WHY MOORE'S LAW APPLIED TO ENERGY GENERATION IS MORE LIKE MOORE'S CURSE

By Steven D. Lightfoot, P.Eng.

BENJAMIN NETANYAHU, the prime minister of Israel, made a speech in 2010 to the United Nations about hope for the future. In it, he stated: "It took us centuries to get from the printing press to the telephone, decades to get from the telephone to the personal computer, and only a few years to get from the personal computer to the Internet. What seemed impossible a few years ago is already outdated, and we can scarcely fathom the changes that are yet to come. We will crack the genetic code. We will cure the incurable. We will lengthen our lives. We will find a cheap alternative to fossil fuels and clean up the planet."

Netanyahu, in describing his confidence in the future, was expressing a commonly held assumption–that the history of telecommunications and microelectronic development will predict the development trajectory of a low-carbon/sustainable energy future.

The phenomenon he spoke of is called Moore's law, named after the co-founder of Intel, Gordon E. Moore, who described the trend of accelerating computing development in the 1960s. He noted that the number of transistors that can be placed inexpensively on an integrated circuit has doubled approximately every two years and this trend has continued for more than half a century.

One person who has given due consideration to the viability of applying Moore's law to technological systems and, in particular, energy systems, is Professor Vaclav Smil of the University of Manitoba's faculty of environment. Smil has written extensively on the history of technological development, taking a multi-disciplinary approach. His basic philosophy can be summarized in one sentence, from his 2006 speech, "Energy at the Crossroads": "Future technical developments will not conform to simplistic notions of accelerated development and exponentially declining costs of new conversions." He states further, "Energy transitions span generations and not, microprocessor-like, years or even months: there is no Moore's law for energy systems." Smil has even given a name to the belief that transitioning to a low carbon/sustainable energy future will follow a Moore's law-like trajectory–Moore's curse.

There is a societal cost of incorrectly believing that Moore's law applies to energy systems development.

1. Ineffective and wasteful policies. When political leaders have unrealistic views of the likely outcomes of decisions, the result is bad decisions and ineffective policies. For example, Ontario's *Green Energy Act* (GEA) forces utilities to buy "green" electricity, whenever available, at prices three to eight times the current cost of electricity. This extra cost is passed on to residential and industrial consumers. George Smitherman, former energy minister for Ontario, famously said that any additional cost to consumers would be minimal and that their electricity bills would increase by about 1 per cent each year. The Ontario government's own Task Force on Competitiveness, Productivity and Economic Progress recently cited a report that shows residential electricity costs are expected to increase at an annual rate of 6.7 per cent to 8 per cent over the next five years. One of the objectives of the act is to reduce carbon dioxide emissions by eliminating the use of coal while keeping electricity costs competitive. Costs are non-competitive and the government's own departments show that the emission reductions are minimal. The Ontario Power Authority suggested that developing more hydro power near Sudbury was a more effective option, but this was ignored in favour of the GEA.
2. Distracts from pursuing real solutions. The fundamental reason alternative and renewable energies are difficult to implement in the real world is that they are dilute. For this single reason, it is difficult to replace energy-dense fuels like petroleum with renewable energy.

If the ultimate objective is to wean our society off the use of carbon-based fuels while maintaining our material standard of living, the only real-life solution is to electrify as much of our infrastructure as possible (including massively increased public transportation), and expand the use of nuclear power electrical generation. While we in North America dither with renewable energies, France and China are taking the rational path. Nuclear power for electricity generation accounts for 80 per cent of electrical power used in France, while China has 25 nuclear power stations under construction as of 2010.

3. Sets unrealistic expectations with the public. Ask any motivational psychologist about goal setting and they will tell you it is critical to set significant, but achievable, targets for improvement. Without pushing oneself to achieve progressively better performance in any endeavour, the result is stagnation. But setting unrealistic and unachievable targets is no better. Striving for, and then failing to achieve one's goals, leads to demotivation. This demotivation can take many forms. Being sold exaggerated capabilities that are constantly unrealized, leads to a pernicious cycle of disenchantment with authority. This distrust of authority leads to progressively increasing cynicism in the population.

