Towards an Optimistic Future

Hardin Tibbs, September 2000

Change in the Global Context

The world stands at a crossroads. The global population has now grown to six billion people and is still growing fast, although the underlying growth rate is slowing. The scale of human activity is threatening to seriously alter ecological functioning at a planetary level, with climate change providing the first example. Human technology has reached a level which gives small groups the potential to destroy the basis of life on earth, or at the very least to threaten the lives and livelihood of millions of people. At the same time, this same technological capability could be used to solve the myriad problems that we now face at all size scales from the global to the local. It is widely agreed that the current pattern of activity cannot be sustained indefinitely: the scale of destructive impact and the rate at which this is expanding are literally unsustainable on the surface of a finite planet. Something must change.

The change will not arise from human capability alone, whether technological or otherwise. We already have the technology needed to address the issues we face. The crucial determinant is our collective discipline to apply the technology in the ways needed to address the problems. The source of the will to act constructively must ultimately come from individuals and groups arriving at the realisation that action is needed, and determining to do what it takes to achieve it. The potential for change thus emerges at the top level of the global context framework and then percolates down to the lower layers. We will know if the necessary decisions are being made by looking at the political system and how it is addressing the issues. We will know how we are doing by looking at the way technology is deployed, and at the measure of impact this is having on the problems.

Two crucial points emerge from an exploration of these issues from a futures perspective. First, the need for significant change to the global system, and the very high risks involved if we fail—essentially risks to human survival on this planet—mean that the road ahead to a successful outcome is not a ‘business as usual’ scenario. Second, there is not a great deal of time available for making the necessary changes. Estimates of how far we are from the onset of possible crisis conditions vary, but the general indications are that we have only a few decades at best.

This means that the next two or three decades will mark a significant transition point in human history. Failing this we will find ourselves facing what would be in many ways a return to prehistory—an effect reminiscent of playing the 'snakes and ladders' board game and landing on a very long snake.

The use of scenarios as a tool for assessing the range of future uncertainty usually involves an implicit assumption that the playing out of the various uncertainties in different ways leaves the world as a whole much the same, in spite of differences from the perspective of specific groups or organisations. In the case of the world system over the next 30 years, this appears not to be true. The major theme of global 30-year scenarios must be that the world as a whole is in crisis, and that the outcome is, to use the earlier simile, either a big ladder or a big snake.

If there are essentially only two scenarios, 'Big Snake' and 'Big Ladder', it is hard to test responses to small differences in contingencies in the conventional way, since even small deviations will potentially flip the system between the two scenarios. And since we are attempting to look out 30 years in an immensely complex and unprecedented situation, in practice it will not be possible to identify which particular fine-scale deviations tip the scales one way or the other.

This difficulty raises the need for an alternative methodological approach, one that does not implicitly treat the risks and uncertainties as being subsets of an essentially stable overall system. The concept of backcasting from a normative or desirable future has not previously been applied to the long-range global future but it does constitute a potentially advantageous approach. If indeed we face a critical global transition over the next 30 years or so, this prompts a simple question: what do we hope the world will look like after the transition? The essence of the 'Big Ladder' scenario is that the outcome is good—in this scenario the major global systemic problems are resolved and the world system achieves sustainability. But this construct just posits the absence of problems, it does not define the outcome in positive terms. If we do this it is possible to identify a series of specific positive outcomes or indicators of success. We can then ask what needs to happen, and by what date, for us to achieve the normative or optimistic outcome.

This approach creates a normative path or overall trajectory for the global system. In effect this defines a broad global strategy for the decades immediately ahead. The strategic intentions of individual players within the global system—organisations or governments—can then be compared

with the overall strategy to determine if they are likely to contribute to the 'Big Snake' or the 'Big Ladder' scenario. This kind of comparative test then becomes a very important means of ensuring that critical long term issues are fully reflected in current strategic thinking and actions.

