ICT Solutions for Energy Efficiency

Richard Youngman

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Introduction and Key Takeaways

The context and purpose of the report

In 2009, the World Bank Group (WBG) issued the *World Development Report 2010: Development and Climate Change* (WDR10)[1], in which the world was challenged to "act now, act together, and act differently" to confront climate change impacts.

Acting now concerned the demand for urgent actions, to avoid options narrowing and costs increasing, in a scenario where the world commits itself to high-carbon pathways and largely irreversible warming trajectories.

Acting differently argued the case that business as usual will not work, if increased demands on natural resources for food, bioenergy, hydropower, and ecosystem services were to be met while at the same time conserving biodiversity and maintaining carbon stocks in land and forests. Acting differently quite simply means that the world's energy systems must be transformed so that global emissions drop 50 to 80 percent; infrastructure must be built to withstand new extremes; and 3 billion more people need to be fed without further threatening already stressed ecosystems, meaning agricultural productivity and efficiency of water use must improve.

Acting together is seen as key to keeping the costs down and effectively tackling both adaptation and mitigation. It argued that high-income countries would need to lead and to take aggressive action to reduce their own emissions. That would free some "pollution space" for developing countries, but more importantly, it would stimulate innovation and the demand for new technologies so they can be rapidly scaled up.

This latter point is the key link to this report. The purpose of this report is to explore the transformative role Information and Communication Technologies (ICT) can play in acting now, together and differently. ICT has played a significant role in the last decades of improving economic productivity. It now has the opportunity to enable us to make further significant productivity improvements, helping us transform the world to a more sustainable, lower carbon and more resource-efficient future.

The report is illustrative, not comprehensive. It is focused on showing a wide range and variety of ways in which ICT solutions could play a transformative role, and so the bulk of the report provides case studies of actual examples of ICT solutions already developed and in action to enable energy efficiency in three particular areas – namely, smart logistics, smart grid/smart metering, and smart buildings.

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[1] The World Bank, September 2009, *The World Development Report 2010: Development and Climate Change*

Ultimately, in line with the WBG's charter, this study is concerned with the question of how ICT can play a transformative role in developing countries' climate-smart future. However, as the World Development Report 2010 recognized, this is bound to start in higher-income countries, who have the incentives (being high-energy and high-cost users), the technical know-how and the resources to innovate and implement pioneering solutions to cut their costs and their carbon emissions. Some such solutions will have applicability to the developing world; a minority rightaway, more year by year as technology is proven and efficiencies of scale kick in.

For these reasons, the majority of case studies in this report are drawn from the developed world. They have been chosen purely to illustrate a variety of ways in which ICT can play a role in acting differently, in bringing forward new offerings, approaches and business models. They have been chosen to stimulate thinking, not to pass comment on any one solution over another, any one solution provider over another.

The report concludes with some thoughts, drawn out of these case studies, on the trajectory of ICT in energy efficiency in the world generally, but especially within the focus areas of logistics, the grid and buildings, and on what these case studies might mean for developing countries and their priorities in terms of energy efficiency.

Here are the key takeaways of the report.

Key Takeaways

- Energy efficiency is a huge opportunity for both the developed and developing world, and ICT will be the key enabler in a huge variety of ways across the full range of industries.
- Solutions and applications are still in their infancy and are more commonly found in the developed world. Data and long track records on successfully- implemented projects are not in plentiful supply. Especially at scale.
- Distinctions between what can be done today versus what is years away is important for making progress in the 2010s.
- The ability to technologically innovate will be less of a barrier to progress than the development of financing models and policy and standard frameworks so these ICT solutions can be integrated and invested into at scale. This applies to both the developed and the developing world.
- Innovative ICT will not provide a barrier to progress. Business and finance models that are adaptable to different situations, different building codes, electricity grid networks, different inefficiencies and challenges, and that can offer a multitude of stakeholders benefits are far more the challenge.
- ICT is beginning to play a significant role in efficiency by providing automation and communication technologies for appliances and the electric grid. But the low-hanging fruit for ICT is simply providing customers with information and insight into behaviors and decisions that increase energy and fuel

consumption. Successful energy efficiency schemes will focus on such cost-saving techniques when financing is a challenge.

ICT in the low carbon world

The world is using more and more energy, as its population continues to increase and the general rise in average living standards continues. To continue living our lives as we do, we need to make more efficient use of our natural resources. The application of Information and Communication Technologies (ICTs) can make it possible.

ICT sector itself is a huge consumer of energy, so innovations within its own equipment and processes can make a significant contribution to a lower carbon world.

The use of ICT applications for activities and practices and products that tend towards dematerialisation can provide energy savings through increased energy efficiency and reduction in the consumption of other resources (e.g. paper, CD material). Examples might include e-government (focus on e-health and e-taxation), audio/video conferencing, e-work, and the dematerialisation of materials and services (including e-ticketing, mobile ticketing, e-banking, e-invoicing, e-books, etc.).

However it is the use of ICT in other areas that are the game-changers for a low carbon world, that speak to an 'act differently' mantra. Take buildings alone which in the developed world are responsible for close to 50% of energy consumption, large percentages of which is being wasted.

This report sets out to illustrate examples of how ICT can help the development of a more energy-efficient and lower carbon world. It does so by focusing on the following three areas - smart logistics, smart grid/smart metering, and smart buildings.

ICT solutions: in action

We hear much talk, read many studies of how ICT can make a big impact on energy efficiency but it only truly comes alive when we look at actual examples.

These examples have been chosen not only to illustrate ICT in action, but also to show the variety of solutions. They are grouped around our three themes. The three themes are each introduced to give context to why the case studies have been chosen. The case studies are formed around projects undertaken by companies with innovative technologies. These companies have been chosen to illustrate the point; in no way, should my choosing them for case studies be seen as constituting the provision of any kind of recommendation or validation of these companies.

Smart Buildings: an introduction

Buildings represent nearly 40% of primary energy used on average globally, and between 25% and 40% of energy demand in OECD countries[2]. Including the energy consumed in building construction, this number grows to more than 50% and is rising fast thanks to economic development and a construction boom in countries like China and India.[3]

The Intergovernmental Panel on Climate Change (IPCC) has estimated that CO2 emissions from building energy use could be reduced by 29% by 2020 at no net cost.[4] Other studies have indicated that demand reduction measures could almost halve the expected growth in global electricity demand.

The U.S. market alone for energy efficiency in buildings is approximately $236 billion annually, and is expected to triple by 2030[5]. About $6 billion of that is due to revenues of energy-service companies, or ESCOs, which contract with property owners to finance and deploy energy efficiency upgrades to a building, ultimately being paid over the next seven to 10 years. Its revenue is directly linked to energy savings. The U.S. Environmental Protection Agency estimates that the ESCO industry has experienced on average a 20% annual growth rate since 1990.[6]

ESCOs are also seen as key to energy efficiency upgrades in developing countries because they remove the barrier of the high upfront cost. The Asia Development Bank (ADB) reports that ESCOs in many countries in Asia and South America are seeing double digit growth year-on-year, with India's ESCO sector reporting a compound annual growth rate of 95.6% from 2003 to 2007. The entire energy efficiency sector has been sized at about $12 billion in India, with $2 billion linked to efficiency in buildings. ADB estimates the ESCO market in India at $800 million,[7] while Brazil's ESCO companies produced annual revenues of $344 million in 2008, and China reported $121 million in 2006.

The four measures that can have the biggest impact on the energy efficiency of buildings are: insulation; heating, ventilation and cooling (HVAC); appliances (including lighting); and behavior of occupants[8]. Energy efficient roofs and walls can prevent air leakage, reducing the

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[2] http://aceee.org/pubs/e083.pdf?CFID=1664432&CFTOKEN=20896320
[3] http://www.med-enec.com/docs/EE-in-buildings-in-China.pdf
[4] http://www.pewclimate.org/docUploads/EEBSummaryReportFINAL.pdf
[5] http://www.nrdc.org/energy/sunlocking.pdf
[6] http://www.energystar.gov/ia/partners/spp_res/Introduction_to_Performance_Contracting.pdf
[7] http://pdf.wri.org/powering_up_full_report.pdf
[8] http://hmccc.s3.amazonaws.com/docs/Element%20Energy_final_efficiency_buildings.pdf

load of HVAC systems by as much as 50%[9]. Building automation systems aim to optimize efficiency in HVAC and appliances, while enabling occupants to have more direct impact on energy use. These systems rely on information and communications technology as the network backbone, as well as for two-way communication of data that impacts energy distribution with buildings. The case studies have been chosen to illustrate.

German company **EnOcean** uses energy-harvesting sensors and communications systems to help improve energy efficiency—all without wiring or a dedicated power supply.

One of the simplest energy efficiency upgrades is lighting, which accounts for 25% of energy use in commercial buildings in the U.S. but 60% in India. Not only are the majority of the world's lights highly inefficient, information and communications technology is enabling a new wave of control systems that can optimize today's lightbulbs. ICT provides the backbone for lighting control systems that allow central command of all a facility's light source over a network, such as the system described in the case study for **Adura Technologies**. Advanced systems like Adura's can also be used to automatically control lighting levels based off information relayed by sensors measuring occupancy and natural light. Simpler, LED-based solutions, as illustrated in the study of **MIC Electronics,** shows the massive potential for the developing world.

