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Appropriate Technology: The Poetry of Science

The case is made for increased use of appropriate technology to solve pressing engineering challenges from a Christian perspective. The rapid advance of technology and its impact on culture and research priorities are discussed. Appropriate technology is introduced as a practical and ethical alternative to the increasingly complex solutions favoured by many.

'L'invention n'est-elle pas la poésie de la science?'[1] *E. M. Bataille*

'The world is very different now. For man holds within his mortal hands the power to destroy all forms of human poverty and the power to destroy all forms of human life.'[2] *John F. Kennedy*

Key words: technology, technopoly, sustainability, world poverty, appropriate technology.

Introduction

In this paper, the role of technology is examined from a Christian perspective. We begin by considering the interrelationship between technology and culture, and the effects that the rapid advances in science and engineering have had on the developed and developing world. It will be shown that research priorities are increasingly being set by the desire for complexity rather than by addressing practical needs. Appropriate technology is defined and introduced as an attractive alternative to the technology race. In particular, sustainable appropriate technology solutions are considered with reference to some case studies. Finally, conclusions are drawn as to the future of technology.

In the last two centuries, engineering technology has advanced at a staggering rate. Innovations continue to arrive, making last year's top-of-the-range computer, mobile phone and digital camera look decidedly outmoded even before their warranties have expired. The historical impact of technology on humanity and on religion is well documented.[3] The progress made in material science, power generation, machine tools, transport and communication has transformed human existence throughout most of the world, removing muscu-

1 'Is not invention the poetry of science?' E. M. Bataille, C. E. Jullien. 'Traité des Machines à Vapeur'. Paris 1847-49, quoted in Smiles, S. *The steam-engine: Boulton and Watt*, London: John Murray (1878).
2 Inaugural Address of John F. Kennedy, White House, Washington, USA, Fri, January 20th, 1961.
3 Alexander, D.R. *Rebuilding the Matrix – Science and Faith in the 21st Century*, Oxford: Lion (2001).

lar effort and drudgery from the factory and the home.[4] These advances have led to engineering being described as a great profession, creating employment, elevating the standards of living and adding to the comforts of life.[5] Hoover saw the role of an engineer as both a high privilege and great liability: 'If his works do not work, he is damned.'

The influence that technology can have on culture is discussed by Postman,[6] who classified cultures into three types: tool-using cultures, technocracies, and technopolies. Until the seventeenth century, all cultures fitted into the first type. Tools were invented to do two things – firstly to solve urgent basic physical problems such as grinding corn, ploughing land, transporting water, etc, and secondly, to serve the symbolic world of art and religion. The integrity and dignity of the culture was not threatened by the use of such tools. Perhaps this was because tools were made by individuals as needs arose, rather than mass-produced, and carried no special status. However, in a technocracy, tools play a central role in the thought-world of the culture. The very instruments created to meet the needs of society threaten to transform and indeed overthrow it. In Huxley's *Brave New World*, the revolution is complete – Technopoly eliminates alternatives to itself by creating a culture that seeks its purpose and finds its satisfaction in technology. The means to an end has become an end in itself.

The Indian theologian Dr M. M. Thomas expressed these concerns in an address to the Christian Medical College at Vellore on 11th October 1993.

> There is no doubt that the scientific and technological revolution of the modern period has been a tremendous expression of human creativity, It has eliminated distances and created the global community materially. It has given us the knowledge necessary to produce goods and services in abundance. It has given us power for social, psychic and genetic engineering, to control disease and death as well as birth. But as we survey the world situation today, the general feeling is that along with many benefits, many of the promises of technology stand betrayed and there is evidence of a lot of technology having become instruments of exploitation of peoples, destruction of cultures and dehumanization of persons and pose threat of destruction not only to the whole humanity through nuclear war but also to the whole community of life on the earth through the destruction of its ecological basis.[7]

While we may be reluctant to identify our own culture with Huxley's *Brave New World*, it is fitting to ask just how far along the road to Technopoly the (so-called) Developed World has come. Indeed, the very classification of nations as

4 Radford, J. D. *The Engineer and Society*, Macmillan (1984).
5 Hoover, H. *Memoirs of Herbert Hoover* Vol.1. (1951).
6 Postman, N. *Technopoly: The surrender of culture to technology*, New York: Vintage Books (1993).
7 Thomas, M. M. *The Church's mission and post-modern humanism*, The Indian Society for Promoting Christian Knowledge (1996).

