Sida Partnership Forum

What will You Do Now, Sweden?

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Sida

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Preface

From Stockholm to Stockholm… and Beyond

It has been argued that the UN Conference on the Human Environment began the modern era of international environmental action.

Some claimed even greater achievements for that gathering in Stockholm in 1972. Anthropologist Margaret Mead told the delegates gathered there that the event was "a revolution in thought fully comparable to the Copernican revolution by which, four centuries ago, men and women were compelled to revise their whole sense of the earth's place in the cosmos. Today we are challenged to recognize as great a change in our concept of man's place in the biosphere."

According to the conference *Declaration*: "Man has constantly to sum up experience and go on discovering, inventing, creating and advancing. In our time, man's capability to transform his surroundings, if used wisely, can bring to all peoples the benefits of development and the opportunity to enhance the quality of life. Wrongly or heedlessly applied, the same power can do incalculable harm to human beings and the human environment."

It added: "In the developing countries most of the environmental problems are caused by under-development. Millions continue to live far below the minimum levels required for a decent human existence, deprived of adequate food and clothing, shelter and education, health and sanitation.

The Stockholm Action Plan makes less compelling reading: a long list of 109 very vague recommendation such as "It is recommended that Governments be mindful of activities in which there is an appreciable risk of effects on climate…". However, the main purpose of the conference was not to argue science or develop treaties but to coordinate international policy, the little that existed at the time. Thus in the Action Plan, the words *ozone* and *biodiversity* do not appear, and there is virtually no reference to climate change besides the one quoted above.

Yet the conference "marked the entry of the environment onto the international agenda."[1] There was wide agreement among governments. The meeting paved the way for the establishment of the UN Environment Programme (UNEP) and for many of the conventions, treaties, and protocols that followed.

It also made clear, in its Declaration and in the speeches of many of the delegates from the developing world, that managing environmental challenges in poorer countries requires a certain amount of economic growth and specific forms of development. It argued that development and the environment were not mutually exclusive, but it did not

1 Neil Carter, The Politics of the Environment (Cambridge; Cambridge University Press, 2001)

LLOYD TIMBERLAKE TOGETHER WITH REPRESENTATIVES FROM ARENA ENVIRONMENTAL FOCUS, COUNTY OF VÄSTERNORRLAND DURING A VIST AT DOMSJÖ DEVELOPMENT AREA AND BIOREFINERY OF THE FUTURE IN ÖRNSKÖLDSVIK.

convincingly integrate the two. Fifteen years later, the Brundtland Report did this by developing and championing the concept of *sustainable development*, which it defined as forms of development that meet the needs of the present without compromising the ability of future generations to meet their own needs. Thus environment and development were shown to be inseparable, two sides of the same coin.

The report, by the World Commission on Environment and Development (or the Brundtland Commission, after its chair, Norwegian Prime Minister Gro Harlem Brundtland) also brought the concept of sustainable development into the real world by noting that it "is not a fixed state of harmony, but rather a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development, and institutional change are made consistent with future as well as present needs. We do not pretend that the process is easy or straightforward. Painful choices have to be made. Thus, in the final analysis, sustainable development must rest on political will."

The Brundtland Report was also forceful on a concept that is really the theme of this paper: all environmental and development challenges can be boiled down to the problem that human systems are out of sync with natural systems. The Brundtland commissioners wrote almost 25 years ago "the real world of interlocking economic and ecological systems will not change; the policies and institutions concerned must."

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1. Sweden Today

Today the environment mantle as come back to Sweden, perhaps best symbolized by the fact that Stockholm became in 2010 Europe's first "Green Capital."

"Clear and effective measures towards reducing noise pollution. A protection plan setting new standards for cleaner water. An innovative integrated waste system. 95 % of the population living less than 300 meters from green areas. These are just some of the reasons why Stockholm was the first city to be awarded the European Green Capital title," according to an official EU website on the event.[2] It continued: "The City of Stockholm operates with a holistic vision, one which combines growth with sustainable development for the benefit of its almost 800 000 citizens. Transport emissions are relatively low, and all trains and inner city buses run on renewable fuels. Furthermore, greenhouse gas emissions have been reduced by 25 % since 1990, and the city council has the ambitious target of becoming wholly independent of fossil fuels by 2050."

More important than the symbolism of the award is the technology that helps Sweden win such awards. Sweden is gradually becoming a – if not the main – center for cleantech development in Europe. There is no precise definition of *cleantech* or "clean technologies," but has been defined by the US research firm Clean Edge as "a diverse range of products, services, and processes that harness renewable materials and energy sources, dramatically reduce the use of natural resources, and cut or eliminate emissions and wastes. Clean technologies are competitive with, if not superior to, their conventional counterparts. Many also offer significant additional benefits, notably their ability to improve the lives of those in both developed and developing countries."It is the range of technologies that can make sustainable development possible in a world of growing populations and increasing consumption.

And, with the right backing by governments and the public, it can be extremely good business. In 2010, 29 international companies, members of the World Business Council for Sustainable Development (WBCSD) issued the report *Vision 2050*, in which they tried to envision a sustainable planetary society by the year 2050 and to lay out the paths to get there.[3]

Vision 2050 had three main findings. The first is that "business as usual" would lead to vast societal disasters – bad for humanity and thus bad for business.

The second is that "the transformation ahead represents vast opportunities in a broad range of business segments as the global challenges of growth, urbanization, scarcity and environmental change become

2 ec.europa.eu/environment/europeangreencapital/green_cities_submenu/awardwinner_2010.html

3 World Business Council for Sustainable Development, Vision 2050 (WBCSD, Geneva, 2010)

the key strategic drivers for business in the coming decade. In natural resources, health and education alone, the broad order of magnitude of some of these could be around US$ 0.5-1.5 trillion per annum in 2020, rising to between US$ 3-10 trillion per annum in 2050 at today's prices, which is around 1.5-4.5 % of world GDP in 2050. Opportunities range from developing and maintaining low-carbon, zero-waste cities and infrastructure to improving and managing biocapacity, ecosystems, lifestyles, and livelihoods. Enabling these changes will also create opportunities for finance, information/communication technology, and partnerships."

The third finding was that for there to be any chance for a sustainable world by 2050, much must be accomplished in the decade we are entering: 2010-2020, a period the report labeled the "turbulent teens."

Sweden and Swedish business is well placed to take advantage of these opportunities. It has many trade organizations, regional networks, and state organizations that support Swedish companies wanting to invest in developing and exporting environmental engineering solutions. These offer expertise, contacts, and financing. The Swedish Trade Council estimates that there are at least 100 networks that Swedish companies can turn to for help. Swedish universities are also working with companies to provide the science and technology behind cleantech inventions. Stockholm even hosts the Sweden Green Tech Building, a meeting place for individuals and companies involved in cleantech.

The Swedish International Development Cooperation Agency (Sida) has a Sida Partnership Forum that brings together the best of Swedish cleantech entrepreneurs with representatives from other nations, particularly the developing world.