Also on the lighting theme, Israel's **Metrolight** has developed a lighting control system that improves the efficiency of high-intensity discharge lighting with extremely efficient ballasts fitted with communications technology to enable central software control.

Smart Buildings: the case studies

Example 1

Turnkey lighting management systems based on a low power wireless mesh networking system

Description of the ICT technology deployed

There is a rapidly growing market for building efficiency retrofits driven by not only straightforward cost savings opportunities, but also in some cases by governmental incentives.

Adura Technologies' system has been chosen to illustrate projects that are taking advantage.

The Adura LightPoint system consists of controllers attached to lighting fixtures connected to ZigBee compliant radio-enabled communication and networking capabilities. The network feeds data to a central system where an administrator can control and monitor the power consumption

[9] http://aceee.org/pubs/e083.pdf?CFID=1664432&CFTOKEN=20896320

of the entire lighting system. Each lighting element can be adjusted independently allowing for granular control of the system.

Software administration can also be tied into motion sensors, access controls, and light sensors to compensate for natural light, occupancy control, and other changes to the building environment. Because the system is wireless, it significantly reduces the cost of installation avoiding the need for rewiring or structural penetration.

Detailed description of projects

Webcor Concrete: Webcor Concrete's facility in Hayward, California, like many commercial office facilities, has a large open plan area occupied by a mix of project and administrative personnel. The occupancy pattern of the 2,300 ft^2 open plan area is very dynamic; several employees occupy this office for parts of the week, other employees work off-site during the day leaving many workspace areas vacant. The result of this employee occupancy pattern was that the lights in the open plan area were always on, burning kilowatts for unoccupied spaces. This application required a control system that could respond on a personal level to variations in occupancy and personal preference. The overhead lighting was originally installed with line-voltage wall switch control. The fixtures were installed with two ballasts each for bi-level control (one inboard lamp, two outboard lamps), but because the wall switches controlled the entire open plan area, this functionality was rarely used. As a result, the lighting in the open plan area was left on at full brightness from the 6 a.m. opening until 11 p.m. (Mon-Fri) when the cleaning crew departed. Webcor Concrete's facilities maintenance staff was trained to install the wireless relay without any additional ballasts, control wiring or power wiring. Multiple zones were created within existing lighting circuits without any additional power wiring or control wiring. The wireless relay controllers were installed in each fixture, so that controls could be assigned to a single light fixture and/or a group of light fixtures. Personal wireless remotes were given to each cubicle occupant so that they could control their own overhead lighting. Each wireless relay controller has two relays, enabling the light level to be controlled in increments of 0% - 33% -66% - 100%. At Webcor Concrete, this meant that the lighting over each occupant's workspace was either off or at low power by default until they arrived to set their own personal lighting level, thereby saving energy.

University of California, Santa Barbara: A demonstration project was conducted at the University of California, Santa Barbara, on the second level of Lot 18 parking structure. The structure previously used 150 W (170 W system wattage) high pressure sodium canopy luminaires. All luminaires operated 24 hours a day, 365 days a year. The cost of electricity was $0.128 per kWh. The goal of this retrofit project was to demonstrate cost-effective perimeter daylighting. Due to existing circuit configurations, a traditional wired photosensor that controls all circuits serving the daylighting zone would extinguish too many interior garage luminaires. This control scenario would potentially create dark interior conditions with light levels below standards. To avoid costly rewiring, and demonstrate a cost-effective solution that achieved project goals, the demonstration team replaced ten perimeter HPS luminaires with

deck-mounted bi-level induction fixtures equipped with wireless daylighting systems. The new fixtures used were 70 W induction step-dimming garage luminaires.

University of California-Berkeley – 2 libraries: Previously, the lights were on 24/7 in both facilities. In the Moffitt Library, the system allows the lighting to be scheduled according to the nuances of an academic schedule—allowing different hours for exam periods, holidays, and recess—through a web interface. The retrofit allowed facility managers to control their lights with a customizable scheduling application that is accessible via a web portal while also allowing local overrides for the cleaning crew. The system also allows the control of any number of luminaires in a circuit run, from a single fixture to the entire circuit. In the Doe Library, the system turns off the fluorescent lights during the day when daylight is provided by a series of skylights.

Cost-benefits analysis

Use of a wireless system significantly reduces the cost of installation avoiding the need for rewiring or structural penetration.

Webcor Concrete's facility saw the daily lighting energy use in the controlled areas decline from 50 kWh to 17 kWh per day, saving approximately $0.15/kWh. The project resulted in a more-than 65% reduction of energy used by lighting, estimated at savings of $1,300 per year. The project cost of $5,500 had a payback of 4.2 years without rebates or tax incentives.

The University of California-Santa Barbara's retrofit reduced energy demand by 900 W and produced annual energy savings of 12,790 kWh. This translates to annual energy savings of about $1,637 and a simple payback period of six years on the project cost of $9,890. Of the energy savings, 7,884 kWh (or $1,009.15) annually was attributable to the luminaire retrofit. The energy savings from daylighting were 1,815 kWh annually, or $232, while the energy savings from occupancy sensing was 3,091 kWh annually, or $396.

At the University of California-Berkeley, the two library projects were installed for $28,000. The installation is expected to cut annual electricity use by a combined 170 megawatt-hours (MWh), paying for itself in less than a year.

Example 2

Autonomously-powered, energy harvesting sensors and communication systems for use in building automation systems

Description of the ICT technology deployed

Widespread use of energy-harvesting sensors is still fairly limited, but is expected to grow. A number of companies are developing technology to address demand for these sensors in commercial and industrial buildings. This example focuses on projects done by a German company called EnOcean.

EnOcean manufactures and markets energy harvesting technology, sensors, and RF (radio frequency) communication systems. Common applications for EnOcean components include wireless switches, sensors, actuators, controllers, gateways, and integrated building management systems. Its products are based on a combination of miniaturized energy converters, ultra-low-power electronic circuitry, and reliable wireless links. Its devices use ambient energy, avoiding the need for batteries or other sources of power, and are capable of transmitting signals up to 300 meters.

Its battery free sensors and communication platform operates as a single solution for building and home automation, lighting, industrial, automated meter reading and environmental applications.

Detailed description of projects

Here are a few examples of applications where this kind of ICT technology is in action:

BSC Computer GmbH headquarters, Allendorf, Germany: BSC Computer chose to automate its corporate headquarters in Allendorf, north Hesse. The solution included window handles based on EnOcean wireless. The status of all sensors is visualized by BSC BoSe software on a touch panel and by a client at each workstation. BSC BoSe is also able to control all other devices, for example lights, the entire data processing installation and other loads such as coffee makers or copiers. Putting the controller PC on the internet means that all functions can be queried and controlled remotely, by SMS or e-mail. BSC BoSeMobile, a client for conventional mobile phones, enables all supervisory and controlling functions to be performed from a cellphone. Also connected to the BoSe system are IP cameras that transmit single shots and live video streams by UMTS/GPRS. Access to the system requires authorization, and is protected by a key. Lighting, heating and ventilation are governed by a step 7 controller, connected to EnOcean components. Building automation is linked on a BSC BAP (IP gateway) to the S7. These components and the alarm system are controlled by the BSC software. The use of an air/heat pump with appropriate insulation together with the new controller cut energy costs in the corporate building of BSC by about 80%. The investment of €35,000 is estimated to have a payback of four years.

Hotel Kempinski, Dubai, UAE: The five-star Kempinski Hotel in Ajman wanted to retrofit its entrance and bar area. The upgrades desired were a new, comfortable and energy-efficient lighting system and interior automation. The hotel installed solar-powered lux sensors and a remote control – for automatic operation and facility management – based on EnOcean technology, as well as a control system for dimmers. The existing fittings were replaced by new fittings with a more efficient aluminum reflector and provided with electronic control for a compact fluorescent lamp that enabled the wattage in the lobby to be reduced from 80 W to 18 W with an increase in light output. Furthermore, to increase energy efficiency, a combination of lux sensor field devices was introduced, enabled by batteryless and wireless EnOcean communications with centralized phase-dimming controls of the existing lighting circuits for the halogen areas.

Retirement home, Bilbao, Spain: EnOcean technology was used to reduce energy consumption and control the operating costs in a retirement home in the Spanish city of Bilbao. Next to hospitals, senior and nursing homes rank among the public buildings with the highest power consumption because of constant occupancy of the rooms, higher indoor temperatures than in a private household, and special health requirements of course. To keep proper tabs on their energy and operating costs, the realty developers of a retirement home in the north-Spanish city of Bilbao decided on the assistance of EnOcean's wireless technology. This works entirely without batteries, making it fully service-free and repositioned at any time without building work. EnOcean-enabled products were installed in all 24 rooms of the retirement home: solar-powered presence detectors, window contacts, temperature controllers and EnOcean/LON gateways. The presence sensors ensured that lighting is controlled to match the occupancy, while wireless window contacts ensure that heating or air-conditioning are turned off as soon as a window is opened. The air temperature in a number of rooms, bathrooms for instance, is controlled separately according to specified times and temperatures by a thermostat.