developed/developing presupposes that culture is defined by access to technology. In a culture defined by the Internet, the mobile phone and the car, have the tools become idols? Bacon wrote that knowledge should be sought, not 'for superiority of others, or for profit, or fame, or power…but for the benefit and use of life'.[8] In today's consumer driven society, many engineering and scientific projects undertaken by industry and academia alike, fall far short of these high moral standards. For example, it is difficult to see George Bush's plan for a manned mission to Mars[9] primarily for the benefit and use of life rather than as an attempt to grab newspaper headlines and political support, particularly with the recent success of unmanned exploration by the Mars Rover.[10]

While a deeper understanding of how atoms are held together may provide clues as to the foundations of matter, and exploring deep space with costly telescopes and space probes may hint at the origins of life, considering the needs of people in developing countries has led some to question scientific research priorities. Raymond Brand was bold enough to state in 1987, that, 'There are some extremely expensive areas of research that should not be pursued now.'[11] Brand commented specifically on a plan at that time to spend three billion US dollars on a superconducting super collider. Unfortunately Brand's advice seems to have been taken on board by the U.S. House of Representatives rather belatedly, as in 1993 they decided to call a premature halt to the project after 14 miles of tunnelling had been completed and two billion dollars spent.[12]

It is of particular concern that, while richer nations can perhaps afford such expensive failures, in countries where poverty is more acute, engineering priorities are governed by the desire for superiority over neighbouring lands through the development of nuclear weapons, the launch of space programmes, and so on, rather than being governed by the need to tackle hunger, malnutrition and disease. In an address to the British Association,[13] Professor Sardar stated that most Muslim countries (many of them in the developing world) are happy to imitate research priorities of industrialised countries rather than work at shaping their own science policy based on their own needs and resources. 'So instead of focusing, for example, on diarrhoea and dysentery in Pakistan, flood control in Bangladesh and schistosomiasis in Egypt and the Sudan, these countries blindly follow the international agenda and devote their meagre research funds on equally meagre work on cancer and heart diseases.' All the while, urgent work is needed on developing materials for quick and clean temporary housing, efficient and cheap methods for supplying emer-

8 cited in Alexander, D.R. 'Worshipping God with technology', *Cambridge Papers*, December 2003.
9 http://news.bbc.co.uk/1/hi/sci/tech/3381531.stm
10 http://news.bbc.co.uk/1/hi/sci/tech/3560867.stm
11 Brand R. H. 'At the point of need', *Perspectives on Science and Christian Faith* (1987) 39:1.
12 http://www.hep.net/ssc/
13 Sardar, Z. 'Science, future and religion', BA Festival of Science, 8-12 September 2003, University of Salford.

gency water, and mechanisms for providing basic health care and preventing the spread of diseases.

But before those of us from developed nations attempt to claim the moral higher ground, we need to realise that we are engaged in technology races of our own, and that the Technopoly that we have become is the goal to which many nations aspire. In developed countries too, research objectives are increasingly being set by multinational corporations rather than by national governments. In the 1990s, public investment in research and development in science and technology stagnated while private funding increased five-fold, from $100bn to $500bn.[14] According to the Consultative Group on International Agricultural Research, the most striking case was in agricultural research. Private sector research amounted to $10 billion a year – much of it in the field of biotechnology – 25 times greater than the combined annual research budgets of the international network of agricultural research institutions. The 2001 Human Development Report commented that scientific research effort will be concentrated towards the priorities of multinational corporations rather than the needs of the developing world, quoting that as a result we are more likely to find a cure for baldness than for malaria.[15] Channelling government and private sector funding into meeting the needs of developing countries is not straightforward. There is no guarantee that the money saved by not supporting one type of research would lead to increased funding for appropriate technology, unless governmental priorities change.

Reclaiming Technology

Engineers are familiar with the bleak picture painted above of technology as a root of all kinds of evil. However, abandoning technology is neither a practical nor a morally acceptable option. While some communities such as the Amish have earned a reputation for surviving without many of the creature comforts that have become necessities,[16] to illuminate houses with paraffin lamps rather than electric lighting is no more noble, particularly if the consequences of the former are more damaging to the environment and are achieved at greater risk to public health and safety. Moreover, excluding technologies developed after an arbitrarily chosen point in history without assessing their benefits is to deny the validity of their inventors' God-given talents.

