CHAPTER 3

HUMAN FACTORS AND ERGONOMICS FOR BUSINESS SUSTAINABILITY

Craig Brown and Stephen Legg

There is evidence of increasing pressure for and good intentions towards corporate social responsibility (CSR) but there is a gap between good intentions and good deeds. This is unsurprising given that changes must occur in the context of complex sociotechnical systems. Human factors and ergonomics (HF/E) is a discipline that operates in such a context and concurrently aims to optimize system performance in multiple dimensions. This chapter outlines what HF/E is and then describes why it is well suited to implementing sustainable development (SD) goals and gives case studies to illustrate the point. Because HF/E design is done in a sociotechnical systems context, outcomes tend to maximize all three (economic, environmental, and social) dimensions of SD.

SD (as one model of the broader field of "sustainability") is now seen as highly relevant to the business sector. There is evidence that companies are experiencing increased societal pressure to take on public responsibilities and are rapidly increasing their efforts to respond to this, with the more successful organizations seeing this as an opportunity, not a burden (Oppenheim, Bonini, Bielak, Kehm, & Lacy, 2007). However, "there are material practical challenges in translating good intentions into good deeds" with 72% of surveyed CEOs believing that environment, social, and governance (ESG)

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issues should be embedded into strategy and operations, but only 50% believing that this was actually implemented (Oppenheim et al., 2007).

Another study (GEMI-BSR Survey, 2006) found that CSR was widely discussed and communicated within and from top management and that there was a strong connection between companies' words and actual support for CSR. Key performance indicators were in place for all aspects of CSR. Employee health and safety and environmental issues were most tracked and labor and community and social issues were least tracked. Public reporting of performance mirrored tracking, except that community and social issues were given more prominence. Sixty-six percent believed that their environmental efforts had strong positive impacts on their business success and 68% believed the same for social responsibility efforts. Sixty-seven percent cited product and process improvements resulting from CSR and 94% thought that CSR would have more important impacts on their business strategy over the next five years (from the date of the survey).

The two preceding surveys may be unrepresentative of wider corporate strategy and behavior as they were completed by members of groups such as the UN Global Compact, Global Environmental Management Initiative, and Business for Social Responsibility, so there is a selection bias toward CSR-oriented businesses. As such they might be considered to be at the vanguard of business attempts to address SD issues. This is more likely to increase than to decrease their relevance. Assuming that one accepts that CSR (or ESG, or SD) is important and that wider interest and commitment will follow (or has followed since the surveys were conducted), then the issues raised by the surveyed companies are those that will be relevant to other businesses aiming to implement CSR strategies, now or in the future.

An IBM survey of business leaders worldwide has shown that 60% believe that CSR has become more important over the last year, compared with 6% that felt it had become less important (Riddleberger & Hittner, 2009). Strikingly, two thirds of businesses in the survey stated that they did not understand their customers CSR concerns well (*ibid.*), but consumers too believe that CSR is of high importance (Fleishman-Hillard/National Consumers' League, 2007). Consumers surveyed in the United States stated that they actively sought CSR information. Two thirds of them claimed that CSR performance would influence their purchasing and investment decisions. They also expressed dissatisfaction with corporate CSR efforts and supported global standards and governmental intervention (*ibid.*). To restate the earlier point: There is burden but also opportunity attached to the increasing demand coming from consumers, governments, and other businesses.

Hermel (2008) found a "growing comprehension of the advantages of a proactive approach to management and … CSR" but stated astonishment "at the enormous gap existing between the … discourse and effective corporate practices … Although businesses have clearly advanced in the perception of issues fostering social responsibility, it seems that less progress has been made for effectively turning their efforts into a reality." Again the point is made that CSR success has not flowed easily from CSR awareness and CSR effort.

Lindgreen, Swaen and Johnston (2009) found that organizations implement CSR differently, with some models being more akin to the traditional model of managerial capitalism, where CSR activities relate only to primary stakeholders (customers, employees, suppliers, and investors) and others described as "extended stakeholder organizations" (which includes philanthropic activities) or "transcending organizations," the latter being where CSR is linked to the pillars of SD, rather than being designed to satisfy customers, suppliers, or employees. IBM's study found that levels of "proactive engagement with stakeholder groups" varied, depending on the group, listed here from highest to lowest levels of engagement: employees, investors, business partners, government, consumers, community, and NGOs (Riddleberger & Hittner, 2009). This correlates reasonably well with the increasing levels of CSR implementation found by Lindgreen et al. (2009).