Olympic Village, Whistler, Canada: The development was designed to have a flexible floor plan to accommodate a variety of uses without the expense of retrofits. Whistler was the host mountain resort of the Vancouver2010 Winter Olympic and Paralympic Games. Cheakamus Crossing, a residential community located in Whistler, reconfigured its walls to accommodate the athletes by converting living areas into bedrooms for the athletes, but afterwards the residences reverted to their original designs. Unexpected challenges surfaced when the installed wireless lighting controls failed to function properly—light switches in one unit were turning the lights on and off in neighboring town homes because there were too few channels available. Traditional wired solutions were estimated to cost $75,000 ($1,000 for each of the 75 units). The installers then found Echoflex Solutions, which would save 70% of the installation cost by integrating EnOcean-enabled controls. The development installed 75 self-powered light switches and 75 relay receivers, with unique IDs provided by EnOcean to correct the misplaced transmission issue. In addition, it was estimated that the use of EnOcean technology would save money when it came to restoring the townhomes after the Olympics were over because the remodelers will be able to remove and re-mount the switches without having to worry about any wiring.

Cost-benefits analysis

This type of technology offers two forms of cost saving: reduced energy consumption, and cheaper installation than wired devices. At the BSC Computer headquarters in, Allendorf, Germany, the €35,000 investment in energy efficiency upgrades is estimated to have a payback of four years. At the Olympic Village in Whistler, Canada, use of wireless-enabled controls reduced the cost for installing 75 light switches by 70% compared to traditional wired devices, a savings of $52,000.

Example 3

Smart ballast control for high intensity discharge lighting

Description of the ICT technology deployed

HID lighting (high intensity discharge lighting) is used to illuminate large spaces such as big-box retail stores, factories, and freeways. HID lighting constitutes 22% of electricity used for lighting applications in the U.S.

While HID may be challenged in the years ahead by LED and other lighting advances, it represents a significant installed base of the world's current systems. Retrofitting these systems to lengthen life and improve energy efficiency is therefore highly attractive.

Israeli firm Metrolight has developed such a solution, consisting of a sophisticated electronic ballast with an integrated communication interface. Utilizing a central software control, the system monitors the lamp and ballast status, defines schedules for dimming, and can switch lamps on and off. The product allows for analog as well as digital dimming. The company's products range from 20w to 1000w and have compact form factors to provide for integration into systems.

Detailed description of projects

Changi Prison Complex, Singapore, correctional facility case study: The original Changi Prison was constructed in 1936 as a civilian prison. In 2000, the prison was demolished and the redevelopment of the Changi Prison Complex (CPC) project began. The complex has the capacity to accommodate 23,000 inmates. The main lighting requirements for the streets and fence area of the new cluster at Changi Prison included reduced maintenance, lighting control and energy saving capabilities. The prison installed Metrolight's 250w SmartHID electronic ballast, together with a lighting control and monitoring system. The lighting control system using photocells, cameras, sensors and motion detectors was operated by one central monitoring station that communicated with the individual lamps through an Ethernet system. The lamps were programmed to operate at 40% dimming, except when incidents such as fence tampering occurred and the lights automatically increased to full power.

bauMax DIY retail store case study: Baumax AG is one of the leading and fastest growing DIY chains in the Central Eastern European region, with 130 stores in Austria and Central Eastern Europe. Several years ago bauMax began implementing an energy saving campaign, and found that its annual energy spend was €4.14 million, with lighting constituting over 50% of energy expenses. BauMax initially deployed 6,000 Metrolight systems in 39 stores, later expanding it to 30,000 units across its stores that could be centrally controlled from the head office. Metrolight reduced lamp power in the stores from 400w to 280w, while allowing control and dimming capabilities. Metrolight's systems allowed lumens to go unchanged for 20,000 hours of operation.

London Borough of Tower Hamlets - WestFerry Circus street lighting case study: The London Borough of Tower Hamlets council is responsible for the design, installation and maintenance of streetlights

and traffic signals. Westferry Circus has an underground roundabout that is lit 24/7/365. The underground roundabout lighting system was originally comprised of 400w magnetic ballasts and 246 luminaires operating 24 hours a day, 7 days a week, 365 days a year. The annual lighting-related energy cost was £106,800. The council asked Metrolight to introduce energy-saving lighting solutions to the underground roundabout while also improving the light quality. Metrolight installed 186 of its 400w HPI-T lamps, with ballasts programmed to operate at 80% of full power.

AB&I Foundry industrial case study: In 2008, Lockheed Martin's Heavy Industry Energy Efficiency Program performed a site audit at the AB&I Foundry Oakland Plant to assess the possibility of improving the efficiency of the lighting system and evaluate potential energy savings opportunities. The foundry is more than 100 years old, and its lighting system was not upgraded for the 10-15 years. The foundry's annual cost of operations was approximately $180,000, with a substantial portion of costs attributed to continuous lighting in many areas for safety, security and surveillance monitoring. Its installed lighting consisted of 1,000- and 400-watt metal halide (MH) high bay fixtures. Metrolight's Electronic HID technology was chosen for the project. The 1,000- and 400 watt MH fixtures in the production areas, storage areas and shops were replaced with 450- and 320-watt electronic ballasts MH fixtures. Additional energy savings were gained through the use of dimming schedules. Using the internal pre-program capabilities of the ballast and an external timer, the input wattage of the ballasts were further programmed to dim to 269w and 160w according to a pre-determined energy saving schedule.

Cost-benefit analysis

Changi Prison Complex, Singapore, correctional facility case study: The solution provider claimed to have doubled the life of the installed lamps, leading to reduced maintenance. The lighting system enabled a 44% saving on energy and approximately a 50% decrease in maintenance costs. The overall project had a payback of 2.8 years.

bauMax DIY retail store case study: The installations produced a 40% energy savings and a 50% decrease in maintenance costs, with a payback of 2.5 years. The annual energy spend was reduced from €4.14 million to €2.47 million, resulting in savings of €1.6 million. Approximately 15,891,200 kWh of energy use were prevented in total.

London Borough of Tower Hamlets - WestFerry Circus street lighting case study: The annual energy cost was reduced to £34,800—a yearly savings of £72,000. MetroLight estimates total energy savings of 63%, while maintenance costs were reduced by 50%. The payback for the installation was 2.5 years.

AB&I Foundry industrial case study: In all, the project represented a total annual saving of $102,486, or 732,000 kwH/yr, and a simple payback of 1.52 years. The installation also reduced peak demand by 97.6 kWpeak.

Example 4

LED based lights for grid and off-grid applications

Description of the ICT technology deployed

Abundant sunshine in Africa and India is providing a solid basis for low-voltage solar-powered lighting to serve those with little or no grid access in rural and mountainous areas. In situations where grid based power is available, LED lights help reduce power consumption, while in situations where access to grid based power is not available, LED luminaires connected to solar panels can serve as decentralised, self sufficient light sources. Solar-powered lanterns eliminate the hazards (fires, burns, fumes, spills and explosions) of conventionally fueled lanterns. In addition, LED lights also reduce maintenance needs, including primping fuel pumps and replacing mantles.

Hyderabad, India-based MIC Electronics Limited designs, develops and manufactures LED lighting solutions for urban and rural areas. In addition, the company sells LED-based video displays, text, graphic animation displays, and display services including LED video walls.

The company’s solar LED Lantern consists of a built-in handle, a 6V, 4AH rechargeable battery, a 2.5-watt photovoltaic solar panel, and a cluster of diffused 5MM white LED from Japanese manufacturer Nichia Corporation, with a life-span of 100,000 hours. The solar panel collects energy during the daytime and charges the battery, with an energy conversion efficiency of more than 80%. A dead battery requires 13 hours of bright sunlight to be fully charged, and a fully charged battery offers 8 to 12 hours of illumination. Users can expect 500 charges

before battery replacement is necessary. The lantern and solar panel weigh 2.06 pounds. The lantern is made from ABS Plastic. A 3W solar lantern of MIC gives out about 300 lumens of output, which enables customers to attend to household works, read and go outdoors.

The company also produces luminaires for street lights, which can offer 50% energy savings, low-heat radiation, and improved safety because of low voltage. MIC Electronics sells solar-powered LED street lighting systems, and solar LED home lighting systems that include battery storage for non-electrified rural areas and emergency backup power.

Detailed description of projects

MIC has installed solar powered street lights in the village of Serilingampally on the outskirts of Hyderabad, as well as through partnerships with the Chattisgarh Renewable Energy Development Agency, Karnataka Renewable Energy Development Limited and Haryana Renewable Energy Development Agency.

On a trial marketing basis, MIC has also supplied grid based LED indoor and outdoor lights to Maruti Udyog Limited, Mahindra & Mahindra, ITC Limited, Steel Authority of India Limited, Singareni Collieries Company Limited, Punjab Energy Development Agency, Andhra Pradesh Industrial Infrastructure Corporation Limited, National Institute of Rural Development, TVS Motor Company and CRI Pumps.

MIC's grid based street lights are undergoing evaluation in Pittsburgh, Pennsylvania, and the Blair Athol Community Centre in Campbell, Australia.

Case 1: Portable Solar Lanterns in rural areas. Public sector enterprise Indian Oil Corporation (IOC) is engaged in refining, marketing and retailing of petrol and diesel products across the country through its 17,000 outlets. The government of India, through companies including IOC, is subsidising the cost of kerosene, which is one of the main fuels for cooking and lighting applications of the rural population of the country. IOC is looking for alternative and renewable sources of energy, and has helped MIC launch sales of solar powered portable lanterns. MIC has entered into MOUs with IOC in seven states of India in order to help the government reduce the cost of the subsidies to kerosene.

