draft Outline Project Proposal by UNESCO for an International Study on Capacity and Capacity Building in Engineering and Technology
Needs and Numbers: International Study on Capacity and Capacity Building in Engineering and Technology

Engineering, science and technology play a key role in social and economic development, as reflected in the increasing interest in “knowledge societies” and “the knowledge economy” around the world. At the same time, there is a disturbing decline of interest among young people in science at the secondary level, and of enrolment at the tertiary level - with fewer young people going into engineering courses at universities in most countries. It also has a gender dimension - in most countries, less than 25% of students in engineering are women. At the same time, there is also a concern with the loss of engineers through brain-drain. These trends of disinterest, downward enrolment and brain drain, if not reversed, will have major adverse consequences in the future for capacity-related aspects of development, especially in developing countries.

The application of engineering, science and technology to social and economic development requires adequate human and institutional capacity and continuous capacity-building. The need to build capacity in engineering, science and technology for development was underlined in the 2004 InterAcademy Council report, the Main Report of the UN Millennium Project in 2005, the report of the Africa Commission and, most recently, at the UNESCO Forum on Engineering and Technology for Poverty Reduction held in February, 2006, in Johannesburg.

All factors relating to capacity and capacity building in engineering and technology education are in need of urgent attention. At the tertiary level, courses need to be made more interesting and exciting, as does science teaching at the secondary and primary levels, for it is here that loss of interest in engineering begins. Systemic reform of engineering education is required to make courses at the tertiary level more interesting, through better pedagogical approaches and innovative curriculum development, linked to promoting the greater public understanding of engineering.

To address these issues, however, we need to better understand the situation of demand and supply and the attitudes of young people that lead to them turning away from engineering – to provide an evidence-based picture and approach to change. To respond to this challenge, it is proposed to conduct an international study on capacity and capacity building in engineering and technology – with a regional approach and initial study on Sub-Saharan Africa.

This study is proposed by UNESCO - the UN agency responsible for the sciences, in conjunction with partner agencies and organisations. UNESCO has a mandate to work with member states on issues relating to science and engineering, including the gathering of statistics and information. Partner and sponsor organizations include the World Federation of Engineering Organisations (WFEO), the International Council of Academies of Engineering and Technological Sciences (CAETS), the Royal Academy of Engineering and South African Institution of Civil Engineers (SAICE) – who completed a study on civil engineering in South Africa in 2005 and have agreed to cooperate in this study. It is estimated that the initial study of sub-Saharan Africa, with six or seven countries, would take around 12 months, with a budget of around $100,000. Other sponsors will therefore be required.

For further information, please contact:
Tony Marjoram, Basic and Engineering Sciences, Natural Sciences Sector, UNESCO
tel: +331 456 84178; fax:+331 456 85821/85820, email: t.marjoram@unesco.org
References

African Engineers Forum (2004) A E F Protocol of Understanding.

Akin Adubifa, O. (2004) A T P S Special Paper Series No 19: An Assessment of Science and Technology Capacity Building in Sub-Saharan Africa, African Technology Policy Studies Network, Nairobi.

Alberts, B. (2001) Talk to the Substantive Session of the Economic and Social Council of the United Nations: Science for African Development, Geneva.

Alberts, B. (2004) A World That Banks on Science, National Academy of Sciences, Washington DC.

Alberts, B. (2005) Summing Up: Creating Scientific Temper for the World, National Academy of Sciences, Washington DC.

Annan, K. (2005) Forward in United Nations (Ed.) The Millennium Development Goals Report 2005, United Nations, New York.

Benn, H. (2005) European Parliament Debate - Africa, Globalisation and Poverty: Closing Statement by U K Secretary of State for International Development, 6 July 2005.

Benn, H. (2006a) 1st White Paper Speech: Growth and Poverty Reduction, 19 January 2006, www.dfid.gov.uk accessed 20 April 2006.

Benn, H. (2006b) 3rd White Paper Speech: Political Governance, Corruption and the Role of Aid, 2 February 2006, www.dfid.gov.uk accessed 20 April 2006.

Benn, H. (2006c) 5th White Paper Speech: Development Beyond Aid, 23 February 2006, www.dfid.gov.uk accessed 20 April 2006.

Calvocoressi, P. (2001) World Politics, Pearson Education, Harlow.

Chang, H.-J. (2002) Kicking Away the Ladder: Development Strategy in Perspective, Anthem Press, London.

Chataway, J., Smith, J. and Wield, D. (2005) Partnerships for Building Science and Technology Capacity in Africa: Canadian and U K Experiences Building Science and Technology Capacity with African Partners, Canada House, London, 30 Jan - 1 Feb 2005.

Chen, S. and Ravallion, M. (2004) How Have the World's Poorest Fared since the Early 1980s? World Bank Research Observer, 19 (2), pp.141-69.

CIA (2006) The World Factbook www.cia.gov/cia/publications/factbook/fields/2098.html accessed 6 February 2006.

Commission for Africa (2005) Our Common Interest, London.
Commission for Africa (2006) http://www.commissionforafrica.org/english/about/story.html, accessed.