"Transcending" organizations were older, larger, and had better performance in terms of corporate image and impact on social and economic health (Lindgreen et al., 2009). They were also more likely to dedicate employees or entire departments to CSR activities. While this may support the notion that CSR, especially linked to SD, is beneficial to organizational image and performance, a viewpoint that has been advanced elsewhere (e.g., Kaufmann, Reimann, Ehrgott & Rauer, 2009), caution should be observed due to the cross-sectional nature of the studies. An alternative hypothesis would be that better performing organizations are more likely to be able to afford the "luxury" of comprehensive CSR policies, and by providing more resources are able to achieve greater success.

A general picture is that CSR is important – increasingly and perhaps vitally so – for businesses and consumers alike, possibly more led by consumers, but with an increasing percentage of organizations seeing it as an opportunity. There are some examples of benefit being derived from implementing CSR and there is little, if any, evidence of CSR having negative impacts on organizations. One can probably assume that CSR, especially where linked well to SD, is beneficial for society, so there appears to be ample opportunity for "win–win" (or at least "win–neutral") outcomes for society and business. Yet, wide gulfs exist between good

intentions and successful implementation. What can be done to bridge the gap or to improve already successful initiatives?

HF/E can function as a method to help bridge the gulf between "good intentions" and "good deeds." It is argued that this can result in "good business," in the sense of improving bottom lines for the three pillars of SD: economic, environmental, and societal. Case studies at the end of this chapter show how HF/E is able to contribute benefits to each of these pillars.

HUMAN FACTORS AND ERGONOMICS DEFINED

The International Ergonomics Association (IEA)'s definition of HF/E includes the following:

> Ergonomics (or human factors) is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance … Organizational ergonomics is concerned with the optimization of *sociotechnical* systems, including their organizational structures, policies, and processes. (IEA Council, 2000)

HF/E includes sociotechnical systems theory. It also includes usability issues and is concerned with future users. It employs feedback and participation, change management, and the implementation of total quality management (TQM). All of these are used to improve the match between systems and people. Despite the holism of its scope, HF/E is a widely misunderstood discipline.

Marketing of products as "ergonomic" is the public's greatest source of visible exposure to HF/E. But this does not require any input from professionals educated and experienced in the field and the products often disappoint. It is no more possible to call a product "ergonomic" than it is to call a product "sustainable." The context of the wider system in which it is manufactured, used, and disposed is all important. To make value judgments and design decisions one needs to consider the system as widely as possible. A consumer product cannot possibly be designed for all uses, in all environments, by all users.

Although HF/E can and does have input into industrial/product design, and can and does have input into health and safety, it does not do this because that is what HF/E is about. Rather it does this because historically HF/E has been successfully applied to these areas. But HF/E by nature is a systems discipline and nothing about its methods or theoretical underpinnings prevents its application to other topics.

Sociotechnical Systems Theory

HF/E includes sociotechnical systems theory–which recognizes that technology can be ineffective and its implementation counter–productive to organizational goals if the social element of work is not optimized alongside the technical element (Badham, Clegg, & Wall, 2000). This means that technology should not be applied without understanding of, and design for, people and their needs, desires, abilities, and limitations. By jointly optimizing both the technological system and the social system, overall optimal system performance can be achieved. By optimizing only the technical or the social subsystem, suboptimal performance can result. Moray (2000) produced an approximation to the sociotechnical systems model that HF/E professionals might use (see Fig. 3.1). Note that the discipline of political economics also aims to address the outermost (''macro'') rings of the model and there may be scope for greater integration of HF/E and political economics.

Usability

HF/E designs products that are more usable because they are designed based on application of knowledge about the needs, abilities, and limitations of people; also the specific situation/context that they will be used within. This is sometimes called a user-centered approach. Usable products are kept for longer, resulting in less materials waste. Because they are easier to use, they are less likely to be accidentally broken or cause the breakage of something else. They tend to lead to more efficient operations with greater productivity and less consumption of materials.

Future Users

Another aspect of HF/E is that all users, including future users, should be considered in design. For sustainable products that means designing for maintenance, reuse, and/or recycling. Work by Olsen, Legg and Hannon (2007) found that recycling of e-waste exposed workers to hazardous substances, bad postures, repeated movements, and other risks. Solutions were identified, but primarily there was a call to design computers for easier disassembly. In the context of the expansion of extended producer responsibility schemes (where producers are responsible for the waste their products create) such solutions make good business sense.