One means of reclaiming technology was proposed by Schumacher. In his groundbreaking book, *Small is Beautiful*,[17] he proposes that the use of technology in any culture should be appropriate to the needs and resources of the

14 Coventry, C. 'the role of technology in poverty reduction', http://www.itdg.org/docs/region_south_asia/cowan_coventry.doc
15 http://hdr.undp.org/reports/global/2001/en/
16 Foster T. W. 'Amish society', *The Futurist* Dec 1981.
17 Shumacher, E. F. *Small is Beautiful*, Hartley & Marks (1999).

community it is intended to serve. The precise definition of appropriate technology varies from author to author.[18] *The Appropriate Technology Sourcebook*[19] suggests some general characteristics that tools and techniques must possess to be in keeping with appropriate technology:

1. Be low in capital costs.
2. Use local materials wherever possible.
3. Create jobs, employing local skills and labour.
4. Be small enough in scale to be affordable by a small group of farmers.
5. Can be understood, controlled and maintained by rural dwellers with agricultural skills and non scientific-technological education.
6. Equipment can be produced out of a small metal working shop, if not in a village itself.
7. Will bring people together to work collectively and bring improvements to local communities.
8. Involve decentralised renewable power resources.
9. Make technology understandable to the people who are using it.
10. Be flexible so that they can continue to be used or adapted to fit changing circumstances.
11. Do not involve patents, royalties, consulting fees or import duties.

These points are discussed with reference to Christian doctrine towards the end of this section.

Schumacher described such technology as vastly superior to technology of bygone ages but at the same time much simpler, cheaper and freer than the super-technologies of the rich. He also called it 'self help technology', 'democratic or people's technology', or 'intermediate technology' describing the concept as technology to which everyone can gain admittance and which is not reserved to the rich and powerful.

Schumacher's vision has been interpreted in many ways. Some advocates of developing world interests have baulked at the idea that appropriate technology might mean denying people the right to develop, and have seen the philosophy as a convenient device to perpetuate the rich-poor divide, with some countries locked into an inferior second division of low productivity and drudgery.[20] However, the concept of appropriate technology is more about fostering a responsible attitude to the use of technology than restricting it to a particular level.[21] Schumacher described himself as 'a practical man: I run things and get them going' rather than 'a scholar, or even a writer'.[22] Nevertheless, the appro-

18 Willoughby, K. W. *Technology choice*, Westview Press (1990).
19 Darrow, K.& Saxenian, M. *Appropriate Technology Sourcebook*, Volunteers in Asia (1993).
20 Emmanuel, A. *Appropriate or Underdeveloped Technology?*,John Wiley & Sons (1982).
21 Black, J. K. *Development in theory and practice*, Westview Press.
22 Fager, C. 'Small is beautiful, and so is Rome: surprising faith of E. F. Schumacher', *Christian Century* (1977) April 6, 325.

priate technology philosophy has been analysed at length from socio-economic, moral, technological, ethical and religious perspectives. Although Schumacher has stated that 'all this lyrical stuff about entering the Aquarian Age and reaching a new level of consciousness and taking the next step in evolution is nonsense', his teachings have found disciples among economic, political and environmental radicals, eager to replace an old establishment world-view with something more to their liking. Attention is often drawn to a chapter entitled 'Buddhist Economics' in *Small is Beautiful*. Schumacher admitted to a certain amount of attention seeking in his choice of title, and many of the values expounded in the chapter are equally at home in a Christian ethic. Indeed, although Schumacher explored Buddhism, and was influenced by Gandhi, he affirmed that Catholicism was where he felt most at home and where, in his view, the essentials of Christianity are best preserved.

