

Creating Social Change

10 Innovative Technologies

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Social entrepreneurs are inventing new technologies to solve the world's problems – disease, malnutrition, pollution, and illiteracy – to name just a few. But it takes more than a fancy new gadget to make life better. That's why the organizations profiled here are working with businesses, NGOs, and governments to get their inventions into the hands of those who need them most.

ALMOST EVERY DAY WE READ ABOUT some cool new technology that promises to change the world. Many of these products will indeed do that – but their impact will be greatest for those of us already living comfortable lives in industrialized nations. Meanwhile, most people in developing countries are left to contend with deadly diseases, smoggy air, dirty water, poor nutrition, widespread illiteracy, outdated tools, and unreliable electricity. Who creates gadgets to change their world?

The 10 social entrepreneurs profiled in this article do. But they don't just invent gizmos – low-cost eyeglasses, sanitary toilets, cleaner-burning engines. They also ask hard-nosed economic questions that help them understand their products' distribution, adoption, and maintenance. What's the payback period? Will users perceive enough financial return to part with their very hard-won cash? Is the product ready to use on its own, or will someone need to build an infrastructure to support it?

Most of the enterprises profiled here are not in business to make a profit. Yet all apply the principles of running a commercial venture: clarify the value of the product, test the product extensively before launching it, and always listen to customers. Whether rich or poor, customers will let you know whether a product improves their lives.

These social entrepreneurs also discount many of the widespread myths about technology in the developing world. They agree that poor people can afford technology as long as they see how it financially benefits them and their children. And poor people can maintain technology, as long as someone trains them to do so.

A few of the products we profile are technically complex: Envirofit's engine kit (see p. 47), which reduces pollution from two-stroke engines while improving fuel economy; Hib Vaccine Team's vaccine against influenza (see p. 51), which relies on a completely synthetic antigen; and the Massachusetts Institute of Technology's OpenCourseWare (see p. 49), which takes advantage of the Internet to offer its course materials to everyone.

Other projects use small-scale, local technologies that sidestep reliance on expensive infrastructures like electricity. The Enviro Loo (below) provides sanitation without water or electricity. The VitaGoat (see p. 48) uses only human power and local fuels to preserve food. And the Kinkajou LED projector (see p. 50) lets people study at night without electricity or books.

All 10 enterprises received awards for "technology benefiting humanity" from the Tech Museum of Innovation in San Jose, Calif., in November 2005. For these awards, the museum received 560 nominations from 80 countries, and then chose 25 recipients. The 10 technologies profiled here were selected from among these 25.

THE DEVELOPED WORLD HAS LARGELY SOLVED the problem of keeping freshwater and wastewater separate – a feat that requires treating sewage properly. Absent proper sewage treatment, latrines and septic systems pollute the precious aquifers that supply clean water in many developing countries. Today, almost half of the world's population – or 3 billion people – lacks access to fresh drinking water.

To tackle this problem, South Africa's Enviro Options (Pty) Ltd. invented the Enviro Loo. Because the toilet uses no water or chemicals, it doesn't contaminate groundwater. And because it doesn't require electricity, it can be used anywhere. The Enviro Loo is odorless and does not breed flies – a lifesaving spec in areas suffering from insect-borne disease.

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Here's how it works. The sealed dehydration/evaporation system drains liquids into a trap below the solid-waste drying plate. As the liquids evaporate, the solid wastes are subjected to enough radiant heat and ventilation to evaporate their liquid content and dehydrate the rest. Aerobic bacteria then convert the solid waste into a dry, compostlike material that has 10 percent or less of its original mass. Once or twice a year, users rake this material into a drying bag for further dehydration – considerably less maintenance than traditional latrines and septic systems require. A patented fan at the top of the vent pipe spins one way, carrying odors out of the unit.

As an added value, virtually everything the Enviro Loo produces can be reused after treatment. The dried waste can be used as fertilizer because the dehydration process kills off pathogens. The drained liquids can be treated and routed so that plant roots absorb their nutrients. And the liquid waste can also be diluted with household wastewater to create liquid fertilizer.

Since 1993, more than 25,000 Enviro Loo toilets have been sold in Africa, South America, Australia, and Greece. Most installations are financed by African national or provincial governments, although the World Bank, the United States Agency for International Development, and the Japanese government have all funded individual projects. The Enviro Loo was recently launched in the United States, where construction companies, homeowners in areas where septic systems are impractical, and the U.S. Army Corps of Engineers have shown the most interest. The Enviro Loo retails for \$3,550.