Case 2: LED indoor lights and lanterns for the state of Bihar: Beltron Telecom Green Energy Systems, a subsidiary of Beltron Telecommunications Limited (BTL), signed an agreement with MIC in May 2010 to deploy lighting systems in off-grid applications in rural areas of the state of Bihar. BTL uses biofuel-powered generators as part of a rural electrification program, using paddy fodder and paddy husk to provide 3 to 4 hours of electricity a night. MIC’s solar powered portable LED lights are expected to enhance the utility of the lighting systems in rural Bihar by extending the duration of light availability in the night and also in the early hours of the day. The LED based lanterns and fixed indoor lights can be charged through solar power panels, community charging centers, and through biofuel powered generating stations. These facilities will help reduce end user

costs. MIC has signed a Memorandum of Understanding (MoU) with BTGES to supply solar lanterns in large quantities.

Case 3: Off-grid applications in railways: Indian Railways, the largest railway network in the world, decided to replace the luminaires in the railway coaches with LED lights to reduce the cost of replacing and maintaining the lights, which are expected to last for 15 years. LED coach lights also reduce the power consumption from the existing level of 1527 watts to 609 watts, resulting in sizeable savings to Indian Railways because of the reduction of battery capacities. MIC says it is the only Indian company to have supplied the full spectrum of coach lights to Indian Railways.

Cost-benefits analysis

The government of India is reported to spend about Rs.38,000 crore per year on kerosene subsidies. Residents can purchase three liters at the subsidised price of Rs.11 per liter, and then four more liters at Rs.33 per liter. A typical rural household needs 6 to 7 liters of kerosene for lighting applications. The distribution deal with IOC enables MIC to supply portable lanterns with solar panels for an end-user price of about Rs.2000 per lantern. The battery, which costs around Rs.150, needs to be replaced every four years. Without subsidies, users can get back their investments within a year. MIC says the lanterns, when properly taken care of, can be useful for 12 to 15 years.

Smart Grid: the introduction

The generation of electricity is responsible for about 40% of global CO_2 emissions, presenting an enormous opportunity for savings due to smart grid/metering technologies.[10] Improving the efficiency of the U.S. electricity grid by 5% would alone be the equivalent of eliminating the fuel use and carbon emissions of 53 million cars.

Information and communications technology plays a significant role in enabling the transformation to the smart grid. A 2008 study from the Electric Power Research Institute (EPRI) calculated that ICT could reduce America's electricity usage by 200 billion kilowatt-hours, or 4.3% by 2030.[11] That could prevent the release of more than 200 million metric tons of carbon dioxide emissions by 2030.

Just the communications portion of the global smart grid deployment is expected to be worth $20 billion a year over the next five years, according to Cisco[12]. That includes functions such as integrated communications among components of the grid, sensing and measurement technologies, and improved interfaces and decision support for grid operators.

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[10] http://www.pewclimate.org/technology/overview/electricity
[11] http://my.epri.com/portal/server.pt?Abstract_id=000000000001016905
[12] http://cleantech.com/news/4471/cisco-chases-billion-dollar-smart-grid

Information and communications equipment and software is poised to help the electricity industry make the transformation from a centralized, producer-controlled network to one that enables visibility into generation, transmission and usage. Essential (but sometimes less visible) infrastructure projects are underway, including transmission upgrades, substation automation, and distribution automation.

The transformation will take years and indeed decades for the full benefit to fully realize but there are areas where savings and progress can be made today.

The technology area that show the greatest potential for energy savings in the near-term, according to the EPRI study, are in-unit displays that let users view real-time energy use and pricing. This contextualizes the choice of the **Hara** case study, which aims to help customers reduce carbon emissions by providing visibility into power consumption.

Utilities across the globe have pledged to deploy extensive smart meter installations during the next decade, using devices from companies including our case study choice in this field, **Landis+Gyr.**

Also in use today are demand and response systems, which control the use of power to avoid blackouts and reduce peak-time consumption. Enhanced demand response systems are still being developed that use two-way communication to power down equipment to avoid blackouts or reduce the amount of power consumed at peak load times. Such a solution has been developed by **RLtec**.

Smart Grid: the case studies

Example 1

Software-as-a-service dashboard using enterprise resource accounting to reduce energy and water consumption

Description of the ICT technology deployed

Increased government regulation and demands from consumers and shareholders are prompting greater accountability from corporations on energy use, water consumption, and waste production. Carbon accounting software is giving corporations real-time insight into their consumption levels, allowing them to measure reductions and track progress toward goals. The market for carbon accounting software is booming because of the efficiency gains that can be made once you are measuring the underlying consumption patterns and associated costs.

To illustrate this type of ICT, we could have used examples from established firms such as SAP, SAS, IBM, Microsoft, Accenture, or Deloitte. Instead, we are using a younger company, named Hara.

Hara Environmental and Energy Management (Hara EEM) is a software-as-a-service product that attempts to provide complete visibility and accounting into enterprise resource use for corporate and

municipal clients. The Hara dashboard is capable of tracking energy, water, waste, carbon, and other natural resource use providing insight and data for managers to improve efficiency, manage future risks, and to comply with regulatory reporting requirements. In addition to software, the company provides consulting and training services to help enterprise customers use natural resources more efficiently.

Detailed description of projects

Hara is primarily working with power companies, retailers with large supply chains, commodity manufacturers, and municipalities.

City of Palo Alto, California: In 2009, the city of Palo Alto set a goal of reducing total greenhouse gas (GHG) emissions by 5%. The city's Sustainability Team wanted a solution to track emissions and provide transparency across electricity, gas, and solid waste among 13 departments. The Hara software application automatically uploads utility data from utility meters and the city's SAP ERP system. Additionally, each employee can enter commuter and other data that impact overall emissions. Having the Hara application to easily collect these data inputs ultimately enabled the city to develop, model and manage emissions reduction plans. In addition, the system produced reports for the city's website to share with residents and businesses, and automated reports for agencies such as the California Climate Registry.

Intuit Inc., Redwood City, California: In February 2010, Intuit Inc. implemented Hara to help it meet the company's goal of reducing its carbon footprint by 15% in 2012 from their 2007 levels. The software is enabling Intuit to collect and manage energy and emissions information related to the company's energy usage, waste, travel, and materials across its global facilities and data centers as well as for its flagship Quicken, QuickBooks and TurboTax products and connected services. In addition to providing a detailed account of the collective resources consumed and expended across the business, the software is allowing Intuit to identify objectives and metrics, find cost savings opportunities, plan and implement energy reduction strategies, monitor the results and impact of its efforts, and share best practices across the organization.

Cost-benefits analysis

The city of Palo Alto is reportedly spending $24,000 a year on the software. In the first three years, the city projects an annual savings of $600,000 to $700,000, mainly as a result of reduced electricity, water and natural gas use. Other savings are expected to result from reduced waste collection and paper use. The return on investment for this deployment of the Hara software solution is expected to be less than three months.

Example 2

Smart metering, energy management solutions and related services

Description of the ICT technology deployed

Landis+Gyr's Gridstream technology has been chosen to illustrate the metering aspect of the smart grid. The technology is said to provide improved operating efficiencies of up to 10%, greater network reliability and power quality, optimized utility network investments, improved customer service, reduced energy consumption by over 10%, and potential customer cost savings of 15% through these technologies:

- Meters: Landis+Gyr have developed multienergy meters that cover electricity, gas and water for applications including residential, commercial, industrial and grid metering. In-unit displays allow consumers to manage energy consumption in real time while viewing current tariff rates. The increased awareness enables users to save energy and money, and the meters can relay messages from the utility asking consumers to reduce their consumption at critical times, helping utilities level peaks and optimise the network load.
- Communications: Landis+Gyr have developed technology to enable two-way communication over GSM/GPRS technology, Ethernet, PSTN and low or medium voltage PLC communication—or any combination of these—using open communication standards. The standardised communications protocols ensure interoperability with existing utility software and data management systems. The technology enables its utility customers to have real-time communication as well as advanced programming capabilities such as remotely reading meters, controlling distribution components, offering real time system updates, and verifying demand response. Its software covers meter reading, controls, system operation, and value-added data management such as validation, tariff and profile calculators. Analysis can be tailored for billing, finance, customer service, operations, distribution planning and engineering.
- Network Management: Landis+Gyr have developed technology to provide increased awareness of network status and tools for load management. The technology provides visibility and control of electric, gas, and water distribution equipment. That information can be used to increase supervision and maintenance efficiency by optimizing electricity network usage. The system enables the utility to identify at which metering points power outages and voltage changes are occurring, using this information to improve network reliability and to decrease outage restoration times. The technology also enables utilities

to shape the load curve and reduce peaks in response to network congestion.

Detailed description of projects

China: The province of Heilongjiang is about the same size as California and two-thirds the size of France. Because the province is so large, any meter that goes into the field has to have the highest reliability simply because of the amount of time it would take for technicians to get to any faulty meter. By ensuring that the meters require minimum maintenance the utility immediately saves money. In addition, Heilongjiang is in the northeast of China where temperatures in winter get down to -40 to -50 degrees Celsius (-40 to -58 Fahrenheit). Grid meters must be of high quality to withstand such temperatures.

