CARBON-CENTRIC COMPUTING – IT SOLUTIONS FOR CLIMATE CHANGE

A REPORT PREPARED BY THE UNIVERSITY OF WOLLONGONG WORKING GROUP ON THE CARBON-CENTRIC COMPUTING INITIATIVE

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IT has a role to play in the current debate on climate change. The current discourse on IT and climate change views IT in a negative light, as a polluter. What remains unrecognised is the *critical* role of *IT as a source of solutions* to the climate change problem. We live in a massive, inter-connected *Planet Earth Supply Chain*. IT provides a range of tools to *model*, *manage* and *optimise* this supply chain.

The University of Wollongong *Carbon-Centric Computing Initiative (CCCI)* seeks to seed a program of research that addresses the climate change problem with a range of computing technologies including (but not limited to): optimisation technologies, supply chain management technologies, business process management/process improvement technologies, grid computing (e.g., utility grid) and virtualisation technologies, ICT-enabled conferencing and collaboration technologies as well as ICT for knowledge sharing and network-centric advocacy.

The contours of this new and exciting space for research and industry development are described in this report. The report provides insights into a set of representative points within this new space. It describes how existing web infrastructure could be leveraged to devise the optimising web – a massive, globally inter-connected network of optimisers helping support decisions that would reduce the global carbon footprint. It describes how computer simulation models can provide the basis for sustainable manufacturing and environmental management in the enterprise. It describes how IT based techniques can help support supply chain optimisation audits to determine if and how value might be best derived from the judicious use of optimisation technology. It describes the critical role ICT-enabled collaboration technologies can play in reducing the carbon footprint. It also addresses the key role ICT-based knowledge sharing and network-centric advocacy can play in obtaining broader social engagement in this debate. The report addresses the *policy dimension* to these issues and the need for an *industry-academia consortium* to drive such an agenda forward.

The DSL: The Decision Systems Lab has engaged in cutting-edge research in the areas of industrial optimisation, business process management, service-oriented computing, software engineering and the applications of artificial intelligence technology for over a decade. It prides itself in being able to effectively span the spectrum from basic to applied research, and has generated a range of high-impact insights and industry applications.

ATUL: As the Activity Theory Usability Laboratory, ATUL was opened in 2001. Able to support both research and practice, ATUL was then equipped to conduct holistic and realistic usability evaluations of computer applications and websites. Since its opening ATUL has expanded to acquire an exciting range of tools in innovative areas of business analysis and training: team-building, group decision support, systems modeling, content analysis among these.

INTRODUCTION TO THE REPORT

There is a growing awareness in the IT community of its climate change impact, but this is largely in a negative sense. Much of the current discourse focuses on themes such as *green computing*, which involves attempts to reduce the carbon footprint of computing infrastructures such as data centres, server farms, organisational IT infrastructure and even individual computers. The emphasis is thus on the *IT industry as a polluter*.

IT as a source of solutions to the climate change problem is a perspective that appears to be entirely ignored. Yet, as a source of technologies that enable efficiencies and optimisation in operational processes of almost every conceivable variety, IT solutions must be central in our thinking on how to address climate change. Consider the following examples of IT solutions to the problem:

- *OPTIMISATION TECHNOLOGIES*: Systems that optimise the design and execution of operational processes are fundamental to energy savings and carbon footprint minimisation. Examples include systems that optimise production and maintenance processes to obtain energy savings, systems that optimise vehicle routing for fuel savings or systems that minimise waste of fuels that are industrial by-products (instances of all these have been developed in the Decision Systems Lab (DSL) at the University of Wollongong). A wide range of optimisation technologies exists with the potential to contribute to the problem.
- *BUSINESS PROCESS MANAGEMENT SYSTEMS*: The field of business process management (BPM) focuses on documenting, modelling, analysing and improving key business processes within organisations. These could be financial processes such as billing and invoicing, document-handling processes of various kinds or operations/production processes. Business process improvement holds promise as a means for carbon-footprint minimisation (primarily through the use of a range of techniques for *business process improvement*), although the discourse on climate change (and indeed the BPM community) does not quite recognise this.
- *OTHER SUPPLY CHAIN TECHNOLOGIES*: A range of other innovative supply chain technologies can have an impact on the climate change problem. Consider the following two examples:

  1) “Pre-emptive traffic control” technologies have been developed that permit public transportation systems (such as metropolitan bus services) to control traffic lights in a distributed, autonomous fashion to ensure that buses do not waste energy idling at red lights, and are guaranteed unimpeded flow through traffic intersections.