VISITORS TO MOST LARGE ASIAN CITIES CAN'T help but notice the byproduct of the region's sturdy, yet inefficient, two-stroke engines: a haze of blue smoke and unburned oil. In Western countries, two-strokes primarily power chainsaws, go-karts, small boats, and other such machines. But in Asia, more than 50 million two-strokes power many basic vehicles, including the three-wheeled "tuk-tuk" taxis of Thailand.

Cleaner four-stroke engines cost more than \$1,000 apiece – an exorbitant sum in developing countries. So a nonprofit company based in Fort Collins, Colo., Envirofit International Ltd., has developed a retrofit kit that greatly reduces two-stroke engines' emissions. In trials in Manila last year, the kit reduced hydrocarbon emissions by 89 percent, carbon monoxide by 74 percent, and particulates by 80 percent. Just as important to the people who buy the kits, it also improved fuel economy by 30 percent or more.

Based on technologies first developed at Colorado State University to reduce emissions from snowmobile engines, the kits use a direct fuel injection system licensed from Orbital Engine Co. of Perth, Australia. The fuel injectors replace one or more carburetors, which ordinarily blend air, fuel, and oil together before sending the mixture to the engine's cylinders for combustion. Standard two-strokes suck some unburned air-fuel mixture – along with its pollutants – through the cylinder and into the exhaust. Directly injecting fuel into cylinders eliminates this "blowby," increasing efficiency and decreasing pollution.

The target price of the retrofit kit is \$250, which is about the same amount of money that a taxi owner will save in one year from reduced fuel costs. Because portions of the kit are designed to be produced in its target markets, it also creates employment opportunities for mechanics and machinists.

The first large-scale deployment of the kit will be in the Philippines, where 1.3 million two-stroke tricycles are used as taxis. In Vigan, a UNESCO World Heritage site, the city government is requiring the 3,000 taxi owners to convert their engines by the fall of 2007. Because Vigan has little industry and few other two-stroke or diesel sources, its air should quickly clear as a result of the mass retrofit.

In the Philippines, the World Health Organization (WHO) estimates that particulate emissions produce 2,000 premature deaths each year and impose an annual economic burden of \$430 million. If the trial goes well in the Philippines, it will offer a model for the rest of Asia and other countries throughout the world

ELECTRIC POWER IMPROVES THE LIVES OF THE world's poorest consumers. But until recently, bringing electric power to rural areas required building costly infrastructures of power plants, substations, and electric wires. As the cost of photovoltaic technology has fallen, it has become increasingly economical for residents of unwired locations to generate their own electricity using the power of the sun. Yet the poorest households, which could benefit from solar power the most, still have to borrow money to buy a system.

That's where SELCO Solar Light Private Ltd., a Bangalore, India, firm, comes in. With 25 centers throughout India, the company not only sells the solar systems, but also helps customers pay for them by working with local banks and microfinance companies to finance the purchase. The company also works with local businesses to devise earned-income schemes to pay off the loans. For example, when SELCO linked home garment workers with a local hospital that needed a steady supply of blankets and pillow covers, the workers realized that they could afford a solar power system that would power their sewing machine, among other things.

"Technology is just one part of a whole chain of linkages," says Harish Hande, the founder and managing director of SELCO. "It is possible to achieve social change on a commercial basis – at SELCO, we've provided solar power to 55,000 poor people in rural areas, and they paid us for it!"

SELCO's standard solar home lighting system (SHS) can operate lights, a black-and-white television, a radio or cassette player, and a small fan. The next size up (of four possible sizes) provides enough power for four hours of lighting from four lamps each evening. Each SHS is a turnkey system that includes a photovoltaic module, a battery, a charge controller, wiring, fluorescent lights, and outlets for other appliances. Providing all of the necessary components makes it easy to install the SHS in a home. SELCO also organizes networks of service personnel to maintain the systems, dramatically improving their reliability.

Hande is passionate when he talks about the power of commercial ventures to serve the poorest consumers. "They're the smartest users, because they have to look at the financial benefits more closely than anyone. And if we listen to them – and provide financing mechanisms matched to the income generated with new technologies – we can do well." As he says, it's not about the technology. "What was relevant in 1995 – financing, income generation, service and repair – is just as relevant today."

IN MANY VILLAGES IN THE DEVELOPING WORLD, seasonal oversupplies of produce are often wasted for lack of ways to preserve and store them. Because these villages don't have affordable and reliable electricity, solutions that depend on refrigeration are not workable.

The VitaGoat system allows villagers to preserve their extra produce without relying on electricity. The device uses a bicycle- powered grinder and wide variety of locally available fuels to prepare protein-rich soymilk, soy yogurt, tofu, and nut butters, as well as fruit and vegetable purees and energy drinks.