Hungary: E.ON Hungária Zrt. is Hungary's leading energy provider and one of the country's largest utilities. During the privatisation of the energy sector it acquired shares in three electricity service providers—EDE, ETI and EED. In 2007, in order to improve operational efficiency, the organisations were restructured into the current corporation. Its annual sales are 15,575 GWh electricity and 16,5 mio m^3 gas. Its service area for electricity is 55,181 km^2, and gas is 26,145 km^2 with 2.47 million electricity customers and 602,107 gas customers. Recently it decided to renew all the data acquisition systems of its energy utility companies, seeking operational flexibility, efficient data exchange and a high performing interface. The basic requirement was that the system acquired active and reactive energy as well as load profiles and billing values. One of the major determinants of the system was a highly automated and high performing interface for billing values and load profiles to the SAP billing system. Another important factor was the data exchange between the market participants and the market operator MAVIR with pre-defined XML-formats (Import and Export), which needed to run smoothly and efficiently. Furthermore the focus was on the investment savings and operating costs, which would be reached by using one single system, Application Service Provision (ASP) by all three energy providers. E.ON Hungária Zrt. decided to use the Converge Meter Data Warehouse from Landis+Gyr to achieve the project targets. Initially the project started with 2,000 meters. Since then, it has been extended continuously with meter points, interfaces and server hardware, by approximately 1,000 meters every two to three months. System size in the autumn of 2008 was reported at 19,000 metering points. The system is prepared for future extension in various ways, for example by including additional meters in the system, serving further utilities as ASP customers, by including gas meters in the system or by upgrading hardware to high availability with the addition of a standby configuration.

ERDF (a subsidiary of Electricite de France (EDF)): ERDF recently began plans to modernize their grid using smart meters, remote meter reading and billing, and devices that link to water heaters and pumps. The changes are expected to enable load shedding and restoration, monitoring of energy consumption by consumers, and real-time pricing. ERDF decided to proceed with a 300,000-meter pilot project and 7,000 concentrators. Landis+Gyr is supplying one third of the meters and half of the concentrators. The pilot phase is being deployed into the two

regions of Tours, a rural area, and Lyon, an urban area. By using these two diverse areas, the widest possible variety of installation requirements are being tested. The installation began on March 1, 2010, and is to be finished in October. The net stage of the project calls for the installation of 35 million smart meters, which will take more than five years to complete. The final system will be smart enough to inform the central system if they have an outage, in near real time. The network will have load shedding and restoring functions. It will also be able to analyze load curves on the meters in the low-voltage nodes. With this information, appropriate investment and development of the network will be possible as the sectors requiring this will be highlighted. This will go a long way to making this process more accurate and cost-effective by removing the "art" of doing this work via the use assumptions. Quality of power supply is also an issue. With the AMM system voltage drops or increases outside the accepted margins will also be detected. The service capability will also greatly benefit from the capability to monitor the substations, with local events and even temperature of the substations surveyed remotely. The project is estimated to require a € 4 billion investment, with installation about 50% of the full investment.

Example 3

Energy-balancing software that allows appliances to communicate with the grid for demand response and grid stabilization

Description of the ICT technology deployed

To keep the grid balanced, traditional generators have a throttle control that enables them to vary their output instantaneously. The grid also maintains a buffer of spare capacity from 'balancing stations' which can be called on at extremely short notice. If a power station goes down, or there is a problem in transmission, these spare stations swing into action. The problem the grid operators have is that this insurance policy is expensive. It adds to the cost of power supply and, because it must be kept running at a low level at all times, it produces energy and CO_2 emissions even when power is not being used. Spinning reserve requires rapid response, and the kind of generation that can provide it is usually powered by fossil fuels, frequently coal, which produces emissions of between 0.48 and 1.3 tonnes of CO_2 equivalent for every megawatt hour (MWh) generated.

RLtec has been chosen to illustrate a form of demand response solution known as dynamic demand. The software is typically incorporated into the existing electronic control unit of a new appliance, together with additional hardware and sensors as required. It can also be retrofitted into existing appliances. Custom modules for larger commercial appliances are also available and complete control units can be retrofitted into existing equipment. RLtec's technology is bi-directional, so it can increase and decrease consumption when necessary.

The software measures signals from the electric grid and enables appliances to adjust their power consumption automatically, reducing demand when there is a supply shortage and drawing energy when there is excess capacity on the grid, including during power surges.

System frequency can be measured from any standard A/C electrical socket in the country and is effectively uniform, so appliances fitted with the dynamic demand device will receive an identical signal, regardless of where they are connected on the electricity grid.

This technology enables appliances to react rapidly to changes in the grid – in about three seconds – which can impact the supply-demand balance more quickly than traditional methods. This provides a balancing service to the grid that makes the grid more efficient, cheaper, and less polluting.

Dynamic demand also provides a buffering effect when operating with wind and other intermittent power supplies.

Detailed description of projects

nPower, UK: RLtec's dynamic-demand technology can be retrofitted into existing appliances or installed into new units. It is suitable for national grid operators, industrial consumers, power suppliers, and appliance manufacturers. The technology is particularly suited to implementation on hot water heaters, domestic refrigeration units, stand-alone air conditioning, and discretionary industrial loads such as mains water pumping. The consumption of electricity of these types of appliances is not time critical, because although they need energy, as long as they operate between expected limits, such as temperature, it does not matter precisely when that energy is delivered. As a result, dynamic demand technology enables those appliances to shift their consumption by minutes and seconds without any loss of performance.

RLtec says one of the primary applications for dynamic demand is in domestic and commercial refrigeration units, which present significant opportunities for reducing CO_2 emissions. More than three million domestic fridges are sold each year in the UK, representing more than 35 megawatts of response. If fitted with dynamic demand technology they would reduce the amount of reserve electricity generation required by 35 megawatts. Eliminating this generating capacity from the grid would reduce CO_2 emissions by 15,000 tonnes a year. The refrigeration units in one of the country's major supermarkets represent a response of 10 megawatts. Thirty million domestic fridges represent 350 megawatts of response, which is the equivalent of an entire power plant running inefficiently solely to provide reserve supply. Dynamic demand would make this plant obsolete.

A typical domestic fridge motor draws 100W when running. During normal fridge operation, the motor's electricity consumption follows an on/off pattern as temperature oscillates between five and eight degrees Centigrade. A typical fridge spends 25% of the time cooling, when the motor is on, and 75% warming up when the motor is off. The temperature, or 'coolth', of the fridge represents energy storage. By modifying the timing of the motor in response to grid frequency (changes in the balance between supply and demand), it is possible to provide a response to changing supply from generating plant, without loss of performance of the fridge. The technology is bi-directional and so can increase or decrease consumption, and does not require the

fridge to be switched off at any point. Temperature remains steady, and food storage properties are not compromised.

RLtec's dynamic demand technology has undergone laboratory testing and is now being trialed with UK energy supplier npower. In the first phase of the trial, 300 fridges have been fitted with dynamic demand and will be distributed to consumers. This will allow rigorous analysis of how the technology works in appliances in everyday use. Indesit Company, the UK's leading white goods company, will provide and distribute the fridge-freezers, which will have RLtec's dynamic demand technology installed. In the second phase of the trial, a total of up to 3,000 fridges and freezers of different types and models will be deployed so that the carbon savings from dynamic demand can be measured in a wide variety of situations. The trial is the first Demonstration Action to be approved by the UK's energy regulator, Ofgem, under the CERT (Carbon Emissions Reduction Target) legislation. Npower plans for the technology to help meet its obligations to reduce its customers' carbon emissions. The technology is expected to eliminate the need for some balancing stations, which could produce 2 million tonnes of carbon dioxide savings every year.

Cost-benefits analysis

Dynamic demand technology eliminates the need for energy balancing capacity. In the UK, the portfolio of energy balancing services contracted by the National Grid plc currently costs approximately £200 million per annum, an amount that is estimated to increase year on year. The UK government estimates that dynamic demand could reduce greenhouse gas emissions by approximately 1.74 million tonnes of CO_2 from electricity generation and save £200 million per year. In California, approximately 750 megawatts of so-called regulation is contracted by grid operator CAISO, at a cost of $113 million per year.

Smart Logistics: an introduction

Recent studies have been aplenty on the savings that can be achieved through technologies for smart buildings and smart metering/grid. There are fewer on logistics. According to the Smart 2020 report, ICT-driven applications across logistics could achieve a reduction in total global emissions of 1.52 GtCO2e, by improving the efficiency of logistics operations in a number of ways. These include "software to improve the design of transport networks, allow the running of centralised distribution networks and run management systems that can facilitate flexible home delivery services. Specific levers include intermodal shift, or moving to the most efficient type of transport, eco-driving, route optimisation and inventory reduction."

Import and export trade relies on cost-efficient supply chain management, including freight and distribution. Those costs are directly correlated to the consumption of natural resources such as oil and gas, meaning that efficiency of spending frequently results in energy efficiency.

The boom in manufacturing and consumption in developing nations will lead to increased market opportunities for third party logistics providers. India's logistics industry, for one, is considered disorganized and fragmented, requiring coordination among many players and multiple rounds of paperwork.

