European Support Centre
of the Club of Rome

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Using Foresight to Retool Technology for Improved Environmental Performance

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Using Foresight to Retool Technology for Improved Environmental Performance

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Preface

Since its beginning, the work of the Club of Rome has been dedicated to the analysis of possible futures. "Limits to Growth" outlined various scenarios and has been updated several times.

Today, 32 National Associations with altogether more than 1800 members support the international Club of Rome and work in an interdisciplinary way on the World Problematique - the complex set of the crucial problems (political, social, economic, technological, environmental, psychological and cultural ones) facing humanity. The problems are mutually interdependent, and it often takes time until the impact of action and reaction in this complex system becomes visible.

Several National Associations have a special focus on future oriented topics, among them is the Canadian Association which has seval experts in the related fields among its members.

At a seminar organized in 2008 in Vienna by the European Support Centre of the Club of Rome, Jack. E. Smith, Member of the Board of CACOR, outlined specific aspects of foresight methodology and applications. The presentation is summarized in this broschure - we hope that it provides some material which inspires further thinking about the topics.

Thomas Schauer

Director, European Support Centre of the Club of Rome

1. Introduction

Foresight offers the prospect of exploring, in advance of social and technological change, what some of the most challenging, appealing and impending implications of those changes might be for organizations, communities and societies that will be affected. No one is unaffected by change but being able to ask ourselves: what may we have to contend with? opens the discussion about the multiple, plausible pathways change could take and the contingent realities that may be encountered along those different pathways. Foresight therefore is a structured way of asking what might we do (or have to do) when faced by various situations that can be imagined and assessed for their relative impacts, probabilities and degrees of disruptiveness from present experience.

WHAT IS FORESIGHT ?

A set of strategic tools that support government and industry decisions with adequate lead time for societal preparation and strategic response.

Foresight:

- **Anticipates multiple, plausible futures;**
- **Looks ahead with a 5 – 25 year time horizon;**
- **Enables us to rehearse and prepare for a variety of potential futures;**
- **Accommodates uncertainty & diversity;**
- **Highlights emerging opportunities & threats**

We are all well aware by now that circumstances in the global ecology are under increasing pressure from humankind and that this is having many diverse impacts on policy-economy and environmental policy worldwide, many of which are believed to be amenable to improvement or reversible before entropy takes over. The motivation for applying foresight techniques is that by examining many plausible pathways, we may discern some new opportunities as well as increase our adaptive chances through earlier development and deployment of solutions and technologies that can alter the practices and trajectories of key resource using dependencies that have thus far deepened rather then alleviated our ecological concerns.

As the following table illustrates, foresight has many objectives, not just those that have been highlighted for our focus on environmental improvement.

TYPICAL FORESIGHT OBJECTIVES (thanks to Walter Derzko for this list)	
Main Objective	***Sub-Objectives***
1. Increase societal and economic well-being	• Economic growth and national competitiveness. • Societal well being, covering social, environmental, cultural and economic factors. • Identification of solutions to problematic areas. (need-driven) • Understanding the interaction between technology and the society. (e.g. what gets enhanced ? made obsolescent ? retrieved? reversed? –McLuhan Tetrad Model)
2. Define priority areas for technology policy	• Survey national technological development. • Stimulate development in priority areas of technology development and research; thus stimulate the development in these areas. • Better understanding the interaction among technologies and realize gains resulting from this interaction. • Allocate funding for research and the improvement of industrial competitiveness.
3. Develop technology and innovation policies	• Improve the co-operation among different stakeholders • Develop the planning and implementation of technology policy. • Understand the best methods and use of foresight

This publication provides a short tour through two areas of technology-society where we believe foresight can make a substantial difference to how we approach current and future problems:

• PACT: Prospective Applications of Converging Technologies – i.e. the potential of converging technologies involving nano-bio-info and eco interfaces to enable better environmental data, more exact and less wasteful resource allocations and usage and more beneficial human-nature relationships;
• EID: Emerging Infectious Diseases – where technology options and human systems knowledge can improve our prospects for anticipating, tracking and managing new and emerging diseases which could threaten pandemics and diminish our human and social ecologies.