Relating the eleven principles of appropriate technology defined above to the biblical view of technology is not straightforward: the two-tier technology of today was not as pronounced then. Many of the technological challenges described in Scripture are on very large scales: Noah's ark, building the temple, reconstruction of the walls of Jerusalem and so on. In addition, none of these projects could be classified as low in capital costs (point 1), although local materials were often used (point 2). However, in all these cases the emphasis was on the individual. Local skill and labour was used (points 3, 6), particularly in rebuilding the walls of Jerusalem (Neh. 3). In the construction of the tabernacle, specific tasks were undertaken by Spirit-filled craftsmen (Exod. 31:1-11). The status of craftsmen depended entirely on their God-given talents and to what use they put them. Craftsmen who make idols are described as 'nothing but men' who 'will be brought down to terror and infamy' (Isa. 44:11). God's concern is for individuals: for the sake of ten people he was willing not to destroy Sodom and Gomorrah; he counts hairs on heads and falling sparrows. The social and economic units that are often encountered in the Bible tend to be the family (Josh. 24:15, Prov. 31:15, Acts 16:15,33, 1 Tim. 3:4-5) with the responsibility to provide physically and spiritually being placed on both husband and wife. Concentrating on small units such as the family, meant that individuals could be known by name and cared for as their needs required (points 4, 8).

Paul placed particular emphasis and value on working with the hands (1 Cor. 4:12, Eph. 4:28, 1 Thes.4:11) and demonstrated his flexibility in supporting his preaching ministry with practical work such as tent making as the need arose (point 10).

God's special concern for the poor (Deut. 15:4, Ps.14:6, James 2:5-6) and his desire to alleviate poverty (Ps.113:7) fits well with the goals of appropriate technology (points 1, 3, 5, 9). Although the Bible has no references to patents, (point 11), Samuel warned Israel that their desire for a king would bring with it royalties in the form of taxation, conscription, and even slavery (1 Sam. 8:10-17).

The benefit to the community (of Israel) of completing engineering projects

was often made explicit by God even before they had commenced (point 7). For example, when Solomon expressed a desire to build a temple, 'The word of the LORD came to Solomon: "As for this temple you are building, if you follow my decrees, carry out my regulations and keep all my commands and obey them, I will fulfil through you the promise I gave to David your father. And I will live among the Israelites and will not abandon my people Israel"' (1 Kings 6:11-13).

The Challenge of Sustainability

In a world of finite resources, obscene poverty, widespread human suffering due to disease (much of which is curable and/or preventable) and conflict, our own levels of consumption need to be assessed with Christian accountability.[23] If our 'standard' lifestyle is unattainable for the vast majority of the world without miraculous increases in provision of food, energy and raw materials, then what right do we have to live in the way we do? We are faced with three options: maintain the status quo, increase productivity, or to reduce over-consumption.

Although Jesus stated that there would always be poverty (Jn. 12:8) this can hardly be taken as a biblical mandate for the oppression and injustice we see in the global marketplace; there is a big difference between description and prescription. Indeed, much of the Old Testament, the Law and the Minor Prophets in particular are given over to ensuring that widows, orphans, and other marginalised groups are provided for physically (Lev. 23:22, Zech. 7:10) and protected in the courts (Exod. 26:3, Amos 5:12). The Judaic responsibility to care for, rather than exploit, the poor was expanded by Jesus to include those outside the family / tribal group, even extending to those of other races and cultures by defining 'neighbour' in the broadest possible context (Lk. 10:25ff). Jesus' mission statement in Luke 4:18, 'to preach good news to the poor', has often been interpreted in spiritual terms, but his frequent association with those at the bottom of the social pyramid – the poor, the sick, foreigners, the unclean, women and children – implies that Jesus was concerned to bring about both physical and spiritual healing (see also Matt. 9:5). Miraculous provision of food for the hungry crowds on at least two occasions (Mk. 6:30ff, 8:1ff) complemented his spoken message.

Increasing productivity has always been a goal for the engineer, and sits well with God's instruction to Adam to fill the earth and to subdue in (Gen. 1:28). Unfortunately this has often been taken as a licence for exploitation rather than as a mandate for careful management of resources and stewardship. Three great (and successful) engineering projects undertaken in the Old Testament – the building of the Ark, of the Tabernacle and of the Temple – illustrate God's vision for technology.[24] However, when technology is used to try and meet unre-

23 Gittens, A. J. 'Ecology and world poverty: a Christian response', *Spirituality Today* (1986) 38.
24 Alexander, D.R. 'Worshipping God with technology', *Cambridge Papers*, December 2003.