Information technology holds promise to address these challenges but has not been widely deployed. It has been estimated that underdeveloped trade and logistics infrastructure conversely affects the GDP in Western Europe and North America by less than 10%. In India, the estimated impact on GDP is as high as 13%.[13]

What is striking about the logistics area in contrast to the other two areas I have looked at is how hard it is to find ICT solutions that are singularly focused on energy-efficiency.

Instead, with all 3 examples chosen, the benefits of the technological investment have a number of facets and motivations, of which energy is but one, and not always the prime. This may change over time but I struggled to identify, from my scour of the clean technology world, examples of 'pureplay' energy-efficient smart logistics.

The first example, **RouteMatch**, is that of logistics software used to automate scheduling, routing, dispatching and billing based upon trip requests, customer locations and vehicle availability. The technology aims to minimize the total cost of ownership by improving the efficiency of trip routes and vehicle use. Fuel savings would be one of the efficiencies achieved; others would be the reduced need of clerical staff for manual data input or billing.

Although I found no case of deployment in the developing world, why not, now or in time? With 65% of domestic cargo distributed on India's roads,[14] for example, surely there are significant opportunities for technologies that can calculate the most efficient routes and schedules for drivers?

The second case study's benefits are very much indirectly carbon-related, not directly energy savings related. However, I felt it was an important case to help illustrate the power of ICT in 'acting now, and acting differently' in developing countries. **Helveta**'s supply chain software to manage the logistics of the supply chain of timber (almost exclusively sourced from developing countries) has the benefit of improving the supply chain's speed and efficiency and in reducing illegal logging. Illegal logging is often cited as a major contributor to climate change; deforestation and degradation of forests is estimated to account for 17 % of global CO_2 emissions. Estimates of the extent of illegal logging range from 12% to 17% of the global timber trade.

ICT similarly can help the agriculture industry in its logistical operations use resources such as vehicles, fuel, labor, seeds, fertilizer and water

[13] http://www.isb.edu/facultydetails/Viswanatham/Download/Vis.WP1.pdf
[14] http://www.slideshare.net/akumar16/us-india-infrastructure-and-energy-opportunities-imacs-virtus-report

more efficiently. The third study concerns the use of software to help farmers map their fields, movements, seeding, fertilizer distribution and water flow. The software is focused on efficiencies across the entire range of farm operations, not just energy. Most notably, it tracks farm vehicle monitoring, crop management, staffing, field mapping, chemical and fertilizer management. In addition, the system, produced by **FarmWorks**, can calculate how terrain impacts water flow, helping the farmer devise an efficient irrigation strategy that requires less energy for pumping water. With agriculture being such a significant part of the developing world's economies and employment, this seemed an interesting case study to include in 'smart logistics'

Smart Logistics: the case studies

Example 1

Transport logistics software used to maximise the efficiency of passenger transit service, especially in rural areas

Description of the ICT technology deployed

The passenger transportation sector still largely relies on employees to manage transit routes, schedules, dispatching, billing and reporting. The labor intensity increases for demand-responsive transportation management, in which vehicles are not on fixed routes. Examples include public and private para-transit services, medical and non-emergency transportation, and commercial fleet management.

Transportation companies are now turning to logistics software to automate scheduling, routing, dispatching and billing based upon trip requests, customer locations and vehicle availability. The technology aims to minimize the total cost of ownership by improving the efficiency of trip routes and vehicle use.

Atlanta, Georgia-based RouteMatch has been chosen as a case study to illustrate the use of ICT to reduce energy use and carbon emissions through a computer-assisted data management system to automate trip scheduling and routing, and give dispatchers the ability to electronically assign trips and send schedule changes to vehicles instantly. RouteMatch's offering is comprised of multiple software modules that can deliver results of 10% to 20% increase in schedule and route efficiency. The TMS is designed for small or medium sized transportation providers in the demand-response and paratransit industry.

Detailed description of projects

Iredell County Transit System (Statesville, North Carolina): Iredell County Transit provides for the human service and general public transportation needs, running over 160,000 trips per year. After taking over the county's transportation business in 2003, it sought a faster, more reliable and cost-effective routing and scheduling system to handle the large number of demand-response trips in a rural transit setting. Iredell also needed to accommodate an increasing ridership while reducing vehicle usage and overall operational costs. The software allowed ICTS to increase the average number of trips from

350 per day to 450 per day, a 28.6% boost in ridership. At the same time, vehicle usage dropped from 25 to 18, having a significant impact on fuel cost savings, and part-time staff also decreased.

S.C.M. Elderbus, Inc. (Charlton, Massachusetts): S.C.M. Elderbus is a non-profit, private transportation company providing paratransit services to seniors and persons with disabilities throughout central and south-central Massachusetts. Providing over 55,000 trips annually with 23 wheelchair equipped passenger vans, S.C.M. Elderbus provides transportation services to 21 communities covering over 540 square miles. S.C.M. Elderbus switched from a manual scheduling process to this more advanced transportation management system, saving about $100,000 in one year, and paying for the system in less than one year. Elderbus saw a 72% reduction in the time it takes to schedule trips on a daily basis, a 75% reduction in daily verification processes, and a 12% reduction in total driver hours per week. The agency also reduced the van fleet by one vehicle.

Provide A Ride (Cleveland, Ohio): Provide A Ride (PAR) is a private, for-profit transportation provider servicing 6 counties in Northeast Ohio. PAR provides over 1100 trips/day with 65 vehicles. PAR services a range of customers with special transportation needs such as welfare-to-work participants, students, seniors citizens and the disabled. PAR wanted to increase the size of its operation and implemented RouteMatch software. The software enabled it to increase trips per day by 30%, from 750 to 1100, while reducing the number of vehicles from 72 to 64. The agency reduced payroll by $222,000 because it needed few drivers and dispatchers. The agency reported a reduction in overall miles traveled, gas and insurance expenses, and a 16% reduction in annual maintenance costs. An unexpected hurdle was that going from a manual system to one with full automation took time, retraining and personnel changes.

Cost-benefits analysis

S.C.M. Elderbus saw a 72% reduction in the time it takes to schedule trips on a daily basis, a 75% reduction in daily verification processes, and a 12% reduction in total driver hours per week. The agency also reduced the van fleet by one vehicle. Elderbus reported that it saved about $100,000 in one year by using RouteMatch TS, and paid for the system in less than one year.

Example 2

Software to track and manage supply chains

Description of the ICT technology deployed

Clients use supply-chain management software to control and improve production processes, while identifying and addressing supply chain production problems. Key benefits can include reduced stock losses, improved speed and accuracy of inventory taking, and higher profit margins. The technology also enables traceability, which can help clients prove the origin of products to satisfy legal and consumer requirements, thus earning price premiums for fully traceable products.

Helveta developed a software platform to track and manage global supply chains from source to final destination. The software platform provides a range of task specific modules for managing supply chains. Customers can select the modules they need or the integrated system, depending on the current and future business requirements. Clients can also add additional functionality as their business grows. Deployed projects have used satellite communication, mobile, wireless-enabled notebooks, servers, wireless handhelds and RFID tags.

Clients tag products with RFID labels and use handheld computers loaded with Helveta's data capture software to read the tags and record additional information on each tree. The data is then transferred to the central server via Internet or mobile phone connection. The traceability system tracks every log, truck and mill involved in the supply chain. It can be used to check, analyze and reconcile captured information, issuing alerts when supply chain inconsistencies are identified. The server generates business information and delivers reports and alerts based on specific customer requirements. The software can be installed on local servers or provided as a hosted solution and accessible via the Internet. Alternatively, a staged migration from hosted to installed operation is also available.

Detailed description of projects

Helveta completed a pilot project in 2009 in the Malaysian state of Terengganu across 129,143 hectares. The Forestry Department of Peninsular Malaysia and Terengganu State Forestry Department used Helveta's technology to tag and track trees to help individual supplier companies to verify wood legality and sustainability. The technology aimed to replace the traditional techniques for forest monitoring, which can be expensive and time-consuming. Helveta's software allowed users with low literacy levels to record GPS referenced information using touch-screen handheld computers, which can contain a database of icon images in place of text. Officials said they were surprised that the system was simple to use for forestry workers who were not computer savvy. Malaysian officials said they saw improvements in business management and efficiency of the supply chain, ultimately saving money and time.

Cost-benefits analysis

Although they did not provide exact figures, Malaysian officials said the cost of Helveta's system was somewhat defrayed by improvements in business management and efficiency of the supply chain. The approximate cost of setting up and operating the Helveta system was $1 per square meter of timber.

Emerging business models and their relevance to developing countries

Helveta has deployed projects in Cameroon, Liberia, the Republic of Congo, Bolivia, Asia and South America. The technology has applications in several sectors but has found the most extensive adoption to-date in the food and timber sectors.

Example 3

Software and hardware to maximise the efficiency of agribusinesses tools

Description of the ICT technology deployed

The precision agriculture movement is helping farmers and agribusinesses improve the efficiency of their operations. ICT can be used to enable fleet management for the agriculture sector using GPS, as well as wireless communications technologies that assist with aggregation of data from multiple vehicles and workers. The ICT allows for real-time updates on resource distribution between the field and office, while reducing errors to manual input of data. Such systems help farmers to map their fields, movements, seeding, fertilizer distribution and water flow. Precision agriculture systems can help farm workers devise the most efficient route for applying seeds and fertilizer, and keep track of past movements to ensure a site is not missed. In addition, such systems can calculate how terrain impacts water flow, helping the farmer devise an efficient irrigation strategy that requires less energy for pumping water.