2. Trends and Foresight

A starting point for good foresight practice is to understand the ways that change manifests itself through Trends, Drivers and possible Shocks. To briefly differentiate these: trends represent broad forces and tendencies of change that tend to affect everybody and which no one actor, organization or nation seems to have the power to alter the direction or impact of, alone. Drivers on the other hand consist of those change elements and situations where the impacts are more susceptible to action by one's organization – change that affects more directly the well-being, resilience and adaptiveness of a particular industry, field of research, technology prospect etc. Shocks or wild cards represent the low probability but high impact events and situations that when they do (seldom but with real force of change such as Sept. 11 Al Quaeda attacks) strike can alter the game and change the fundamentals of future vectors of action.

Here, the main focus is on general trends in S&T and society that are creating a more favourable environment for innovation that would involve technological convergence and for new approaches and technologies for combating infectious diseases. As the box below indicates there are many developments in society, science and technology that can be considered Trends. From the macro-societal to the three revolutions in science, we are witnessing an unprecedented pace of change and so it is very timely and useful to ask ourselves- what impacts might we see from these trends, and which new technologies may emerge as opportunities for improved capacity to address our environmental and disease threats

MACRO TECHNO-SOCIAL TRENDS

- **Ambient Intelligence – progress toward the Singularity**
- **Miniaturization of Technology**
- **Globalization of Capital, Terror , Disease, Environment**
- **Anti-globalization of Biodiversity, Culture, Sustainability**
- **De-Carbonization of Energy Economy**
- **Harmonization - Standardization for Trade**
- **Migration, Multi-Culturalism of Populations**
- **Intensification, Differentiation, of Wealth**
- **Bi-polarization of religious Values and Secular Evolution**
- **Transformation, of Infrastructure Systems**
- **Virtualization, Digitization & Integration of: Business-Professions, Manufacturing & Production, Communications, Entertainment, Education**
- **Acceleration of Knowledge Services as Economic Driver**
- **Proliferation of Surveillance – Security**

Without addressing each macro trend, the purpose of the list is to initiate a strategic conversation about the types of broad changes and implications that these are having on first the world-at-large and second, the world of interest to us (convergent applications potential and disease management solutions involving new technology and systems thinking).

The boxes below extend this conversation into the kinds of S&T changes that we may have to be ready for as the pace of innovation quickens. In most domains of S&T and research, leading innovators are now asking as a matter of course- how can these new capabilities be developed and implemented so that they also result in less resources required, greater efficiencies of energy usage and better control of any emissions. For example, the ICT industries in Canada (and linked globally, please see http://green-broadband.blogspot.com/ or http://billstarnaud.blogspot.com) are now actively examining how their next generation network systems and operational architectures can be designed to dramatically reduce greenhouse gases and increase net efficiencies from ICT equipment sources and from their ability to control other systems used in manufacturing, power distribution etc.

What is becoming clear from examples such as those below and those which will eventually be derived from the trends in S&T listed further on is that many substantive opportunities may "soon" (5-25 years) exist for significant improvements in performance of materials, energy processing systems and in new product designs and management of societal functions such as conveyance of goods, travel etc. And while today these may be difficult for many observers to imagine – just as our forefathers could not easily have imagined the ways that the internet has revolutionized information access and spread – one of the best uses of foresight is to make concrete the real potentials of innovation in transforming that which we regard as familiar. And while there may be limits to growth in the access to and use of conventional resources, there appear to be no such limits on the growth of ingenuity in how to use the resources we have more effectively.

CARBON NANOTUBES-ELECTRONICS

- ***The best field emitters known***
- ***Already developed for field emission displays, lighting***
- ***Molecular wires***
- ***Semiconducting or metallic***
- ***Single-electron transistors demonstrated***
- ***Ballistic transport (109 A/cm2) – up to 1 mA per tube***

CARBON NANOCOMPOSITE MATERIALS

- **Strongest material known to man**
- **100 times stronger than steel,only one-sixth the weight**
- **Stiffness-to-weight ratio 40x higher than that of aluminum**
- **Electrical conductivity better than copper**
- **Thermal conductivity greater than diamond**
- **Hollow:gas storage, drug delivery**
- **Water filtration**
- **Actuation demonstrated**

The text boxes above refer to the emerging new attributes associated with nano-materials and nano-electronics. Although many are concerned about the potential for environmental damage that these new materials may precipitate, many others believe that their eventual properties will become central to our management of future practices of resource conversions, health and communications.

