BigPictureSmallWorld and **Global Education Motivators** present

Design Science Lab

Desiging solutions for global and local problems

ENERGY FOR THE WORLD

DESIGN SCIENCE LAB 2008

Designing solutions for global and local problems

ENERGY FOR THE WORLD

DESIGN SCIENCE LAB 2008

Strategies for Reaching the UN Millennium Development Goals

A Report on the work of the Design Science Lab Summer 2008
held at the UN, New York, NY, and Chestnut Hill College, Philadelphia, PA
Presented by BigPictureSmallWorld and Global Educational Motivators

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INTRODUCTION

Design Science Lab

Design science is a methodology for recognizing, defining, and solving complex problems. It takes a whole systems, global, and anticipatory approach that fosters creative collaboration and synergy in the development of comprehensive solutions to societal problems.[1]

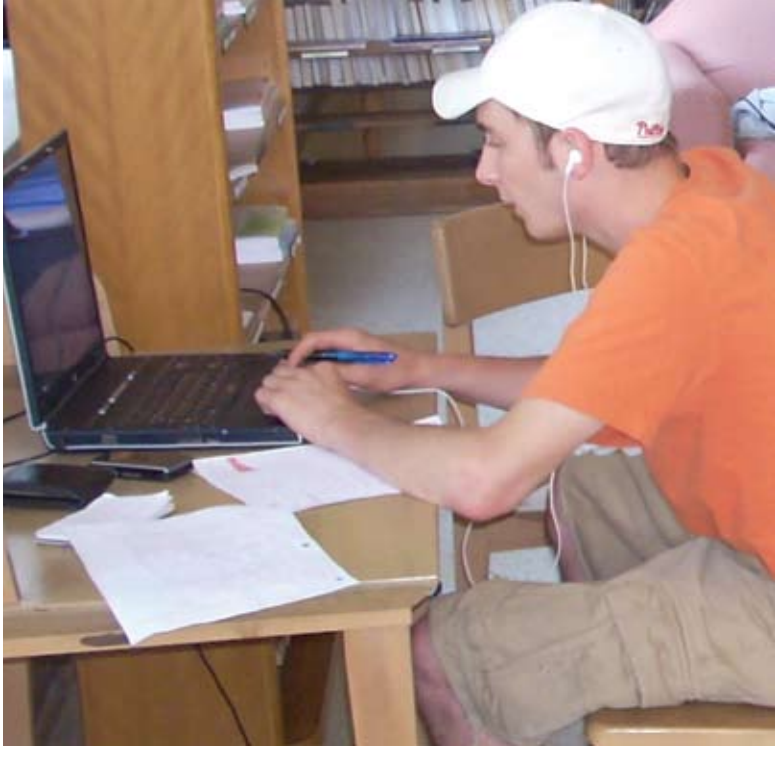
The *Design Science Lab* is a workshop where the tools of design science are used by groups to develop creative solutions to global and local problems and strategies for the implementation of those solutions.

The *Design Science Lab 2008* was the fourth in the annual series that are being held each summer between now and 2015 that will focus on the development of strategies for achieving the UN Millennium Development Goals.[2] The 2008 lab focused primarily on the global energy situation.

The *Design Science Lab 2008* took place in Philadelphia at Chestnut Hill College and at the United Nations in New York. It was put on by two organizations— BigPictureSmallWorld and Global Education Motivators.[3]

The goals of the Lab included:

- Learning about the Millennium Development Goals, their usefulness to the world, and how we can use them to make the world a better place
- Developing viable strategies for achieving one or more Millennium Development Goals
- Learning design science and how to apply it to global and local problems
- Increasing our understanding of global dynamics, world resources, human trends and needs, and options for humanity's success



- Increasing the public's understanding of these issues through disseminating the strategies as widely as possible
- Serving as an incubator and growing force for developing and disseminating design science techniques for complex problem solving and development of viable solutions to the worlds problems
- Learning a methodology for changing the world.

The purpose of the Lab was to:

- Develop strategies for achieving one or more of the Millennium Development Goals
- Develop strategies for meeting the energy needed to meet the MDG and the basic human needs of everyone in the world.

Attending this workshop was a group of college and high school students and professionals ranging in age from 17 to 55. The 2008 lab lasted for one very intense week, where the participants learned and applied the concepts and tools of design science to developing strategies to achieve the Millennium Development Goals (MDGs). The participants were briefed by UN staff from UNEP, UNDP, UNICEF and others on the MDGs, their context, history, measurement, the progress made so far, and strategies in use for reaching them. An introduction to design science was provided by Medard Gabel and the Lab portion was conducted at the Chestnut Hill College where Lab participants typically worked ten to twelve hours a day.

On the last day of the Lab, participants went to the UN where they concluded the Lab with a presentation of their work to UN experts. An overview of this work is what is presented in this report.

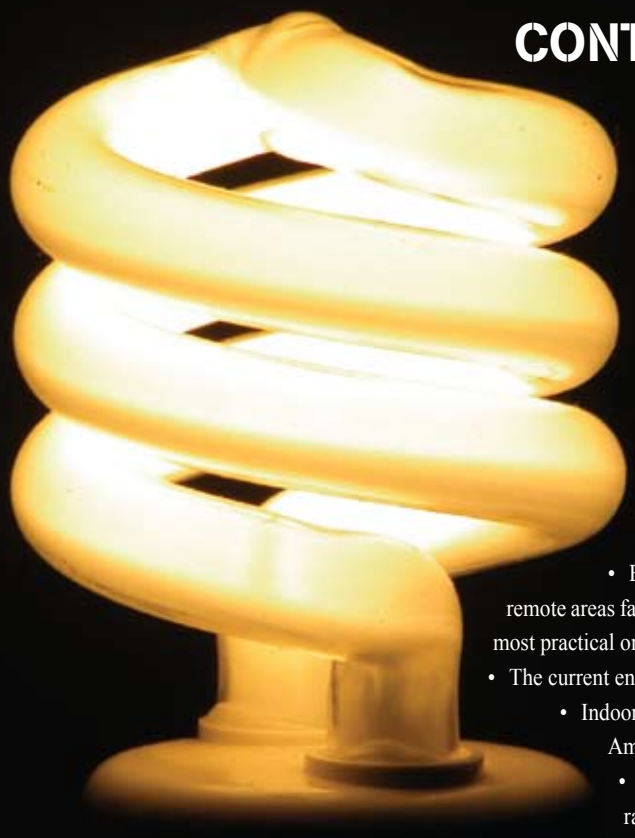
Design Science Lab 2008 Work and Report

The work of the Design Science Lab 2008 was focused on demonstrating how, using present day technology, known resources, and limited financial wherewithal global and local energy shortages could be cut in half between now and 2015, as well as eliminated entirely in another ten years in 2025.

The overall strategy developed by the participants of the Lab consisted of an eight-part strategic plan that when aggressively implemented would have a profound impact on the world.

The results would include over 1.6 billion people free from having little to no access to electricity; improved access to energy for pumping water, food production, lighting and education; higher employment and incomes; and a world that is safer, more secure, stable, and immeasurably richer as more and more people are able to participate in the creation of wealth.

UN Photo/Michos Tzovaras



CONTEXT / STATE OF THE WORLD ENERGY SYSTEM OVERVIEW AND PROBLEM STATE

The work done by the Design Science Lab 2008 is embedded in a context of the global conditions surrounding the world's global energy system. The following basic facts lay out this context:

- 6.6 billion people do not have access to an abundant, secure, clean, affordable, sustainable, energy supply
- 1.6 billion people do not have access to electricity, and 67% of these live in rural areas[4]
- Because the majority of the people who do not have access to electricity live in remote areas far from urban areas, connections to national grids to supply electricity are not the most practical or feasible way of providing access
- The current energy system pollutes the air, land, and water systems of the world
- Indoor air pollution kills 1.6 million people every year (four times the number of American deaths in WWII)
- 3 billion people are at risk from indoor stoves that burn biomass fuels[5] (WHO ranks indoor air pollution 8th among all environmental risks to human health). Women responsible for cooking and young children are most vulnerable
- Inefficient biomass fuels used for indoor stoves result in massive deforestation and cost families much of their income
- Having a clear vision of how things should be is essential for achieving that state. Having specific and measurable goals for the global energy system is critical for making those goals real.

Design Science Lab Preferred State

The *Design Science Lab's Energy Preferred State for 2028* was developed from the values of the Lab's participants.