SOME POLICY SOLUTIONS

There is going to be a slow transition to a low-carbon/sustainable energy future. We must act now to implement government policies and regulations that are rational and lead to optimal outcomes for society. Three suggested policies that can be implemented at the provincial and federal levels are:

Set up an independent, apolitical energy advisory body

One of the challenges that democracies face in this regard is having relatively short-term election cycles. Governments and policies change on a relatively short-term basis, frustrating attempts at long-term planning. John Hofmeister, author of *Why We Hate The Oil Companies* and a former executive with Shell Oil, has written about this problem from an American perspective. Hofmeister proposes that US energy policy be set by an independent, apolitical board of governors, in line with what the Federal Reserve Board does for the monetary system. The governors' terms would be long, like the federal governors' 14-year terms, to insulate them from political pressures and because energy projects are not short-term.

This kind of governing body, workable in both provincial and federal contexts, might operate as an expanded and more powerful version of the existing National Energy Board. This body would have to work within the constitutional and jurisdictional framework as it exists today, although its power to set policy might need to be increased. This body would comprise objective-minded business people, economists, and engineering and legal professionals who have extensive industry experience and are willing to acknowledge the long-term nature of the energy challenges facing our nation and the impending reality of petroleum scarcity. This body might set energy strategy with significant but realistic targets for weaning Canada and its provinces off carbon-based fuels. The members of this board must be progressive realists, but realists nonetheless.

Prioritize research and investment

All future systems that may be used in a low-carbon/sustainable energy economy are not created equal. There are many realities that have to be considered when evaluating and investing in the development of new energy systems.

The reality of energy density is inevitably at the top of the list. Quoting Smil again: "Rational allocation of research monies should take the magnitudes of these (energy) flows, as well as the typical power densities of these resources, into account." For example, nuclear power is very energy dense, while wave power is dilute and intermittent. Investing large amounts of research money in wave power does not make sense relative to investment in improving the safety and usability of the next generation of nuclear power.

Other realities must also be considered, including practicality, scalability, and commercial and regulatory matters. Smil adds: "Dubious claims made on behalf of small-scale, experimental and demonstration-size techniques are no substitutes for mercilessly critical appraisals based on the first principles; biased promotions of grand theoretical solutions rarely survive brutal encounters with scaling up for large-scale, reliable operations in the real world." All government monies that are invested in new energy systems must be prioritized on those systems with the greatest ability to address real-life issues.

The Canadian Society for Senior Engineers recently released a document, *Energy Compass 2020 and Beyond: A Recommended Canadian Energy Decision Framework*, that outlines the most rational approach to investment in Canada's energy future. One of the report's major recommendations is that, "the use of indigenous nuclear energy be the first choice in provinces in which hydraulic energy sources (hydro power) are either minimal or have been essentially fully exploited, followed by indigenous natural gas, oil, coal, biomass, geothermal, wind, solar and tidal in that order." This prioritization is ranked on energy density and practical usability.

Invest in a public relations campaign to educate the public

Consciously changing our energy systems to rely less (or not at all) on fossil fuels is a long-term affair, and one that is essential. As things stand today, there is a great misunderstanding among the population that there are easy and ready solutions. This is at least partly driven by unaccountable interest groups, that for decades have waged public relations campaigns telling us that the wide-scale use of renewable energies is possible. The reality of the

political process in democratic states is that politicians are driven by polls and the public mood. If the public believes easy solutions to energy problems are available, politicians will pander to it, with "easy" solutions.

There are no free lunches. Because there is a direct link between energy use and material standard of living, any rapid decrease in energy use patterns will mean a lower material standard of living. For example, forcing automakers to increase mileage will result in cars that are smaller, lighter (and possibly more expensive if using hybrid technology) and probably less safe. If they are electric (electric cars have been around for more than 100 years and have always had limited range), especially when used in Canadian winters, they will be difficult to operate and have a short range of operation. In short, they will be less than what they are today.

We need a public relations campaign to educate about the reality of the energy challenges facing our society and the importance of energy to our lives. Encouraging politicians to do the right thing requires an educated public that understands the reality of the challenges facing us and the hard choices needed.