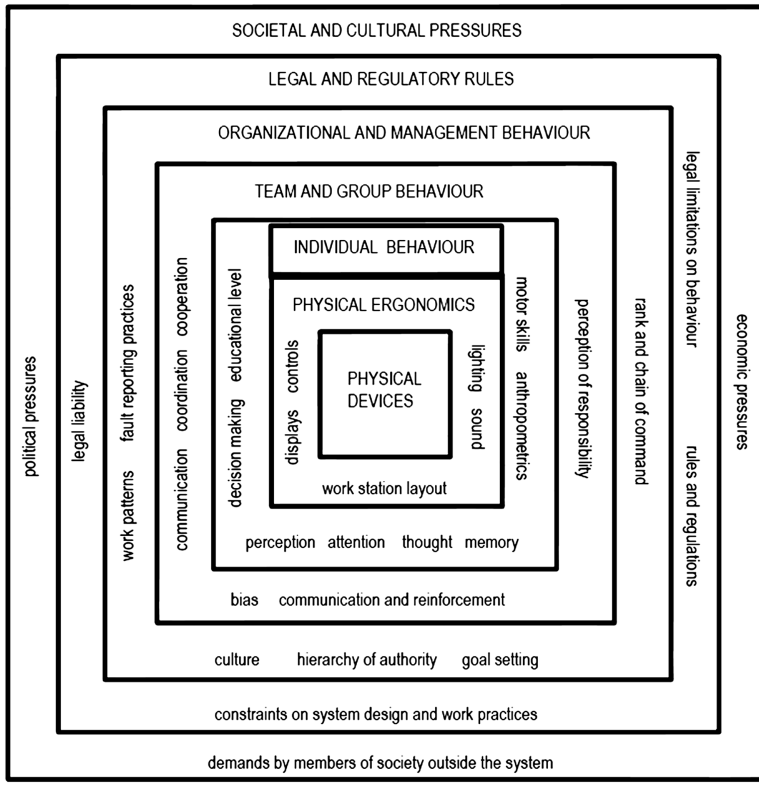

Fig. 3.1. Human Factors and Ergonomics as the Study and Design of Sociotechnical Systems (Moray, 2000).

Feedback

While businesses are beginning to monitor their impacts and using that information for reporting purposes, in future the wealth of data collected can be returned to the system that causes the impacts by effective feedback mechanisms, directed to the points within that business where effective change can be made. IBM's CSR survey report stated:

> Sharing relevant information to educate and inform stakeholders was a primary objective. Interestingly, using information to optimize supply chains, transport and logistics, waste management and product lifecycle was a far less prevalent goal. Given that 87 percent of business leaders surveyed say they have focused their CSR efforts to

> create new efficiencies, we see a missed opportunity to connect operational information with this important CSR objective. (Riddleberger & Hittner, 2009)

Feedback is multifactorial (Flemming, Hilliard, & Jamieson, 2008), and HF/E specialists can contribute their sociotechnical systems experience to its design and to the design of monitoring systems. Within sociotechnical systems theory, feedback is a critical concept. Salient, timely feedback, close to the source of variance, which is presented in such a way as to be meaningful to the person able to alter the system or their behavior, is highly important. When this is lacking, unsustainable behaviors that are occurring may not be corrected (Flemming et al., 2008).

Participation

HF/E is a discipline that employs participative processes. HF/E professionals very commonly use participatory approaches to effect organizational changes with the aim of better matching organizational environments to the needs, capabilities, and limitations of people. Participation is encouraged by a key New Zealand government policy directive on SD (Department of Prime Minister and Cabinet, 2003). Principle 10 of the Rio Declaration states that: "environmental issues are best handled with participation of all concerned citizens, at the relevant level … each individual shall have appropriate access to information … and the opportunity to participate in decision-making processes" (UNCED, 1992).

Imada (2008) stated that HF/E "may be a particular … tool that can help realize global sustainable development. Without active participation from individuals it is difficult to imagine real change occurring to make sustainability a way of life in many societies and organizations … active participation in [human factors and] ergonomics, and … sustainability, can create experiences that lead to ownership, a more profound understanding of the problem, and engaging people emotionally."