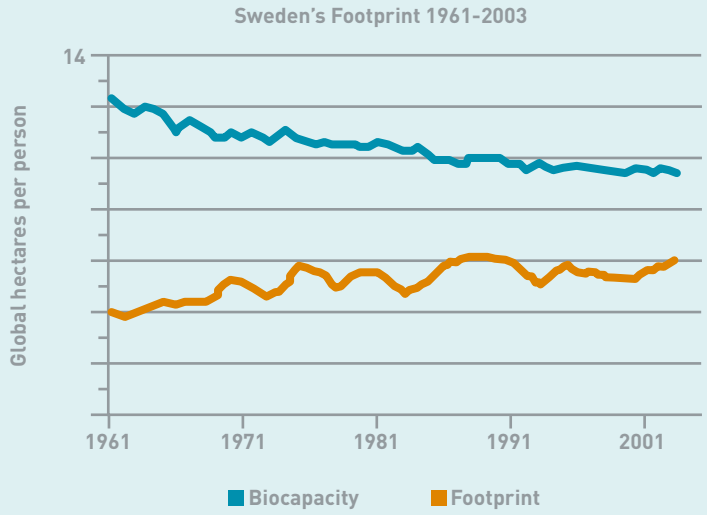
A growing number of countries are able to manage without traditional aid and want to develop new relationships. Thus Sida is investing more in *Business for Development, Loan and Guarantees* and Partner Driven Cooperation, which builds on mutual interests and shared responsibilities – and can lead to long-term, self-sustaining relations. The objective is to create a "win-win-win" situation whereby three groups benefit: the people in poverty, those participating in projects in partner countries, and those involved in Sweden. Partner Driven Cooperation is based on the partners' own initiatives and mutual interest in cooperating. Sida's country teams are responsible for seeing to it that the concept is launched in their respective countries. Sida is prioritizing countries where Swedish aid is now changing: Indonesia, India, China, Vietnam, South Africa, Namibia, Botswana, and with a special focus on Iraq and Serbia.

Swedish Course Change?

Despite its progress in cleantech, Sweden is moving in the wrong direction. See the graph below from the Ecological Footprint network.[4] Every year the average Swede consumes slowly increasing amounts of the planet's ecological resources, and every year the biocapacity of the country declines a bit more. Sweden's performance is better than that of most other European countries and wildly better than that of the United States, whose per capita ecological footprint is rising much more rapidly and whose biocapacity is falling much more rapidly; the two lines crossed before 1970!

4 www.footprintnetwork.org/webgraph/graphpage.php?country=sweden

Figure 1 tracks, in absolute terms, the average per person resource demand (Ecological Footprint) and per person resource supply (Biocapacity) in Sweden over a 43-year period. Biocapacity varies each year with ecosystem management, agricultural practices (such as fertilizer use and irrigation), ecosystem degradation, and weather.



Now take a look at Sweden's place in the world in terms of sustainable development on the box below, also developed by the Global Footprint Network (GFN) and several other organizations. The horizontal axis shows "development" as measured by the UNDP's Human Development Index, which combines GDP per capita with measures of life expectancy, literacy, and educational attainment. GFN decided that an HDI above 0.8 means that a country is "developed": people are meeting their needs. European nations, the US, Asian countries like Japan and South Korea are all comfortably to the right of that 0.8 line. Sweden has (2006) a very high HDI OF 0.96.

The vertical axis suggests the extent to which a country is living within the planet's means, with that broken line below the number 2 being the cut-off point. It is the world average biocapacity per person in 2006; note how it has fallen since 1961. Countries below that line are using resources and ecosystem services at levels the planet can regenerate; countries above that line are in ecological debt. The "developed" countries are all above that line. Most African countries are not borrowing from future generations but are not meeting needs, either. Some Latin American, Middle Eastern and Central Asian countries are living beyond planetary means while at the same time not sufficiently meeting human needs.

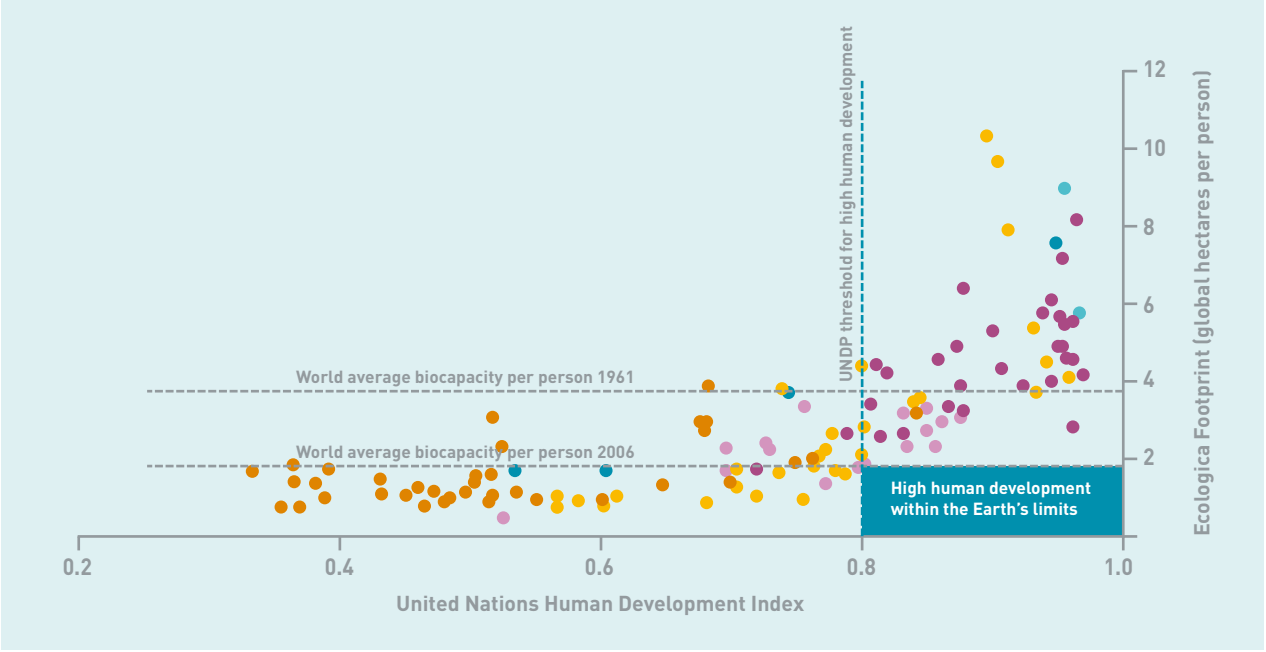
Sweden is using 2.84 global hectares per person, well above the global capacity of slightly less than 2, but admirable compared to most other developing countries. However, Sweden is slowly moving in the wrong direction, gradually using more global hectares per Swede while the national biocapacity to support the average Swede is slowly declining.

Also, Sweden is following a very risky course. According to a press release from the Swedish Environmental Protection Agency: "Swedish efforts to safeguard the environment are moving in the right direction in many areas. But when it comes to the country's objectives for cli-

mate, seas, a non-toxic environment and biodiversity, the situation is highly problematic, with a risk of sudden, irreversible changes in the environment. That is one of the conclusions reached by the Environmental Objectives Council in its latest report to the Swedish Government, Miljömålen – i halvtid (Sweden's environmental objectives at half-time)." It added that according to the Council, "the pace of action to secure many of the goals is not fast enough. For most of the sixteen environmental quality objectives, further measures are urgently required if it is to be at all possible to achieve them."

The key question is whether or not Sweden, and Swedes, care. Do Swedes want to become a new sort of "developing country" and use cleantech to develop their way into that sustainability box? Or are they happy to rest of their relatively green and well-developed laurels? Sweden's present position already proves that a country can be both extremely highly "developed" in terms of quality of life, and yet have a relatively low impact on the earth's carrying capacity. If it could get into that lower right-hand box, it could export its solutions for doing so to the rest of the planet.