  2) A Sydney-area city council was recently in the news for issuing recycling bins with RFID (Radio Frequency ID) chips attached. Using these, and garbage trucks that are able to measure the weight of garbage in a bin being emptied, the city council is able to track the extent of adoption of recycling down to the level of individual households.
- *SUPPORTING INFRASTRUCTURE TECHNOLOGIES*: A range of other kinds of IT research will find application in climate change solutions. To be able to deploy optimisation systems on a very large scale (as must be the case with carbon-footprint applications), distributed optimisation using intelligent agent technology as well as grid computing becomes important. Also of interest is the application of web service technologies in providing decision support services.

- *COMMUNICATIONS AND COORDINATING TECHNOLOGIES*: Information and communications technologies (ICT) are enabling a relatively pollution-free virtual space for a wide range of human activity. For example telecommuting, i.e. working online from home or elsewhere, has benefits in reducing emissions from traditional commuters who often get to work in single occupant cars. A small decrease in the number of vehicles on the road in peek-hour reduces not only their emissions but also those from the rest of the traffic which flows more freely.

THE CARBON-CENTRIC COMPUTING INITIATIVE (CCCI) AT THE UNIVERSITY OF WOLLONGONG

The Carbon-Centric Computing Initiative at the University of Wollongong brings together a group of academics interested in identifying, developing and highlighting computing technologies that can offer critical solutions to the climate change problem.

The specific objectives of CCCI include:

- Highlighting the role of IT as a source of climate change solutions.
- Seeding the development of a new sub-discipline within computing/IT (carbon-centric computing).
- Introducing a new environmentally aware dimension for evaluating/interpreting a wide spectrum of IT research, development and practice.
- Focusing attention on research challenges along the lines discussed above.
- Developing a range of high-impact solutions within this space in partnership with industry and government.

As part of this initiative, a national research summit is planned for the near future that will bring together thought leaders from across the nation and globally to ensure that *practical outcomes* can be obtained soon.

This report aims to achieve the following objectives:

- Describe a new research landscape.
- Identify a set of key policy issues that arise from these insights.
- Identify the need for a large-scale industry-academia consortium that can play a key role in advocacy, in seeding an appropriate agenda, and informing policy formulation in this space.
- Illustrate this landscape by providing insights into a small handful of specific technologies and methodologies.

SOCIO-TECHNICAL SYSTEMS AS THE BASIS FOR CARBON-CENTRIC COMPUTING

While the connections between efficiency gains through judicious deployment of IT and the carbon impact of IT are sometimes clear, the actual application of these technologies is non-trivial. In the following, we will highlight a few representative instances of the substantial research landscape that emerges from the carbon-centric computing perspective.

THE OPTIMISING WEB

The climate change crisis presents an unusual opportunity to develop and deploy an infrastructure for optimisation-in-the-large. For the first time in history, we have a consensus (or at least, a near-consensus) on a global objective function – the minimisation of our collective carbon footprint. For the first time in history, we are presented with an opportunity to enable IT-driven collaboration for optimisation on a global scale.

Optimisation has been a fundamental component of the global business vocabulary since the 1940s, when George Dantzig proposed *linear programming*, the first in a long line of operations research/optimisation techniques that have delivered significant value in both design and operational efficiencies to organisations of various kinds. Optimisation techniques have helped design efficient layouts for manufacturing and warehousing facilities in complex supply chains, devised efficient production plans for manufacturers, optimised production schedules in a shop-floor environment, produced optimal logistics plans for the shipment of goods, generated efficient crew rosters and even informed the design of large-scale public infrastructures such as highway networks, urban layouts etc. Optimisation techniques encode problems in terms of real-world *constraints* that any solution must satisfy, and an *objective function* that encodes organisational/operational/design objectives (such as maximisation of profit, minimisation of cost, maximisation of asset utilisation etc.).