The 'global strategy' consists of a number of target conditions that need to be accomplished within the context of an overall transition. The scope for action in achieving these outcome conditions is constrained and shaped in important ways by the nature of the current global systemic challenges. Similarly, the nature of the transition is defined in important ways by the nature of the structural changes necessary to resolve the challenges. A clear articulation of these structural issues forms an important part of the global strategy.

Normative Outcome and Global Strategy

What kind of world do we want in 50 years?

The Importance of a Normative Objective

All aspects of government strategy in a democratic context are broadly concerned with seeking better outcomes for society at large. The approach here is therefore to use the concept of an improved future condition as a basis of strategic evaluation.

Defining a future normative outcome and the steps needed to achieve it allows backcasting as well as forward exploratory scenario projection, and allows scenarios to be related to an overall strategic intentionality for society as a whole. It also allows current developments and trends to be understood in terms of their relative constructiveness: their contribution to or divergence from an overall positive outcome.

This approach is not intended to be deterministic or absolutist. The optimistic outcome is not seen as inevitable, nor as a tightly defined outcome state. It is based on a broadly desirable set of outcomes given the developments observed on the world stage today: it is related uniquely to this context and time. It blends techniques designed to embrace uncertainty—primarily the scenario-based planning approach—with the motivational importance of a positive psychological response to uncertainty. This response is framed not in terms of an assertion about what will happen, but rather in terms of achieving clarity about strategic choice and overall strategic direction set against a backdrop of the full extent of uncertainty and challenge on the world stage today.

Thinking Optimistically

If we look to the future of our nation and the world at large, what do we see? There is certainly a great deal of to be afraid of: everything from global nuclear war to ecological collapse. And there is a litany of articles, books, and special reports to attest to this. At the turn of the century the future seen from a broad perspective has taken on a bleak tinge. What we do not often see is any attempt to think about how we would like the future to be, what the optimistic outcome would be.

There are of course any number of isolated positive projections being touted—the shining prospects on offer from the forward march of technology, or the expansion of the internet, or business growth in the new economy. But these seem somewhat one-dimensional when set against the backdrop of genuinely overwhelming global concerns, and they certainly do not dominate popular thinking as they did in the 1960s, when change seemed inevitably to be taking us into a better future, as if on autopilot.

There is a subtle difference between asserting that a combination of certain developments could plausibly result in an optimistic outcome—as for example *The Long Boom* argues—and actually identifying what the desirable outcome would be. The former is a positive view of the future that is limited to the best tendencies in the trends that are projected. The latter approach asks, given everything that is happening, what do we hope the outcome will be?

Thinking about the future we would hope to see gives increased strategic leverage—since it is a proactive rather than a reactive strategic stance (Ackoff, 1981). The future is intrinsically uncertain, and we can fill it either with what we think might happen, or what we would like to see happen (a product of our understanding of the strategic environment and our self-knowledge). If we do the latter, we can create a framework in which all our actions—both tactical and strategic—can contribute to creating the optimistic outcome.

The definition of the optimistic outcome depends on the set of framing assumptions we make. We must decide who is choosing, and what they value. This could easily become an elaborate exercise, subject to the criticism that the diversity of perspectives in the country, let alone in the world, is so great that no such effort could ever come to a satisfactory conclusion. If, however, the scope of the answer and the corresponding assumptions are kept simple, it is still possible to say something useful.

The proposal being made here is that the optimistic outcome for the world future can be defined in a fairly general statement along the following lines:
'In fifty years we hope to have a stable, peaceful, prosperous, diverse global civilisation, which honours freedom of personal belief, and in which democratic political processes dominate, with a high level of universal education and health care, and a genuinely impartial and accessible system of justice, and in which both advanced and basic technology is applied in ways that are in balance with the natural environment, and produce an equitable distribution of social benefits.'

This proposed definition has been tested with professional and general audiences both in Australia and in the United States and has met with broad approval. It reflects minor changes suggested by members of those audiences. There is no doubt still some room for disagreement with this formulation, but at least it provides a 'straw man' for stakeholders or strategists to react to. Where views differ, strategists can substitute their own preferences, and then work through the implications of these changes in the reasoning that follows.