The next series of lists dig a bit deeper into the S&T trends that are converging into new functions and new bio-info-material applications. What we have emerging here is nothing less than a triple revolution in science – rapidly evolving into E-Science. From the apparent gradual and in some cases swift integration of functions in info-nano-bio-cogno and eco science thinking and approaches – what we are calling convergence, we can foresee many new and exciting possibilities and human adaptive potentials. From these lists of emergent phenomena, we can begin to visualize a future world in which waste is effectively eliminated and resources are well managed for their optimal contributions to human and societal needs. At this point our interest is not so much seeking a detailed profile of a new product or function but rather in making these prospective applications more visible and then attaching some target areas for the changed capacities and adaptive measures we are seeking to create.

EMERGENT TRENDS IN NANO SCIENCE

- Smart materials with nano films, structures
- ntegration of functions and structure in membranes, fabrics, fibers, self powered entities, biomimetic materials
- New environmental leaps in performance: e.g water filtration and purification, biocidals, bioremediation and decontamination

- Nano sensor networks, tracking capacities – nano-electromechanics
- Wearable personalized nano sensors with data and communications capabilities
- Energy and power efficiencies improvements, battery power management
- Smart dust capability for widespread human, environments surveillance
- Computational devices embedded in consumer, commercial goods
- Functional, programmable nanostructures for controlled drug delivery, performance of implants, protheses
- New devices, building materials and fabrics that incorporate nano film solar power and are climate responsive

EMERGENT TRENDS IN BIOTECHNOLOGY

- Control, improvements in living organisms
- Bio-sensing at the micro and nano level, micro and nano electromechanics
- Integration with wireless, RFID, photonics-molecular level cameras
- Tissue engineering, artificial organs, implants and protheses
- Targeted drug delivery and use of in vitro capacities
- Rapid scaleable bio-assays for molecule ID, medical diagnosis and forensics
- Personalized medicine using large data sets of patient information, disease statistics, gene sequences and genotypes
- Genetically modified insects to counter pathogen carriers
- In silico- computer testing and comprehensive modelling for drug characteristics, side effects and receptor simulation – lab on chip
- Molecular recognition –targeted drug delivery to organs, tumors

EMERGENT TRENDS IN INFOTECHNOLOGY

- Progress toward ubiquitous access and embeddedness;
- Open source collaborative tools and deeper peer- to peer functionality;
- Continued migration towards device and functional convergence;
- Infobased manufacturing, claytronics for distributed fabrication;
- Broader object based nodes and networks so everything can be smart and connected;
- Pervasive E Science and dynamic simulation and modelling;
- Gaming for personal and organizational decisions, learning;
- Emerging horizons for faster, exponentially more powerful encryption, quantum information
- Sustained infomarkets growth for surveillance, sensor networks, tracking capacities, nano-electromechanics
- Wearable, implantable personalized micro-nano-bio info sensors with data and communications capabilities

THE CONVERGENCE QUESTIONS

Which prospective nano-bio-info and bio-nano-info convergent technology applications do industry and government need to pursue to ensure prosperity in the future global economy; what are the prospective areas of application, products and impacts; how should these be stewarded; and what steps should be taken to accelerate their development?

Later, we shall return to the Convergence Question to see what it may offer us. Next let's look into the second area of foresight – environment interest – the global health challenges of Emergent Infectious Diseases (EID). This work (See: http://www.apecforesight.org; and the EID Project references) has been initiated by the APEC Center for Technology Foresight in Bangkok, where the author is a Fellow and Foresight Consultant.