Within the Decision Systems Lab at the University of Wollongong, the *Optimizing Web* project seeks to design and build such an optimisation-in-the-large facility by leveraging the existing infrastructure of the world-wide web. The proposition is to add an additional dimension to the web – one that would enable *distributed continual optimisation* over a globally deployed *web of optimisers* (an optimiser, here, refers to an automated system that provides decision support in determining solutions to an optimisation problem). This model envisages very large-scale networks of optimisers deployed at varying levels of granularity on individual devices, at the level of households, on vehicles, and in even more complex ways throughout the industrial infrastructure. An individual optimiser would seek to optimise the behaviour (and thus, the carbon footprint) of the entity it manages, but would also seek to influence the behaviour of other entities that it interacts with in ways that would help it optimise relative to its local objectives (these would ideally be engineered to be *in alignment* with a global carbon footprint minimisation objective). In an economic market-driven model, such influence can be obtained through the exchange of actual monetary value. In a setting where the objective is carbon footprint minimisation, we need to use (and monetise) *carbon micro-credits* and institute interaction protocols between these optimisers based on carbon micro-credit trading. The notion of carbon micro-credits pioneered in this project will have far-reaching implications.

There are several significant research challenges to address in this context.

- *ENGINEERING OBJECTIVES*: A key challenge lies in devising appropriate *carbon-centric* objective functions. Traditionally, the formulation of objective functions in optimisation problems has been something of a "black art", with no clear prescriptive processes to guide their formulation (which remain heavily reliant on the skills and experience of the practitioner, as well as trial-and-error). As protocols that enable the *monetisation* of carbon emissions begin to emerge (as in carbon offsets and carbon offset trading), there will be a greater level of standardisation in the objective functions used in industrial (and other) process optimisation.

- *OBJECTIVE ALIGNMENT*: The optimising web must take into account the existing optimisation objectives of enterprises, entities and individuals and ensure that these are eventually *aligned* with the global carbon footprint minimisation objective. In this instance, alignment ensures that solutions that are deemed to be optimal relative to local objectives (of organisations or individuals) are in fact those that are also optimal relative to the carbon footprint minimisation objective. We may face three distinct categories of situation in terms of the relationship between the global objective and a local objective. In the first, the global and local objectives are perfectly aligned, ensuring a seamless basis for inter-operation. In the second, local objectives functions can be re-engineered to better reflect an organisation or individual's optimisation requirements, but in a manner that ensures alignment with the global objective. In the third, the local and global objectives pull in different directions. In such situations, incentives will have to be offered to local optimisers (this can be automated via the use of agent negotiation technology) to alter their objective functions to align these with the global objective. This could be done at an instance level (i.e., for specific decisions and at specific times) or in a persistent fashion (i.e., permanently re-designing local objective functions). The incentives could be financial, or in the form of carbon credits or micro-credits in jurisdictions where these apply.
- *INTER-OPERATION STANDARDS*: The optimising web will require significant inter-operation and negotiation between cooperating local optimisers. Message interchange formats will need to be defined and standardised based on existing XML-style standards.

The optimising web will encompass both design and operational optimisation. Automated interoperation between design optimisers permits us to envision scenarios where a supply chain configuration optimiser leverages the outputs of a transportation infrastructure design optimisation system, while also informing its choices. Operational optimisers can inter-operate to ensure carbon footprint minimising product shipping plans, or the optimisation of traffic flow through congested urban environments via inter-operation with optimisers at the level of individuals, or individual vehicles. The optimisers that would populate the optimising web need not necessarily be automated. At the level of individuals, optimisation might simply involve responding to suggestions and/or incentives on the best times to travel, or the best times to operate major power-consuming household devices.

The optimising web can affect a profound and fundamental change in the global strategy to tackle the climate change problem by highlighting a simple principle: *reducing the global carbon footprint can become a win-win proposition for all concerned by enabling smart technology-mediated collaboration.*