THE DANGER OF MOORE'S LAW

There is increasing pressure to develop a low-carbon/sustainable energy future and there is a belief that this transition can and will happen quickly. Moore's curse, or incorrectly believing that Moore's law applies to energy systems, leads to over-optimistic views of how things can change, which leads to wasteful and ineffective public policy and distracts our society from pursuing real, if imperfect, solutions.

No doubt your new smart phone, iPad or computer is an amazing device and fully representative of Moore's law as it applies to microelectronics. Just don't assume that its existence will tell you very much about where your electric power is going to come from in 18 months, let alone 10 years.

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THE NEED FOR RESTRICTIONS ON ARTIFICIAL OUTDOOR LIGHTING

By Robert Dick, MEng, P.Eng.

ALTHOUGH WE HAVE known for more than a century that artificial light at night (ALAN) affects humans and wildlife, it has only been in the last two decades that its full impact has been appreciated. By the end of the 20th century, the annual rate of increase of ALAN has been about 6 per cent each year (Holker, 2010) for a doubling time of 12 years, or about six times Canada's growth in population (World Bank).

Artificial outdoor lighting affects the health of citizens and, through energy use and pollution in the generation process, has an impact on the environment and urban sustainability. The concept of sustainability changes the priorities we place on the services provided by municipalities. Street lighting consumes 13 per cent of a city's electricity budget (Local Authority Services Ltd.); however, current regulations may slow or prevent the adoption of some sustainability programs–specifically the reduction of urban lighting. Regulations should be more proactive to encourage new lighting policies.

ROLE OF REGULATION

Most outdoor lighting is unregulated. Although Ontario's *Municipal Act* places the responsibility of outdoor lighting on municipalities, very few cities have lighting policies or bylaws. Most governments adopt recommendations from the lighting and power industries for minimum lighting levels without question, but there are no upper limits on the brightness of lighting or limitations on the extent or colour of the light used. There is little guidance or regulatory support for municipalities that wish to reduce the use of artificial lighting in response to health and sustainability issues.

The regulation of engineering practice can be approached in two ways: codifying best practice, or taking advantage of new scientific knowledge to lead the practice. Ideally, both have their place in engineering regulations. Scientific knowledge should always support the current best practice, but there are times when scientific knowledge moves ahead more quickly than current practice. In these cases, regulations should actively encourage improvements.

ARTIFICIAL LIGHTING

Artificial lighting has been used to increase human nighttime activity and encourage a 24/7 lifestyle. The streets of most cities are illuminated until dawn, commercial lighting is used long after stores and offices are closed, and cities actively encourage homeowners to keep outdoor lighting turned on throughout the night (*Globe and Mail*, 2010; *YongeStreet*, 2010). This practice benefits a relatively small portion of the population that is outside during the night–estimated with traffic statistics to be 10 to 14 per cent (DOT HS 809 954, UK M25 Traffic, respectively).

The performance of outdoor lighting has increased throughout the 20th century. It began with incandescent lighting with a luminous efficacy of about 15 lumens/watt (Wikipedia), followed by high intensity discharge (HID) lamps in the last half of the 20th century with luminous efficacy of about 100 lumens/watt. We are now entering a new era with light emitting diodes (LEDs), whose current luminous efficiencies are comparable to HID, but promise significant improvements in the future.

The increase of illumination levels is deemed necessary to reduce crime, improve safety and for aesthetics. These are admirable goals, but current illumination levels far surpass those that would provide these benefits (Clark, 2002). The reduction in energy use of ALAN has been undermined by the low cost of power and high efficiencies of luminaires.

LIGHT POLLUTION

Light is now known to be a pollutant. Illuminating the night fundamentally changes the environment. However, until recently, its effects on health were not treated as seriously as air and water pollution. The slow recognition of the adverse impact of ALAN has been due, in part, to its long-term effects and the belief that light is benign.

Light pollution is characterized by three symptoms: glare, light trespass and artificial sky glow.