Change Management

Applying change management from an HF/E perspective (i.e., working to achieve change to the system, in full cognizance of the interfaces among humans, organizations, and technology) has yielded several general lessons that can be applied to the pursuit of sustainability (abridged from Imada, 2008):

- Inertia (people and organizations do not change naturally, due to homeostasis and the fact that people and systems have good reasons not to change)

- Beyond rationality (intellectual buy-in is an insufficient condition to produce change; it also requires task-related, emotional and behavioral components to support that change)
- Fears and concerns (can overcome the best ideas or intentions to change due to questions about adequacy, place, relationship, and acceptance)
- Cultural collisions (group, corporate, regional, or national culture norms may conflict with behaving or managing in sustainable ways)
- Suboptimization (while an organization may have the will to move towards a sustainable future, people in different levels and departments make unique decisions that are sensible to them but counter to the larger initiative; this is partly inertia and partly a rational decision to maximize local processes)
- Power (those who stand to lose power or advantage due to change will put up the greatest resistance because they already have power in the current system, they are formidable adversaries to implementing change)
- Capability (people or systems may not possess the capability or infrastructure to change. Enabling change at an individual level may need training, coaching, tools, and other alternatives. At an organizational level it may need changes in authority, responsibility, rewards, feedback, scope, or expectations).

Implementing Total Quality Management

Zink (2002) noted that "many companies have not been able to implement Total Quality Management in a successful way. In most of these cases, TQM failed because of not realizing a sociotechnical approach. Here … [HF/E] can support organizations in introducing change management concepts in a comprehensive way." Refer to Zink (2008) for discussion of the relationships between HF/E and comprehensive management concepts (TQM, organizational excellence, organizational design, and management) and integrating them within a corporate sustainability context.

HOW ARE SUSTAINABLE DEVELOPMENT AND HUMAN FACTORS AND ERGONOMICS RELATED?

Both SD and HF/E are disciplines that deal with sociotechnical systems. The objective of SD is to optimize the relationship between the economic

system, ecosystem, and social system. The objective of HF/E is to optimize the relationship between humans and other elements of the system.

HF/E is best understood as two things. First, it is a discipline that is well placed (in terms of research base, conceptual framework, and methodology) to understand the human role in systems, which includes environmental, social, economic, and cultural elements. It is human activities that are the cause of environmental degradation and other negative impacts in the SD context. Understanding the causes within a systems context, then designing and implementing system changes is a natural fit for the HF/E discipline. It should be noted that sociological perspectives to SD also emphasize the social, or human, component of systems (e.g., Cernea, 1993); however, HF/E is a design discipline with a set of existing tools that may be readily applied to finding solutions.

Second, HF/E has a moral or ethical framework (Pheasant & Haselgrave, 2006; Vitalis, Walker & Legg, 2001) that states that people should be the element of the system which should be optimized, that is, the system should be designed to suit the worker in that system, or user of that system.

There is a potential issue at a theoretical level that designing systems for the benefit of workers/users may not result in a better system in terms of production (economy), nor environmental benefits. Social elements probably are catered for a priori in this user-centered design philosophy (if one accepts that social system integrity is important for individual well-being). In practice HF/E interventions in workplaces result in better conditions for workers, which are consistently shown to result in greater productivity, fewer errors, less injury time, less compensation, and lower turnover (Beevis, 2003; Dul & Neumann, 2009). There are further examples in the ''Economic Sustainability'' case studies section. The environmental issues we face overwhelmingly result from human behavior. Often the proposed remedies are technological. HF/E is very much about designing for, or successfully modifying human behavior (by first understanding humans, then the system that they are in, then finding a way to design the whole system for an optimal outcome).

Marrying SD with HF/E solves two ''problems.'' First, it brings a rich set of knowledge and methodology to help bridge the lack of connection (outlined earlier) between ''good intentions'' and ''good deeds''; resulting in ''good business,'' in the sense of improving bottom lines for the three pillars of SD. Second, it brings the paradox of a systems discipline that favors a single element of that system into a circular resolution. The paradox has been that HF/E applies certain human values (takes a moral approach) to system design; it thus could be considered not to optimize the overall system, but rather to optimize the human element (the social system), which

in theory could be just as suboptimal as optimizing the technological system at the expense of the social system (Brown, 2007). This paradox has been more theoretical than practical as a "person-centered" approach nearly always does result in improvements elsewhere in the system (*ibid.*); perhaps because the "human factor" is the most neglected. Thus, improvements here are what are most often required to improve system performance.

The issue can be even more neatly resolved by including within HF/E an SD framework (value set), where the needs of *all people*, including future people, becomes the design criterion. It should be noted that SD is an anthropocentric concept, where environmental goals are not an end in themselves, but a necessary prerequisite for durable satisfaction of human needs (Zink, Steimle, & Fischer, 2008) as outlined in, for example, the Rio Declaration on Environment and Development: "Principle 1 – human beings are at the centre of concerns for sustainable development. They are entitled to a healthy and productive life in harmony with nature" (UNCED, 1992). By designing systems for SD, HF/E can be seen to be a method for optimizing the ecosystem, including all people within it and obtaining the most optimal business systems within that context.