A number of assumptions and values are implicit in this definition of an optimistic outcome, and it is worth identifying them, as they underlie the global strategy (below) that is derived from the optimistic outcome statement.

The optimistic outcome or normative objective assumes:
- a timeframe that looks at least fifty years ahead, to 2050, which allows time for significant change, and for transitions now underway to be completed
- the full range of global trends and developments is being taken into consideration
- a global perspective, not a narrowly nationalistic one (because national outcomes are increasingly linked to global outcomes)
- countries are linked in global arrangements or agreements for dealing with global-level issues
- there has been no population crash (although population growth has decelerated)
- the continuity of global culture is maintained (there are no major disasters)
- democratic political processes prevail (no global tyranny emerges)
- international social equity and inclusion is achieved (possibly by new forms of community design rather than by welfare systems as such)
- personal and social freedoms are guaranteed
- an impartial and accessible system of justice exists internationally

- there is universal education and health care (without specifying how this is paid for)
- there is a high level of scientific knowledge and technological capability
- economic and social development aims to achieve the triple bottom line of sustainability
- technology is used for good
- the natural environment is protected and restored
- industrial processes are meshed with planetary biospheric processes

The Role of the Optimistic Outcome

Having a clear definition of the optimistic outcome for the world future has several benefits.

a) It allows a proactive strategic posture: it provides a clear overall objective to aim for, at the highest level of relevance available—that is, it constitutes the frame in which both international and any national strategies would be set. This means that any organisational strategies aligned with it are broadly likely also to align with any democratically-determined national and international goal-setting. This is important since almost no countries today have a defined national strategy.

b) It allows 'backcasting'—a technique that asks 'what would have to happen' in order for the optimistic outcome to eventuate. This allows tracking using early indicators: the signs that would show us if we are on the path to this outcome. An important insight provided by backcasting is that it can tell us whether the 'business as usual' (BAU) path will in fact take us to the desired or optimistic outcome. If it does the current path is sustainable, if not it is unsustainable.

c) The significance of identifying this outcome as the optimistic one for the world, is that, all other things being equal, the global political, economic and social system can be said to be seeking this outcome. To the extent that collective human intentionality is an important driving force, this means that the optimistic outcome also has some predictive power, which makes it useful as a reference point for scenarios that attempt to anticipate future outcomes.

d) The optimistic outcome is of course not inevitable. There are many divergent paths in which one or more aspects of the optimistic outcome fail to occur. Broadly, any of these failures may result in a flip from the 'Big Ladder' scenario described earlier to the 'Big Snake' scenario. However, in practice it is not possible to determine which particular divergences might have this effect. For the purposes of exploratory thought experiments, the optimistic outcome can be treated as a central scenario with the divergent

outcomes arranged around it as alternative scenarios leading away from a normative path. This provides a convenient way of ordering multiple scenarios. The principal strategies in the alternative scenarios are then ones that draw the divergent outcomes back to the desired path.

Backcasting and the Normative Scenario

If a specific plausible future state is defined, in this case a normative global outcome, it then becomes possible to work backwards and determine the events and developments that would have to occur if the envisaged endstate is to eventuate.

An initial version of the normative scenario has therefore been developed in narrative form here, showing the overall series of events. This scenario is based on a combination of backcasting from the normative outcome, informed by research into the global context.

The Optimistic Scenario

Narrative description of the normative trajectory

For the first few years of the normative scenario, exponential physical growth continues unabated and worldwide business activity intensifies. The world marketplace expands, leading to further growth and wealth for OECD countries. The world economy progressively integrates and Third World industrialisation surges ahead, led by India and China. Environmental concern continues to build in response to a steady stream of environmental incidents and problems, but no effort is made to restrict growth.