Figure 2 © Global Footprint Network (2009). Data from Global Footprint Network National Footprint Accounts, 2009 Edition; UNDP Human Development Report, 2009.



Why bother, Sweden?

These questions about what Swedes are going to do lead to a very nasty issue: motivation. Why should any of us who is well off and lives in a prosperous, comfortable country bother to change toward more sustainable ways of doing things? The short answer is "to save our human civilization." But, strangely, that may not be motivation enough.

Let us look at climate change, because it combines so many different ecological issues: spreading deserts, changing water availability, deforestation, changing farming realities, etc. To manage climate change we must move away from carbon as the basis of our energy systems. We have the technology to do this, and as we use this technology, we will improve it and it will become cheaper. We know, because many learned reports have told us so, that if we start decarbonizing our economy now, we will save money. So we have the science, technology, and the economic motivation.

But…

… that is not the way the world works. The average adult Swede does not suffer from carbon-based energy. S/he benefits: most cars and houses still require carbon fuels. All airplanes do. Carbon dioxide takes a long time to rise into the upper atmosphere and start playing its "greenhouse" role. So the carbon doing the damage now was released not by this generation but by previous generations. The CO_2 released by this generation will hurt future generations. The CO_2 now in the atmosphere is killing and destroying the livelihoods of hundreds of thousands of people, but these are not Swedes; they are in dryland Africa, or under the melting glaciers of the Andes and the Himalayas. However, every generation of well-off people – those causing the problem – will be in the same situation: wanting to delay action until the NEXT generation takes over. But the actions required will get harder for each generation.

As a species, we are not evolved enough to tackle challenges that threaten mainly poor people in other parts of the globe and people not yet born. In this case, we lack the legal, ethical, and moral toolkit to "save our human civilization."

US philosopher Stephen Gardiner describes this plight eloquently, and argues that it is so difficult it corrupts us in several ways.[5] We pretend the science is controversial and unclear. We pretend the solutions are more difficult than they are. We pretend we are negotiating solutions when we are not. And we pretend we are making progress in those negotiations, when we are not.

Gardiner wrote this piece before the 2009 Copenhagen meeting of the parties to the UN climate treaty. As he predicted, despite everyone pretending to negotiate in good faith, no progress was made. Yet most observers, even environmentalists, said things like: "Well yes, it was a disappointment, but actually a great deal of progress was made at Copenhagen."

So as we discuss what Sweden will do now. We can never lose sight of the question: why will Sweden do it? It will take leadership from the top of the political, business and NGO worlds. And it will take grassroots leadership to create a bottom-up movement to stiffen the resolve of Sweden's leaders.

5 Stephen Gardiner, "A Perfect Moral Storm: Climate change, Intergenerational ethics, and the problem of corruption," Environmental Values 15 (2006) pp. 397-413

2. Managing climate; we are all developing countries now

Climate change combines the various results of human and natural systems being out of synch. It is changing water availability, making farming harder, degrading ecosystems and biodiversity, acidifying oceans, and destroying infrastructure (including transport systems).

People in the poorest countries, who have contributed least to the problem, are already feeling the effects. In the UN Framework Convention on Climate Change, wealthy countries are pledged to help poorer countries decarbonize their economies and adapt to the climate change to which the planet is already committed.

We shall have to stop using the future tense when speaking of climate change. It is happening right now. Kofi Annan's Global Humanitarian Forum issued a report in 2009 on the human effects of climate change, which found that already some 300 000 people die from the syndrome every year.[6] It added that 325 million people are seriously affected, with economic losses of $ 125 billion. Such figures must remain rough estimates; while it is clear that weather disasters are increasing, as the science of climate predicts, it remains impossible to put a climate change label on any given disaster.

More disastrous effects are predicted to happen soon. The 2007 Intergovernmental Panel on Climate Change report warns that climate change will cut unirrigated farm yields in half in many African countries by 2020 – a vast human disaster in less than a decade. It is further impoverishing the already poor: Inuit who can no longer hunt the way they have for hundreds of years and Sahelian farmers who find it too hot and dry to keep farming. Obviously, if climate change continues unchecked, those of us living in the rich countries will be severely affected by extreme weather events. In fact, the odd weather over the past few years in Europe and the US suggests that it is already doing so.

There is no single solution; but there are thousands of solutions: small individual acts, big government policy changes, unprecedented forms of global governance, new and renewable energies, cap-and-trade systems to establish a high price of carbon, new technology standards, new technology emphases (Nuclear? Nanotech? Join the debate about these and other controversial technologies at www.hardrainproject.com/xxx), but mainly changed human minds. We need to build a new world of human activity and human living.

Little of this will involve hardship. It can clean air and water, make cities more livable, require less dependence on pulling carbon fuels from land and sea and shipping them worldwide. It can wean us off primitive technologies and onto exciting new ones that work with the grain of nature. There is a coffee mug making the rounds in the United

6 Global Humanitarian Forum, Human Impact Report: Climate Change – The Anatomy of a Silent Crisis, Global Humanitarian Forum, 2009, Geneva

States that reads: "So-called global warming is just a secret ploy by wacko tree-huggers to make America energy independent, clean our air and water, improve the fuel efficiency of our vehicles, kick start twenty-first century industries, and make our cities safer and more livable. DON'T LET THEM GET AWAY WITH IT!!"

It is not just Sweden; the radical and exciting changes mean that ALL countries are "developing countries" now.

BLACK LIQUOR, A WASTE FROM THE PAPER-MAKING PROCESS.

Energies: different and less carbon

Some of the more standard approaches to using different kinds of energy – no- and low-carbon – are discussed below. But Sweden is different from many countries in that it has long, cold winters and a lot of forests and forestry industry. This offers it some non-standard solutions.

In 2000, Sundsvall Hospital inaugurated the only cooling system in the world that is based on snow. It saves energy, cutting electricity consumption by over 90 %, and cuts back sharply on the hospital's use of dangerous chlorofluorocarbons (CFCs), which destroy the ozone layer. A 10 000 square meter tank (700 000 cubic meters) is filled with snow in the winter; if there is not enough snow in a given winter, snow cannons are used to make more. This snow is covered with a layer of woodchips at the end of the winter. In summer the melting snow produces water at about 1° Celsius, which is piped to the heat exchanger, and coolant is piped into the hospital's cooling system. The water, which after having done its work reaches a temperature of 8°, is pumped back to the snow pile to be cooled again and to melt more snow.

THE CHEMREC COMPANY TURNS THE BLACK LIQUOR INTO LOW-CARBON CHEMICALS AND FUELS.

Jan Lindberg, an energy controller at the Västernorrland County Council, says that "Both the environment and our budget come out winners." The private company Snowpower in Luleå is working to commercialize the technology (www.snowpower.se). Given the amount of snow in a Swedish winter and the number of snowy countries in the world, the approach could have vast global potential.

Sweden traditionally burns a lot of woodchips for energy. However, the CHEMREC company (www.chemrec.se) is helping pulp and paper

mills become "biorefineries" by offering them gasification technology to turn their black liquor, a waste from the paper-making process, into low-carbon chemicals and fuels. This gives the entire industry a new product line. The company reckons that full implementation of its technology in all Swedish pulp mills would reduce CO_2 emissions by about 6 million tons a year – roughly 10 % of current Swedish CO_2 emissions – while supplying 25 % of Swedish automotive fuel consumption. It adds that the technology could provide the equivalent of over 45 billion liters/year of gasoline.