CASE STUDIES OF HUMAN FACTORS AND ERGONOMICS CONTRIBUTING TO BUSINESS SUSTAINABILITY

This section provides examples of case studies that show how HF/E can work as a method to achieve business sustainability from economic, environmental, and social perspectives.

Economic Sustainability

The economic advantages of HF/E interventions are well recorded in the literature. One example, employing a predictive cost–benefit calculator, showed that the mean benefits for 250 HF/E intervention studies were: payback period 0.7 years, cost/benefit ratio 1:18.7, productivity increased by 25%, lost workdays decreased by 75%, and errors and wastage decreased by 67% (Goggins, Spielholz, & Nothstein, 2008).

Case 1: Good HF/E Is Good Economics
Hendrick (1996) detailed numerous HF/E interventions with economic benefits and some of these are summarized in Table 3.1 without further citation.

Table 3.1. Good HF/E is Good Economics (Abridged from Hendrick, 1996).

Industry/ Application	Intervention	Economic (and Other) Benefits
Forestry	Design and introduction of anthropometrically appropriate leg protectors	Massive reduction in injuries and sick time. Conservatively saving South African hardwood industry $4 m annually
US Airforce	Redesign of aircraft fit-out, simplifying conversion of aircraft between alternate uses, reducing operational weight	Reduced operation and maintenance costs for more than 200 aircraft over more than 35 years. Also reduced installation time and labor and storage requirements for the kits. Also saved over $2 million in the initial cost of the aircraft fleet. These and other human factors evaluations and improvements during the design phase cost less than $500,000, but the cost savings they achieved were over $5 million. In addition the designer contends that the Human factors and ergonomics (HF/E) input was a significant factor in the aircraft's exceptional safety record
Materials handling	A semiautomatic materials handling and stock-keeping system for steel pipes was redesigned	Noise dropped from 96db to 78db, production increased by 10%, rejection due to dropped pipes reduced from 2.5% to 1%. Redesign and development costs repaid in 18 months and thereafter resulted in profit
Forklift truck design	Raymond, a manufacturer of forklift trucks employed the HF/E Laboratory at Cornell University to assist with the design of its new range, with the aim of maximizing operator comfort, minimizing accident risks, and maximizing productivity	Raymond's market share had eroded from 70% to 30% prior to the project. Following the introduction of the new line, Raymond's order books were full and the company's stock rose from $6 per share at the start of the project to $21 after the product launch
Telephony	Ameritech (a US regional telephone company) employed HF/E professionals to redesign their directory assistants' displays and redesign their training program using a simulated work environment and error feedback	A 600 ms reduction in average call time was achieved, saving $2.94 million annually. The training program was reduced from five days to one and a half days

Table 3.1. (*Continued*)

Industry/ Application	Intervention	Economic (and Other) Benefits
Automotive safety	The US federal government sponsored a program to develop improved brake lights, to reduce collisions. The center high-mounted stop lamp was selected from the trialed configurations due to it resulting in a 50% reduction in rear-end collisions and collision severity. It was mandated for all new vehicles from 1985	The research program cost $2 million and the regulatory program cost $3 million. Based on actual production costs and accident data, the cost savings based on property damage alone (no medical costs) have been calculated at $910 million per annum, just in the United States, although the design is now implemented worldwide
Petroleum distribution	A participatory HF/E approach was used with all levels of employees of a petroleum distribution company, from management to truck drivers, to examine and modify aspects of its organizational design, management structure, and processes. Employee-initiated changes were made to some of the equipment and employee-designed safety training methods and structures were implemented	All types of injuries were reduced by more than 50% and lost workdays by 94%. $60,000 savings per annum have been realized. Safety has been installed as part of the organization's culture, locking in the advances and giving opportunity to increase them
Clothing manufacture	A HF/E approach was used to introduce a total quality management (TQM) system to L. L. Bean Corporation	There was greater employee satisfaction, improvement in organizational quality measures and a reduction of more than 70% in lost time injuries

The second example in the table, of the U.S. aircraft design (by Hendrick himself), can serve to illustrate a general principle, which is that HF/E input can have the greatest impact and benefits during the specification and design stage. Unfortunately most HF/E professionals report that they are only asked to work on a system or product when design is complete and a problem is apparent. In this case the scope and value of interventions is necessarily limited and comes at greater cost, though it can still be significant and beneficial.