3. Foresight for EID - Key Principles, Elements & Solutions

KEY ORGANIZING PRINCIPLES

- **Integrated Trust Networks;**
- **Knowledge Management;**
- **Joint Risk Assessments;**
- **Innovative, Shared Training;**
- **Expand Stakeholders;**
- **Develop & Use Technology**
- **Emphasize Speed, Integrity & Traceability**
- **Adopt Shared Standards;**
- **Rehearse Emergency Preparedness**

What is first apparent is that this challenge is only partly about technology – and its main focus is in the human systems interfaces that can be improved to identify, track analyse and contain disease before it rapidly spreads. Although each of these approaches or Key Organizing Principles are also "technologies" (knowledge embodied in new capabilities), the approach will involve less traditional R&D and more training, outreach and simulation.

EID – THE NEED FOR ADVANCED COMPUTATION + HUMAN SYSTEMS

Key user requirements: 1) integrated, smart systems that provide powerful, instantaneous networked information, 2) human-machine interfaces that can enable early detection from distributed sources, sensors and institutional data; 3)early alert protocols and rehearsals for bio-terror, pandemic and avoidance-management of social panic.

The text boxes above on EID provide the critical context of what the 2020 requirement may be regarding user needs, network capacities and alert functions. The next text boxes outline what solutions are thought to be available by 2020. These pieces of stimulus information were used to facilitate a foresight process in which expert teams from across Asia were engaged to consider what a highly competent, agile and technically competent EID management system might look like by 2020. Below are what the foresight community within APEC identified as key need and computational possibilities by 2020.

EID 2020 KEY DATA –COMPUTING ELEMENTS

- **Global sensing of patterns & situations;**
- **E Science & GRIDs for massive data mining and collection;**
- **Distributed access & processing;**
- **Robust regional climate and disease incidence model;**
- **Pervasive RFID monitoring of animals;**
- **Review of long term climate models;**
- **Detection-correlation of target populations and climate oscillations**
- **Global intelligence networks aligned with WHO-CDC & regional partners;**
- **Smart sensor systems at traffic points.**

EID: FUTURE READINESSS SYSTEM

- **Affordable RFID tags + procedures for wildlife & domestic animals;**
- **Cost-effective vaccines & easy distribution for major threats;**
- **Very small aperture terminals, simple mobile data collection & entry systems;**
- **EID consistent, easy, multilingual KM systems for diverse user interfaces;**
- **Automated easy reporting systems using cell phones or similar;**
- **Regional EID go data system maps and resource call networks;**
- **911 type alert system for hospitals to manage loads and sort emergency cases**.

4. PACT-Convergence Applications

Returning now to the PACT Convergence applications horizon, the text boxes below profile some of the important sub sectors and prospective applications for new technologies from convergence that are likely to make real impacts on how we manage energy-environmental challenges in the future - roughly by 2020-2025.

These were identified by literature research then validated by expert panels in 2006, and a full report was produced for the Office of the National Science Advisor of Canada by The Center for Innovation Studies (THECIS) located in Calgary, Alberta (www.thecis.ca).

KEY ECO-SUBSECTORS FOR CONVERGENT APPLICATIONS

- **Climatic events warning and prediction**
- **Bio-nano devices, arrays, diagnostics**
- **Bio-fuels, bio-energy systems optimization**
- **Energy production and distribution**
- **Energy end use and device efficiencies**
- **Environmental stewardship + toxicology**
- **Environmental monitoring + sensing**
- **Bio-remediation, toxic removal**

5. Conclusion

The final two boxes sum up the key results from the foresight processes into PACT and EID conducted in 2006-07. First the top (11) possible convergence applications that would have the greatest impact on Canadian society are listed. These are what could be termed – desirable and plausible but not currently available solutions to key problems Canada faces in managing its energy and environmental future.