Solar energy

Solar energy is free, and there's more than enough for everybody in the world. The sun provides thousands of times more energy than we actually need. If we could capture solar power efficiently, each person's energy needs could be provided by an average area five meters wide and five meters across. Countries that are not particularly sunny can get their energy by putting solar collectors in deserts, with the heat from the sun driving a steam turbine that produces electricity. Long-distance power lines can take this power to where it is needed.

Solar might be the cheapest and most convenient way of replacing fossil fuels. It's also non-polluting, safe, and does not need to use land that could be used to grow food. Solar energy can be stored overnight and used to keep the power flowing all the time. At a much smaller scale, individual houses can be entirely powered by solar photovoltaic panels sitting on the roof.

Surprisingly for a northern country, Sweden is becoming a pioneer in solar power: for electricity, heating, and cooling. Atop the hospital in Härnösand sits an Absolicon Solar Concentrator AB system that provides all three. It is a series of reflective troughs that focus the sunlight on both thermal panels and photovoltaic panels, as the troughs track the sun across the sky. In this case, the main focus is air cooling in the summer, through a system that has salt dissolve in a liquid solution and then re-solidify. These are big systems, not for individual homes but for hotels, industrial plants, apartment buildings, and hospitals. Several have also been installed in Marbella, Oviedo, and Seville, in Spain. The solar concentrators are also part of the Clean Tech Demonstration Arena project owned by the Foundation for Research on Concentrated Solar Energy in Härnösand. According to foundation chairman Joakim Byström, "There are many interesting companies and plants in the region, and at least 20 of them are already open to visitors. Now we are making a concerted effort to publicize and market them."

THE COMPANY CLIMATEWELL HAS ESSENTIALLY CREATED AN ENTIRE INDUSTRY OUT OF "HEAT PUMPS" BASED ON THE ENERGY RELEASED AS VAPOR PASSES BETWEEN SALT AND WATER.

The company ClimateWell has essentially created an entire industry out of "heat pumps" based on the energy released as vapor passes between salt and water. At the base of the industry is a method for storing solar energy called the Thermo Chemical Accumulator (TCA), which transfers solar energy to heat energy in a vacuum. The company has received a lot of prizes, including Sweden's Stora Teknipriset, and also attention, including the headline in the British newspaper, *The Guardian*: "ClimateWell Most Likely to Change the World." It has a factory in Spain to manufacture its V9 air conditioner, and has sold many there for homes, hotels, schools, retirement homes, and public baths. According to company CEO Per Olofsson, "We want to contribute to global, sustainable, and renewable energy production. And we

SURPRISINGLY FOR A NORTHERN COUNTRY, SWEDEN IS BECOMING A PIONEER IN SOLAR POWER: FOR ELECTRICITY, HEATING, AND COOLING. ATOP THE HOSPITAL IN HARNOSAND SITS AN ABSOLICON SOLAR CONCENTRATOR AB SYSTEM THAT PROVIDES ALL THREE.

encompass the entire chain: from molecule to machine and company." (www.climatewell.com)

The sun is not only energy; it is also light. The Parans company has pioneered a way to collect and focus the sunlight outside a building and channel it into the interior. Its SP2.1 system uses 62 pivot-suspended optical fresnel lenses that follow the sun's path and focus sunlight into optical fibers. These fibers are bundled into four flexible optical cables that transport the collected sunlight up to 20 meters. The SP2.1 can be installed on both roofs and facades, which generates a wide range of installation possibilities. Other products include solar "spotlights" and rectangular lit areas. Providing light with little or no electricity use can save vast amounts of energy.

Parans was founded in 2002, and the first version of its patented technology was commercialized in 2004, having been developed through extensive R&D in collaboration with Chalmers Technical University.

Wind

After 20 years of rapid progress, wind energy is the best-developed source of renewable electricity. Across the world, people are investing billions in putting up huge wind farms. On high plateaus in China, across the US Great Plains, and on Spain's Atlantic Coast, tens of thousands of elegant, quiet turbines capture energy from moving air. On windy days, turbines provide almost half Spain's electricity. Many other countries could eventually get most of their power from wind. Onshore wind power is inexpensive and technically mature, and turbines out to sea, where winds are generally stronger, should eventually provide viable sources of low-cost power.

The wind does not blow all the time at any particular point, but international networks of electricity grids could move electricity from where there is surplus to where the wind is not blowing. We can develop new methods of storing energy to meet short-term needs. One of the

THE FLEXENCLOSURE COMPANY HAS PRODUCED A WIND AND SOLAR ENERGY GENERATOR THAT CAN ACT AS A BASE STATION FOR MOBILE TELEPHONY. IN THE MODULE ARE BATTERIES AND HIGHLY DEVELOPED SOFTWARE THAT "LEARNS" THE LOCAL CONDITIONS AROUND THE MODULE TO KEEP IMPROVING ITS OPERATING EFFICIENCY.

most effective ways of dealing with the variability of the wind is to convert to electric cars with high capacity batteries. When the wind drops, stationary cars can boost the power supply for many hours by pushing their electricity into the local grid. Eventually, wind needs to be part of a portfolio of electricity sources, but it is already saving huge amounts of CO_2 emissions in many countries around the world.

Sweden is experimenting with wind energy in forests, as SCA Forest Products AB is putting six wind farms into its woodlands in central Norrland – a total of 450 wind turbines. When fully operational, the venture is expected to generate 2 400 GWh of renewable electricity per year, 2 % of Sweden's total requirement and three times the present wind power production of all of Sweden.

The Flexenclosure company has produced a wind and solar energy generator that can act as a base station for mobile telephony. It is a box or "module" atop which are solar panels; a tower rises beside the module, which contains an antenna and atop which sits a wind generator. In the module are batteries and highly developed software that "learns" the local conditions around the module to keep improving its operating efficiency. In many parts of the world, particularly in developing countries, such base stations are powered by diesel, which means expensive delivery systems. The Flexenclosure "E-site" is self-contained and can reduce fuel consumption by up to 90 %. It has a short pay-off time and increased component lifespan. Given the rate that cell phones are leapfrogging landlines throughout the developing world, such low-cost E-sites have a vast market potential.

Sweden is also powering ahead with offshore wind, with the inauguration in the summer of 2008 of the Lillgrund offshore wind farm in Øresund near Malmö, a huge operation with 48 2.3 MW wind turbines, making it one of the largest such installations in the world.

Tide and Waves

Unlike sun and wind, tides are utterly predictable. We know to the second when the peak flows will arrive. And at some points around the world, they provide an almost limitless energy resource. A few miles off the coasts of parts of Canada and Britain, tidal currents could generate from huge underwater turbines much of the electricity these countries need. In Russia, dams across some of the main rivers could provide reliable power for millions. It's not just tides. The power in waves is untapped around the world, but the energy in a small area of the waves off an exposed coast can meet the total electricity needs of a family.

Because wave energy can be so frighteningly powerful, it's not going to be cheap to develop reliable technologies to make electricity. But in places such as Australia, Britain, and Portugal, innovative companies are working to perfect large, robust devices that capture the power of the waves.