Farm Works, our chosen illustrative case study, provides integrated office and mobile software solutions for both the farmer and the agriculture service professional. Among its capabilities, Farm Works software can automatically capture field event data, downloaded from an in-cab display or handheld computer, for record keeping. The software also tracks most farm operations including vehicle monitoring, crop management, staffing, field mapping, chemical and fertilizer management, and cost accounting. The software also includes a herd management and genealogy program for livestock producers.

The software integrates guidance and mapping—reducing overlap and eliminating skips in a field - and enables the user to save money and time by helping them apply the proper amounts of seed, chemicals, and fertilizers to the areas of the field that need it the most. There is also the facility to assist with the optimal placement of tile and surface drains. This helps drain the field adequately, and subsequently increases crop yields.

Detailed description of projects

The Hartung Brothers Farm ranks 5th in the U.S. for seed corn and vegetable production. Family owned since 1975, the farm has offices in Wisconsin, Illinois, Ohio, and Texas. The operations were growing, and Hartung Brothers needed technology to help it improve efficiency and save time. Hartung Brothers deployed Farm Works' wireless software with the existing precision agricultural equipment, which allowed them to exchange important information including A-B guidance lines, prescription maps, and application data between multiple workers in the field and the farm office to improve access to data while improving their field record keeping in the office. The farm deployed the technology on spraying jobs, and in May 2010 began deploying wireless data transfer for planting jobs on about 6,000 acres of seed corn and 2,000 acres of vegetables. The planting jobs require record keeping of planting

locations, dates, and seed populations of the various inbred corn varieties.

Cost-benefits analysis

Although exact figures on cost savings could not be obtained, the company claims that its customers report that they save money and time by using the software to help them apply the proper amounts of seed, chemicals, and fertilizers to the areas of the field that need it the most. And by reducing the overlap and eliminating skips in a field, efficiency gains are achieved in the use of farming vehicles and workers' time.

ICT solutions: in detail

This part of the study provides 3 more cases, 1 for each area explored. As well as providing more detail, these cases have tried to pinpoint energy-efficiency solutions, which are either already being applied to the developing world, or where some application is foreseeable.

This has required working within certain constraints – of time and data availability. Data availability is partly a function of time but indeed it is also a case of how relatively immature the application of ICT for energy efficiency purposes is. There simply are not that many projects which have been implemented, with long track records. There are a lot of interesting ideas, applications, businesses and pilot projects being developed, mostly in the developed world.

The following three studies should keep that in mind.

Example 1

Replacing kerosene lanterns with solar-powered, rechargeable LED lights

'Smart buildings' is simply not a notion that directly translated to the developing world. There are more basic problems to attend to than the use of sensors and wireless automated systems to reduce the energy-intensity of commercial and residential buildings, spending thousands of dollars per annum to run buildings.

So, for the Smart Building case study, I have taken a key function of a 'building' and a key focus area for energy savings – namely, lighting – and looked at its applicability to the developing world. This has led me to profile this example of using ICT for carbon emission gains.

Detailed description/ background

A primary source of greenhouse gas emissions in the developing world comes from hazardous and expensive fuel-based sources such as kerosene. About 1.6 billion people in the developing world—especially

Asia and Africa—still depend exclusively on kerosene or candles to light their homes[15] once the sun sets; millions more have unreliable electrical connections. It is estimated that a single kerosene lamp emits 400 pounds of greenhouse gases per year, or 1 ton of CO_2 over a lifetime of 5 years. Every year, kerosene lamps are responsible for over 100 million tons of CO_2 emissions. Kerosene lamps are also a key contributor to indoor air pollution, which claims the lives of 1.5 million people each year, over half of which are under the age of five. Kerosene lamps have caused countless deaths by suffocation, burns and fatal fires.

This has led me to choose **D.light Design**, which specializes in the design of low-cost, durable and highly efficient lighting technologies that use light-emitting diodes (LEDs), as a way to illustrate 'smart buildings' for the developing world.

Some lights are sold directly to consumers, while others are distributed through relief agencies and aid organizations. In its first year, 2008, D.light reached about 100,000 people in 8 countries; by 2009, D.light distributed lights to an additional 500,000 people in 28 countries. In April 2010, in a recent interview conducted with the company, it said its lights were helping 1 million people in 30 countries. By the end of 2010, D.light's goal is to distribute lights to between 2 million and 5 million people.

In late 2008, D.light began partnering with the microfinance organization Beyond Solar to bring solar lighting to households in rural India. The trial began in Puki, Ganjei Pradar, and New Kerenga—three tribal villages in the Koraput district of southern Orissa, in which families were 100% dependent on kerosene for lighting. All three were recently displaced as a result of the construction of a hydro-electric dam, yet all are without grid-supplied electricity. The average village household of three to four people earned approximately Rs 625 ($12.50) per month, with the primary source of income in selling agriculture products and manual labor such as breaking stones. The average monthly kerosene expense was approximately Rs. 100-150, with all reporting damage to homes and injuries from kerosene lamp fires. The villagers made approximately two or three trips to the market per week to get fuel, with the average distance to the nearest market of 5 km.

Field workers from the local NGO South Orissa Voluntary Action (SOVA) and Beyond Solar made one or two trips to the village simply to ask questions, demonstrate the benefits of the lights, and build rapport with people. The field workers left a few lights with the villagers so they could experience the benefits of the lights firsthand. After this trial period, the workers returned to the village to hear about their experiences and then to sign up interested villagers for D.light Design's Nova lantern, which provided up to 40 hours of solar powered light on one charge using an ultra-efficient LED lighting source. Beyond Solar established a financing program that required a small down payment followed by weekly installments. The trial resulted in an average

[15] http://www.iea.org/textbase/nppdf/free/2002/energy_poverty.pdf

adoption rate across the three villages of 72%. After two months, the on-time repayment rate of loans was 100%, and the average kerosene usage of 11 liters per family per month was eliminated among households that adopted the technology, also eliminating trips to the market. The target for the trial was 50 households, but 162 ended up participating.

Description of the ICT technology deployed

D.light designed a range of rechargeable, solar-powered LED lamps that can serve as portable or stationary lights, without the necessity of grid access. D.light drives down costs through concentration and expertise in product design, mechanical and electrical engineering, high-volume manufacturing, and quality assurance. The company sources components such as LEDs from partners including Korea's Seoul Semiconductor and uses some contract manufacturing, but oversees the manufacturing chain from prototyping to production engineering and factory production. The company has also focused on intensive product development research, spanning ethnographic and user studies, market studies, design and technology.

As access to electricity can be nonexistent or limited in rural areas, D.light focused on deploying a light that would use scarce amounts of energy efficiently. D.light says its LEDs are 30% to 50% more efficient than fluorescent lights. D.light solar products come equipped with a high-quality, efficient solar panel that is weather-resistant and installation-free. An extensive outdoor wire is included when the panel is separate from the lantern. D.light products are designed to withstand daily usage and harsh environmental conditions. Each individual product is manufactured to ensure weather-resistance, ability to withstand a two-meter drop, and protection for internal circuitry from dust and insects. D.light lamp models offer two to four brightness settings to allow customers to optimize light output and energy usage based on specific needs. D.light lamps can also serve as an energy source for charging mobile phones, with full charging in as little as two hours. Some lamps are also equipped with a smart battery indicator to show when the battery is 25%, 50%, 75% and 100% full.

There are three series of lamps offered:

- Nova series: The Nova Mobile provides high-quality light while doubling as a mobile phone charger. It can provide up to 12 hours of bright light on a day's charge, and can recharge a mobile phone in as little as 2 hours. Now available globally, the Nova Series uses highly efficient LEDs. It is 8 - 10 times brighter than a kerosene lantern. The lamp gives an even white light projected at a wide angle, and can effectively illuminate an entire room. All Nova solar models include an efficient, portable solar panel with a lengthy outdoor cable for convenient solar charging.
- Kiran: The Kiran provides up to 8 hours of light on a full battery and uses highly efficient LEDs. It is four times brighter than a kerosene lantern and provides 360-degree illumination. The

lamp gives an even white light that can illuminate a workspace and can be used for a variety of activities like studying, cooking, or walking. A highly efficient solar panel is integrated into every Kiran for solar charging.

- Solanta: The Solata provides up to 15 hours of light on a full charge and uses highly efficient LEDs. It is 5 – 6 times brighter than a kerosene lantern, and performs exceptionally well for tasks where light is required from specific angles. Each Solata includes an efficient, portable solar panel with a lengthy outdoor cable for convenient solar charging.

Implementation issues / challenges

Current challenges for adoption of new lighting technologies in developing markets include:

- Customer education
- Creating a supply chain
- Technology improvement
- Affordability of products

Customers for off-grid lights are in some of the remotest areas of the world, and many have never seen electricity or solar-powered products. Successful deployment requires companies to create a strategy to spread the word that the product exists, and to convince customers to abandon a lighting source they are familiar with for an unfamiliar technology. Especially in Kenya and India. In more active markets, companies must combat tainted market perception caused by low-quality lighting products.