1. Glare refers to the reduced visibility and distraction of light that shines directly into our eyes. Even relatively little light can cause glare–far less than that needed to illuminate the ground. The best solution against glare is to shield lamps from direct view.
2. Light trespass was once considered to be just a nuisance, but it is now known to be a much greater problem. Light that shines where it is not wanted wastes energy and causes glare for motorists and pedestrians. Light trespass is now also known to affect human health.
3. Sky glow is produced by unshielded light that shines across the landscape producing glare and light trespass. Particles suspended in the air scatter the light into the sky, producing the expansive dome of light we see from the countryside. The amount of scattered light depends on the size of the scattering particles and inversely on the wavelength (Rayleigh scattering). For example, visibility is reduced for motorists when driving through dust and fog. Short wavelengths (blue light) are scattered about 50 per cent more than longer wavelengths (amber light).

Sky glow over urban areas has been found to promote chemical reactions in the air over our cities. Instead of polluting gases dissipating at night, the chemicals are maintained by the absorption of artificial light, resulting in increased nitric oxides and ozone (Stark, 2010)–increasing daytime levels of photochemical smog.

LIGHT AT NIGHT STUDIES

Current engineering practice has no limit or control of how we illuminate our cities and this has made the effects of light pollution more evident in recent years.

Understanding how light affects both wildlife and humans is only now being published in outside research journals and in more accessible literature on organization websites (International Dark-Sky Association; Royal Astronomical Society of Canada), online conference proceedings (Cinzano, 2002; Ecology of the Night Conference, 2003), other publicly available publications (Rich and Longcore, 2006), and in trade publications and the popular press.

The key to understanding the impact of artificial light on life is the observation that all life on Earth has been subjected to a day-night cycle–the nights were dark, being illuminated by only the stars and, periodically, the moon. Any change to the amount of nocturnal darkness fundamentally alters the environment to which all life has evolved.

The impact of artificial light affects the environment in two ways: the duration of dark nights and the colour of ambient illumination. I'll briefly review these to put their impacts on human health into perspective.

CIRCADIAN RHYTHM

Humans are daytime creatures. The rhythmic nature of our biological processes has been known since the early 1800s and documented by medical researchers throughout the 20th century. This circadian rhythm is critical to the proper functioning of our bodies and those of all wildlife. Our biochemistry takes advantage of the darkness to let us rest and repair damage acquired in our daily activity. The changing length of day over the seasons requires a cue to keep biological processes synchronized to the daily schedule of activity. Hormones required to perform these repairs are prepared in the late afternoon as determined by our circadian rhythm, but some of them are not released until after dark while we are at rest.

We subconsciously determine that it is time to sleep when non-imaging ganglion cells in our eyes with peak sensitivity to blue light detect darkness (Figure 1). This enables the release of the hormone melatonin that slows our metabolism and enables the release of hormones. These hormones have a limited shelf life and begin to break down after a few hours. Any significant delay in their release, due to elevated levels of ALAN, reduces their effectiveness, or it can abort the repairs altogether. Therefore, it's

critical that our bodies detect darkness at night if we are to remain healthy.

We would like to know the light detection threshold that controls the initial release of melatonin to derive practical limits on ALAN. Illumination above this threshold will delay or inhibit these repairs.

Ethical reasons limit studies on humans, but research has been performed on laboratory and wild animals. They show that the illumination levels of approximately the full moon affect their behaviour and health (Rich and Longcore, 2006). To put this level into perspective, city streets are illuminated from 10 to 100 times this level! The sky glow above major cities can be seen for more than 100 km and can illuminate the countryside brighter than the full moon. So, even at great distances, city lighting can impact the ecology of a large region.

The increase in ALAN in developed and developing countries has been convincingly tied to the increasing incidence of cancer (Haim, 2010). Other maladies linked to ALAN are obesity, diabetes through direct hormonal disruption and increased stress and depression (Bedrosian, 2010).

EFFECT OF COLOUR

The colour of light is also important. Bright white light has been helpful in treating certain mental disorders. Seasonal affective disorder and jet lag have been effectively treated by exposure to bright white light in the morning. The light resets the circadian rhythm and makes us more alert and energetic (Paul, 2009). If we are exposed to white ALAN, the inappropriate timing has a similar effect but with adverse results.