In the sea near the Swedish coastal town of Lysekil, a number of giant yellow buoys represent technology that may help tame the power of the waves.

At the Swedish Center for Renewable Electric Energy Conversion at the Ångström Laboratory, Uppsala University, researchers have been working for the past six years on a unique wave power technology. Team leader is Professor Mats Leijon, a leading authority on renewable electric energy conversion. Leijon believes wave power

is superior to other renewables because of basic physics. "Energy is the integral of power over time," he explains. "That means that it's important to have some power, but it is more important to have it over a longer time."

The Uppsala approach, claimed to be simpler and thus cheaper than most other wave approaches, turns wave power directly into electrical energy, creating no emissions or waste. The technology consists of a piston-driven generator on the seabed linked by a cable to a buoy on the surface. The up-and-down movement of the buoy drives the generator, generating electricity. The electricity is then fed into the grid by cables on the seabed.

Half a dozen companies have spun off from Leijon's research in Uppsala; Seabased is the one commercializing the wave power technology. What one magazine dubbed his "energy empire" also consists of companies involved with wind power and sea current power, both of which are based on the same basic principles as wave power.

The solution has generated considerable interest; in one month at the beginning of 2008 more than 1 000 people from around the world visited Leijon's research department to find out more. Two of Scandinavia's largest energy companies have placed orders with Seabased, which was named "one of the hottest technology companies in the country" by two Swedish magazines in March 2008.

Combined Heat and Power

Conventional, big power stations waste most of the energy they use. They burn fossil fuels, but convert only a third or a half into electric power; the rest is lost as useless heat. We can reduce this problem in two main ways: develop technologies that increase the efficiency of electricity generation, or that use the heat. Among the most exciting prospects for electricity generation are small ceramic fuel cells – battery-like devices that generate electricity from chemical reactions. These cells can be as small as a domestic washing machine and will work in a domestic kitchen. About 60 % of the energy in their fuel can be turned into electricity, a percentage that matches the best big power stations. And the other big advantage is that the waste heat they produce can be used to heat the home or to provide hot water. Countries such as Korea and Japan are pushing the development of domestic fuel cells in the belief that this will be the best way of reducing energy costs and domestic emissions. The most innovative fuel cell companies are now producing home units that can be run on renewable fuels such as second-generation ethanol made from wood wastes.

But what about the heat wasted in large power stations? We need to develop district heating systems that use this energy to provide home and office warmth. Ideally, we also want the power stations to use renewable sources of energy such as wood and straw. Countries like Sweden and Austria heat some of their homes through shared heating systems that pipe in hot water from biomass power stations. We need to develop low-carbon district heating elsewhere.

Sweden is a world leader in combined heat and power (CHP) plants, many of them fueled by wood chips rather than fossil fuels, although the district heating in Malmö also taps geothermal and solar energy.

Alex Wilson, founder and executive editor of BuildingGreen, LLC in the United States, argues that Sweden has two huge cultural differ-

IN THE BACKGROUND CHP PLANT AT KRISTIANSTAD, WHICH BURNS 18-20 TRACTOR-TRAILER LOADS OF CHIPS PER DAY. IN ADDITION TO BEING VERY IMPRESSIVE FUNCTIONALLY, IT IS STRIKING TO SEE HOW CLEAN THESE FACILITIES ARE.

ences that put it ahead of the United States in non-fossil CHP. First, Sweden believes in the reality of climate change, and second, it has a tax structure that charges utilities high carbon and sulfur taxes if they burn coal. And the failure to capture the heat generated by creating electricity in the United States means that about two-thirds of the total source energy is wasted, usually heating local rivers.[7]

Wilson described his impressions on visiting CHP plants at Kristianstad, which burns 18-20 tractor-trailer loads of chips per day and Växjö, burning about 60 tractor-trailer loads per day.

"In addition to being very impressive functionally, it was striking to see how clean these facilities are," he wrote. "Advanced pollution-control equipment captures most of the emissions, so there is very little pollution coming out of the stacks. Inside, the plants are spotless. One could practically eat off the floors. The control rooms look like they belong at NASA, with banks of monitors and control panels, all efficiently managed by one or two operators. It's a picture of efficiency – as one might expect in Sweden."

Super Efficient Homes

Architects and developers are finally beginning to understand. No longer can we build leaky, badly insulated homes that cost huge sums to heat and cool. New homes today are much better than houses of even a few years ago. They are built airtight and with new technologies for providing thermal insulation. Ventilation comes from pumping new air into the house, and the heat from the stale air that leaves the building is captured. The best known of the techniques for building low-carbon housing is called the *passivhaus* approach, and houses built to this standard don't need central heating systems even in cold countries.

But only a tiny fraction of the housing stock is replaced each year. Whatever we do to improve the standards of new housing will do little to lower the emissions from heating and cooling existing buildings. The good news is that most of the techniques pioneered for new *passivhaus*

7 www.greenbuildingadvisor.com/blogs/dept/energy-solutions/combined-heat-and-power-sweden

buildings will work in existing homes and commercial buildings. Countries like Germany have introduced low-cost financing and other incentives to help encourage really effective eco-refurbishments. Hundreds of thousands of homes are being improved each year, cutting emissions by several tons in many houses and dramatically reducing heating bills.

Sweden has a great many green houses and other residence buildings; the trick is to turn these from "demonstration" projects into the norm. One leading Swedish architect in this effort is Anders Nyqvist, who is responsible for Nydalahuset in Umeå. It is a multi-family house built of renewable, recyclable materials and heated by biofuels. All excess heat is used, and waste and sewage are separated and reused. The house is designed to create natural interfaces between the residents while also offering privacy.

Karin Adalberth has taken the passive house concept a step further to create the Plus-energy-house, which essentially creates its own energy, with a surplus. This is achieved by the use of solar collectors, solar cells, heat exchangers to transfer heat from the ventilated air to the incoming fresh air, air tightness, high-efficiency windows, low energy appliances and lamps, and good insulation.

In Njurunda, outside of Sundsvall, a whole house has been built with recycled bottles and crushed glass from cars. It uses cellular glass modules: 600×1200 mm insulating sheets of cellular glass that are reinforced by u-profile lightweight girders. The modules both hold the house up and insulate it.

Innovator Björn Bellander noticed that the human body is very efficient at managing the gases, liquids, and solids that make it function. He then developed a system of "combined piping" for the gases, liquids, and solids that a house needs in terms of ventilation, water supply and waste disposal, his main contribution being greatly improved valves. Today the technology is called SplitBox sold by the company SplitVision AB. It reduces the energy loss in household air circulation and water movement, and also handles sewage.

Living Better – Differently

The world's booming human population grew from 3 to over 6.8 billion in just 40 years. It is expected to stabilize at 9+ billion around 2050.

But it is not just the numbers. "Population" is ultimately about what people know and how they live. The United States produces a quarter of the world's carbon dioxide emissions with only 5 % of the global population. And, unlike Europe, the US population is growing fast – from 200 million in 1970, to over 303 million today and a projected 420 million in 2050.

Since 1950, the richest fifth of humanity has doubled its consumption of energy, meat, timber, steel, and copper per person and quadrupled its car ownership, while the poorest fifth of humanity has increased its general consumption hardly at all. The big increases in consumption are now happening in countries such as China, and India, countries that together are expected to add a half a billion more people to the planet's population by 2050.