For a fortunate minority in the successful economies there is a very high level of affluence, and society is largely shaped by a materialistic business-oriented value system. Individualism and competition dominate everyday life, and the gap between rich and poor widens, both within countries and between countries, as social and environmental problems continue to accumulate.

Australia continues to urbanise, and rural areas steadily lose population. The major urban centres grow in area and population, in spite of immigration to Australia being held in check by successive governments. A handful of ultra-tall buildings are planned for urban centres with the highest property values.

Just after 2008, following the successful implementation of the Kyoto Protocol, an international consensus is reached that drastic action is needed to prevent the breakdown of the global ecological and economic system. This happens in response

to mounting social and environmental concern but without a major crisis. The agreement takes the form of a United Nations Global Sustainability Protocol, which sets binding international targets for pollution control, resource efficiency, and deep institutional, economic and industrial restructuring.

With this UN agreement in place, there is rapid business adjustment as OECD countries move to introduce measures and policies that will shift their economies towards sustainability.

One of the key policy measures adopted internationally is to shift the tax system away from taxes on labour, income and investment to taxes on energy, materials and consumption. This de-emphasises consumerism and increases employment. Fossil energy consumption drops dramatically, in favour of minimalism and renewable energy. There is a move away from very large differentials between the highest- and lowest-paid, and many new businesses form as cooperatives instead of traditional companies. In 2010, the global population reaches 6.5 billion, but the growth rate is beginning to slow.

By 2015 the target for industry is a major reduction of total throughputs of energy and materials, and a near-total elimination of pollution. An important part of achieving this is to move towards a fully cyclic materials economy. This is assisted by reducing the scale of production capital to allow it to be more geographically dispersed. Manufacturing businesses shift to a service approach by leasing products and retaining ownership in order to facilitate remanufacture and recycling. The parallel objective for agriculture is a localised low-inputs approach with high biodiversity that regenerates soils and is ecologically restorative.

Social and economic institutions and regulatory regimes are redesigned to support the changes in industry and agriculture, and most importantly to avoid major disparities of wealth within and between countries. An indirect objective of these policies is to bring all communities through the demographic transition, in order to limit population growth.

Education and communications have a high priority, and changes are made to media legislation to support the values associated with the new policies and to encourage a longer time horizon, and more exercise of foresight. Particular attention is given to developing indicators that show how well the 'new' new economy is meeting its objectives and maintaining social and ecological health.

There is an emphasis on achieving these policies by means of locally integrated solutions. This is because natural resources and environmental diversity always exist in specific localities, communities are always rooted locally, and together with knowhow these form the basis of prosperity. From this flows a recognition that the socio-economic system is best integrated locally. This also allows effective local solution of social problems such as unemployment in a way that could never

be achieved by macro-economic policy. In fact, early examples of this approach had existed in Australia and New Zealand in the 1990s, encouraged by the United Nations Agenda 21 initiative.

There is a new approach to the development and application of science and technology. All new technology has to pass stringent social and environmental tests, and much previously existing technology is modified and adapted to the new criteria. Technological solutions favour subtle and minimal designs and a brute force approach is no longer acceptable. New technologies that were emerging on the fringe of the old economy are now taken up and developed rapidly. Probably the most significant developments of this sort are completely new sources of environmentally clean energy that have become possible thanks to fundamental breakthroughs in physics.

By the mid-2020s, these changes are resulting in significant shifts in the distribution of population and in the design of communities. The global population reaches seven billion in 2025, but is now growing far more slowly than at the turn of the century. Cities shrink, and many people move out to small dispersed communities in the urban hinterland. Advanced technology is used to provide services that required centralised urban infrastructure in the old economy. Most food is grown locally with a mixture of low-impact high technology and some labour-intensive practices. The old city cores together with their newly resurgent hinterlands are the primary units of the new cellular economy.