The natural illumination level and spectra of artificial light is profoundly different from that during the day, and the biochemical response to this light is also different. In the late evening, bright white light with a significant amount of short-wavelength blue light in the spectra is interpreted as an extension to daylight. Although bright light will keep us alert, it will also prevent necessary biological repairs at night. This can result in the slow deterioration of our health. The blue component in white metal halide lamps and LEDs target the blue sensitivity of ganglion photoreceptor cells, which resets the circadian rhythm (Brainard, 2001). This blue component in light should be avoided at night to prevent a delay in human repair mechanisms.

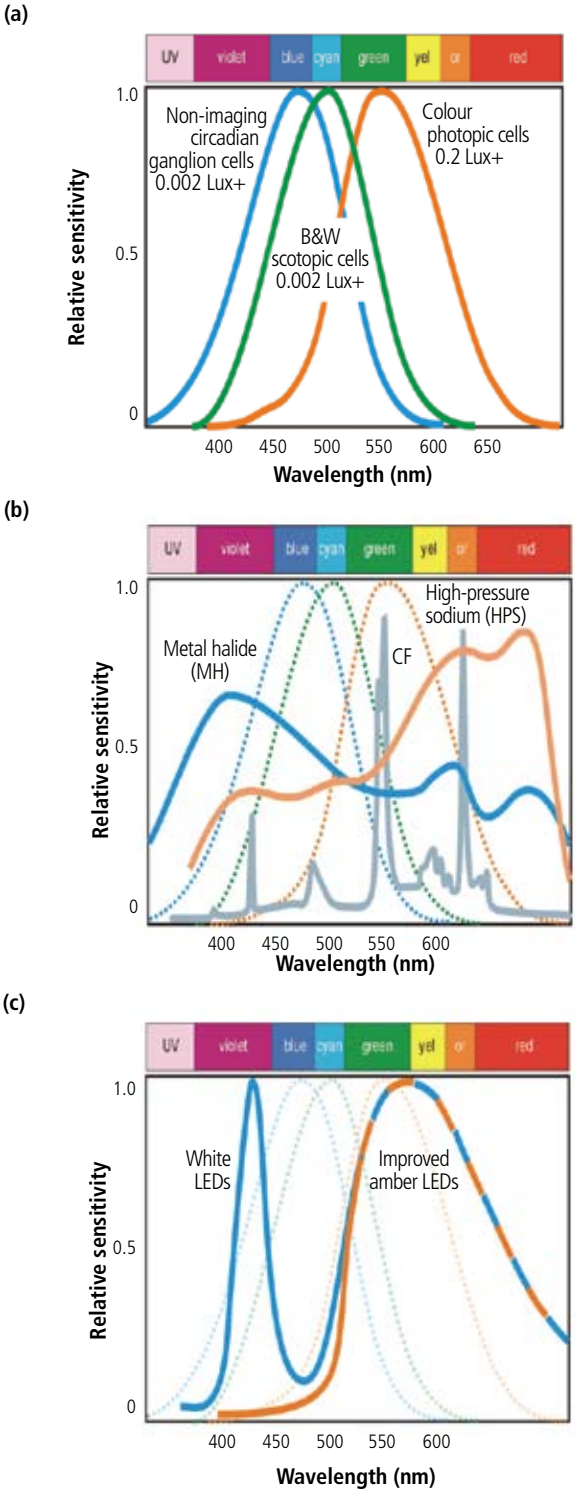

Figure 1: The trend toward brighter and whiter light has changed the luminous environment after dark, which disrupts our normal biological functions. A few years ago, the principal cells responsible for timing our circadian rhythm, and their functions, were discovered. These non-imaging ganglion cells on our retina are most sensitive to short-wavelength blue light (a). They are sensitive to the light of our current metal halide luminaires and fluorescent lights (b) and the experimental white LEDs that are being used in trial projects (c). Although illumination engineers are striving for "daylight" colours at night, longer-wavelength light sources are better for the health of the general population.