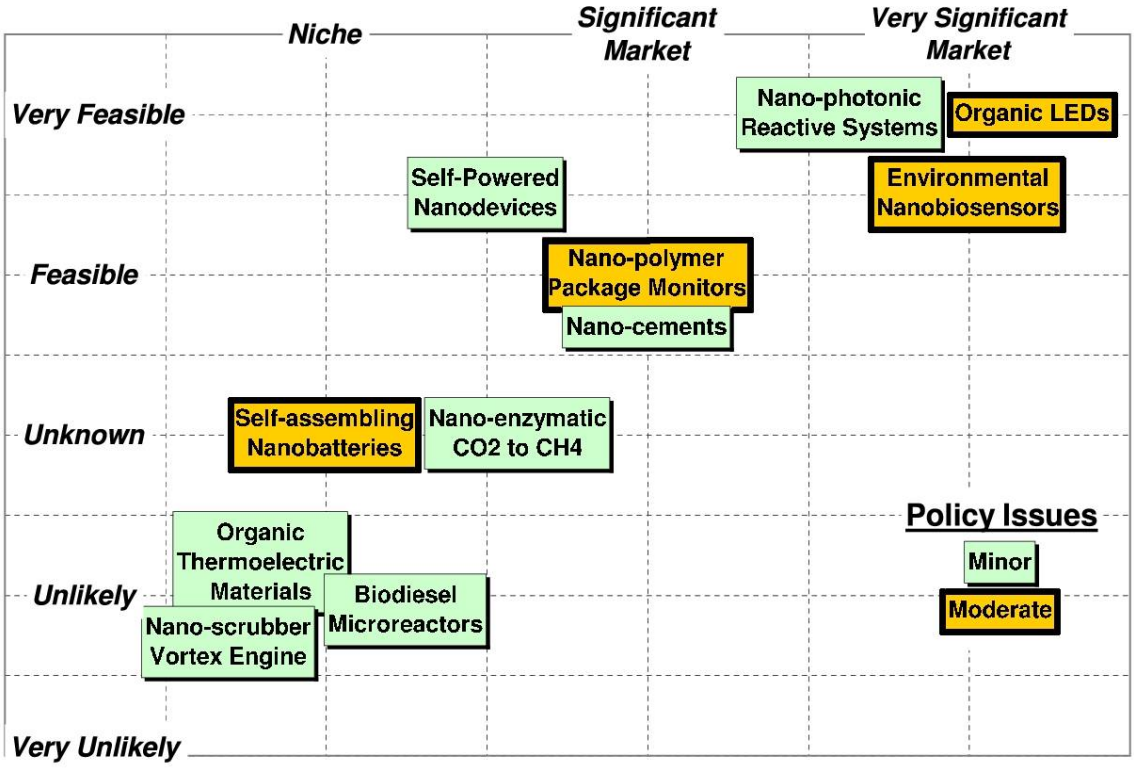
Finally, the four cornerstones of an effective APEC EID strategy are summarized, indicating that with a combination of strengthened human systems and computer-assisted science and technology alert and analytical capacities, new management powers to prevent global disease pandemics may also be accessible by 2020.

PROSPECTIVE CONVERGENCE APPLICATIONS: HEALTH & ENVIRONMENT

- "Clean Coal" technologies (science incubator)
- Bio-nano-health Monitors (application developer)
- Implantable Nanoarrays for Livestock (application developer)
- "CO2 Sequestration" technologies (application developer)
- Environmental nanobiosensors (producer/application developer)
- On-time Nano-vaccinology (technology developer)
- "Biomass à Biofuels" technologies (application developer)
- Medical "Tricorder" (producer)
- Smart Agri-bio Nanoencapsulation (tech. developer)
- Food-tracking Nanotags (science incubator)
- Directed Evolution Chips (technology developer)

EID: A COLLABORATIVE RESPONSIBILITY

- Build & Maintain Vibrant Networks – Frequent Events;
- Collaborate Globally on Disease Tracking, Public Health and Technology;
- Prepare for Threats & Contingencies Continuously;
- Regional EID Networks are Global Innovation Systems Assets



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This publication summarizes a presentation and discussion in Vienna in 2008 organized by the European Support Center of the Club of Rome. It covers recent work in Canada on science and technology foresight for which the prospects for future environmental improvements through innovation in systems and technological approaches appear possible. The publication also argues for more S&T focused foresight as a way that policy makers can better appreciate the challenges and opportunities that may be associated with emerging and novel technologies, and that having adequate lead time to reflect on how best to manage these prospective developments can enable more robust policy options and more effective choices for society in adapting to change.

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