VitaGoat users first apply pedal-power to grind soybeans, cereals, fruits, or vegetables at a rate that is 10 to 50 times faster than hand-grinding. This process alone produces flours, pastes, nut butters, and even ground coffee. For foods that require cooking, users then feed VitaGoat's steam boiler with wood, coal, gas, or even dung chips. The boiler, which is 10 times more efficient than open-fire cooking, injects steam into a 15-liter vessel, where cooking under pressure saves both time and fuel. A final feature of the VitaGoat is a hand-operated screw-press that can be used to extrude liquid out of cooked proteins for products like tofu and soy yogurt.

VitaGoat was created by Malnutrition Matters, an Ottawa, Canada-based nonprofit that designs small-scale food processing equipment. The organization partners with larger NGOs and private companies to manufacture and distribute VitaGoats to local villages.

Initial tests in Guinea, Mozambique, and Chad have shown that the VitaGoat can produce 20 to 40 liters per hour of soymilk, sauces, purees, and juices, and 6 to 12 kilograms per hour of ground meals, nut pastes, and coffee. In other words, a single VitaGoat operated for several hours can provide 0.25 liter of soymilk for 500 to 1,000 people.

The benefits from VitaGoat go beyond preserving food. An individual, a cooperative, or a microenterprise can base a business on it, using the VitaGoat to add value to produce and then selling the product at a profit.

This year, Malnutrition Matters' goal is to manufacture up to 90 percent of the VitaGoat components in Africa. The organization also wants to expand fabrication and training to India, where the construction of the first five models is now under way. Malnutrition Matters is also seeking small- and medium-scale food equipment producers in Latin America and Asia. Three VitaGoats have already been sent to North Korea through the Canadian group First Steps.

SUPPOSE ONE OF THE WORLD'S GREAT RESEARCH universities made all of its course materials – their syllabi, lecture notes, videotaped lectures, problem sets and solutions, exams, the works – available to everyone on the Internet. Free. That's the mission of the Massachusetts Institute of Technology's OpenCourseWare (OCW) project. To date, the project has uploaded materials from more than 1,400 courses, representing 34 academic disciplines and all five of MIT's schools. Educators can use the material to develop their own courses, and students can use them to teach themselves or to supplement existing coursework.

Why is MIT giving away the intellectual property for which it charges matriculated students \$32,000 a year? The answer is simple: The university wants to lower the barriers to highquality education for the billions of people who have neither the money to pay for it nor the physical means to reach it.

Course materials on MIT's OCW Web site may be used, copied, distributed, translated, and modified by anyone, anywhere in the world, under a Creative Commons license. The license requires only that all uses are noncommercial and notfor- profit, that materials are kept open and publicly available by licensees, and that full attributions and citations are retained.

Not all materials can be fully licensed, of course. Two fulltime MIT employees do nothing but obtain permissions, verify citations, and create replacements for copyrighted artwork. In last October's publication cycle alone, OCW dealt with more than 3,000 intellectual property issues. This year, the organization hopes to sign a blanket permission agreement with a major publisher, simplifying the process considerably.

Over time, initially skeptical professors have grown to support the project, with a full 73 percent of the MIT faculty now volunteering their materials to OpenCourseWare. Why the change of heart? Professors see the project as a way

to promote their work and “build their personal brands,” says OCW’s Jon Paul Potts.

IF YOU ASKED PEOPLE TO LIST THE ITEMS THAT would most help the world’s poorest citizens, they probably wouldn’t mention a slide projector. But this tool of salesmen and tourists holds remarkable possibilities for the one in five adults around the world who cannot read.

In Mali, illiteracy isn’t due to a lack of desire, but to a lack of resources – specifically, lighting and books. Most adult students must work during the day, leaving only evenings for reading. In villages without electricity, lanterns and flashlights provide light to read by. And even where electricity is available, books remain prohibitively expensive.

One solution to the high cost of books is microfilm. By projecting books onto a screen, large groups of people can read simultaneously, and a \$12 roll of microfilm can hold up to 10,000 pages of text. But until now, the machines needed to project the microfilm demanded reliable electric power. That obstacle has been removed by the advent of low-cost light-emitting diodes (LEDs), which require a tiny fraction of the power used by high-intensity projector bulbs.