The primary elements in this scenario can be presented in the form of a timeline which shows broad developments under each of the main framework headings. The timeline illustrates the broad developments that occur during the scenario. These can be summarised, first, as a move from unsustainability to sustainability. Progress towards the sustainability of global economic activity will be apparent from a reduction in the level of social and environmental impact. This in turn will serve as a measure of success in meeting the challenge of global integration and social maturation. As these developments occur, technology continues to advance rapidly. Second, when physical environmental improvement has been achieved, development progressively moves into the area of human culture and individual development, but this is only fully apparent towards the end of the period.

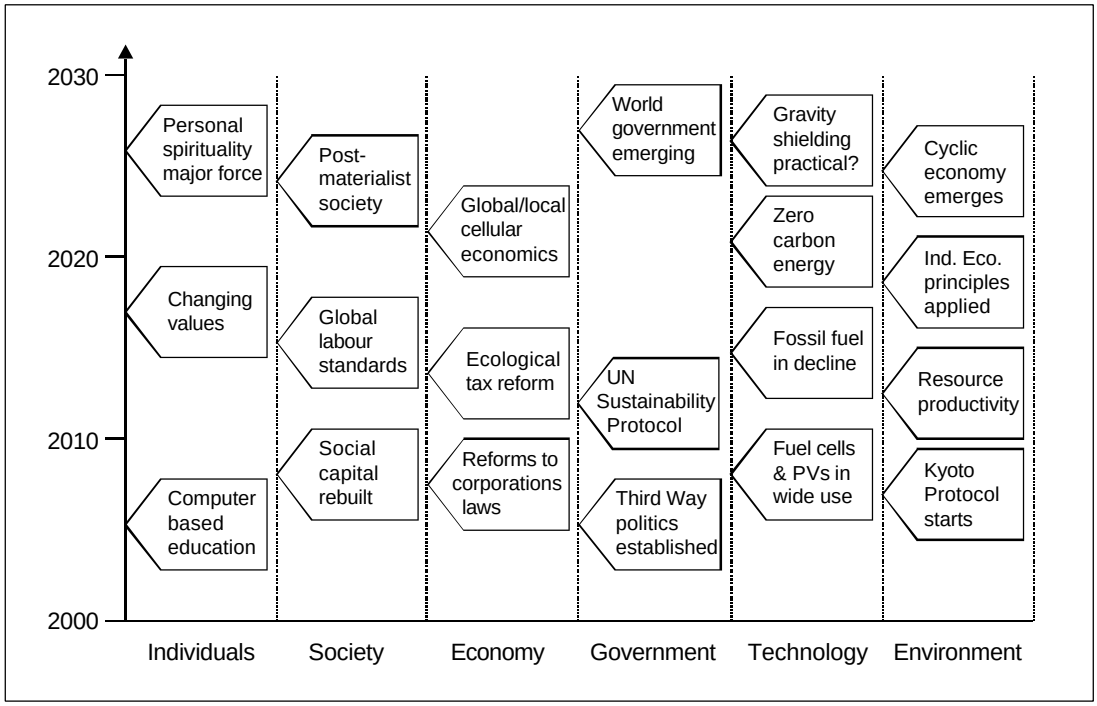

Figure 1: Normative Scenario Timeline (Illustrative)

It is important to emphasise that the normative scenario is not inevitable, and that at any point along the normative timeline there are alternative scenarios that deviate from the central optimistic trajectory. In principle these scenarios can be generated by a breakdown of any of the normative assumptions and are extremely diverse.

A Global Strategy

The identification of a normative trajectory allows an overall 'global strategy' to be defined. The objective of this strategy is to achieve the main elements defined in the 'optimistic outcome' as the transition to sustainability plays out. Broadly, these elements are:

- Peace and global political stability
- Democracy, justice, human rights and the rule of law transnationally
- Social stability and cohesion, high levels of social capital internationally
- Universal availability of high quality education and health care
- Equitably distributed global economic prosperity
- Natural environmental stability and diversity, high levels of natural capital worldwide
- Global population deceleration with no collapse

• High level of science and technology, but with high social and environmental yield.