The following are the major components of that vision:

By 2028, 20 years from the present, 100% of humanity has access to fuel, electricity, and energy-related technologies that are:

- Sustainable
- Clean
- Ever-increasingly efficient
- Appropriately matched to local needs
- Affordable
- Abundant
- Reliable
- Adaptabl
- Flexible
- Transparent
- Safe
- Secure
- Health promoting

By 2028:

- 100% of humanity's energy needs are met with safe, abundant, affordable energy supplies
- The production of energy is done in environmentally regenerative ways
- There is an ever increasing diversity of energy choices
- There is an ever increasing resource efficient energy system that is knowledge, rather than energy and materials, intensive
- There is ever increasing local self-reliance and global interdependence of our energy systems and sources
- National and local energy systems are subsidy-free and open-market based
- There are emergency backup systems and anticipatory crisis management systems in place
- Local and global energy systems are adaptable, flexible, and transparent
- Local and global energy systems are conflict free; energy is never used as a weapon or bargaining chip
- The global commons are managed for global wellbeing, not national, local or individual gain

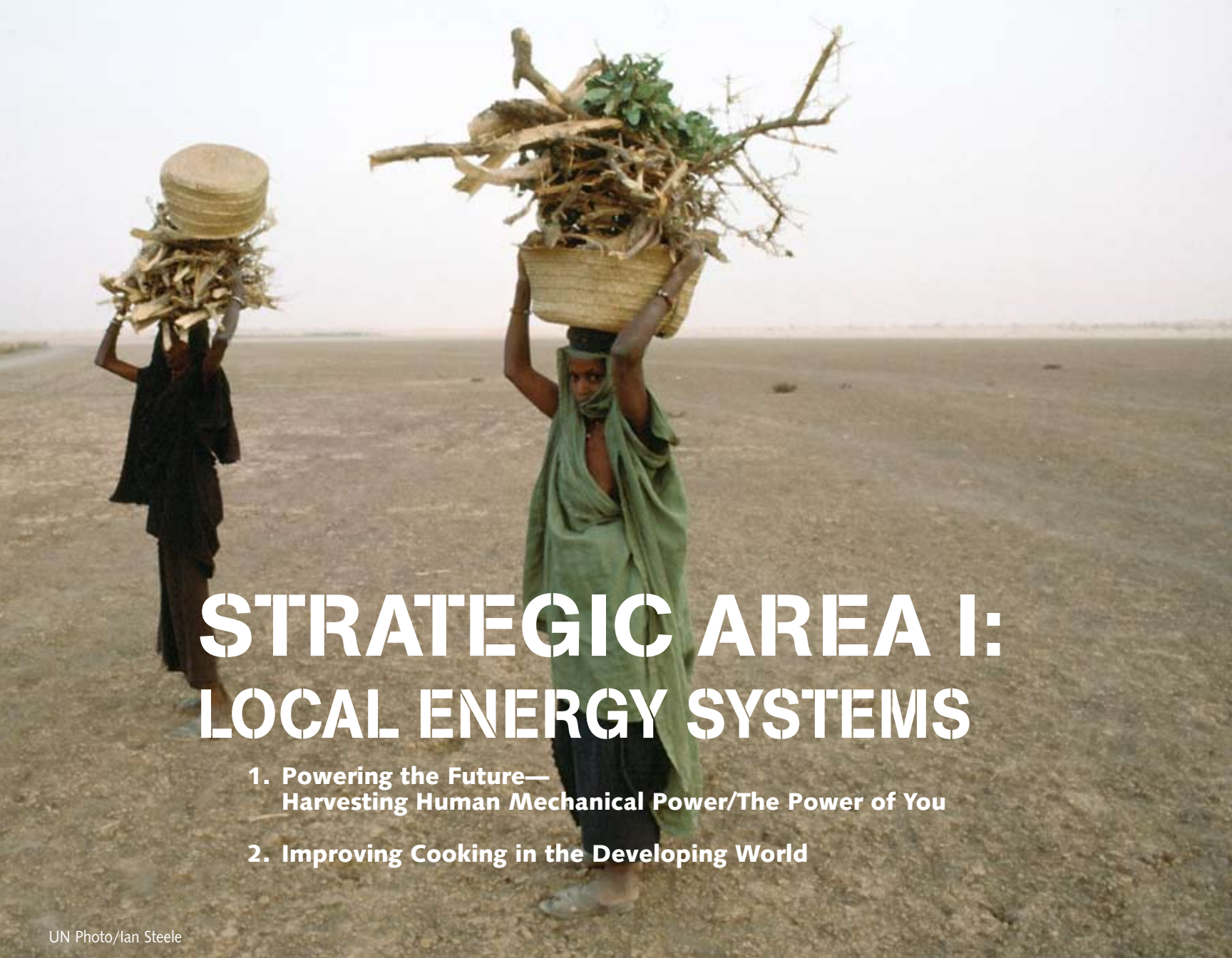
The strategies that follow this section were designed to achieve the Millennium Development Goals by 2015 and the above Preferred State by 2028.

STRATEGIES for achieving the Millennium Development Goals in 2015 and the Design Science Lab Preferred State in 2028

Millennium Development Goal:
Cut Energy Shortages by 50% by 2015

Design Science Lab Preferred State 1:
Eradicate* Energy Shortages completely by 2028

• TARGET: Reduce to zero, between 2008 and 2028, the number of people who suffer from energy shortages



STRATEGIC AREA I:
LOCAL ENERGY SYSTEMS

1. **Powering the Future—**
   Harvesting Human Mechanical Power/The Power of You

2. **Improving Cooking in the Developing World**

UN Photo/Ian Steele

"The green revolution is about how we produce abundant, cheap, clean, reliable electrons, which are the answer to the big problems we face in the world today. I would point to five problems, and they're all related: Energy and resource supply and demand, petrodictatorship, climate change, biodiversity loss, and energy poverty. They all have one solution: abundant, cheap, clean, reliable electrons. The search for and the discovery of a source of those electrons is going to be the next great global industry. And I think the country that mounts a revolution to be the leader of that industry is going to be a country whose standard of living is going to improve, whose respect in the world is going to improve, whose air is going to improve, whose innovation is going to improve, and whose national security is going to improve."

—Thomas Friedman

Teleconference briefing by UN officials.

"If you don't have a system, you don't have a solution. Only a system will allow ordinary people to do extraordinary things. And if ordinary people can't do extraordinary things, we have no chance to achieve the scale we need to address this problem."

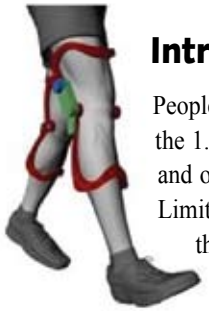
—Thomas Friedman

1. POWERING THE FUTURE–HARVESTING HUMAN MECHANICAL POWER/ THE POWER OF YOU

By Komal Patel

Strategic Summary

The human body has the capacity to generate useful amounts of energy in non-coercive, sustainable, and non-exhausting ways. Recent technology harnesses this power in ways that produce significant amounts of electricity that can power lighting and communications devices in areas of the world currently without any other reliable electricity supplies. This strategy shows that making high-tech devices that harvest human mechanical energy available to those who lack access to electricity holds enormous promise for meeting the electrical needs of individuals and families. Furthering development in rural areas by combining human energy harvesting and micro-finance techniques will increase the access to this form of electricity production.



Introduction

People living in rural areas constitute nearly 80% of the 1.6 billion people without electricity in the world, and over 50% of these are small subsidence farmers.[6] Limiting factors for energy access and production for these people include no access to a national grid, little access to credit to put in place appropriate energy infrastructure, and lack of access to affordable energy supplies. *The Human Power: Electricity from Human Action Program* proposes a creative strategy centered on some revolutionary new technology that harnesses the power of the human body.

Strategy

Decentralized methods of providing rural peoples with electricity need to be developed and implemented to improve the standard of living for rural people by providing them with a greater opportunity for communication and productivity. One method of providing decentralized power to rural populations is to make available to them new technologies that harvest energy from human mechanical power that can then be used to power radios, flashlights, lights for home illumination during the night or even to charge cell phones.

Biomechanical Energy Harvester

One of the newest technologies that captures energy from human mechanical power is a knee brace that converts power from muscles into

electrical energy while a person walks.[7] The device uses a mechanism similar to that used by hybrid cars that recharge their batteries when the brakes are applied to the car.

The knee brace, called the *Biomechanical Energy Harvester*, was developed by scientists and weighs three and a half pounds. It generates up to 13 watts of power from each leg without requiring any additional human effort: enough energy to power a cell phone for 30 minutes of talk time for every minute of walking.[8] Current estimates for the cost of the knee brace are approximately $1,000. It is estimated that with further development and mass production the price of the product will be able to be reduced to a more affordable rate that would make it a viable solution to providing electricity in rural areas.[9] Additionally, the knee-brace is easily adaptable to an everyday life style, and it would also promote healthy living, as it is a means of exercise.

Adaptations of the *Biomechanical Energy Harvester* might also be developed for cattle and other animals, thereby greatly expanding the power available to rural families.

The *Pull-Cord Generator* weighs 14 oz. and has an average power output of 30 watts

Pull-Cord Generator

Another piece of newly developed technology is the *Pull-Cord Generator* developed by Potenco Inc. The *Pull-Cord Generator* is a device that weighs 14 oz., has an average power output of 30 watts, and can produce enough energy to power a cell phone for 20 minutes of talk time, an iPod shuffle for 4 hours, or an hour of ultrabright-LED flashlight use with one minute of use.[10] The device produces energy in a similar manner to hand-crank generators, but is much more efficient, compact, and portable.