It is striking that the cost savings accruing from the HF/E interventions are ongoing. Any intervention that results in ongoing reductions in injuries and absences, increases in productivity, or reduced damage to equipment or property is clearly contributing to economic sustainability. HF/E programs that result in changes to organizational culture, structure, or processes that themselves result in further interventions are even more sustainable as they are devolving capability from the HF/E expert to the organization.

Environmental Sustainability

One example where HF/E could assist environmental sustainability is waste management. Nickerson and Moray (1995) indicated that a major problem of waste recycling is getting sustained citizen participation in recycling programs. They argued that education and advertising campaigns are not very effective, efforts to motivate people to recycle sometimes meet with modest short-term success but do not manage to effect lasting change. In some cases, simple positive reinforcement schemes can produce unwanted behavior. Planning and executing recycling programs that will effect the lasting changes in attitudes and behavior that are essential to make real progress on the problem of waste remains a significant unmet challenge. A specific example of this is Auckland City Council's waste management policy, which recently changed in favor of a centralized sorting and recycling operation. The implications of this are that local recycling operations have been minimized or abandoned, reducing community involvement and removing the effective short feedback loops that are possible with community operations. The socially optimized community recycling model in one locality, Waiheke Island, was replaced by a technically optimized, centralized model. These models and a third sociotechnically optimized alternative are described more fully by the authors in an article which is in preparation.

Case 2: HF/E in architecture

HF/E is also recognized as offering benefits in architectural design. A successful collaborative design approach was employed in the development

of the NowHome in West Auckland, built in accordance with sustainability principles by a Beacon Pathway consortium. The design team had a flat structure (it was not led by an architect) and comprised a draftsman, consultant architect, and HF/E professional responsible for drawing up the design, in association with engineers, building scientists, and others (Moore, 2007).

The need for HF/E input in architecture is recognized and experience has shown that the HF/E professional needs to have direct involvement in the design – it is not enough to provide guidelines or standards, as uptake is not good (*ibid.*). There are now drivers to include HF/E in building projects in the United States as there is a point available for implementing HF/E measures under the U.S. Green Building Council's LEED rating scheme (Hedge, 2008).

The New Zealand Green Building Council does not yet have a point for HF/E specifically, but it does offer credit for indoor environment quality and is developing tools that assess the building's actual performance in use. HF/E input would help to achieve higher scores in both of these categories. Indoor environment quality, including temperature control, ventilation and air quality, and lighting design, has significant impacts on performance and health (colds, flu, and asthma levels) in offices and schools (Hedge & Gaygen, n.d.; Kats, 2006). In schools it has been shown to lead to improved learning, behavior and test scores, and greater teacher retention (Kats, 2006). Performance in use is the interaction between the building systems and the occupants. An unoccupied building does not use water, energy, or produce waste.

The building-related elements of the system in Fig. 3.2 are shown interacting with the behavior-related elements affecting use and disposal. Also of interest is the consideration of the building within the neighborhood. This might include elements such as the "walkability" of the area, availability of public transport, and proximity to work, school, shops, and community facilities.

An example of an eco-designed office is Waitakere City Council's building "Waitakere Central." Brown (2007) found the most effective features were those that optimized the interaction with the occupants of the building and with its neighborhood. It is easily accessible and benefits from its location and proximity to public transport, but also contributes to the neighborhood as well, offering a new crossing over the railway line and increasing foot traffic through the town center. The building has:

- a wide, gently sloping, well-ventilated, light-filled stairwell that encourages socialization and walking from floor to floor (lifts are not prominently placed)