SUPPLY CHAIN OPTIMISATION AUDITS

The climate change crisis provides an implicit incentive for organisations to optimise their operations, but poses a major managerial challenge. Organisations must work with limited budgets for the deployment of optimisation systems, and must therefore be judicious in deciding where and how to invest in optimisation technology. The *Supply Chain Optimization Audit (SCOA)* methodology developed at the Decision Systems Lab provides a principled basis for these decisions. SCOA helps organisation identify the "low hanging fruit", from a carbon footprint minimisation perspective, that would provide the best "return" (not merely in the traditional sense, but also in the sense of "green returns") on investment in optimisation systems. SCOA helps organisations identify decisions on which to deploy optimisation systems, the scope of the optimisation and the modalities involved in the deployment of optimisation systems. SCOA relies on IT tools for supply chain modelling and analysis, for the identification of *causal models* from historical data, for modelling and analysing optimisation processes and for *decision triage* (i.e., the prioritisation of supply chain optimisation decisions). It is not our intention to provide detailed description of SCOA here (additional information can be found at the Decision Systems Lab website: www.dsl.uow.edu.au), but to highlight yet another representative sample point in the rich research landscape that is carbon-centric computing.

COMPUTER-BASED SIMULATION MODELS

Few companies with a large carbon-footprint exhibit the capacity or will to utilise technologies that provide computer-aided analysis of sustainable manufacturing and environmental management in the enterprise. Computer-based simulation models are used to provide a virtual snapshot of an enterprise (and its supply chain) so that a holistic view can be developed. This facilitates an integrated systems dynamics approach so that the sustainable, environmental and economical aspects of an enterprise can be investigated.

Computer-based simulation models quantify and measure the environmental performance and the associated costs in industry, and demonstrate the potential cost savings or incentives achieved, in terms of productivity, quality, and costs, when implementing cleaner or "greener" technology. The modelling tools are also used to create process methodologies to aid the implementation of an environmental management system.

A strategic and multidimensional approach for the process of selecting or executing various operational policies is essential when developing a business case for managers to implement sustainable practices. An understanding of the environmental impact of operations and its relationship to productivity, efficiency, costs, quality and the strategic goals of the enterprise facilitates a consolidated business case and a balanced scorecard of key performance indicators, including environmental and sustainable issues to obtain optimum performance.

The underlying concept which underpins this approach to modelling the enterprise is that sustainability is not only "free" but that it is in fact, commercially a far better proposition for the business in the medium to longer term than adopting a management strategy which is based purely on profit. The research therefore focuses on promoting sustainability to managers by arguing the business case. Sustainable and environmental issues taken into account include natural resource consumption, energy consumption, scrap and waste levels, pollution and the transportation of material between industries. The use of simulation models demonstrates the combined effects of productivity, operating costs, quality and environmental issues (such as pollution, solid waste, and energy and material consumption) for industrial plants and their supply chains. Case studies have successfully demonstrated that sustainable issues are not isolated from operating costs, productivity and quality and can, in fact, have a positive impact on the bottom line. Sustainability can bring about a substantial improvement in productivity, quality and cost. In other words "sustainability is an operational and strategic advantage to the enterprise".

SIMULATION MODELLING AND THE SUSTAINABLE ENTERPRISE

In industry, there are usually three generic performance concerns that have to be balanced: productivity, quality and cost. In order to remain competitive, it is important to lower cost while increasing productivity and improving quality. A sustainable enterprise must however consider the extra and equally important dimension of the environment (Figure 1). Environmental issues, such as reducing waste from the production stream, must be closely associated with the production and economic aspects of the product, such as reducing costs.

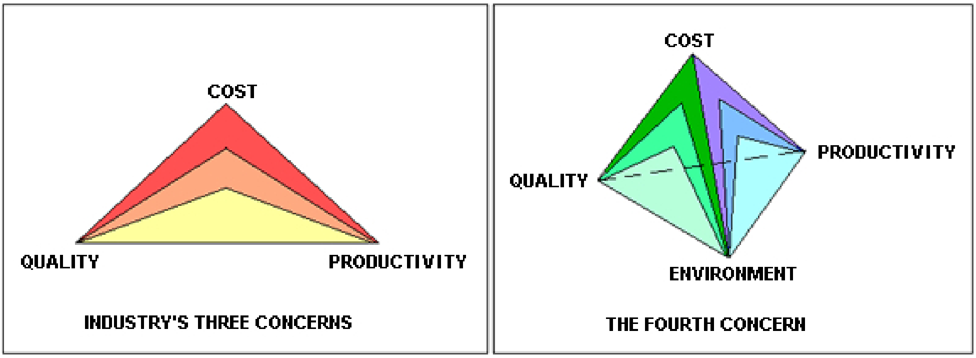

Figure 1 Industry's Performance Concerns

The industrial system, consisting of activities which have complex interrelations and random processes, has a two-way interaction with its environment and therefore its activities will affect the environment. The areas of concern in the pursuit of applying sustainable manufacturing may be summarised as follows:

- the need to quantify and measure environmental issues within industry, in terms of a business case: ie costs, quality and productivity;
- the need to integrate environmental issues (such as pollution and waste), and economic issues (in terms of total costs);
- the importance of seeing the whole, that is, to see from beginning to end the activities making up a system (both within each component of a supply chain and between each element of the end to end supply chain);
- and finally, the development of a tool that can be used to apply a systems approach and integrate all the requirements stated above.

Discrete Event Simulation models represent complex and dynamic environments which typify the twenty first century enterprise. Models are based on a network of stochastic processes so that the interactions and variability of complex operations can be analysed. In doing so a multidimensional systems dynamic approach can be developed which consider performance issues such as productivity, cost, quality, efficiency and effectiveness whilst taking into account sustainability and environmental factors such as pollution, scrap, carbon emissions. The advantage of using this approach is that it can incorporate past and present data to accurately represent a dynamic and holistic view of an enterprise as it is currently operating. The model can then be "fast forwarded" into the future to investigate the implications of various operational and strategic decisions on a comprehensive set of performance indicators and environmental measures. Simulation tools effectively integrate sustainable issues and costs into a unified framework to demonstrate that sustainability is not only free, but may also save costs in the long run.

The concept is illustrated through a case study of an actual end-to-end metal supply chain consisting of a generic Refinery, a Smelter and Metal Feedstock Producer (all based in Queensland), Australia, and a Metal Casting Company (based in Singapore) (Figure 2). The industrial activities were modelled to simulate the flow of material, cost, products, waste and pollution, within each component and across the supply chain. Once the model of the supply chain was developed it was possible to explore scenarios such as allowing suppliers to move closer together. This reduction in transportation reduces impact on the environment, whilst cutting down transportation costs and facilitating a more flexible and efficient supply chain. It is important to note that environmental improvements of this kind are commensurate with state-of-the-art manufacturing practices such as lean thinking.

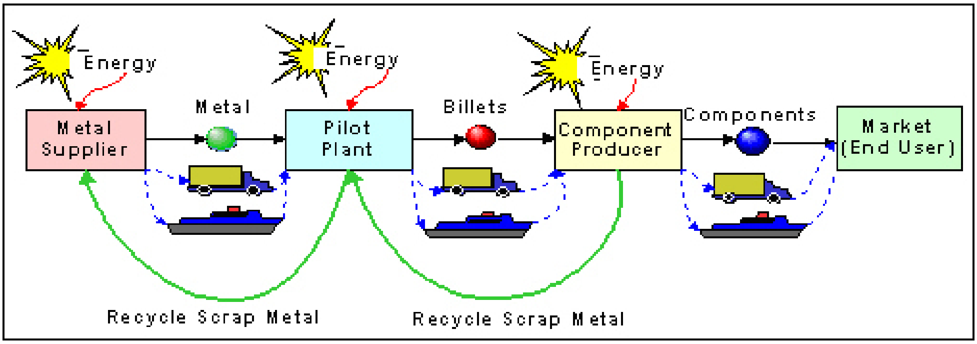

Figure 2 A Supply Chain Case Study

Once a simulation based model of this kind as been developed it is possible to use it to develop a virtual interactive "road map" for the implementation and maintenance of environment management systems (such as ISO 14000). A further extension is to use the model as an execution and monitoring system for the complete enterprise. Usually simulation models are based on past and current data. However it is possible to connect the simulation model to "real time" information so that data is streaming from the actual process and continually updating the model so that it represents a "live" snapshot of the current state of the enterprise in terms of productivity and environmental performance. It is then possible to explore the effects of issues facing the operations by "fast forwarding" the model into the future to investigate the implications of strategic decisions.

A further extension of these models is the integration of human issues which need to be considered when implementing a change process. These factors can be integrated into simulation models through techniques such as soft systems methodology and artificial intelligence (soft computing techniques). The introduction of these factors allows an extra dimension to be introduced into a simulation model of an enterprise so the effects of the "human activities and their decision making processes can be considered when developing an implementation methodology for a sustainable enterprise.