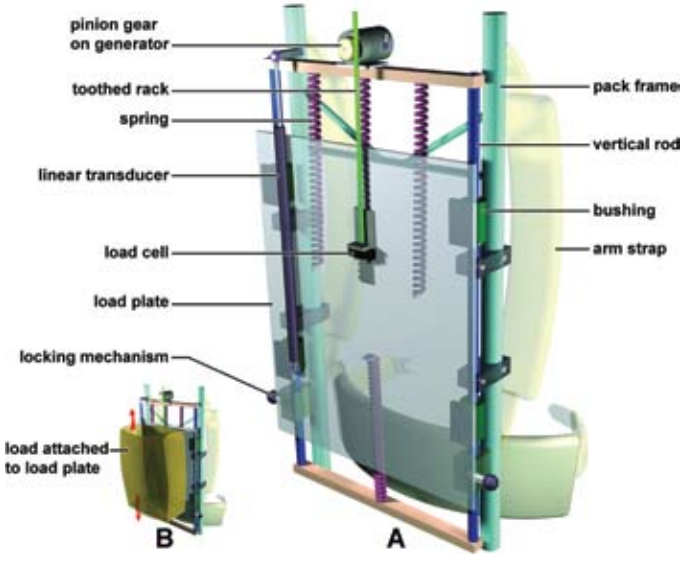
The *Pull-Cord Generator* is not yet available on the market (as of August 2008) but field research is being done by introducing the product to rural communities in parts of Bangladesh, India, Africa, and Brazil.[11] Potenco plans on partnering with the One Laptop Per Child program by providing a *Pull-Cord Generator* with each laptop so that children have a way to recharge their computers.[12]

The cost of the Pull Cord Generator is etimated to be between $3 and $5.

Suspended-Load Backpack

Another prospect for harvesting human mechanical energy is the *Suspended-Load Backpack* that generates power from the vertical oscillation of the pack that occurs while the person wearing it walks. Currently, the *Suspended-Load Backpack* requires loads between 40 and 80 pounds to generate a significant amount of energy and the marketing for these products is focused on soldiers and hikers.[13] With further development, the *Suspended-Load Backpack* could be adapted to meet the needs of women in rural communities who carry their small children on their backs. If the *Suspended-Load Backpack* could generate power with lighter weight loads and a safe carrier for children were created, rural women could produce electricity while carrying their children on their backs as they walk to perform their daily chores such as fetching firewood and water and walking to the market place.

Baby carried on mother's back at the market in Chichicastenango, Guatemala, in a traditional backpack/sling.



MicroPower MicroLoan

In order to finance a project to give people in rural parts of developing nations access to devices that harvest human mechanical energy, a micro-finance scheme similar to that of the Grameen Bank in Bangladesh could be established to work specifically with the proposed technology. The basic framework of the *MicroPower MicroLoan* institution would be that small loans would be made to individuals in rural communities so that they could purchase either a *Biomechanical Energy Harvester* or *Pull-Cord Generator*. The individual who buys the device can then start a business by renting out the device to other members in the community who may need to harvest electricity to power their cell phones or the lighting in their homes. The income earned through the rental business would then be used to pay off the loan and additional earnings are kept as profits for the individual and their family, leading to an increased standard of living and development within the community.

Human Power: Electricity from Human Action

Financial Summary

Investment needed to reach ten million families with mass produced Pull-Cord Generator per year for ten years:

COSTS

YEAR 1

Startup funding:	$10,000,000
Product (1 million units @ $5 each):	$5,000,000
Business management/delivery logistics:	$1,000,000

YEARS 2–10

Product (10 million units/year @ $3 each):	$30,000,000/year
Management/delivery logistics:	$2,000,000/year

INCOME

YEAR 1

1 million units sold @ $6.00 each:	$6,000,000

YEARS 2–10

10 million units sold @ $4.00 each:	$40,000,000/year

Measurable Positive Results

After ten years, nearly 100 million families, approximately 500 million people, will have access to electricity for small-scale lighting, communication devices and battery recharging.

Conclusion

The *Human Power: Electricity from Human Action* strategy is an economically feasible way to directly target the energy needs of reaching the Millennium Development Goals. It is a locally and globally viable strategy that is affordable and scalable. It can play an important part in reaching a future global preferred global energy system.

2. IMPROVING COOKING IN THE DEVELOPING WORLD: A BLUEPRINT FOR A NEW COTTAGE INDUSTRY

By Kit Cali, Lauren Horneffer, Bartolomeo Misana, Michael Turri

Strategic Summary

One form of energy use that directly impacts the quality of life for everyone in the world is the energy we use to cook our food. In many parts of the developing world, the use of biomaterials such as wood and dung has large negative impacts on the health of families and the environment. There are current technologies that can replace existing inefficient and dangerously polluting cook stoves while also creating local industry and employment. This strategy shows how this can be done in three phases, leading to improved health, increased productivity and sustainable economic development.

Present State

Indoor air pollution kills 1.6 million people every year, primarily in the poorer parts of the developing world. There are more deaths each year from this cause than from AIDS. Three billion people are at risk from using biomass fuels in their indoor cooking stoves. In addition, the use of inefficient biomass fuels result in massive deforestation and cost families much of their time, income and health.

Many women and girls spend hours searching for firewood—which in some parts of the world exposes them to harassment, attack, rape or murder. There is also seriously damaging denudation of trees and other vegetation cover, which can, and has, led to soil erosion and desertification. And the problem is getting more serious as more biomass is used for fuel, out stripping the environment's capacity for renewal, thereby leading to environmental destruction and longer and longer times to collect the firewood needed to cook food.

Overuse of biomass fuels for cooking also result in decreased animal grazing land; dry, dusty winds; and increased CO2 emissions.

Preferred State

The Preferred State for developing country cooking stoves is a system that provides a convenient, affordable, clean, safe and easy way of cooking food in ways that are culturally appropriate and not damaging to the environment. For this to happen, the fuel source for cooking needs to be abundant, inexpensive, and usable by an efficient technology that is affordable. In addition, the preferred state for developing country cooking systems needs to be one that helps stop and then reverse desertification, does not increase the amount of CO2 in the atmosphere nor produce indoor air pollution.

Strategy

East-African Cooking Technology[14]

One technology that meets most of the above criteria, and would be a good transition to a solution that meets all the design goals of our preferred state, is the ceramic-metal jiko stove.

At the moment, 80% of urban families in East Africa use a traditional metal "jiko" charcoal stove. In rural families, 90% use a three-stone fireplace and wood stove. It is this technology that is doing the most damage to the most people's health and the surrounding environment.

The burning of wood is used for cooking, light and heat by 96% of the families in rural Tanzania, 90% of the families in rural Uganda, and 80% of the families in rural Kenya. An improved ceramic-metal jiko stove could reach all the families in these regions (and else where). One such stove is currently in limited use. Our strategy seeks to scale up and make its use pervasive.

Improved Ceramic-Metal Jiko[15]

This stove features an intuitive design derived from the familiar metal jiko. A single pot rests directly on the stovetop.

The familiarity of the design will help insure its rapid adoption. The stove features an hourglass-shaped cladding manufactured locally from scrap metal and a perforated interior ceramic liner.

There is also a larger version—an institutional Jiko that incorporates a thin, insulating layer and a self-contained ash collection box.

Advantages of the ceramic-metal Jiko[16]

- Reduces charcoal use by 40%
- 50% more efficient
- Safer
- Affordable: domestic jiko sells for $1–$3 USD
  (Fuel cost savings pay for jiko in two to three months)
- Fosters local economic growth (It can be fabricated locally from scrap and renewable materials— the ceramic parts can be made from readily available clay)
- Decreases cooking time (Boils water faster for longer)
- Durable; Lightweight: (3kg–6kg)
- High adoption rate: there are already 150,000 current users

Health benefits of the ceramic-metal Jiko

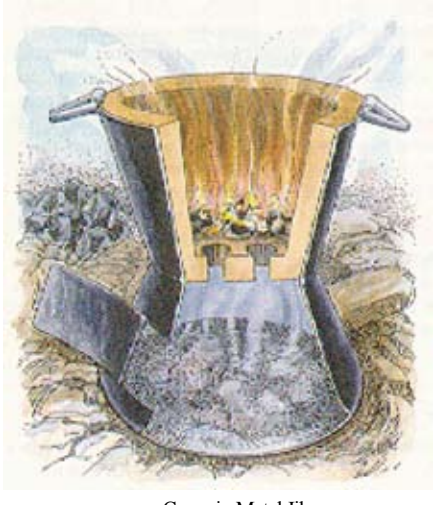
- Brings CO levels within WHO guidelines
- Substantially lowers airborne particulate matter

Environmental benefits

- Current users save 5,000 hectares of forest per year
- 100,000 tons of CO2 emissions per year averted

Traditional three-stone fireplace cooking

Ceramic Jiko

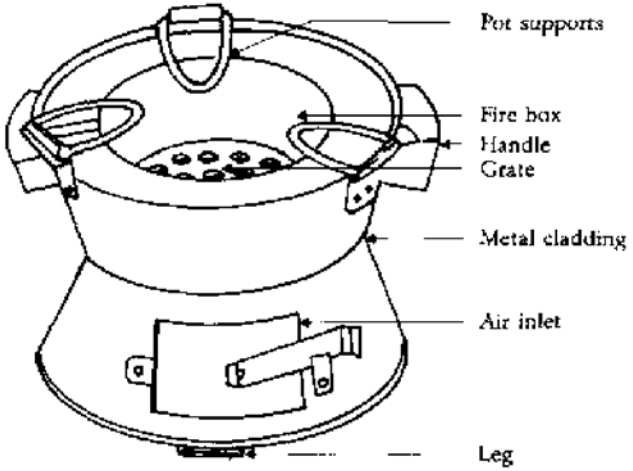


Ceramic-Metal Jiko

Old style metal Jiko

Production of Ceramic-Metal Jiko

Ceramic-Metal Jiko



Blueprint of a New Cottage Industry

There are four phases in our strategic plan for the development of a sustainable Ceramic-Metal Jiko stove cottage industry.