alistic expectations, risk inevitably increases. Man's quest to build a tower to reach the heavens to demonstrate his skill was doomed to failure (Gen. 11:1-9). Many man-made tragedies have come about through over-confidence in the ability of engineers to predict and control systems operating at the very limits of performance. For instance, the Chernobyl disaster was caused largely as a result of human error and human greed in trying to extract more energy from a nuclear reactor than it was designed for.[25] The two space shuttle crashes – Challenger and Columbia – were due partly to components failing under extreme loading conditions, and partly due to management complacency after many previously successful space flights.[26] Engineering codes of conduct[27] emphasise the need for designers to take into account the consequences of failure, and the possible after-effects on people and the environment.

Of course, increasing productivity in an environmentally sustainable way (to meet genuine need) should be encouraged. For instance, much more use could be made of alternative energy such as wind, solar and wave power. Improved farming practices, land management and access to better varieties of seed that have been thoroughly trialled and tested (GM or otherwise) could make a substantial difference to the lives of millions. However, the real problem is with increasing levels of consumption both in the developed and developing world.

Appropriate Technology Solutions

The need for energy is a rich area for application of the principles of appropriate technology. Countries in the developing world consume far less energy per capita than those in the developed world. For instance, in a year, the average US citizen consumes 12.4MWh per person, whilst the figure is only 8.4kWh for a Cambodian (a difference of 1476-fold). There is a positive correlation between power consumption and standard of living, and as nations become more developed, energy usage tends to increase. In order to live in a sustainable manner, global energy usage must not be allowed to increase; this requires a reduction in energy use in the developed nations, and a managed increase for developing countries. The source of power must be considered carefully. Rather than building more coal and oil-fired power plants, appropriate solutions should be sought. These could be to make more use of energy efficient methods of transport – buses, trains, trams and bicycles – and looking for alternative power sources. These might include high-tech wind farms, wave power, hydroelectric schemes, and other 'expensive' technology for developed countries, whilst developing nations might be more attracted to simpler windmills, biogas and solar engines. Solar power is a particularly good example of where an appropriate solution may be a photovoltaic cell, a solar collector, a solar engine or a simple

25 Dowswell, P. *The Chernobyl Disaster (Days That Shook the World)*, Hodder Wayland (2003).
26 Troxell, J. Columbia Accident Investigation Board (CAIB) Synopsis (2003).
27 http://www.imeche.org.uk/membership/pdf/CodeofConduct.pdf

solar cooker, depending on the location and available resources and technology.[28]

Collating and disseminating examples of appropriate technology solutions that work, is facilitated by charitable organisations such as Engineers Without Borders,[29] Students Partnership Worldwide,[30] Intermediate Technology Development Group,[31] Tearfund[32] and many others. This is achieved by an increasing use of websites with fact sheets on many aspects of technology: energy production, transportation, water and sanitation, construction, manufacturing, food processing, and so on. Visits to partners in developing countries enable appropriate technology solutions to be tested and demonstrated, for local knowledge and skills to be applied, and for volunteers to gain a deeper appreciation of the challenges faced by local communities.

A visit by volunteers from Students Partnership Worldwide to Image, in Tanzania, involved building and testing fuel-efficient stoves with different groups of villagers. The stoves used much less firewood than traditional stoves. Villagers have adopted the new design, and stoves are manufactured *in situ* to generate income, by building stoves for other members of the village, and in nearby towns.

Projects undertaken by student volunteers working with Engineers Without Borders include design of refugee tents from readily available materials, optimising cooking stoves, water filter design, hydropower and solar power solutions.

Many other case studies exist of appropriate solutions in providing employment in developing countries. These include setting up small industries such as making soap, bicycle production, footwear and furniture manufacture, and passenger transport schemes.[33] A key factor in all these cases is the involvement of local communities in decision making, and the appropriate use of indigenous technical knowledge.[34,35] It is also important in such situations to try and counteract the perception that goods from abroad are of greater value that locally produced alternatives. This can be difficult in the face of aggressive advertising from multinational companies.[36,37]

28 Congdon, R. J. *Introduction to Appropriate Technology*, Rodale Press (1977).
29 http://www.ewb-uk.org/
30 http://www.spw.org/
31 http://www.itdg.org/
32 http://www.tearfund.org
33 Dunn, P. D. Appropriate technology. Technology with a human face, Macmillan, 1978.
34 Carr, M. *The AT reader*, Intermediate Technology Publications (1985).
35 Eglash, R. et al. *Appropriating Technology: Vernacular Science and Social Power*, University of Minnesota Press (2004).
36 Ginneken, W.van, & Baron, C. *Appropriate products, employment and technology*, Macmillan (1984).
37 Khor, M.&. Lin, L.L. (eds.) *Good Practices and Innovative Experiences in the South: Social Policies, Indigenous Knowledge and Appropriate Technology Vol II*, Zed Books (2002).