SOLUTIONS

There is a trend in our cities for the use of brighter illumination. We are also seeing the increased use of white light. What began as a problem for astronomers in the 20th century and a nuisance is now considered by the International Agency for Research on Cancer of the World Health Organization and the American Medical Association (AMA) as a health risk (AMA, 2009).

Most citizens are unaware of the health risks they are subjected to by artificial light shining in their windows or during nightshift work. New regulations must overrule the popular although naïve requests for more ALAN if we are to reduce the health risks to society and improve sustainability.

The dangers of ALAN are well founded and warrant our profession to take steps to lower the risks. Cost-effective technologies exist to halt the increase in light pollution and even reduce it. When phased in during scheduled infrastructure renewal (Figure 2), there is little or no extra cost to municipalities. Indeed, with improved visibility without glare, lower-wattage lamps can produce significant energy savings, as has been done in Calgary, Ottawa and other municipalities. An additional strategic benefit is a reduced carbon footprint for municipalities with increased sustainability.

Regulations and legislation should lead the movement toward more responsible and sustainable lighting practices. Specifically, we should reduce the illumination levels of urban lighting and require fully shielded fixtures to reduce glare, light trespass and sky glow. Artificial, outdoor white light should be minimized to prevent disruption of our circadian rhythm.

A number of cities are already actively reducing light pollution by setting aside older standard practices and have developed lighting policies and bylaws. Our profession can learn from the new scientific findings on the health risks from ALAN and the experiences of the municipalities that are working to actively reduce light pollution.

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Figure 2: Re-lamping during infrastructure renewal is a cost-effective way to upgrade street lighting. The improved visibility without glare (foreground) is evident compared to the unshielded fixtures in the distance. However, the glare from commercial lighting continues to affect visibility and the visual clutter decreases safety by distracting drivers even after businesses have closed.

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GREEN TRENDS IN SUSTAINABLE CITY DESIGN

By Jeanette Southwood, P.Eng., and Jonathan Buckley

New York's Central Park is a good example of forward-thinking in setting aside land for public parks.

A healthy urban forest, as in this park on the Rideau River in Ottawa, is an important aspect of sustainable cities.

Urban densification, as seen in these high-rise residences in central Mississauga, supports sustainability through better use of land.

WITH ABOUT HALF the world's population living in urban areas–and 80 per cent of Canadians–it's clear that how city people live is important to the sustainability of our planet.

Yet how can cities be sustainable? None of them is able to grow all the food or provide all the energy its people need within its boundaries. However, if we define sustainability as "acting in a way that allows the current generation to meet its needs while not impeding future generations from meeting theirs," there are many ways sustainability principles can be applied to urban management.

Climate change, food security and energy security are focuses of current thinking on sustainability as it applies to cities. We believe that improvement in these three areas of concern can come through a better understanding of green infrastructure and implementation of the ideas implied by this term.

WHAT'S GREEN?

At one level, green infrastructure involves the conventional definition: parks and other open space.

This has historically been seen as a cost to be borne–land that cannot be turned into corporate profit or tax-generating space. Many cities have grown up with less parkland and open space than many residents want, partly because it takes an act of political will to set aside land from development. Virtually all parks, including New York's Central Park, are on land that was outside of intensively built-up areas when it was marked off as protected from development.

Recently, however, there has been growing awareness of the economic as well as social value of parkland, which is reflected in property values. Homes and work space advertised as adjacent to or within walking distance of a park are more in demand. However, new open and green spaces are often constructed on a small scale or piecemeal way, which can only ever provide a certain level of "greening" in the more holistic definition.

The sheer numbers of people enjoying parks and other green space shows that they have value to the local population. But it is the cumulative effect on a city as a whole that is largely unrecorded or valued in contributing to the need to meet the issues posed by energy demand, the effects of climate change and food security. In addition, the positive benefits of open and green space in providing for mental as well as physical well-being are generally accepted but have been difficult to quantify.

Green space provides valuable habitat for birds that help control pests such as mosquitoes, improving human health as a consequence. Green space also helps reduce the "heat island" effect in many cities, helping absorb heat radiated by buildings and other hard surfaces, thereby reducing the need for energy-intensive artificial cooling.