More than three quarters of the world's people live in nations that are ecological debtors, where national consumption has outstripped their country's biological capacity. (See www.hardrainproject/xxx or www.footprintnetwork.org to see your countries footprint.)

The wealthier among us must find ways to live within planetary boundaries – renewable energy; efficient heating, cooling, and transport; diets that need less land and water.

Most of the growth will take place among the poorer, less developed nations, with some big countries such as Pakistan and Nigeria on course to triple their numbers by the middle of the 21st century. Many people there cannot meet their basic needs, and the goal of such countries may be to skip the "big grids" of the North and go straight to cell phones and local energy, water, and sewerage solutions. Another goal is to stabilize population as quickly as possible, through education and reproductive health programs. This would also reduce poverty and increase human potential. But since the mid-1990s, population has been a neglected issue.

It is time to educate and empower women, so they can take better care of their families, make their own reproductive decisions, and play more powerful roles in the development of their nations.

This point highlights the need for more inclusive democratic systems that include the ambitions and views of all minorities as well as some poorly represented minorities such as – in some countries – women and the poor. A number of Swedish NGOs are working on this issue, including Forum Syd, which has recently highlighted and encouraged work by civil society organizations all over the world to make political systems more democratic.

There are also many ways to meet the needs of growing populations – needs ranging from steel and fabrics to fresh air and outdoor fun.

The future is going to require a lot of steel – but made differently. In the Bergslagen area of Sweden there are many steel companies trying to use less energy, create less waste, and recycle all energy back into the steel-making process. The first stages of a Clean Production Centre was established in 2009, and it has already attracted 30 companies into its cluster of buildings. Some 20 development projects have been identified, and three are nearing the commercial stage. The Centre, in Hofors and originally run by the Hofors Municipality, is now run by Triple Steelix. It has become a regional development project that involves eight municipalities, three counties, eight major steel companies and around 200 smaller companies in Bergslagen, all under the auspices of the Swedish Steel Producers Association.

Since 2006, Domsjö Fabriker has developed into the Biorefinery of the Future (Framtidens Bioraffinaderi) in Örnsköldsvik, the vision of which is that forest products can go a long way to replace the fossil fuels that are the basis of our society. It is *an initiative and a meeting place focusing on getting more from the forest and involving* companies, public functions, and universities in the Örnsköldsvik and Umeå region.

Oil is a fossil biomass. Therefore, virtually anything made from oil can also be made from the biomass that is wood and its various components. However, forests have the added benefit of constantly renewing themselves. Biofuels to run cars and buses are already being developed. Much of the work at the biorefinery is to find new ways to turn cellulose into fibers for the textile industry – especially a fine fabric known as *viscose*.

This is a good alternative to cotton, one of the more environmentally damaging crops. The refinery is also experimenting with lignin,

which greatly reduces the amounts of CO_2 released from concrete. (www.bioraffinaderi.se)

The company NKO Drives has developed a control method for electric motors that provides energy savings of up to 25 %. The company's main product is a converter for induction motors, the NFO Sinus frequency converter, which provides a pure sine curve to the motor, making it entirely free of interference. Thus great energy savings can be made wherever there are electric motors: hospitals, homes, commercial property, offices, hotels, schools, and factories. Given the number of electric motors in use, the potential is vast.

A lot of technology development is and will be based on mimicking nature. The company Rectus Levande Filter AB in Sundsvall has commercialized a technique developed and patented by Swedish Professor Lars Thorfelt: a living air filter. It consists of plants potted in glazed soil containers, with drainage and watering systems and a fan at the top. As the air circulates, pollutants – both particulate and gaseous – attach to the plants' leaves. Two times an hours the plants are watered for about 10 seconds and the pollutants run into the soil, where they are broken down. The living filter cleans and oxygenates the air, reducing the need for mechanical ventilation and energy to heat the ventilated air. It can cut energy consumption by 70 %. According to CEO Christer Swedin, "It is like standing by a stream on a brisk spring day. When we temporarily removed the filter from our office both my colleagues and our visitors complained about the poor air quality."

More clean technology and sustainable progress does not mean less enjoyment and recreation. Companies such as Lundhags of Jämtland produce outdoor products in harmony with nature, making sure that their supplies from other firms are also ecologically sound. Another Jämtland company, Klättermusen, produces backpacks made from 100 % recycled nylon made in Korea from old fishing nets and carpets. Sweden is also leading in wilderness recreation centers that operate in harmony with nature.

Meeting the needs of all

The planet is too small and interconnected for the rich to be comfortable and secure while billions suffer poverty.

Poverty is disastrous for people and planet. Over three billion people, almost half the world population, live on less than $ 2.50 a day; and more than four-fifths live in countries where the income gap between rich and poor is widening. Aside from being a personal tragedy, poverty can keep people from taking part in solutions – for themselves or their societies. The only way poor people can adapt to the climate change that will come is through sustainable economic development: having incomes, savings, insurance, and mobility.

Governments cannot "solve" poverty, but they can set up the conditions whereby people can pull themselves out of penury: access to credit, fair laws fairly enforced, streamlined bureaucracies, education for all, effective safety nets for the poorest. Developing country governments would be helped in this effort if all the richer countries kept their promises: to establish a global trade regime that helped countries trade out of poverty, increase aid, and help poorer countries adapt to climate change.

Many countries have "aid agencies" or "development agencies such as the US Agency for International Development (USAID) or the UK's

Department for International Development (DFID). Sweden has tried to get development assistance out of the an agency or department ghetto by conducting government-wide surveys to see that all policies promote the development of poorer countries – or at least do not hinder it.

In 2009, Sweden was the biggest development assistance provider in terms of percentage of gross national income (GNI), with its aid being over 1 % of GNI. All aid giving countries have promised to provide at least 0.7 % of GNI in aid, but only Sweden, Norway, Luxemburg, Denmark and the Netherlands consistently honor this promise.

The Swedish International Development Cooperation Agency (Sida) is the most public face of Sweden's development assistance. It channels resources through NGOs, multilateral cooperation, and the EU, among others, and promotes the idea of "international development cooperation" to replace the one-sided giving indicated by the term "assistance." Supporting over 2 000 projects in over 100 countries (20 of them designated as "target countries"), Sida creates partnerships on development projects with companies, popular movements, organizations, universities, and government agencies.

"Systematizing" cities

In 2008, for the first time in history, more than half the global population (3.3 billion) lived in cities. By 2030, some 5 billion will live in cities. In Africa and Asia, the urban population is expected to double between 2000 and 2030.

No country has developed economically without urbanizing. And people moving to cities have fewer children than those remaining in the countryside. But today's cities tend to "sprawl" unplanned across the landscape, particularly in the developing world, where influxes of poor people build huts and shanties on dangerous land, where it is hard for the city officials to bring in services such as sewerage and electricity.

Cities must be planned more systematically and holistically, to take advantages of economies of scale, to limit their ecological footprints – which is easier to do when people live closer together. This means things like building smart transport systems, in which cars, trains, subways, bikes, and walkways are not separate systems but part of one whole system. It means combined heat and power, and lots of recycling of water and wastes, and it means bringing nature into cities, in parks, gardens, and reserves.

The systemic approaches required are not just about mechanics and infrastructure, but also about human behavior and political systems. And a lot of the answers will involve getting more participation into planning city growth.