Phase 1: Increase Ceramic Jiko Adoption

Phase 1 introduces biomass briquettes to the target markets as a superior fuel source to the traditional use of gathered firewood. These biomass briquettes use agricultural and/or paper waste as feedstock. The resulting product is cheaper and cleaner burning. Its use will reduce deforestation.

The biomass briquettes burn 75% hotter than charcoal and are therefore more efficient and require less fuel. Two briquettes per person (250g briquette vs. 1.2kg charcoal) per day is needed to cook the average family's meals. Replacing charcoal and gathered wood with biomass briquettes will lead to the growth of a new cottage industry.

New Briquette Industry

The new cottage industry would be organized around the production of the biomass briquettes. Presses made from very simple, local parts are used for this operation. The basic fabrication process is clean and uses free or low-cost and renewable raw materials. A six-person team operates a single biomass briquette press. Such a press typically produces 750 to 1,000 briquettes per day—the amount needed to supply the daily fuel needs for 375 to 500 people.

Biomass Briquettes

Phase 2: Box-Type Solar Cooker

Phase 2 of the strategy features the introduction and widespread adoption of a box-type solar cooker. These solar cookers would supplement or replace the biomass briquette burning Ceramic-Metal Jikos when the sun was shinning. This would reduce the emissions of CO2 from the use of biomass briquettes.

The box-type solar cooker could be easily fabricated from jiko materials. It can easily reach 150°C (300°F) and so is therefore hot enough to cook any food. It is safe, and can allow unsupervised cooking, thereby allowing the food preparer to do other activities. The solar cooker requires minimal training to make it work effectively, can be used by a family or business, and can be used to pasteurize water or milk. And in combination with a Jiko stove, a family would be able to cook when the sun is not available, such as in the early morning, night, or when it is raining.

Phase 3: Scheffler Reflectors

Phase 3 of the strategy features the introduction and widespread adoption of Sheffler Reflector solar stoves. These solar powered stoves can be used indoors or out, and at times when the sun is not shining. Iron cylinders are used to store heat for night cooking.

There are a number of specialized designs of this type of stove. Most use simple materials and can be manufactured locally by a welder. They are ideal for large scale cooking such as is needed in institutions such as schools, hospitals and community center.

Phase 4: Community Solar Steam

Phase 4 of the strategy features the introduction and adoption of community solar steam plants that produce steam for electricity generation. The solar steam engine drives an electric generator that supplies the local area with electricity.

Solar steam power plant

One solar steam engine currently in use is spreading throughout India. The Indian Ministry of Non-Conventional Energy is helping this happen. The device is popular for use in rural schools.

Financing the Jiko System/Expanding/Bringing it to Scale

One way of generating the revenue needed to bring the Jiko cottage industry to scale is to generate funds by selling the Jiko stove in retail outlets in the developed world.

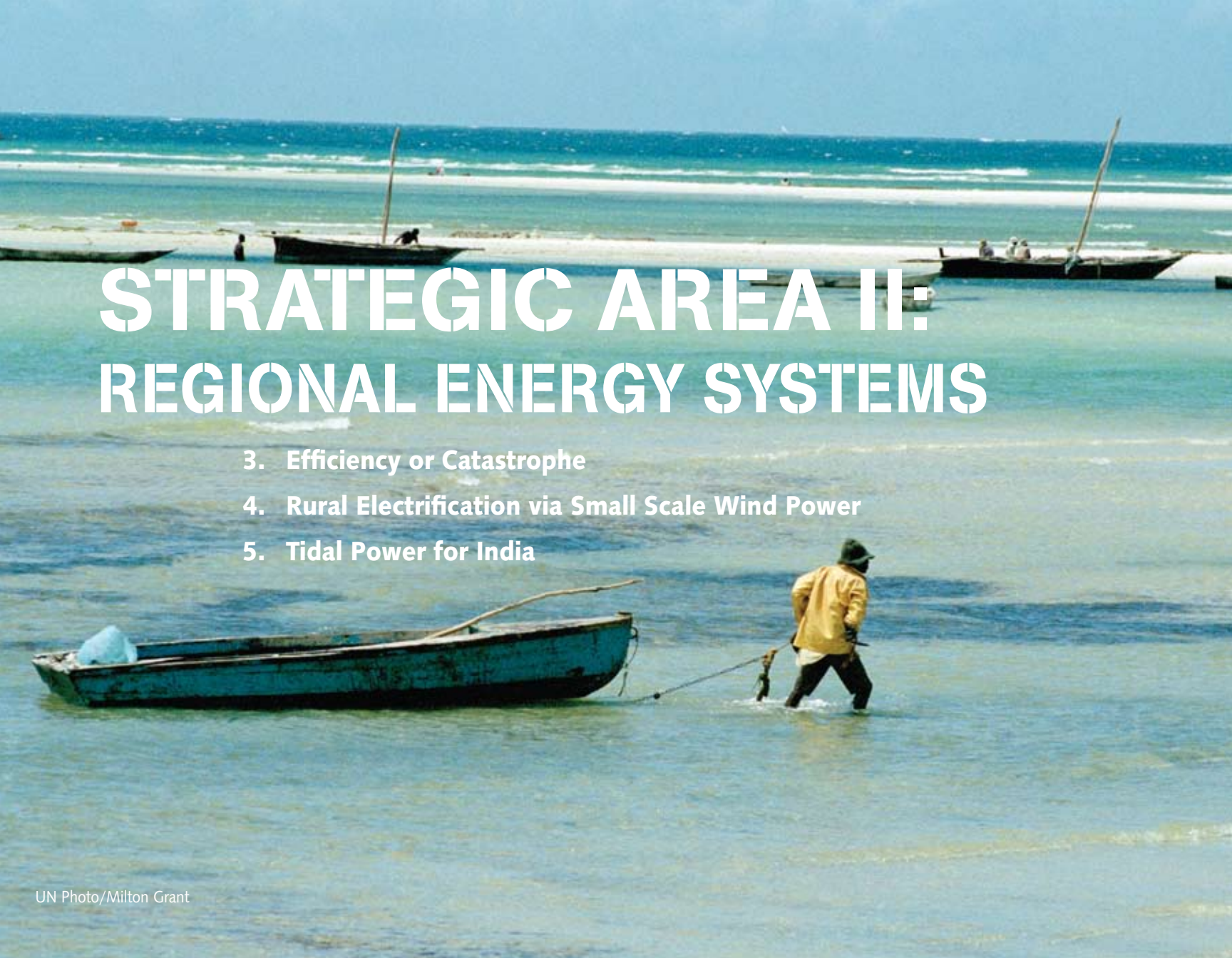
If a Jiko stove was sold for $25 in US outlets like Home Depot or Target, it could generate enough funds to bring a new Jiko stove to four families in the developing world.

$ 2.50	per jiko
$ 2.50	for shipping, packaging, etc.
$ 5.00	standard 100% profit to retailer partner
$ 15.00	tax-deductible donation
$ 25.00	TOTAL

This provides four stoves to needy families plus $5.00 to the Solar/Steam Fund

Conclusion

The *Improving Cooking in the Developing World: A Blueprint for a New Cottage Industry* strategy is an economically feasible way to directly target the energy needs of reaching the Millennium Development Goals. It is a locally and globally viable strategy that is affordable and scalable. It can play an important part in reaching a future global preferred energy system.



STRATEGIC AREA II:
REGIONAL ENERGY SYSTEMS

3. **Efficiency or Catastrophe**
4. **Rural Electrification via Small Scale Wind Power**
5. **Tidal Power for India**

UN Photo/Milton Grant

3. EFFICIENCY OR CATASTROPHE: HOW A DEVELOPED COUNTRY CAN BECOME MORE EFFICIENT WHILE DECREASING EMISSIONS

By Brittany Mixson and William W. Sheehan

Strategic Summary

Inefficient use of energy is one the primary causes of our energy and environmental problems. There are numerous policies, programs and actions that can be taken that will increase the efficiency of our energy use throughout society.