Design That Matters Inc., a Cambridge, Mass.-based organization, incorporates LEDs in its Kinkajou projector, a durable, low-cost device that runs on batteries charged by a solar panel, all of which are included. The Kinkajou projector, named for a nocturnal South African mammal with exceptional vision, is optimized for nighttime use in classrooms without electricity. It can project microfilms onto any flat surface for a projection area of up to 3 meters. It requires no tools more complicated than pocket change for maintenance.

Design That Matters organizes corporate volunteers and college students from the California Institute of Technology, Harvard, Stanford, and MIT into project teams that tackle specific issues in underserved communities. Other teams are currently tackling water cleanliness, renewable energy, and healthcare. The funding comes from a mix of sources, including donations and private foundations, patent revenue, development agencies, and corporate sponsors.

The organization field-tested 45 Kinkajous in Mali last year and is now analyzing the data. Starting this summer, up to 1,500 copies of a refined design will be sent to Mali, funded largely by nongovernmental organizations. By January 2007, the technology will be helping an estimated 50,000 people a year learn how to read. The target price for full-scale production (10,000 units or more) is \$50 per unit.

Mali does not have the plastic or optical facilities to manufacture the projector, but the project team will generate job opportunities by training local residents as repair technicians and as instructors who show teachers how to use the projector. In India, by contrast, a commercial venture selling educational goods may build and distribute the Kinkajou.

IN INDUSTRIALIZED COUNTRIES, DEATH BY pathogens has been eclipsed by the “lifestyle” illnesses that catch up with us after years of smoking, drinking excessively, exercising too little, and eating too much. But in much of the rest of the world the situation is quite different: The drugs that were long ago developed to fight once-widespread diseases are still too expensive and rare to be widely used. And so pathogenic diseases remain the big killers among the world’s poor.

A case in point is *Haemophilus influenzae* type B (Hib) a bacterium that kills more than half a million infants every year. In the 1990s, a new vaccine dramatically reduced the incidence of bacterial meningitis and pneumonia – illnesses caused by Hib – across industrialized nations. But the cost of the drug has kept it out of the reach of most of the world’s children.

In 1994, a team of scientists from the University of Havana and the University of Ottawa set about developing an alternative vaccine that would be less expensive to manufacture and that could be sold at a significantly lower cost to people in developing countries. Their solution was to synthesize the antigen – that is, to make an artificial replica of it – rather than culturing it, as had been the common practice.

The team’s synthetic replica has proven as safe and effective in humans as the licensed vaccine. The synthetic vaccine is also less likely to cause an allergic reaction than is the cultured version, since the synthetic one doesn’t contain the allergenic byproducts that are sometimes produced in a culture.

The resulting vaccine is now manufactured in a plant operated by the Center for Genetic Engineering and Biotechnology, a Cuban government agency in Havana. Last year, more than 1 million infants were successfully vaccinated in Cuba. The WHO funded early research, and the university and research teams can now generate revenue from licensing their technique, thanks to a U.S. patent.

FAR MORE PEOPLE IN THE WORLD NEED SPECTACLES than there are optometrists to fit them. In fact, the WHO estimates that 1 billion people – almost one out of every six people on the planet – need vision correction but do not have it. Training optometrists is expensive and takes years, and lens-manufacturing equipment is also costly. But without needed glasses, schoolchildren often can’t read or learn, and adults may lose their jobs as their vision

deteriorates with age.

To solve these problems, wondered Oxford University professor and inventor Joshua Silver, would it be possible to create inexpensive spectacles that users could adjust or “tune” themselves – taking optometrists out of the picture altogether?

The answer turned out to be yes. Silver’s adaptive lenses consist of thin Mylar membranes with colorless silicone between them. While reading an eye chart, the wearer uses adjusters on the frames to pump fluid into or out of a lens to change its shape. A thicker lens magnifies better, compensating for nearsightedness, while a thinner lens helps farsighted users. After both eyes are correctly focused, the wearer snaps off the adjusters to seal the holes and maintain the correct focus.

Developing the adaptive lenses took many years. Silver began tinkering with the idea in 1985. His first prototypes weren’t tested until 1996 in Ghana. After that, a larger test with 213 participants was conducted in South Africa, Ghana, Malawi, and Nepal, and his team published the results in 2003. Now more than 20,000 pairs of his Adspecs glasses have been manufactured in China and delivered to Africa. And the need is huge: According to ERC Statistics International, whereas 45 to 50 percent of U.S. and European residents have corrected vision, the figure is 10 percent for Asia and just 5 percent in Africa.