ICT-ENABLED CONFERENCING AND COLLABORATING

For human enterprises to perform effectively, they need to develop social capital by meeting, coordinating, communicating and collaborating. Traditionally, people have preferred to meet face-to-face (F2F), to have a daily routine where they 'go to work', to read printouts rather than the screen and so on. However we now recognise that such activities have a significant carbon footprint, travelling, commuting and producing of all manner of paper documentation. Potential IT solutions to these problems have been around for some time, namely teleconferencing, telecommuting, the virtual office, group decision support systems, and digital document management. Despite research showing their benefits, their take up has not been particularly widespread as people have resisted the combination of technical, economic, social and cultural changes to the way things are done. Putting the 'C' (communication) into ICT, together with the new imperative to take environmental concerns into account, and the ICT-enabled conferencing and collaborating tools are now firmly back on the agenda.

Research of the Activities, Tools, Usability and Learning (ATUL) group takes a holistic approach to the complex issues of human activity in modern social-technical systems. ATUL research integrates the technical, economic, social and cultural issues of working in the modern digitally networked world, understanding organisations as complex evolving eco-systems and finding ways to prepare managers and staff for a new way of working in this environment. Without this generation of new human capability and will, no amount of technical innovation is sustainable.

ICT can play a beneficial, environmentally friendly role in re-organising and transforming the ways we work if an informed, balanced approach is taken. Findings from our research suggest the following:

- form work teams and units of diverse members with complementary, not similar skills;
- replace some F2F with online when appropriate and with suitable training;
- set up teams with F2F to build trust and social capital and meet again from time to time to celebrate success and renew team bonds;
- use appropriate groupware technologies under the guidance of those who know how, with moderators and facilitators;
- build capability in virtual social skills, encourage community spirit;
- develop ways to create, store and access information digitally;
- allow/trust people to work/collaborate virtually in less formal ways, self-organised; self-directed, letting team roles emerge;
- allow workers to use technologies of their own choosing;
- provide appropriate incentives and rewards.

THE POSITIVES AND NEGATIVES OF SOME EXAMPLES

TELECOMMUTING / WORKING AT HOME

- Studies show that a small drop in road use can make traffic flow and have a much large drop in emissions – so allowing workers to telecommute even one day a week can make a difference.
- Managers have concerns that employees will slack off working at home.

- Conversely there are concerns that employees will work overtime and have poor work/life balance.
- However responsible employees reap the benefits of flexibility, reducing the time and stress of travelling to work.

MEETING VIRTUALLY

- Teleconferencing is now widely available and useful but is a rather poor medium for building teams.
- Support facilities are also available – common whiteboards, slide shows.
- Video conferencing was once very costly but is now cheaper and available on the desktop over IP.
- Some companies support meeting in richer virtual worlds such as second-life.
- Using group support technologies keeps a digital, paper-less record of opinions and events as content is typed in by the participants (not reinterpreted by the facilitator).

THE VIRTUAL OFFICE

- In some organisations, sales teams no longer use a central office – simply laptops and wireless internet connection and it seems to work well.
- Team meetings take place in cafes or such.
- Client meetings take place in homes.

THE POLICY DIMENSION

Australian industry will need to be prepared to participate in a carbon Emissions Trading Scheme (ETS) within the next several years. The ETS is intended to serve as a macro-economic lever to incentivise organisations to reduce their carbon footprint. A fundamental pre-requisite of carbon footprint reduction is operational efficiency – this can only be achieved through the judicious use of optimisation technology and the development of a pervasive optimisation-oriented mindset. While the benefits of operational efficiencies are self evident, large portions of Australian industry are not aware of the potential for optimisation technologies, or the immediate returns that accrue from an optimisation-oriented mindset. The ETS will serve as a *major* incentive for the deployment of optimisation technologies, but industry needs to be assisted in becoming *optimisation-ready* but that assistance is not always easy to come by. The government Climate-Ready Program is relevant but diffuse in scope, providing matching support for *any* industry R&D that addresses climate change solutions.