Problem State

Inefficiencies in the use of energy cause everyone to suffer. Inefficient energy use is the main cause of pollution and climate change as well as a major culprit in using up our limited supply of fossil fuels.

Increasing utility bills, driven by increasing costs and the inefficient use of energy, are driving people out of their homes.

Inefficient transportation, such as 18-wheel trailer trucks that get four miles to the gallon of diesel fuel and use 50% of their fuel solely to counteract drag forces are raising the cost of basic necessities as well as putting people out of work. Up until the present day, efficiency standards were not valued as much as the low purchase price of an item.

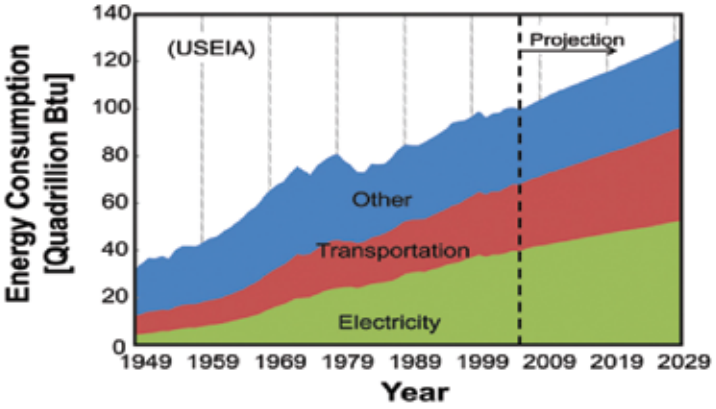
Preferred State

An ever increasing energy-use efficiency results in a cleaner, more affordable, abundant energy supply and a healthier economy.

More specifically, the energy efficiency preferred state calls for:

- motor vehicles getting at least 60 miles per gallon
- powered by non-fossil fuel energy sources such as ethanol made from non-food feed stocks and/or bio-diesel
- houses being at least twice as efficient as they are now.

U.S. Energy Consumption



Strategy for Reaching the Preferred State

Part 1
Energy Efficiency Assistance Agency and International Efficiency Standards

Part 1 of the *Efficiency or Catastrophe* strategy is to establish a global energy efficiency agency and international standards for energy efficiency.

The mission of the *Energy Efficiency Assistance Agency* (EEAA) is to educate the private and public sectors as well as individuals on energy and fuel efficiency. Part of this mission is to work with the United Nations on the establishment of *global* energy efficiency standards. These efficiency standards will be set for appliances, housing, vehicles and industrial processes.

Part 2
Green Training

Part 2 of the *Efficiency or Catastrophe* strategy is to set up *Green Training* programs all over the developed world for workers displaced by globalization. Graduates of these programs will work as retrofitters and installers of energy conserving measures for housing and businesses.

Part 3
Green Trucking and Shipping

Part 3 of the *Efficiency or Catastrophe* strategy will have the EEAA team up with the EPA and other regulatory agencies in other countries in regulating emissions and rewarding increases in the efficiency of trucking and shipping.

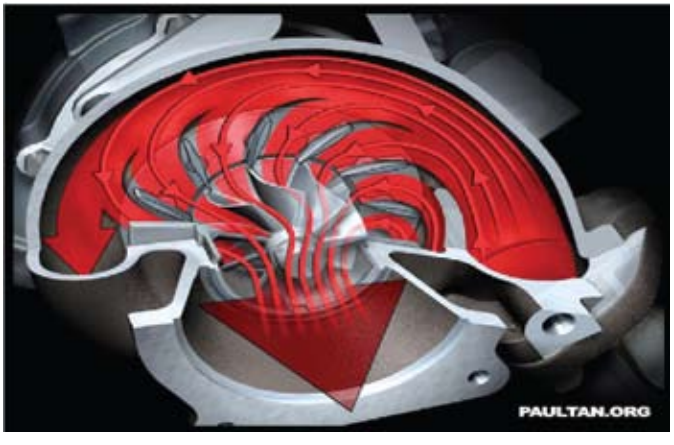
Some of the new engine efficiency technologies that will be encouraged through incentives and, where needed, penalties, are Humid-Air-Motors and Variable-Turbine-Geometry turbine add-ons. Both are turbo-charger add-ons. The former sprays an aqueous

Humid-Air-Motors

mist into the combustion engine alongside the fuel that purifies the emissions and maintains the engine. It is most effective with diesel engines, primarily those that run on bunker fuel (ship engines). The Variable-Turbine-Geometry turbine comes in the form of a turbo-charger add-on. It works with self-adjusting turbines that channel the force of the exhaust in such a way that it recycles the exhaust, increasing the efficiency of engines and reducing emissions (nitrous oxide emissions are reduced by 80%).

Another technology that will be used will increase the efficiency of trucks as it cuts down on their wind resistance. Drag resistors are easily attachable for trucks and have a payback in saved costs of less than a month.

Variable-Turbine-Geometry turbine



Truck Drag Resistors

Part 4

Green Rewards

Part 4 of the *Efficiency or Catastrophe* strategy will have the EEAA working with country based regulators to reward and/or enforce efficiency standards on residential buildings. Part of this effort will be to reward those who consume 20% less than the average amount for a house of their size and to tax those who consume more than 20% of the average. Tax funds from this operation will fund the rewards that go to energy conserving households and to finance low-interest loans for energy efficiency improvements for low-income households.

What the UN Could Do to Make this Strategy Real

To make this strategy real the United Nations needs to either add an "efficiency clause" to the Millennium Development Goals, create an additional set of Millennium Goals dealing with energy, or set up a new *Global Energy Agency.* This agency would advocate efficiency treaties and standards among world governments, develop renewable energy sources in global commons areas, and be the advocate for getting basic electricity into all the parts of the world. In addition the UN would make itself—its numerous buildings and operations—energy efficient as an organization in order to model its benefits.

4. RURAL ELECTRIFICATION VIA SMALL SCALE WIND POWER

by Angela Burcham and Daniele Seldomridge

Strategic Summary

There are over 1.6 billion people in the world without access to electricity. Hearly 80% (1 billion) of these people live in rural areas where the electric grid does not reach. Decentralized electricity production devices could make an enormous contribution in these regions. Small-scale wind generators, as outlined in the following, could meet many areas' electricity needs.

Problem State

Almost all of rural Africa does not have electricity to meet basic needs. Electricity is unavailable, and when it is available, it is unreliable and not affordable by the people who need it the most.

Preferred State

Undeveloped areas of the world will have access to clean, safe, affordable, and renewable sources of energy.

Strategy

Motorwind is a small-scale wind powered electric generator capable of powering lights, radios, mobile phones and re-chargers for numerous battery powered devices. It is lightweight, easy to use, adaptable, modular and mobile.

Very importantly, it works without being connected to the grid and its low cost makes it affordable for many areas of the world.

The *Motorwind* generator works in a minimum wind speed of 2m/s (4.47mile/hour) and can work in high wind speeds as well. It is a fairly low-tech device that can also store excess power in batteries. It is made from recycled plastics and is recyclable when its three- to five-year life span is over.

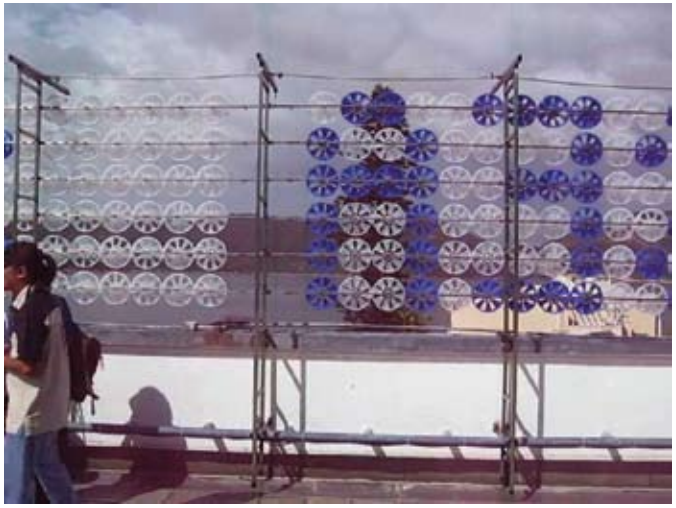
The cost for a set of eight *Motorwind* turbines is currently $150. Cost will be reduced when the units are mass-produced.

This strategy calls for the mass distribution of *Motorwind* turbines to rural areas in Africa by economic development Non-Governmental Organizations. The costs of the devices will be borne by the recipients of the power. The initial capital to purchase the devices will come from microloans. These will be paid back through the sale of electricity and the recharging of batteries to surrounding neighbors and other electricity using organizations and people.