This strategy does not take the form of a single prescriptive ‘grand plan’—it functions more as a common strategic direction with the potential to align communities, corporations, and governments around the world. For many of the objectives a top-down prescriptive articulation of the strategy would not be possible. In the case of the social aspects, the desired outcome will only be achieved through the active participation of nations, businesses and communities working on their own detailed issues. They will need to work together to achieve the objectives in specific ways that cannot be foreseen at the outset. In other cases it is more a question of protecting attributes that currently exist from emerging threats—as with the protection of environmental quality. However, for some of the objectives an overall framing concept can be identified, within which detailed strategy will need to unfold. This is most obviously the case with aspects of the application of science and technology, and this is described below as the ‘meta-strategy’ for technology.

The global strategy has potential as a psychologically powerful means of alignment. When the overall objectives are presented in general terms it is possible to compare them with the strategic objectives of organisations or groups. If their objectives do not align with the global strategy this highlights systemic inconsistencies and presents a powerful challenge to the organisation concerned. Correcting misalignment may require action by several players, not merely by the organisation concerned. The widespread adoption of this form of comparative strategic benchmarking would be a powerful way of identifying and correcting dysfunctionalities in the global socio-economic system.

Direct strategic comparison would be psychologically powerful because it would highlight the wider obligations of citizenship of the organisational leaders concerned. As Anthony Giddens puts it ‘Many business leaders do not act as full citizens, since they ignore the social outcomes of their business decisions’ (Giddens, 2000 p.119). He quotes Benjamin Barber: ‘the wall between public and private sectors has insulated corporations and their personnel from civic responsibility and allowed this corporate schizophrenia to insulate their men and women, whether employers or employees, from their obligations as citizens’ (Barber, 1998). The power of the normative global strategy is its potential to highlight publicly this ‘corporate schizophrenia’ and motivate those concerned to look for a better alignment.

Meta-Strategy for Technology

The concept of a meta-strategy for technology is a specific component of the normative global strategy. Essentially, it comprises the means for social framing of ultra-high technology in a technology saturated economy. The meta-strategy is presented here at a conceptual level, while the specifics—for example the concept of industrial ecology—are discussed in more detail elsewhere.

The double deceleration envisaged in the normative scenario—of population and materials flows—marks the end of the physical growth stage of industrialisation. For the first time since the onset of the industrial revolution there will be a net per-capita dematerialization of economic output internationally. This 'turning of the corner' from the historical growth phase of the planetary industrialisation process to the 'sustained development' phase will involve very significant social, technological and economic change.

Whether we view these changes defensively or proactively, it is apparent that most industries and activities will experience a deep shift of perspective and values, and a parallel shift to a new legislative, economic and technological base. The result will not be an incremental modification of the way we do things now—it will be an entirely new kind of economy.

It is useful to think in terms of an emerging 'meta-strategy' that will shape technology in the 'sustained development' economy. This meta-strategy for technology is an overall framing of technology itself in a future sustainable society and in the institutions and organisations within it, including corporations. It relates the application of technology by a corporation to the larger goals of society. It sits beyond or behind the strategies of individual firms, shaping their individual strategies and being expressed by them through their detailed technological programs, product development, manufacturing systems and support infrastructure.

The meta-strategy for sustainable technology addresses our total use of technology around the world and our ability to make it serve both society and individuals. It includes our need to work within geophysiology on both the large and small scales, the need to do this equitably, and the ability to keep doing it over time. The meta-strategy aims at ensuring human application of technology can meet the needs of all peoples and exist in harmony indefinitely with natural global biogeochemical systems, based on the creation of large-scale technology ecosystems specifically adapted to this planet we call home.

The technology meta-strategy involves a balance between technological development and the development of social values. At present, the extremely rapid advance of technological power is not being matched by a corresponding development of social values for shaping and guiding its application. This imbalance is the source of techno-economic unsustainability, both environmental and social.