It is inevitable that information technology will have an increasing role in developing countries. The availability of mobile phones in countries like Uganda and Rwanda, where three competing networks provide coverage even of many rural areas, makes the internet within the reach (if not within the pocket) of many remote communities. Such access could transform local farming practices (for instance) with access to information about agricultural management – seed and fertiliser information, weather forecasting and so on. Organisations such as The African Agricultural Technology Foundation – a public-private partnership designed to respond to the needs of resource-poor farmers in sub-Saharan Africa seeks to use current technology to improve food security and reduce poverty by drawing upon the best practices and resources of both the public and private sectors. It does this by linking the needs of resource-poor farmers with potential technological solutions and acquiring technologies from technology providers through royalty free licenses or agreements along with associated materials, promoting the wide distribution of technologies.

The Cajamarca province of Peru, has benefited from ITDG's InfoDes service.[38] Small-scale producers now have access to a customised database with details of locally appropriate technology, trade and business issues from a central coordinating unit. An internet link provides opportunities to gain information on subjects including better crop production and processing methods. Remote access points linked to the central unit were established to serve the widely spread rural communities where most of the province's inhabitants live. A touring mobile information unit containing video links introduces village residents to the service.

The information technology revolution could also assist with education. In Jordan, for example, King Abdullah has launched a programme called 'big ideas for a little country' which intends to reform the education system by the use of computers in schools. The scheme has backing from US multinational companies, but has faced opposition from within Jordan by those who think that the immediate needs of the country will not be served by education alone.[39] A more appropriate response to the desire for technology has been the development of the 'simputer', a cheap handheld computer developed by scientists and engineers at the Indian Institute of Science in Bangalore. This computer is the first to be designed and manufactured in India and is aimed at providing cheap and accessible computing.[40] Unfortunately, the project has suffered delays and setbacks partly due to the diffidence of computer manufacturers and software companies in the developed world and lack of financial support. An appropriate future scenario is one of mixed technology, where

38 http://www.itdg.org/?id=new_technologies_case_studies
39 http://news.bbc.co.uk/1/hi/technology/3591027.stm
40 http://news.bbc.co.uk/1/hi/technology/3578309.stm

imported high tech equipment works alongside locally made and maintained technology.

One area that has benefited from the mixed technology approach is food processing. Although agriculture forms the economic basis for many developing countries' economies, the income from primary food products is often unable to provide a reliable livelihood. Alternative or additional income-generating opportunities are needed. One such opportunity is in agroprocessing: turning primary agricultural products into marketable commodities. ITDG has established small-scale, appropriate and sustainable processing businesses that are flexible, require little capital investment and can be carried out in the home without the need for sophisticated or expensive equipment. In Bangladesh, training from ITDG and partner organisations in processing products ranging from Bombay mix to pickles, jam, cheese, coconut balls and cake has enabled more than 2,000 businesses to be successfully established or expanded. Similar programmes have been successful in Darfur, Eastern Sudan and Nepal. A key aspect of the training involves identifying and meeting market needs in order to sell products.[41]

Conclusions

The challenge to engineers is to make technological developments instruments of justice, rather than of exploitation. Appropriate technology offers engineers (and others) useful principles for development and invention. Commenting on the achievements of James Watt and others, Bataille saw invention as the poetry of science. By carefully balancing the need for innovation with finite resources, and by avoiding the negative effects that change can bring about, through harmonious relationships with local communities, engineering can again become truly poetic. As Kennedy noted, the world is very different from that of James Watt, but the changing face of society, the technological know-how and recent scientific advances can bring hope as well as despair.

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41 http://www.itdg.org/?id=agroprocessing