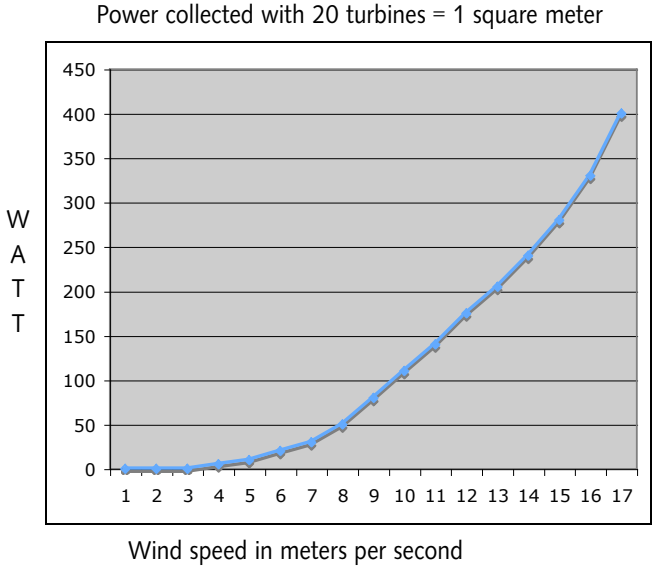
To supply a million families with basic electricity per year for ten years, so that approximately 50 million people are reached, would cost about $100 million per year.[17]

Motorwind Power Output

Wind speed m/sec.	2	3	4	5	6	7	8	9	10
Wind speed miles/hr	4.5	5.5	9	11	13.5	15.5	18	20	22
kWh w/ 8 turbines	0.4	1.3	3	6	10	17	25	36	50
kWh w/ 20 turbines	1	3.3	8	15	27	42	64	91	125

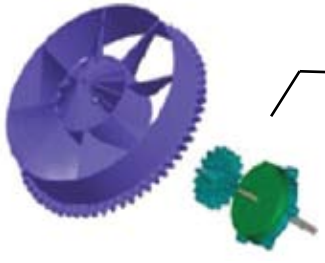


***Motorwind* Turbines in Hong Kong**



From Basic Installations to supplementing the grid:[18]

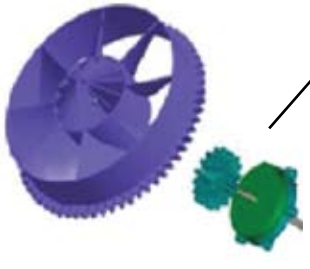
Electrical installation for basic lighting



12v halogen light

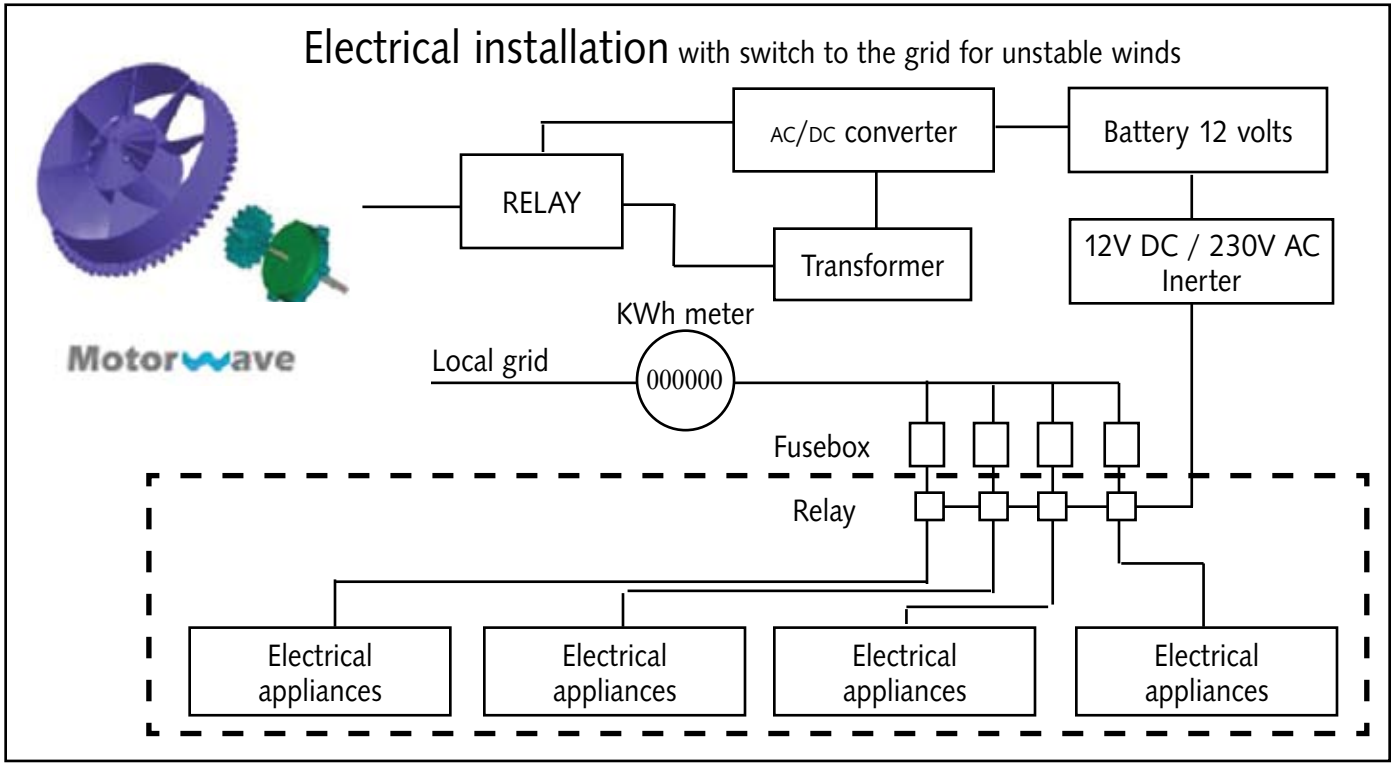
This is the most basic installation. It does not require any extra components.The light intensity will simply vary depending on the wind speed.

Electrical installation for basic lighting



AC/DC converter — Battery 12 volts — 12v halogen light

This is the second most basic installation. The light intensity will be stable regardless of wind speed.



Tanzania Case Study

In Tanzania, the average annual wind speed is 19 miles per hour. A single Microwind turbine will generate approximately 6.5 kWh/year in wind speeds of 5 meters per second (11 miles per hour). In wind speeds of 18mph, 25 kWh per year is generated. A 20 Microwind turbine installation would generate 500 kWh per year in Tanzania.[19] A million Microwind installations in Tanzania would generate 500 million kWh of electricity. This is 41% of Tanzania's total current consumption of electricity.[20] As such, this amount would have a profound impact of the availability of electricity in the country.

5. TIDAL POWER: HARNESSING AN INFINITE RESOURCE– INDIA AND BEYOND

By Emily G. Gleason

Strategic Summary

Tidal energy is a vast untapped energy source that could provide significant amounts of energy throughout the world. It can do this without increasing carbon inputs into the atmosphere. This strategy shows how developing nations, in particular India, can increase their electricity supply through tidal power.

Present State

India is growing. Its population is at 1.1 billion people,[21]and an increasing amount of resources are needed to sustain its booming population and economic growth. India's energy demand grew by 6.8% in 2007, the third largest growth after China and the United States.[22]

One of the most significant energy resources needed is electricity. So far, India has approached this problem largely through coal power. India's coal consumption grew by 6.6% in 2007, compared to the average global rise of 4.5%.[23] Thirty-eight percent of India's energy consumption is coal powered.[24] In 2007, India consumed 208 million metric tons (in oil equivalent) of coal.[25] India's overall energy demand is 404.4 million metric tons (in oil equivalent).[26] Sectors that consume the most coal in India are the industrial sector at 29.4 thousand metric tons, the commercial sector at 2.9 thousand metric tons, and the public services and residential sector at 2.7 thousand metric tons (in oil equivalent).[27]

We have known for decades that coal combustion, although inexpensive in today's current monetary accounting systems, is very expensive in other areas. For example, it is unhealthy for the environment and detrimental to human health. Every year an average coal plant generates 3.7 million tons of carbon dioxide, 10 thousand tons of sulfur dioxide, 10 thousand tons of nitrogen oxide, 720 tons of carbon monoxide, as well as significant amounts of arsenic, mercury, lead, and airborne particles.[28] These emissions have been proven to cause fatal illness such as respiratory disease and cancer. Sulfur dioxide is a

source of acid rain that degrades the environment; carbon dioxide acts as a heat-trapping gas in the atmosphere and is the major contributor to global warming.

Preferred State

A preferred state to the current energy situation in India is one where India has a clean, abundant, affordable, and reliable supply of electricity that is produced in a sustainable manner.

Strategy

Tidal power electricity generation has minimal environmental impact, unlike coal and other fossil fuel power generation. It requires no fuel, and generates no pollution. Unlike wind turbines, there is little visual impact, as the turbines are submerged under water. Unlike hydroelectric dams, tidal turbines do not alter the flow of the current, block migration paths, nor require flooding and displacement of populations on surrounding land. Some scientists even suggest that the turbines can become hubs of aquatic life as small organisms latch on the turbine attracting larger species.

Negative environmental effects are possible, such sediment stir-up in the water, possible collisions with the moving blades by fish, and also a restriction on boat movement, depending on water depth. The major disadvantage of tidal power is that the technology for harnessing it has, up to now, been only suitable for large-scale tidal sites, and there are relatively few of these in the world.