Copenhagen Consensus Center (2006) http://www.copenhagenconsensus.com/Default.aspx?ID=668, accessed 17 April 2006.

DFID (2002) *Making Connections: Infrastructure for Poverty Reduction*, DFID, London.

DFID (2006) *Eliminating World Poverty: A Consultation Document*, DFID, London.

Easterly, W. (2001) *The Elusive Quest for Growth*, MIT Press, Cambridge, MA.

Eldis (2006) http://www.eldis.org/africa/, accessed 20 February 2006.

Encyclopaedia Britannica (2006) http://search.eb.com/eb/article-9108323, accessed 16 January 2006.

Engineers Against Poverty (2006) http://www.engineersagainstpoverty.org, accessed 30 January 2006.

Engineers Without Borders - UK (2006) http://www.ewb-uk.org, accessed 30 January 2006.

ESW (2006) http://www.esustainableworld.org/about/, accessed 30 January 2006.

FCO (2006) http://www.fco.gov.uk/servlet/Front?pagename=OpenMarket/Xcelerate/ShowPage&c=Page&cid=1007029394365&continent=4, accessed 24 March 2006.

G8 Leaders (2005) *The Gleneagles Communiqué*.

Gibson, I. (2004) Science: No Use by Itself *Science and Public Affairs*, Sept 2004 pp.30.

Giles, J. (2006) Tide of Censure for African Dams *Nature*, 440 (23 Mar 2006), pp.393-4.

House of Commons Science and Technology Committee (2004) *The Use of Science in UK International Development Policy (HC 133) Volumes 1 and 2*, The Stationary Office Ltd, London.

ICE (2006) http://www.ice.org.uk///about_ice/icenearyou_adp.asp, accessed 27 January 2006.

ICE Presidential Commission (2005) *Engineering without Frontiers*.

ICEExtra (2005) accessed 13 April 2006.

IMF (2005) *Afritacs: Independent Mid-Term Evaluation*.

InfraPoor (2006) *Guiding Principles on Using Infrastructure to Reduce Poverty*.

InterAcademy Council (2004) *Inventing a Better Future: A Strategy for Building Worldwide Capacities in Science and Technology*, InterAcademy Council, Amsterdam.
Jerome, A. (1997) *Infrastructure in Africa: The Record*, African Development Bank.

Jones, R. (2005a) *Engineering for a Better World* American Society for Engineering Education Annual Conference.

Jones, R. (2005b) *Technical Capacity Building in Developing Countries to Promote Economic Development* American Society for Engineering Education Annual Conference.

Jones, R. and Oberest, B. (2003) *Capacity Building - Engineers for Developing Countries* American Society for Engineering Education Annual Conference.

Juma, C. (2005a) *Introduction* in Juma, C. (Ed.) *Going for Growth: Science, Technology and Innovation in Africa*, The Smith Institute, London.

Juma, C. (2005b) *Reinventing Growth* in Juma, C. (Ed.) *Going for Growth: Science, Technology and Innovation in Africa*, The Smith Institute, London.

Juma, C. and Lee, D. I. Y.-C. (2005) *U N Millennium Project Task Force 10, Science Technology and Innovation. Innovation: Applying Knowledge in Development*, Earthscan, London.

Khalil-Timamy, M. H. (2002) *A T P S Special Paper Series No 12: State of Science and Technological Capacity in Sub-Saharan Africa*, African Technology Policy Studies Network, Nairobi.

King, D. (2003) Building Science and Engineering Capacity in the Developing World *Engineering Management*, 13 (1), pp.15.

King, D. (2005) *Governing Technology and Growth* in Juma, C. (Ed.) *Going for Growth: Science, Technology and Innovation in Africa*, The Smith Institute, London.

KIST (2006) http://www.kist.ac.rw/about/about.htm, accessed 19 February 2006.

Lawless, A. (2006) *Numbers and Needs: Addressing Imbalances in the Civil Engineering Profession*, SAICE, Johannesburg.

Lord May of Oxford (2004) www.royalsociety.ac.uk/publication.asp?id=2723, accessed 1 August 2005.

Maconick, R. (2002) *Introduction* in Maconick, R. (Ed.) *Capacity-Building for Poverty Eradication*, UN, New York.

Make Poverty History (2006) http://www.makepovertyhistory.org/whatwewant/index.shtml, accessed 18 April 2006.

Maxwell, S. (2005) The Washington Consensus Is Dead! Long Live the Meta-Narrative *Overseas Development Institute Working Paper*, 243.
Meredith, M. (2005) *The State of Africa: A History of Fifty Years of Independence*, Simon and Schuster, London.

Michigan State University (2006) http://exploringafrica.matrix.msu.edu/curriculum/lm20/intro.html, accessed 4 January 2006.

Mistry, P. (2005) Reasons for Sub-Saharan Africa's Development Deficit That the Commission for Africa Did Not Consider *African Affairs*, 104 (417), pp.665-678.

Morgan, P. (2002) *The Evaluations of the Work of the UN System in Capacity Building and Poverty Eradication* in Maconick, R. (Ed.) *Capacity Building for Poverty Eradication*, UN, New York.