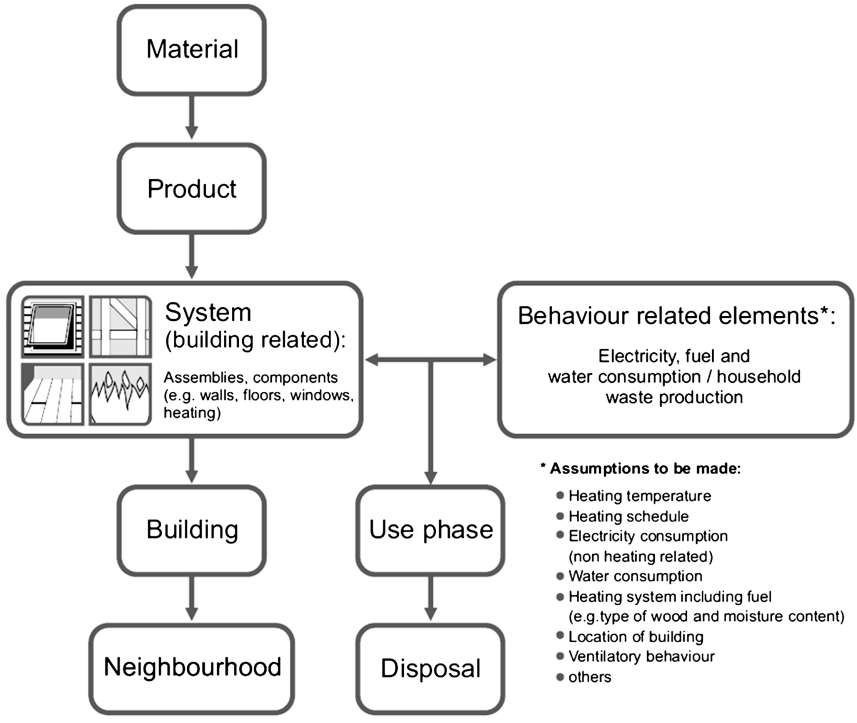

Fig. 3.2. Beacon Pathway Model (Nebel, 2008).

- printers that won't print until the staff member actually walks to a machine and activates it with a key card
  - encouraging people to get up from their desk, and
  - saving toner and paper as nonessential items are less likely to be printed (unprinted items are deleted after an hour)
- few car parking spaces (reducing each year) available only to carpoolers, but subsidized public transport and indoor cycle parking and showers
- a bridge over the railway to connect to the community and open the town center to easy pedestrian access (classical music is played to deter vandals)
- been built separate from other council buildings (they are not clustered) as part of a plan to reinvigorate Henderson economically and socially.

The benefits of these aspects of the design clearly derive more from the way they accommodate people and their needs and also how they influence

people's behavior toward more positive environmental, social, and economic outcomes. The owners of such buildings can be expected to benefit from ease of attracting and retaining staff, fewer injuries and time off, reduced consumption of resources and materials, reduced waste, reduced operating costs, and community goodwill.

Social Sustainability

Social sustainability includes community HF/E and HF/E in industrially developing countries. Community HF/E "focuses on distressed community settings characterized by poverty, social isolation, dependency, and low levels of self-regulation (and control) … the individual is viewed as an organized system within a community in which the guidance and course of behavior is determined by the ability of the person to develop reciprocal feedback control over the economic, social and cultural aspects of the community environment … the optimal system design will be achieved when the development of individuals and communities are promoted and the design fits with the built-in or learned behavior of individuals. On the other hand, system design can adversely affect behavior, learning, and development of individuals and communities when individual needs are not considered" (Smith et al., 2002). Although community-led, there is substantial room for corporate involvement in community HF/E programs. One such program is described in Smith et al. (2002): *the Milwaukee Community Investment Partnership (MCIP)*.

Case 3: Industrially Developing Countries

Scott (2008) argues that HF/E can be most effective in industrially developing countries, where there is more room for improvement. Systems in developing countries can be improved greatly at low or no expense, and poor economic performance by developing nations is largely a function of a workforce that is undernourished, under-skilled, overworked, and consequently underperforming. By investing in improvements to workers' situations and their interactions with their workplace, often very simply and cheaply, productivity gains more than compensate for the costs of the intervention. By way of example she gives not one company, but a whole nation:

> Any company run on sound [human factors and] ergonomic principles brings benefit not only to the workers but also to the company and indeed to the Nation as a whole. South Korea provides us with an excellent example. By adopting a culture of unremitting progress orientation, this society has moved its post-war economy (equivalent to that of

> Ghana in 1960) to 10th ranked in the world. They have done this largely by a productivity-orientation which endemically recognizes that their chief resource is their people. It is not coincidental that in 2003 the South Korean Ergonomics Society hosted the Triennial IEA Ergonomics Congress, a strong indication of its commitment to [human factors and] ergonomics (*ibid.*).

Moore (2009), visiting central Chile as a guest of the University of Concepción HF/E team, reinforces this point. One of the highlights of his trip was:

> Seeing a new camp for forest workers built by Mininco. For years the [human factors and] ergonomics team at Concepción had argued that there was little point in focusing on improving job elements if life outside still failed to provide subsistence conditions. Studies therefore had looked at matters holistically, and covered overall nutrition, pay and living conditions; and crucially, the benefits of improving these things on industry performance. Judging from the menus of the meals provided for the crews, the Chilean loggers now eat a lot better than our guys in the Kaingaroa.