A government-supported scheme for achieving *optimisation-readiness* can go a long way. The proposed ETS will, quite correctly, have a major impact on certain sectors of the economy that will inherently have a major carbon footprint (e.g., thermal power plants) while having a smaller impact on other sectors (e.g., large parts of the service sector). A government-sponsored optimisation-readiness scheme should achieve two useful outcomes:

- It should provide the right kind of assistance required by industry to adopt optimisation-oriented technologies and practices.

- It should provide *across-the-board* incentives to all sectors of the economy to improve operational efficiencies, to complement a differential scheme that provides for significantly greater penalties for sectors that are (arguably by historical accident) intrinsically heavy emitters.
- The scheme should provide for *optimisation-readiness audits*. Such audits could be used to establish whether organisations have been effective in leveraging the opportunities (both from a technological and a business process design perspective) for optimising their operations, in a manner commensurate with their size and scope of operations. Organisations that are able to effectively make such a case could arguably be provided "credits" under the emissions trading scheme. The SCOA methodology developed at the University of Wollongong provides a basis for such a scheme.

AN INDUSTRY-ACADEMIA CONSORTIUM

The carbon-centric computing proposition can only be taken to its logical conclusion via an industry-academia consortium. Concurrently with this effort, a group of large North American IT companies have come together to form the Global e-Sustainability Initiative (www.gesi.org) with an intersecting agenda. Key vendors of IT solutions that enhance operational efficiency need to participate in this consortium to be able to engage in pro-active advocacy, both with the government and with the public and market at large, on the value that such IT-based solutions can bring to bear in this context. Academia provides the vital link in the picture, by generating impartial insights that can inform this debate and by providing thought leadership. The University of Wollongong Carbon-Centric Computing Initiative seeks to seed such a consortium in the immediate future.

ICT FOR KNOWLEDGE SHARING AND NETWORK-CENTRIC ADVOCACY

Despite many decades of lobbying by scientists and environmental groups, climate change has only really captured the attention of national leaders over the past couple of years. It is interesting to speculate on the reasons why.

The Internet emerged as an 'Information super highway' with exponential increases in uptake during the 1990s. Almost overnight people throughout the world became interconnected by a technological infrastructure that was flexible, malleable, accessible and, in most places, not controlled or planned. People everywhere contributed to the development of what this global information system could do and who could do it. In the 21st Century it cost very little to have a presence on the World Wide Web, to do global business from home, to post text, pictures, video for all to see and to collaborate with friends and strangers to create and publish knowledge.

This gives new meaning to the phrase 'Knowledge is Power'. The balance of power with respect to knowledge is now shifting from the 'official versions' in the hands of governments, big business, media moguls, formal libraries and publishing houses. Now if anyone wants to 'know' they are more likely to go to Google or Wikipedia. Many, particularly young, consumers of news are cynical about what they read in newspapers or see on television. They read blogs from people on the scene, get personal opinions from postings on Myspace or Facebook, become immersed in virtual worlds on Second Life, see pictures on Flickr or videos on Youtube.

This has democratised knowledge and provided a form of network-centric advocacy which is changing the political landscape. Voters are now exposed to new perspectives on issues and are able to collaborate with others to get new messages out there. This phenomenon is almost certainly helping the environmental movement with knowledge sharing and network-centric advocacy.

In order to have the knowledge that promotes the climate change debate into positive appropriate action, all of us need to sift through information that may be:

- from official sources but with expedient political spin;
- broadcast by the official media with vested interest;
- from individuals or groups, who maybe real experts or honest eye-witnesses to events but who may be biased, or worse: con artists, hoaxers or criminals.

ATUL has a research agenda that recognises the need to make information literacy a topic of basic training for everyone. Most people now have the skills to access information on the Internet but must learn how to assess the value of that information and its source, how to manage the information overload and then synthesis the information that comes into appropriate knowledge for decision-making and action. Bring this into the educational curriculum in an appropriate way is difficult. There is a new dynamic in our educational institutions where the students may be more information literate or at least computer-literate and familiar with the new social technologies than their teachers. Generating a common understanding of how knowledge and learning is perceived has not been easy and needs to be the topic of research in the field of ICT education.

On the other hand those who have information to contribute also need the skills to publish and present it to the best effect. ICT will continue to provide new tools to do this.

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