How can the imbalance be corrected? Technology is both part of the problem and part of the solution. New technology will certainly be needed to help solve the problems we already have, yet new technology also has the potential to make the problems worse. The technology meta-strategy therefore affirms the vital importance of improved technology, but asserts that social values must also develop to successfully govern its use.

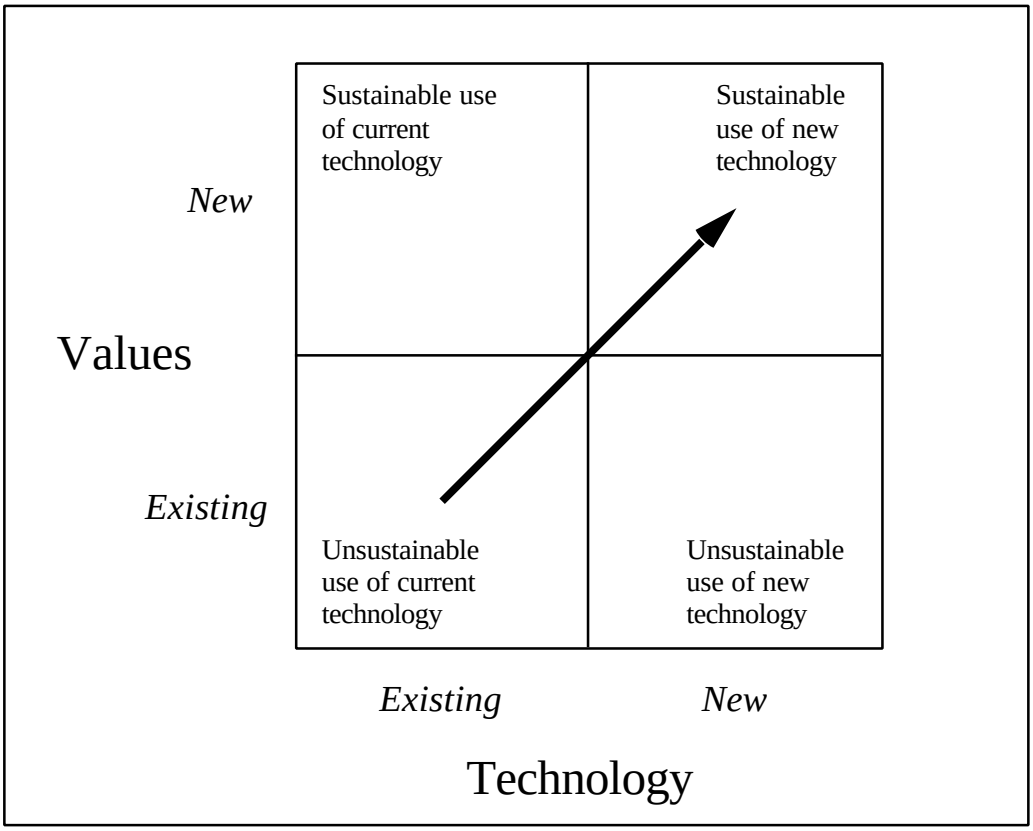

Figure 2: Sustainability Requires Development of Both Values and Technology

Figure 2 shows the possibilities for balance and imbalance between technological development and the development of social values. The path

of viable future development in the normative scenario is from the bottom left quadrant of the matrix towards the top right, as the arrow indicates. Development of either values or technology alone is not enough: the two must happen in conjunction. One of the reasons for this is that technology—and new technology in particular because it is more powerful—can either help provide solutions or make the situation worse. What makes the crucial difference is human intention.

Technology and scientific knowledge are advancing extremely rapidly and are now providing the capabilities we need to create an economy that does not depend on ever-increasing physical growth. If underlying social beliefs shift—with a growing interest in less materialistic personal values and deeper meaning—this can be expected to lead to greater concern about global issues and the environment, leading in turn to new priorities in technological design. In this way, new technological potentials can be directed along a path of development that is part of the solution rather than part of the problem.