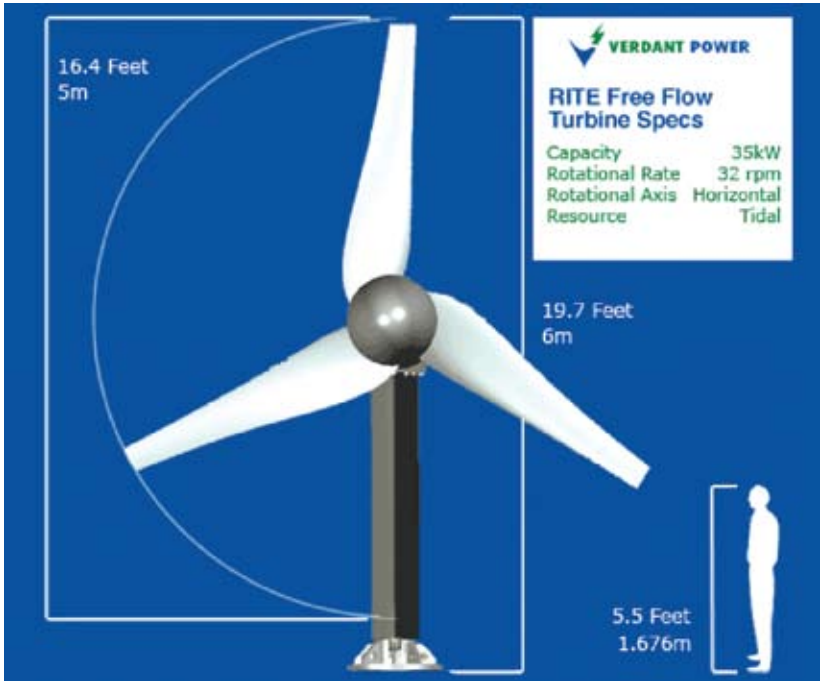
Tidal power—the energy harnessed from the in and out-flows of the currents and tides—is a old energy source. But new technology for harnessing that energy source, made possible by advances in materials, turbines, and wind power, is now available. Some of the technologies are available now, others are in the testing stages.

One new technology is a turbine that is anchored to the sea or riverbed. Blades turn with the flow of the tidal (or river) current, which then turns a generator that feeds electrical current through a cable to a grid. These new tidal power turbines are comparable to wind turbines in design and mechanics.

India Case Study

India could remedy its contributions to global climate change and

reduce health risks to its citizens by reducing reliance on coal as an electricity source. This reduction should be part of a long-term plan to completely phase out coal as a source of electricity, and replace this energy with clean and sustainable energy. Although India has invested in wind turbines and a hydroelectric dam, a vast waterpower resource is left un-tapped in its two western gulfs: the Gulf of Kutch, and the Gulf of Khambhat. Both gulfs possess large tidal ranges and offer ideal environments for tidal power deployment.[29]



At its current stage of mechanical and economic development, tidal power is ideal to power small residential areas with a relatively low electricity demand—such as in the area around the Gulfs of Kuchcch and Khambhat.

There are several tidal power prototypes that have proven successful. A New York company, Verdant Power, has six three-blade tidal power turbines currently deployed in the Manhattan East River. The project was initiated in 2006, and completed in May 2007. The turbine units are six meters tall, with blade diameters of roughly five meters. Rated at 35 kilowatts, each turbine produces 665 kilowatt-hours running nineteen hours per day. The cost to consumers is 7 cents per kilowatt-hour. The cost per *prototype* turbine unit is $4,800 per kilowatt. This high per-kilowatt amount will be lowered with mass-production of the turbines.[30]

The electricity generated by the turbines is being used to power a local grocery store, Gristede's Supermarket. The company projects that further expansion of turbines in the East River can produce up to 10 megawatts, enough to power 8,000 New York City homes.[31]

Given enough space, the number of turbines can be increased to generate far greater amounts of electricity. The deployment of 1,000 turbines would produce 243 million kilowatt hours per year. Such an installation would cost an estimated $70 to $85 million, depending on the economics of turbine mass production.

Current prices for tidal turbine units are high relative to coal fueled power plants, but this cost discrepancy is expected to come down with mass production of the turbines,

the removal of subsidies to the coal industry, and the added operating costs of coal plants when carbon emissions are figured into total costs.[32]

Government subsidies of tidal power and green energy could also help to cut costs significantly. Over all, tidal power right now costs less in the long term, as it does not require fuel with its associated monetary and environmental expenses. Coal power, like other fossil fuel power generation, faces carbon taxation that will further hinder affordability. Coal, unlike tidal power, is a finite resource with serious environmental impacts and should therefore not be relied upon and invested in for the future.

With the goal of lowering India's coal dependence, and providing electricity for a growing population and economy, a tidal power plant could be installed in the Gulf of Kuchcch and the Gulf of Khambhat, using Verdant Power Inc.'s or similar technology.

Ideally, the Verdant Power tidal turbines would utilize and train local labor in installation and maintenance of the power system. One great advantage of the Verdant tidal power system over previous tidal power systems is that it can be expanded modularly. This will allow the tidal power system to grow as need expands.

In order for this tidal power project to have the most positive and sustainable impact on the local population, and India in general, the community needs to be informed and involved from the very beginning. Besides local employment opportunities, informational "town hall" type of meetings need to be held to answer questions and describe changes and opportunities the project will bring about.

Funding for the project could be obtained in a number of ways. Private investment, or a government or foundation grant to Verdant Power, or a similar company, would reduce their risk. Assistance from the Indian government could also provide incentive and reduce risk. Private investors with an interest in green energy could also be a funding source. The NGO community could be of help working with local citizens and insuring their interests and needs were fulfilled.

Beyond India

The governments of wealthy polluting nations, such as the United States, need to assume responsibility for their current and past environmental impacts. One constructive way of doing this that helps both a country such as the US, developing countries such as India, and the rest of the world, is for the US to fund, either outright or as a subsidy, the expansion of green energy technology in developing countries.

Through economic aid to energy-short developing countries and economic incentives within the US for an expanded use of green energy, a worldwide green energy revolution is feasible.

STRATEGIC AREA III:
GLOBAL ENERGY SYSTEMS

6. Market Driven Energy Strategies
7. Global Energy Corps

Photo by Abengoa

6. MARKET DRIVEN ENERGY STRATEGIES: CONVERTING CONVENTIONAL TO SUSTAINABLE

By Karen Guwuriro and Sam Little

Strategic Summary

The global energy market is one of the most important tools for providing manageable energy solutions to communities around the world. Through the removal of subsidies to the unsustainable and carbon-intensive sectors of the energy system, market forces will be able to assist in the transformation of the world's energy system.

Present State

The current problems of the global energy system market include:

- Government subsidized energy supplies that mask the true costs of energy to the users of energy and its impacts on the environment
- Lack of incentives to invest in renewable energy
- Failure to internalize environmental and social costs in price of energy
- Unbalanced distribution and use of energy worldwide.
- Overall low efficiency and high pollution of world energy market
- Newer, more sustainable energies with higher costs are in competition with subsidized conventional energies

In summary, the current global energy system and market is centered around and held in place by artificial props in the form of monetary and other subsidies. The result is an artificially expensive, high profit for the few inefficient, polluting, non-sustainable industries that do not meet the energy needs of the world.

Preferred State

A global energy system and market that would be preferable to the current system is one that:

- Met the needs of 100% of humanity
- Systematically reduced emissions and pollution and increased efficiency of energy generation, delivery and use
- Provided affordable energy for everyone from metropolitan areas to developing rural areas
- Was based on sustainable, renewable, clean and affordable energy sources

Strategy

Globalizing Renewable Potential: Part 1

Markets tend to make better decisions the more informed they are. To make the transition from conventional carbon-intensive energy systems to sustainable, cleaner energy systems, the global energy market place will need some adjustments that, minimally, level the playing field so that renewable energy sources can compete.

Step 1: Subsidy Eradication

Step 1 in this process is to begin the phase-out of all subsidies to carbon-intensive energy systems. Currently these worldwide subsidies are $250–$300 billion for conventional energy sources. World coal receives $63 billion.[33] Subsidies are provided to large energy companies for producing energy, and they are given by governments to promote the consumption of energy. Table 1 provides a glimpse of the positive impacts that could occur if these subsidies were removed.

We propose that this subsidy removal be done over a five-year period, with a 10% reduction immediately, a 25% reduction in year two, a 25% reduction in year three, a 25% reduction in year four and a 15% reduction in year five.