Sweden has traditionally been successful at interdisciplinary activities and providing systems-based solutions. Not only are Swedish cities becoming more systemic, but also Sweden is helping the rest of the world develop sustainable cities. A key figure in this is architect and professor Ulf Ranhagen, head architect at the Sweco consultancy. He led the work commissioned by the Swedish government and Swedish Trade Council to develop a sustainable cities concept before the 2002 Johannesburg World Summit on Sustainable Development. The concept then evolved along one path for developing nations (Sida's Sustainable Cities Approach) and one path that is a platform for Swedish companies that specialize in environmental technology and urban

ANDREAS BRÄNNLUND, "EKOVISION TORSVIK" FROM THE EXHIBITION KRETSHOPP.

development (SymbioCity). But for both, the basic idea is that instead of having vast amounts of materials and energy flow through a city, try to close loops as much as possible. A mainstay of this approach is the eco-cycle model, which links three major elements of these flows – waste, water, and renewable energy – making them an eco-cycle where everything interacts, enabling benefits based on coordination.

Sustainable cities need sustainable vehicles, and the military company BAE Systems of Örnsköldsvik reckons that it is about three to five years ahead of civil competitors in the creation of effective vehicles based on diesel engines and electric motors. Adding the electric to diesel means that components can be located with greater freedom in the vehicle, allowing it to be built safer, lighter, and with more space. Electrical components are generally very efficient with long working lives and little need for maintenance.

One good example of systemic thinking is the Flexiwaggon, which more easily and seamlessly connects road and rail systems. A button is pressed, and one end of a railway carriage uncouples from a train and rotates outwards. A ramp is lowered and a fully loaded truck drives up onto the rail carriage, which then rotates back to resume its position in the railcar line-up. The truck is carried on the train from city to city for a fraction of the energy it would use on the roads. It is off-loaded from the train just as easily. The Flexiwaggon was created by designer Jan Eriksson for County Jämtland. Two prototypes have been built and tested. The retailer Ica Sverige AB found Fexiwaggon to be such an interesting solution that they have bought stock in it and hope to be the first to try it when it is available.

Sustainable cities need sustainable connections. The road tying Scandinavia together from the Atlantic to the Baltic, from Trondheim through Östersund to Sundsvall, is slowly being converted into a "Green Highway." Along the almost 500-km highway will be facilities for filling vehicles with ethanol, biogas, electricity and even rapeseed diesel.

Future farming

Given that there are already so many hungry people on the planet, feeding the 9+ billion people of the year 2050 will require a doubling of present food production levels. This calls for new hardware and "software" – software in the forms of educating farmers for a new

ANDREAS BRÄNNLUND'S FUTURE HOUSE BUILT WITH COMMON SENSE AND WISDOM. IMAGE FROM THE EXHIBITION KRETSHOPP.

Green Revolution, one more sustainable and in tune with nature than the earlier 1960s–70s Green Revolution, in more government efforts in agricultural research, and getting rid of the perverse subsidies that help the world's richest farmers (Europe, USA) better compete against the poorest (Africa, Asia). Software will also include access by farmers to credit, markets, and crop insurance.

The hardware will take the form of new technologies to get the most out of every bit of topsoil and every drop of water. New crop varieties will be needed, especially to cope with extreme and changing climate conditions. Does this mean the controversial genetically modified organisms? Perhaps in places it does, as large parts of Africa lack sufficient organic material for an organic approach.

Needed technology breakthroughs include a mix of the hard and soft: new ways to manage salty and acidic soils; to get plant roots to absorb more nitrogen, decreasing the need for fertilizer; to plant and harvest with less machinery and energy use. Farming has ruined much land, and feeding the world will require reclaiming this land for sustainable farming, along with a lot more farming in odd places like city rooftops.

Being a member of the EU, Swedish agricultural policies are somewhat trapped in the EU Common Agricultural Policy, with its emphases on subsidies and high-energy agriculture. The government says it is trying to improve the CAP. Yet the percentage of Swedish farmland under organic produce has been steadily increasing, as has been the Swedish consumer's interest in organic food. In Europe, the organic food market has been growing by 5-7 % a year, with Sweden leading that list. A study by the European Commission found that 40 % of Swedes had purchased an eco-labeled item over the past month, with the EU average being 17 %.

Yet Sweden's impact on agriculture will probably be most deeply felt aboard, especially if the government can help reform the CAP's destructive effects on agriculture in poorer countries. Sida not only helps farmer in the developing world improve their techniques, but also helps poorer countries engage in agricultural trade negotiations.

Sida also supplies Sweden's with knowledge and experience, as well as actively working with capacity development. Such work can help secure smallholders access to natural resources such as land, water, and forests with the help of democratic and legally secure systems. Development assistance efforts can also help small farmers receive payment for their goods, by building better roads and other infrastructure, dismantling trade barriers, and enabling better access to knowledge and information about markets, laws and taxes.

Sida helps its partner countries secure equal rights for women, and the opportunity for them to work the land. It is promoting mobile phone use and improved services in East Africa, a program that stretched from health information to complex government interactions. But it also provides the farming and agricultural market information so crucial in this largely agricultural region.

Water: the stuff of life

Very little water is available for humans, other animals and plants. Today, a billion people cannot get enough safe drinking water. By 2050, 45 % of human kind will live in countries chronically short of water.

Freshwater is a mess of contradictions: it is scarce – but cheap (or free); it is valuable – but wasted and polluted. It is the stuff of life, but dirty water spreads disease: dirty water and poor sanitation kill 5 000 children a day. With climate change, water is becoming available differently than in the past, requiring new water systems.

The biggest industrial use of water is as a coolant for thermal power stations, and carbon capture and storage systems would require vast amounts of water – yet two more reasons to move from carbon energy to renewable energy.

Two-thirds of all the water taken from nature is used to grow food or other crops. This dries the landscape, empties wetlands, destroys fisheries, and even alters climate.

There are myriad solutions, both big and small. Sanitation systems are available that use little or no water. Drip irrigation, rather than flooding fields, can cut water use by 60 % or more. Some Indian farmers make their own drip systems from plastic sleeves manufactured to hold popsicles.

Simply teaching farmers how to measure and regard their use of water can encourage farmers to use less of it. And effective water pricing can help people and business understand its value.

Many small dams are usually more effective than a few big dams, both in terms of irrigation water and hydropower. Water use must be systematized overall, as Singapore has done. There people are required to have low-use taps and toilets, and water tariffs rise after the first 40 cubic meters a month. So domestic water use has fallen during this decade.

Living things need water. Let's use it carefully.

Sweden provides global leadership in water management through the Stockholm International Water Institute (SIWI), a policy institute that seeks sustainable solutions to the escalating planetary water crisis, by managing projects, synthesizing research, and publishing findings and recommendations on water, environment, governance and human development issues. It also organizes the World Water Week and the Stockholm Water Prize (www.siwi.org).

It is a shame that the standard flush toilet was invented in England, where there is so much water. A Swedish alternative, the Peepoo is a personal, single use "toilet" initiated by Anders Wilhelmson, which sanitizes human excreta shortly after defecation, preventing the feces from contaminating the environment. (www.peepoople.com).

This toilet is a high technology product for a low economy. It is essentially an ergonomically designed plastic bag that provides safe sanitation for the poor, keeping bacteria and viruses out of drinking water and food. It eliminates the up-front investment of installing plumbing for sanitation, and after the excreta becomes sanitized in the bag, it can be used for fertilizer. According to its manufacturers, the Peepoo has been successfully field tested in a shantytown in Nairobi and in Bangladesh.