One trend is to create green corridors so that cooling winds can sweep through urban areas. This helps reduce the city's demand for energy–some of which may be produced through fossil fuels, contributing to climate change–and also helps the city's residents cope with the more severe summer temperatures that are part of climate change.

Increasingly, plants, including trees, are seen as part of a delivery system that provides the benefits of green space to the urban environment, e.g. consumption of carbon dioxide.

Trends in green space include creating it out of brownfields, where former industrial use has left behind impacted soil that has impeded redevelopment. As well, we see more buildings designed with green roofs.

Another trend in green space is toward multi-function space that allows more people to benefit. This might include flood-abatement measures such as wetlands and catchment basins along a watercourse, providing high-quality animal habitat in the process. Near where Toronto's Don River enters Lake Ontario, for example, plans are in place to replace the now-straight channel with a more natural-type channel that curves as it flows through a wetland, partly for flood-management purposes.

Vegetable allotments in parks improve food self-sufficiency, and green energy such as solar, wind and the geothermal energy under a park's surface can reduce a city's need to import energy.

Many public parks are a mixed blessing when it comes to environmental contributions, however. Traditional parks may require extensive irrigation, particularly in the summer, consuming water and fuel in the process. Xerascaping, using plants native to the area and that thrive without artificial water supplies, is part of the answer. Traditional parks also have a great deal of vegetation that must be maintained by lawnmowers and other energy-consuming equipment.

REDUCING CARBON FOOTPRINT HELPS ACADEMIC INSTITUTIONS GAIN AN EDGE

In the competitive world of colleges and universities, gaining an advantage over other institutions has traditionally hinged on such factors as academic excellence and the success of varsity sports teams. Now, a new element of competition for academic institutions has emerged: carbon footprint.

Many students, faculty and staff like the idea of being part of an institution that shares their concerns for the environment. Former students, a key source of funding for current and future academic programs, also like the idea that their alma mater is a force for good.

Accordingly, academic institutions are looking for ways to demonstrate their environmental credentials. One way to do this is through carbon footprint inventories. These inventories can start with analyzing the most direct greenhouse gas emissions, including those from heating and cooling systems and maintenance work, such as lawn mowing. This may point to some relatively straightforward steps for reducing the footprint, such as switching to a green electrical supplier.

Golder Associates carried out a carbon-footprint inventory for one college and, in fact, changing electrical suppliers alone reduced the college's greenhouse gas emissions by almost 17 per cent.

Inventories can also consider the impact of transportation, e.g. buses used to take students to extracurricular activities such as sporting events off campus, and the impact of students, faculty and staff commuting to and from the campus.

Further analysis can look at such options as retrofitting an existing physical plant to make it more environmentally sustainable, and designing new buildings with lower environmental impacts.

Now, there are more naturalized areas in many parks that are allowed to grow naturally, particularly along watercourses.

Elected officials, especially at the municipal level, have a significant role to play, particularly in supporting the best possible use of existing green space and ensuring that planning includes enough provision for more. Environmental professionals, including landscape architects, must play their part in advocating green space and in making sure it meets its goals. The private sector recognizes the importance of open and green space in building communities that ultimately add value to their development. However, an economy of scale principle applies in this respect when smaller sites in less attractive neighborhoods become difficult. This is where a collaborative approach with a city or community needs to happen more urgently to "upscale," i.e. look at a community area or city district, rather than each site individually, to achieve common goals over a longer period of time.

BUILDINGS CAN BE GREEN INFRASTRUCTURE

Public policy and design aptitude also need to be focused on making infrastructure more sustainable. In this regard, attention has been focused on energy efficiency through reducing power consumption for heating, cooling, ventilation, lighting and other aspects of building operation. And, we see more emphasis on ways buildings can generate power themselves–through wind and solar–and increasingly through geoexchange, which is the use of the underground environment as a heat sink for heating and cooling, and geothermal, which taps the heat deeper inside the Earth's crust for heating and power generation.