National Science Academies of the G8 Nations and NASAC (2005) *Joint Science Academies Statement: Science and Technology for African Development*.

Nelson Mandela Institute (2006) http://www.nmiscience.org/home.html, accessed 27 January 2006.

NEPAD (2001) *New Partnership for Africa’s Development*.

NEPAD (2005) *Africa’s Science and Technology Consolidated Plan of Action*.

NEPAD (2006) http://www.nepad.org/2005/files/home.php, accessed 23 January 2006.

Parliamentary Office of Science and Technology (2004) *Scientific Capacity in Developing Countries*, POSTnote, London.

Porteous, T. (2005) British Government Policy in Sub-Saharan Africa under New Labour *International Affairs*, 81 (2), pp.281-97.

Practical Action (2006) http://www.practicalaction.org/?id=about_us, accessed 12 April 2006.

Rand Science and Technology (2001) *Science and Technology Collaboration: Building Capacity in Developing Countries?*, RAND, Santa Monica.

RedR (2006) www.redr.org.uk, accessed 12 April 2006.

Ridley, T. and Lee, D. I. Y.-C. (2005) *Infrastructure, Innovation and Development* in Juma, C. (Ed.) *Going for Growth: Science, Technology and Innovation in Africa*, The Smith Institute, London.

Roche, T. (2005) *Worshipful Company of Engineers Junior Wardens Lecture: RedR-Registered Engineers for Disaster Relief*.

Russell, B. (2006) Brown Pledges $15bn for Schools Plan *The Independent*, 10 April 2006 pp.2.
Sachs, J. (2005) *The End of Poverty: How We Can Make It Happen in Our Lifetime*, Penguin, London.

SAICE (2006) www.civils.org.za/n_and_n.html, accessed 11 April 2006.

Singleton, D. and Hahn, N. (2004) Sustainable Poverty Alleviation - Changing Role for Engineers *Civil Engineering*, 157 (6), pp.37-42.

Stanford University (2006) http://www-sul.stanford.edu/depts/ssrg/africa/guide.html, accessed 4 January 2006.

The National Academies (2006a) http://www7.nationalacademies.org/africa/, accessed 26 January 2006.

The National Academies (2006b) http://www4.nationalacademies.org/iap/iaphome.nsf/weblinks/WWW-65GGU4?OpenDocument, accessed 27 January 2006.

The Royal Academy of Engineering (2005) *Strategic Plan 2005-2010*, The Royal Academy of Engineering, London.

The Royal Society (2005) http://www.royalsoc.ac.uk/publication.asp?id=3902, accessed 27 January 2006.

The Royal Society of Chemistry (2006) http://www.rsc.org/AboutUs/News/PressReleases/2006/Archive.asp, accessed 12 April 2006.

The Times (2004) *Concise Atlas of the World*, Times Books, London.

The United Kingdom Parliament (2006) *Uncorrected Transcript of Oral Evidence HC 921-iii* www.publications.parliament.uk accessed 21 April 2006.

Tickell, C., Rijsberman, F., Carter, R. and Conway, G. (2006) The Importance of Science, Engineering and Technology to a Sustainable Economy on the African Continent *Science in Parliament*, 63 (1), pp.22-29.

UN Department of Economic and Social Affairs (2002) *Capacity Building in Africa: Effective Aid and Human Capital (Report of the Committee for Development Policy on the Fourth Session)*, UN, New York.

UN Millennium Project Task Force 10 (2005) *Innovation: Applying Technology in Development*, Earthscan, London.

UN Secretary General (2001) *Road Map Towards the Implementation of the United Nations Millennium Declaration*, United Nations, New York.

UNESCO Expert Group (1995) *Strategic Issues in Engineering Education in Africa*, UNESCO, Nairobi.

UNICEF (2006) http://www.unicef.org/infobycountry/index.html, accessed 4 January 2006.
UNIDO (2004) *Industrial Development Report: Industrialization, Environment and the Millennium Development Goals in Sub-Saharan Africa*, UNIDO, Vienna.

United Nations (2005) *The Millennium Development Goals Report*, UN Department of Public Information, New York.

United Nations (2006) http://unstats.un.org/unsd/methods/m49/m49regin.htm, accessed 4 January 2006.

West, M. and Shackleton, L. (1999) *Ushepia: Building a Research Capacity Network in Africa*, The World Bank, Washington DC.

WFEO (2006) www.wfeo.org, accessed 27 January 2006.

WHO (2006) http://www.who.int/about/regions/afro/en/index.html, accessed 4 January 2006.

Williamson, J. (1999) http://www.iie.com/publications/papers/paper.cfm?ResearchID=351, accessed 15 February 2006.

World Bank (2005a) *African Development Indicators*, The International Bank for Reconstruction and Development, Washington DC.

World Bank (2005b) http://devdata.worldbank.org/wdi2005/index2.htm, accessed 5 January 2005.

World Bank (2006) http://web.worldbank.org/WSITE/EXTERNAL/NEWS/0,,contentMDK:20382855~pagePK:116743~piPK:36693~theSitePK:4607,00.html, accessed 4 January 2006.