Adspecs are produced by Adaptive Eyecare Ltd., a U.K. company whose mission is to bring affordable eye care to developing countries. The World Bank funded the first deployment in Ghana, through a program in that country’s education ministry that supports adult literacy efforts. The World Bank is now studying the development of a microcredit program that would let users borrow the purchase price of a pair of Adspecs – targeted at \$10 or less – and pay it back over the following year. In addition, the U.S. government has purchased 8,000 pairs for a humanitarian assistance program in Angola and Georgia.

Adspecs may have applications in developed countries as well – venture capitalists have been knocking on Silver’s door for some years now – but, he says, it’s clear to him: “We will introduce this first to those people in the world who will most benefit from having it.”

WEAVING IS A TRADITIONAL INDUSTRY IN MUCH of the developing world. To Westerners, weaving sometimes conjures up images of 19th-century sweatshops, of women or children working 12 hours a day or more on dangerous looms, perhaps even chained to their machines.

In countries like Nepal and Pakistan, those images aren’t far from reality. Most of Pakistan’s 300,000 weavers are women and children; all must squat on the floor over their looms, where their dexterity and small fingers are suited to the finely detailed work. Research by the Centre for the Improvement of Working Conditions & Environment (CIWCE) in the Pakistani province of Punjab estimates that more than 100,000 children ages 5 to 14 work as weavers. Their income is sometimes the only economic lifeline for poor families.

To reduce the demand for child labor, the centre has created a new, ergonomically sound loom on which adults can produce rugs as quickly and easily as children can. Unlike the traditional wood-plank loom, the portable steel pipeframed loom allows workers to sit or stand while weaving, rather than having to crouch at ground level. It includes armand footrests, with particular attention paid to lower-back support. The winding mechanism is driven by gears – eliminating the risk of facial injuries from the traditional chains, which can snap under strain.

A study of 30 looms found that after two years, children made up just 10 percent of the workers, down from 60 percent. Workers reported fewer health problems in all categories, including fatigue and chronic musculoskeletal pain. All had increased their productivity, and almost 60 percent of the homebased workers had improved their incomes as well.

The Punjab government in Pakistan is now planning two larger deployments. The first would subsidize 1,000 looms for families – identified by various NGOs – who either rely on children’s work or are indebted to carpet manufacturers. Small installments from the families would ultimately repay 30 to 50 percent of the loom’s cost. A second, much larger program would install 10 looms in each of 1,200 rural carpet factories. In this case, the factory owners would pay back the installation cost over a five-year period, although the economic implications and feasibility are still being worked out.

Financial support for the test of 30 looms was provided by the International Labour Organization (ILO), as part of a project to eliminate child labor in Pakistan’s carpet industry. The Pakistani carpet manufacturers and exporters association supported the project, along with the U.S. Department of Labor, through the ILO.

IN THE DECADE SINCE THE INTERNET BURST into world awareness, many groups around the world have begun working to bridge the digital divide – the lack of education and economic opportunity in communities without access to the Internet. One organization that has developed a creative approach to solving this problem is the Brazilian nonprofit Communication, Education, and Information on Gender (CEMINA). In Brazil, as in many other developing countries, only 15 percent of the citizens have access to the Internet.

CEMINA was formed in 1988 to give women a voice using the simplest, least expensive, and most accessible medium available: radio. Today, the group trains women to create and produce radio programming, operates a radio production center and a mobile studio transmitter, and broadcasts its original live daily program, “Fala Mulher” (roughly, “Women Speak Up”), to more than 400 stations across Brazil.

More recently, CEMINA has partnered with local community radio stations to create a network of 12 neighborhood telecenters (with 12 more in the pipeline), which gives both men and women access to Internet content and Internet telephone services, as well as trains them in software programs and e-mail. The telecenter program is funded by a variety of sources, including UNESCO, the Kellogg Foundation, infoDev, and software company Sound Factory.

The telecenters grew out of a 1999 initiative to bridge the digital divide for women. CEMINA’s “Cyberela” program was a contest to identify women with the potential to create and manage their own radio programming and then distribute it across the Internet. Their core constituents, poor and rural women, gained access not only to the digital world, but also to each other, listening to radio programming about their specific issues from their homes, sparking discussion and perhaps collective action.

One of the telecenters, the Telecenter Novo Ar, is in São Conçalo, in the state of Rio de Janeiro. Its 1,600 members each contribute a sum equal to 1 percent of the local minimum wage to fund the center. In turn, the radio station gives the center’s members access to the Internet, as well as to professional services in finance, healthcare, education, and other fields. Three days a week, the telecenter opens to the public, charging more than 700 registered users roughly 30 cents per hour for Internet access. On three other days the center offers courses on computers and Internet usage that aim to support small-scale entrepreneurial ventures.

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