The creation of well-designed open and green spaces has a major role to play in the greening of infrastructure, partly through the use of vegetation as a heat sink, and also through the shade offered by trees to reduce energy demand for cooling in the summer, and wind breaks that help reduce heat loss in winter.

We see growth in the popularity of LEED registration in new buildings, which drives mainstream acceptance of environmental impact reduction,

HOW LONDON BENEFITS FROM SUSTAINABLE DEVELOPMENT

While it might sound right to take an approach to sustainable development initiatives in which environmental, social and economic elements are met in an integrated way, does it also have real financial and non-financial benefits?

This is the question Golder's office in London, England, set out to study on behalf of the London Sustainable Development Commission (LSDC): determining what financial and non-financial benefits there are in taking an integrated, sustainable approach to projects.

LSDC wanted to ascertain how "virtuous cycle thinking," in which environmental, social and economic benefits flow from each other to improve quality of life, now and in the future, would help public sector decision makers in their approach to policies and projects in London.

To help understand this, Golder began with a broad initial scoping and screening exercise of sustainability projects and policy implementation in London, selecting two case studies for further research. A multi-criteria analysis was developed by Golder, based on the LSDC's sustainability indicators, and was used to assess the selected case studies. This enabled the relative significance and magnitude of the sustainability impacts of each case study to be compared against what would have happened if the project had not taken place. This enabled costs and benefits to be determined.

Golder summarized its work in a publication on behalf of the LSDC. The publication provided a definition of virtuous cycle thinking, summarized the two cases, including graphical representation of the virtuous cycle for each case study and presented the output from the multi-criteria analysis. The publication then provided a summary of the project findings and benefits of using virtuous cycling thinking in strategic and project development and implementation.

MONTREAL RESIDENTIAL COMPLEX USES GEOEXCHANGE TO REDUCE COSTS

One of the barriers to greater use of geothermal energy can be found in the high upfront cost that must be borne before the system starts returning energy and financial savings. But for the geoexchange system at the twin residential towers of Le Vistal in Montreal, those costs will be tens of thousands of dollars lower due, in part, to Golder Associates' innovative approach in designing and optimizing the underground portion of the system for the real estate developer, Proment Corporation.

Key elements of Golder's role were the planning and completion of test boreholes, in situ thermal conductivity testing, design and sizing of the underground heat exchanger, preparing plans and specifications for the call for tenders, and construction site supervision.

The geoexchange system at Le Vistal includes 59 boreholes that are 182 metres deep. During the cold season, naturally heated water from below ground is pumped to the surface, some of the heat removed through a heat pump, and the water returned to the depth it came from within a closed circuit. The system produces 35 per cent (about 500 kilowatts) of the building's heating and cooling load, generating annual energy savings of about $70,000. Beyond the energy savings, Le Vistal's geothermal heating and cooling system will forestall the need to burn 125,000 cubic metres of natural gas, and prevent emission of more than 230 tonnes of CO_2.

partly through the development of low-cost ways to make buildings more environmentally friendly.

Employers find that to attract the most educated, high-demand employees, being able to offer an environmentally sound workplace is a big advantage. Building owners, too, find that tenants are increasingly interested in buildings with sustainable design features built in.

THE GREENING OF CITY DESIGN

The definition of green infrastructure needs to be expanded further, past parks and LEED-compliant buildings to ways that help people live in more sustainable ways.

To some extent, cities are trapped by the decisions made by previous generations–whether the development is dense and transit-friendly, or as is the case with many Canadian suburbs, spaces were designed for cars. But there is a good deal that can be done. Witness car-friendly suburban Mississauga, whose city centre now bustles with intensive development in the form of high-rise condominium towers, one of which is to be 50 stories high. Better transportation options in the form of improved public transit, bicycle infrastructure, and more places to walk, can all help.

Going further means encouraging more mixed-use development so that more people can work, shop and play close to their homes, with less need to add to traffic congestion by driving and managing growth so as to limit sprawl out into the food-producing farmland around the urban area, which helps food security. Cities can also encourage ways for people to work from home, by encouraging entrepreneurism and supporting telecommuting. Σ

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