Scott (2008) argued that the intergenerational equity dimension of SD is particularly and immediately amenable to CSR and HF/E, given the fact that changes can be assessed by existing, more short-term metrics. She added that "all targets of the Rio Declaration of 1992 relative to sustainable progress (economic, social, and environmental) can be addressed by appropriate ergonomic intervention where it is most needed viz. in developing regions." Specifically this would be achieved by providing "ample, cheap and effective micro-level interventions" and at the macro level "corporate commitment to improve the entire working environment, including the socio-economic status of … workers and [their] … general lifestyle" (*ibid.*). Where currently there are corporate image issues associated with outsourcing of production to developing countries, positive development policies centered on CSR and HF/E can have massive benefits for little cost, leading to improved corporate image.

Whether in developed or developing countries, the consideration of the social subsystem is essential when introducing technology. Specific issues arising from the transfer of technology from developed to developing countries are addressed in Shahnavaz (2002), who considers that:

> The importation of inappropriate technology, which could not be fitted to local conditions … is considered as one of the reasons for the current problems in IDCs. This has created a vicious circle of unemployment, chronic poor health, high rate of accidents, low motivation, increased physical and mental stress and low productivity … The aim of using [human factors and] ergonomics in the technology transfer process is to break this vicious circle of failure by creating productive, safe, and satisfactory condition (sic); for technology users.

THE CASE FOR A SYSTEMS HF/E APPROACH TO SUSTAINABLE DEVELOPMENT

This chapter has sought to make the case that SD, and thus effective CSR approaches, requires a systems approach to achieve satisfactory outcomes. This is neither an original assertion and nor is HF/E the only discipline to employ a systems approach, but it is an *applied* discipline with a pedigree of successful implementation in complex sociotechnical systems, with a particular focus on the human element of those systems. Its focus, body of knowledge and set of tools are able to be turned to the domain of SD, without any or much further development. They are readily accessible to organizations seeking to implement CSR policies that can bridge the gap between "good intentions" and "good deeds," as outlined in this chapter, leading to "good business." In other words, jointly optimized outcomes across the pillars of SD. Possibly the greatest barrier to this is misapprehension of what HF/E actually is. It is hoped that this chapter will go some way to rectifying this, by outlining the theoretical underpinnings of HF/E, relating them to SD and CSR, and then providing examples in the form of case studies.

Each of the case studies was categorized under one specific pillar of SD, but in each case it could easily have been listed under one or both of the other pillars. For example, the architecture case study was listed in the "Environmental Sustainability" section, but it had clear social sustainability and economic sustainability credentials. Likewise, the economic benefits listed by Hendrick (1996) were also social benefits (reduced accidents and injuries) and some were environmental benefits (less waste, greater usability). Community HF/E has social benefits and was listed in that section, but many of the benefits are also financial and environmental (at least concerning the local environment). The case study on developing countries had major economic implications, as highlighted.

These and other examples show that because HF/E takes a systems approach throughout the analysis, design and implementation, more balanced outcomes occur across the system. Thus, by implementing CSR via HF/E it becomes easier to ensure benefits in each pillar of SD, where a nonsystems approach might optimize one aspect at the expense of the others.

CONCLUSION

CSR approaches are a potentially valuable way for organizations to contribute to improvements to societal SD and possibly to their own

performance. Levels of awareness and attempts at CSR implementation by businesses are high and increasing. Survey data suggests that the most successful implementation requires CSR policy to be oriented to the three pillars of SD, but that good intentions to implement CSR have resulted in but partial success. The complexity of optimizing three dimensions simultaneously in the context of complex open sociotechnical systems requires a discipline that is used to maximizing multiple dimensions in such contexts. All changes toward sustainability require the change process to be managed, and specific, salient feedback to be provided close to the source of variance (to individuals, ideally). Human behavior is the cause of unsustainability.

HF/E offers a technology to modify this in a way that individuals accept, or even desire. Whether technological or behavioral changes are required, or both, application of knowledge about the needs, abilities, motivations, desires, and limitations of people will be required. This is the primary component of the HF/E knowledge base and set of methods. Complex systems, sociotechnical interactions, change management, behavior modification by environment design, methods to track and manage interventions, and an interdisciplinary approach are all facets of the HF/E discipline. They are also requirements of a SD approach. HF/E is therefore valuable to organizations wishing to successfully implement CSR and to wider efforts to achieve SD.

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