FlexiClean AB manufactures and sells for export a new filter for cleaning stormwater. It consists of an outer filter casing and a filter cartridge with an easily replaceable filter bag. The filter contains different types of bark. The filter container occupies a maximum of 50 % of the cross section of the well and does not need to be removed to determine the degree of mechanical or chemical clogging of the drain. The company has won prizes for its new product and has been highlighted at a number of environmental events. The new filter should be successful as an export product, as the EU's Water Framework Directive has tightened up the ways countries can deal with stormwater runoff.

Biodiversity: the web of life

Our Earth is alive with species: from ocean bottoms to tops of mountains – perhaps 30 million species in total, fewer than 2 million identified.

Today we humans are driving species to extinction on a scale previously caused only by massive meteorites. We are chopping, burning, plowing, and paving nature's habitats. We are bringing in alien species, like rats and weeds, which gobble up indigenous species.

We are acidifying the oceans. We are poisoning nature with toxic metals and pesticides, oxygen-eating sewage, and fertilizer runoff. And just two degrees of global warming could cause a quarter of the world's species to go extinct as their habitats disappear.

Species depend on each other. So destroying one can destroy many. And the ecosystems formed by networks of species provide humans with the food, water, topsoil and fibers they need for life.

Most biodiversity "hotspots" are in the tropics, where human populations are growing fastest, clearing forests, draining wetlands, and wrecking coral reefs.

How can we continue to share the planet with other species – and reap her benefits? Conservation is vital, especially of biodiversity hotspots. At least on paper, more than 1/10 of the world's land is already under protection. But more is needed, in the oceans, and to provide corridors for species to migrate during climate change.

Various processes can make protected areas valuable to their human neighbors: ecotourism; harvesting wild products like fruit and nuts; agro-forestry; and tapping carbon markets. Polluters and despoilers must pay the real cost of their crimes.

We must protect biodiversity in human landscapes: fields, pastures, cities and along transport links. Eco-agriculture benefits farmers, who

can grow free fertilizer and nurture natural pesticides. Forests and parks air condition cities.

We must stem global warming by decarbonizing energy, and instead tap wind, solar, geothermal, and wave and tidal power.

We must also tap our own wisdom. Fisher folk know they need to conserve fish stocks. Farmers know that neighboring forests protect their water supplies. City dwellers know that green spaces make calmer, crime-free neighborhoods. Our politics and economics must relearn these lessons.

The 1972 Stockholm environmental conference got Sweden off to a head start in environmental management, both by the government and by NGOs and average citizens. Sida is also involved in conservation efforts in partner countries

In 1999, the Riksdag adopted 16 environmental quality objectives (EQOs) and 72 national interim targets. The overall goal is to pass on to the next generation a society in which the major environmental problems have been solved. These objectives are continually evaluated by the Environmental Objectives Council, a special government-appointed body. As noted earlier, the council concluded in 2008 that over half of the objectives will require further action if its goals are to be met.

Sweden is one of the few industrialized countries that claims to have reduced carbon emissions. Between 1990 and 2006, these declined almost 9 %. Over the same period, the economy grew 44 %. An important reason for this is that oil is no longer used for heating purposes to≈the same extent and has largely been replaced by district heating based on biofuels. Compared with 1980, the decline is significant. That year, Sweden released 80 000 tons of carbon dioxide into the atmosphere. In 2006, the figure was slightly more than 51 500 tons.

A number of Swedish companies are developing products that protect the natural environment in different ways. Mantex AB has created a machine that uses x-rays of different energy levels to determine "in real time" how much moisture or pollutants is in any natural raw material, including various forms of wood and plants. This instant reading can eliminate for time-consuming and expensive tests, can speed production procedures, and – most important for the planet and its ecosystems – can help producers get the most product out of the least natural raw materials.

Nitrogen emissions into water can cause a build-up of nutrients that leads to a dense growth of plant life that kills off animals. Manufacturing stainless steel uses a mixture of nitric acid and hydrofluoric acid, but then cannot separate out and recover the resulting nitrates. AventaPolarit and the Swedish Environmental Research Institute (IVL) have collaborated to develop a technique that can both reduce nitrate emissions and recover the nitric acid. AventaPolarit has already installed the first full-scale plant using the new technique at Nyby. It recovers more than 80 % of treated nitrates, and the reduced chemical use make the manufacturing more cost-effective.

Forestry operations can be pretty destructive to forests. Innovator Lennart Lundström, who remembers growing up on a farm where horses were used to move felled timber, had an idea for a "forwarder" that could be smaller, more efficient and less destructive to the forest. (A fowarder moves timber from a forest clearing to the roadside.)

Working with the firm Thordab, the new team started the company El-forest AB, which developed the El-forest F14 forestry machine, the world's first forwarder to use electric-hybrid technology. (The group had help from Volvo Technology Transfer venture-capital company.) The El-forest is a series hybrid involving a smaller diesel engine that drives a generator that, via batteries, provides electric energy to electric motors in the forwarder's six wheels. The technology has attracted great interest among forest companies due, among other features, to the possibility of reducing fuel consumption by 20-50 %, which sharply reduces carbon-dioxide emissions. Also, the diesel engine can be replaced by alternative biofuel engines or even with fuel cells in the future.

More important from a conservation point of view, the El-forest is lighter than a conventional forwarder of the same size, but can cope with the same load. There is less impact on the forest environment due to a patented frame structure that enables all electric-driven wheels to follow the same track with adapted speed.

Getting personal

Hard Rain and What'll You Do Now? make the choice clear: either we carry on in our headlong collision with nature while ever increasing numbers of people are dragged into poverty – or put huge pressure on political and business leaders to live within environmental limits.

So What'll You Do Now?… to align the realities of your daily life with the realities of the billions less well off than you and the realities of nature?

It is hard for governments to get ahead of voters and harder still for business to get ahead of customers. And today voters are not voting to save civilization; they are voting for comfort. And shoppers are shopping like we have infinite numbers of planets at our disposal.

But the tide may be turning. Some 15 million people have seen Hard Rain. Can you imagine the impact if each one had written a letter to a political leader, or even to some corporations with which they deal. Making human progress sustainable will require tough leadership at the top, which will in turn require tough leadership at the grassroots to stiffen the courage of political and business leaders.

WWW.HARDRAINPROJECT.COM

But first, we must each walk the talk, showing we are serious by living those "100 things to do to save the world" lists: cut off the lights and bike to the store, etc, etc. THEN we can encourage friends, family, neighbors and colleagues to do the same. THEN we can join a group and help connect the groups, organize the protests, organize the encouragements, mobilize, mail, and market CHANGE.

Write a letter a day: to newspapers, politicians, companies. Given that climate change affects so much that we do, we can mobilize through the many things we already like to do: outdoor activities like hiking and birding, hunting and fishing, gardening. Whatever you do, make it your own, true to your own self, enriching, satisfying. Do not set an example of joyless martyrdom. Enjoy developing Sweden!

Sida works according to directives of the Swedish Parliament and Government to reduce poverty in the world, a task that requires cooperation and persistence. Through development cooperation, Sweden assists countries in Africa, Asia, Europe and Latin America. Each country is responsible for its own development. Sida provides resources and develops knowledge, skills and expertise.
This increases the world's prosperity.

What Will You Do Know Sweden

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