For example, if biotechnology in agriculture is applied in a narrow reductionist way (bottom right quadrant), it could contribute to ecosystem destabilisation. Yet exactly the same technology applied within an ecosystemic paradigm (top right quadrant) could result in increased food production and improved ecosystem health. (Another way of expressing this would be to say that just because biotechnology is biological, that does not mean it is also ecological.)

Equally, expressing new social values using only today's technology is likely to mean unnecessary austerity. For example, a sustainability outlook might lead people to choose to give up heating and air conditioning and shiver or swelter in conventional houses (top left quadrant). But by expressing their new intent in terms of technology they could choose instead to be comfortable in houses with passive heating and cooling (top right quadrant). Behaving less wastefully is praiseworthy, but why ignore the potential of new technology?[1]

The matrix in Figure 2 represents the main principle of the technology meta-strategy—and it illustrates why we cannot simply rely on the emergence of new technology on its own to enable the safe deceleration of exponential growth. Technology must be actively managed and designed to achieve this outcome, which is the purpose of the meta-strategy.

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[1] Strictly speaking, the example given is not new technology, but since it is not mainstream its widespread adoption would be a major new development.

One important way in which future values will actively shape future technology will be by means of a shift from avoiding so-called Type I to Type II errors when dealing with the possible negative impacts of technology (Lee, 1993).

During the growth phase of industrial development, the emphasis was squarely on the development of new scientific knowledge as a basis for acquiring technological capability. The scientific method calls for caution in advancing ideas as new knowledge unless they are well-grounded in empirical evidence. The emphasis in science is to avoid what are called 'Type I errors'—the error of affirming propositions as true that later turn out to be false. Over time this bias in science and engineering has become the predominant influence in environmental policy making and strategy setting.

In a world which now has a high level of scientific knowledge and which is saturated with technology, another kind of error becomes more important, but is less well recognised. This is the 'Type II error'—the error of rejecting propositions as false that later turn out to be true. This is the kind of error that fire brigades try to avoid—which is why firefighters always respond to what may be false alarms.

When the concern is merely the development of abstract knowledge, society can afford to emphasise the avoidance of Type I errors. But when new technologies with potentially harmful effects are about to be commercially introduced, or when technologies with suspected harmful effects are proliferating rapidly, it can be dangerous to be obsessed only with Type I errors. The time it takes for definitive proof may be precisely the time during which critical harm is done. Far better, in these circumstances, to be much more concerned with avoiding Type II errors.

By emphasising Type II errors, the technology meta-strategy takes a precautionary approach. In this respect it is similar in intention to other sets of systems principles for sustainability. One well-known set of such principles was created by Dr. Karl-Henrik Robèrt, a leading Swedish cancer researcher, with his nationwide initiative in Sweden, *Det Naturaliga Steget* (The Natural Step). These principles were arrived at by a consultation process involving Swedish scientists and academics, with 22 rounds of drafts and corrections, so they represent a refined technical consensus.

The Natural Step consists of four principles:
1) Nature cannot withstand a systematic build-up of dispersed matter mined from the earth's crust (e.g. minerals, oil, etc.)

2) Nature cannot withstand a systematic build-up of persistent compounds made by humans (e.g. polychlorinated biphenyls (PCBs))
3) Nature cannot tolerate a systematic deterioration of its capacity for renewal (e.g. harvesting fish faster than they can replenish, converting fertile land to desert)
4) Therefore, if we want life to continue, we must (a) be efficient in our use of resources and (b) promote justice—because ignoring poverty will lead the poor, for short term survival, to destroy resources that we all need for long-term survival (e.g. the rain forest).

The Natural Step has been criticised because it does not address the full range of possible unsustainability. For example, it may not preclude possible negative impacts of biotechnology—probably because the four principles were developed before biotechnology emerged as a major commercial force. The technology meta-strategy for sustainability would address such gaps—in this case by explicitly calling for the protection and preservation of the informational integrity of the biosphere and ecosphere.