Table 1 Impact of the removal of energy consumption subsidies

Country	Average rate of subsidy (% of market price)	Annual economic efficiency gain (% of GDP)	Reduction in energy consumption (%)	Reduction in CO_2 emissions
China	10.9	0.4	9.4	13.4
Russia	32.5	1.5	18.0	17.1
India	14.2	0.3	7.2	14.1
Indonesia	27.5	0.2	7.1	11.0
Iran	80.4	2.2	47.5	49.4
South Africa	6.4	0.1	6.3	8.1
Venezuela	57.6	1.2	24.9	26.1
Kazakhstan	18.2	1.0	19.2	22.8
Total Sample	21.1	0.7	12.8	16.0
Total World	n.a.	n.a.	3.5	4.6

Step 2: Global Inventory and Assessment

Step 2 calls for a global inventory and assessment of best practices in the efficient use of energy in the industrial sector. Incentives for corporations to reduce their energy consumption by half or more will be set in place.

Step 3: Global Efficiency Standards

Step 3 will set up high efficiency standards for all energy-consuming appliances, buildings and vehicles—and establish incentives and penalties for achieving these standards in ten years.

The *United Nations Framework Convention on Climate Change Technology Subprogramme* is a clearinghouse on technology transfer. We propose that an expansion of this system be used in the greening revolution needed to make the transition to a clean global energy system.

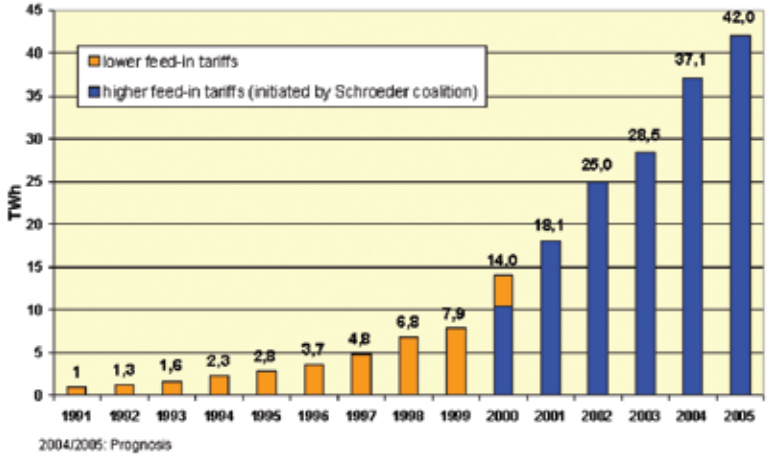
This UN program seeks to improve the flow of, access to, and quality of the information re-

lating to the development and transfer of environmentally sound technologies.[34] By expanding and focusing it on green technologies, and specifically renewable energy harnessing and efficiency technologies, the market will be able to have access to reliable energy-related information.

Energy Assessments

Another part of the strategy is for development banks to offer voluntary energy saving assessments for all energy-intensive industrial sectors. For example, the European Bank for Reconstruction and Development (EBRD) instituted a system of "Polluter Pays" —a system that charges pollution emitters according to the cost of cleaning up their pollution, and that also provides compensation to non-emitters.

Chart 2 Development of the feed-in of renewables to the power grid in Germany



Fixed Feed-in Tariffs

Another tactic is the "Fixed Feed-in Tariffs" (FITs) that have been widely adopted in Europe. These have proved extremely successful in expanding wind energy in Germany, Spain, and Denmark. A feed-in tariff promotes renewable energy technologies that are not currently cost-competitive with subsidized fossil fuels. It does this by requiring electric companies to buy electricity that is produced from renewable energy producers at fixed prices over a fixed time period. This purchase price is fixed by estimating the cost of production or by paying a premium over the cost of subsidized fossil fuel electricity production. The additional costs of this electricity from renewable energy sources are passed on to the consumer in the form of higher end-user prices.[35] Chart 2 documents the results of this strategy in Germany.

Germany gets more than 12% of its total electric energy from renewable power at a cost of about $2.20 per month per home.

Globalizing Renewable Potential: Part 2

Renewable Targets

Establishing legally binding targets for renewable energy in large energy consuming countries will help undo the harm of decades-long subsidies to fossil fuel consumption. Using the EU's "Renewable Energy Roadmap" as a guideline, every country will establish similar binding targets for renewable energy.

The EU targets are:

- Renewable sources make up 12% of energy use by 2010
- Renewable sources to provide 21% of all electricity consumed by 2010
- Biofuels used in transport to reach 5.75% by 2010
- Electricity production from renewable sources will increase from the current 15% (in Europe) to approximately 34% of overall electricity consumption in 2020.

7. THE GLOBAL ENERGY CORPS

By Robert Fink

Strategic Summary

A Global Energy Corps will be formed. It will be open to anyone from any country willing to make an 18- to 24-month commitment. Its mission will be to train members to be skilled green workers that can go into any part of the world and install renewable energy harnessing technology.

Problem State

Affordable or clean energy supplies are not accessible by 100% of humanity. There is widespread inefficient consumption of energy resources. There are high emissions of CO2 and other by-products of inefficient energy use. There is a lack of skilled workers able to install green technology and there is a lack of overall global communication and effective coordination among nation states concerning the global energy system.

Preferred State

One hundred percent of humanity has access to affordable, clean and abundant energy resources and these resources are used efficiently. As renewable energy is developed and fossil fuels are phased out, employment opportunities are made available to millions of people worldwide.

Strategy

A "Global Energy Corps" is set up with funds from governments, foundations, and investors. Continuing funding will come from an extremely small (0.001%) tax on all energy resource company's profits. In 2007 such a tax would yield over $80 million.[36]

The Corps recruits members who are then trained in reducing energy consumption through efficiency as well as in the installation of solar, wind, hydro, geothermal, and other renewable energy harnessing technology. These projects will be funded by the country where the projects are located and that benefits from the projects. If the country(s) does not have the financial capability to fund the project the Global Energy Corps will provide a loan. This loan will be paid back from revenue provided by the new energy installation.

The Global Energy Corps is simultaneously organized around different regions of the world and different energy sources. Solar workers would be in touch with all other solar workers around the world—while "African solar workers" would be in touch with all other workers in Africa.

Summary Conclusions

The strategies described in this report outline a series of policies, programs, and action plans that, if implemented, would help meet various Millennium Development Goals of the United Nations as well as move the world, in the years beyond 2015, to even higher levels of human well-being.

Taken individually, each strategy can stand alone in making a significant contribution to improving some aspect of the human condition. Taken collectively, the strategies are more than the sum of their parts. They would, if implemented together, have a profound impact on our collective wealth, health, and potential.

The global and local strategies described help illustrate the creativity, values, vision, and commitment of the youth and concerned citizens of the world. They also represent what an interdisciplinary, multigenerational group of non-experts can do when provided an opportunity and methodology for tackling the critical and complex problems facing the world.

Your feedback is most welcome—as is your ongoing participation in this evolving work. One way to do this is to send us your comments and suggestions by emailing us at info@designsciencelab.com.

As indicated at the beginning of this document, this is the fourth year of the Design Science Lab. Those wishing to take part in coming Labs are urged to contact BigPictureSmallWorld at www.bigpicturesmallworld.com, or check in at www.designsciencelab.com

2008 Design Science Lab participants share their findings at the United Nations.

ENDNOTES

1 For more information on Design Science, see the Design Science Lab website at http://www.designsciencelab.com.
2 For more information on the Millennium Development Goals, see http://www.un.org/millenniumgoals/
3 For more information on these organizations, see http://www.bigpicturesmallworld.com; and http://www.gem-ngo.org/.
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10 http://www.potenco.com/whats-new/
11 http://www.potenco.com/products.html
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Gulf of Kutch Tidal Range http://books.google.com/books?id=hUkFUPp9pWoC&pg=PA6&lpg=PA6&dq=tidal+range+arabian+sea&source=web&ots=
30 New York Tidal Project http://www.reuk.co.uk/New-York-Tidal-Power-Project.htm
31 Verdant Power Inc. “The RITE Project”. 2008. [29 August 2008] <http://www.verdantpower.com/what-initiative>.
32 Coal power plants produce electricity for about 5¢ to 8¢ per kWh. This cost will go up considerably when carbon has a cost associated with it and coal plants have to pay for dumping it into the atmosphere.
33 “Reforming Energy Subsidies: An Explanatory Summary of the Issues and Challenges in Removing or Modifying Subsidies on Energy That Undermine the Pursuit of Sustainable Development” UN
34 http://ttclear.unfccc.int/ttclear/jsp/index.jsp
35 “How Have Feed in Tariffs Affected Renewable Energy Production in Germany?” http://www.colby.edu/personal/t/thtieten/Nair.htm
36 In 2007 Exxon/Mobil reported that it beat its own record for the highest profits ever recorded by any company, with net income rising 3 percent, to $40.6 billion in 2007. If the Global Energy Corps taxed just the top ten petroleum refining corporations .001% of their profits, the Global Energy Corps would receive $84,361,000 to fund its global renewable energy job training projects. http://www.nytimes.com/2008/02/02/business/02oil.html

"How do we make the world work for 100% of humanity, in the shortest possible time, through spontaneous cooperation, without ecological offense or disadvantage to anyone?"

—R. Buckminster Fuller

A Report on the work of the Summer 2008 Design Science Lab
held at the United Nations, New York, NY,
and Chestnut Hill College, Philadelphia, PA,
USA