Companies have also reported challenges in accessing their target customers, and must develop a supply chain to get products to remote villages. NGOs and relief organizations have helped some companies break into markets. Local entrepreneurs play significant role in market acceptance, but companies must first convince local workers to leave stable jobs to join a startup. Companies face similar challenges when setting up offices in foreign countries, especially those in which they do not know the local languages.

Another focus is improving the efficiency and usefulness of products. Solar power is intermittent and sometimes unpredictable, which reduces the usefulness of solar-powered lights. D.light added an AC power charging option for overcast days for those customers who can access an electrical outlet, but the company is continuing to work to find solutions. Future products may include a more advanced energy storage option to make overcast days less of a problem for these customers.

Companies must find a way for customers with little extra income to afford the upfront cost of lighting technologies. D.light says it was careful not to “over-engineer” the products, aiming to keep the price as low as possible by developing new products based on customer feedback. D.light works with contract manufacturers and suppliers to

ensure the lowest-possible prices for components and manufacturing. The company also recently opened operations in China to help it make products at high volumes and low cost without compromising quality.

Financing is the final major hurdle for adoption of new lighting technologies, and D.light has not yet been able to find partners to offer financing on a widespread scale. D.light has completed successful trials with microfinance institutions in small, poor villages that many companies don't typically reach, but it's not clear if the crossover will work everywhere: D.light has faced some difficulties when educating local credit officers about solar technology.

Lessons learned

Companies must be innovative in marketing and distribution strategies when targeting customers in some of the remotest areas of the world. D.light has launched rural marketing campaigns in India and East Africa, and has developed a rural entrepreneurship program in India, whereby individual people sell D.light products to their family, friends, and neighbors on commission. That increases reach into the most rural areas and provides supplementary income for rural households.

Partnerships are essential in developing new supply chains. D.light's sales and marketing teams actively build partnerships with major distributors and local dealers to reach semi-urban and rural households. In addition, D.light partners with NGOs and distributors outside of primary markets to reach households around the globe. Logistics partners enable the company to ship products to any port in the world to meet the needs of partners worldwide. The company recently provided 35,000 solar lanterns for earthquake relief efforts in Haiti in partnership with multiple relief organizations in the devastated areas, most of which did not have access to electricity and relied solely on generators and solar power. D.light products were distributed among aid agencies and earthquake victims in the affected areas. Previously, D.light distribution partner Food for the Poor had provided over 7,000 Nova products to impoverished families in Haiti.

Rather than viewing poor villagers simply as customers, successful companies consult with them and view them as co-creators. Early on, D.light focused on creating lanterns with rechargeable batteries; after learning that many villagers didn't have an easy way to charge those batteries, they switched to solar. After customers expressed a need to charge their cell phones, the company introduced a new product that includes an outlet for phone charging. D.light did extensive testing in the field with customers and incorporated feedback into the final product. As a result, it designed rugged products that can survive drops of up to 15 meters. The lamps are water resistant, have vents to prevent heat buildup in the batteries, and include built-in mesh to prevent bug zapping and buildup. The products are simple enough for children to operate, and have ergonomic, multiple-setting handles that make them functional for hanging, using on a table, carrying, mounting on a wall, or when walking, cooking, studying, and bicycling.

Cost is extremely important in the developing world, where even a $5 price difference can open new markets, and available financing is

crucial for customers who cannot afford the upfront cost of products. The company initially began selling $15-$30 lamps but found that was still too high for many in the target market. The company worked with suppliers to drive down costs, launching the Kiran lamp in India in late 2009 that retails for $10 to $15.

Cost-benefits analysis

The cost of D.light's trial in southern Orissa was approximately $10,982 for 162 households. After two months, microfinance provider Beyond Solar reported that the on-time repayment rate was 100%. The customers reported tangible cost savings, as well as quality of life improvements.

The average kerosene usage of 11 liters per family per month was eliminated among households that adopted the technology, a savings of $3 per month. Customers were also able to eliminate the 5-km average trip to the market two or three times per week for kerosene. The average household earned $12.50 per month prior to the trial, but the light enabled families perform domestic activities at night, leaving more time for income work during the day. Families also began working at night in leaf-plate manufacturing, netting up to Rs. 10 per day. The average family earned an extra $0.20 per day, with the average monthly family income increasing to $18—nearly 50%.

Customers reported a noticeable improvement in air quality and safety, with typical usage of the lights for three to four hours per night at the highest brightness settings. The lights enabled children to study up to four hours a night, which was not possible with kerosene lighting. The lights were also used to make food preparation at night more sanitary, by preventing insects from getting in food. Mobile uses of the lights included protection from bears and other wild animals at night, and nighttime inspection of crops.

D.light's lamps cost between $10 and $30, depending on the features and exchange rate, and are guaranteed to last one to five years, depending on the product and level of usage. D.light's Rs. 499 ($10) Kiran solar lantern is expected to directly compete with kerosene lanterns, as two kerosene lanterns (Rs. 150 or $3 each) require users to spend Rs. 40 per lantern on fuel per year. D.light says the Kiran lamp pays for itself in 3-4 months with no recurring costs. D.light says families typically spend 5% to 30% of their monthly income on kerosene oil, with a typical farmer or shopkeeper finding the D.light products pay for themselves in about six months.

Emerging business models and their relevance to developing countries

D.light is addressing the distribution model through "rural entrepreneurs," who are the last link in the company's long supply chain. The commission-based positions are used to convince neighbors in remote villages that D.light's product is a worthwhile investment. They have also been instrumental in arranging informal financing plans, installment payments, and loan programs to encourage sales. In Tanzania and other developing countries, D.light is attempting to boost local sales and entrepreneurship through Youth Solar Entrepreneur

competitions that asked students to write a business plan detailing current lighting sources in their village, where would they sell solar lamps, and how would they do their financing and marketing.

D.light is also working with financing institutions that can offer loans to their clients. D.light has done several effective pilot projects with microfinance institutions such as Beyond Solar but hasn't been able to roll out financing on a large scale. The Shell Foundation recently partnered with D.light to provide risk capital to jumpstart these relationships. The poorest customers often do not have the cash flow to pay for the lamps up front, so microloans are enabling them to repay the cost incrementally with money they would have otherwise spent on kerosene. The Shell funding is also being used to test out a variety of marketing activities, from grassroots promotions to mass media radio ads. D.light plans to integrate the most effective strategies into ongoing operations. D.light has rural marketing campaigns in India and East Africa.

Example 2 – Smart Grid

Private utility using ICT to improve energy efficiency, network reliability, billing efficiency and consumer relations.

Most Smart Grid initiatives and innovations seem to be very focused on the developed world – for two reasons, One, the developed world's energy usage is so high that efficiencies can provide a very meaningful payback on investment. Two, fewer places in the developing world have grids, let alone are worrying about smart grids.

However, it may be that this is a missed opportunity as energy is scarce in the developed world and thus too precious to waste. The next case does concern the grid and is in the developing world, namely India.

Detailed description/ background

Established in July 2002, **North Delhi Power (NDPL)** was set up as a joint venture between the state government of Delhi and Tata Power to bring efficiencies to the power sector through privatization. NDPL distributes electricity across an area of 510 square kilometers in north and northwest Delhi, serving 1 million consumers. It has a peak load of around 1250 MW.

When NDPL took over from Delhi Vidyut Board in 2002, the unit's aggregate technical and commercial (AT&C) losses were 53% to 60%, meaning that the company was losing revenue on more than half the power that it distributed. The losses were due to poorly maintained equipment, poor bill collection and power theft. Under the newly established NDPL, a team was assembled to reduce energy losses, improve technology, and reform the financial and personnel infrastructure.

Description of the ICT technology deployed

NDPL developed a smart distribution network that allows most of the 52 grid stations to be remote controlled from a central command center to increase safety, reliability and maintenance savings—and to expedite

the resolution time for faults. The automation was based on a Geographical Information System (GIS) that mapped the entire network and mapped customers to the distribution transformers supplying them. This system was dovetailed into the customer relationship management system so that customer requests could be processed more efficiently. NDPL also deployed a Centre for Network Management comprising state-of-the-art electrical automation systems like SCADA (supervisory control and data acquisition), EMS (energy management system), DMS (distribution management system), and a GSM-based street lighting system. NDPL developed an in-house method for automatic meter reading (AMR) for its industrial customers to register energy usage through remote sensing—reducing the need for manual intervention and the possibility of mistakes or theft.

Implementation issues / challenges

Even as it improved its knowledge of its grid, a continued problem for NDPL was fighting power theft. As a preventative method, the network incorporated modern techniques like a High Voltage Distribution System (HVDS). The utility also incorporated AMR to ensure the accuracy of power bills for its major customers. However, the utility also incentivized legal connections by awarding regular-paying consumers with offers and discount schemes. NDPL also introduced energy coupons called Urja that can be gifted. With a significant part of its customers residing in low-income housing, NDPL set up a program to provide free life insurance policies to those customers to encourage legal electricity connections.

NDPL also had significant work to do in exchanging information with its customers about their bills and energy usage. The new management at NDPL aimed to improve its rudimentary customer relations and engagement, while making it easier for customers to pay. In 2003, NDPL had 19 payment centers for 1 million consumers, but in six years set up 1,200 payment avenues including an online billing and payment site, ATM-like kiosks for automated bill payment, and consumer centers and call centers. NDPL set up an SMS based fault management system that helps improve reliability of power supply by allowing consumers to alert the company of outages.

Lessons learned

NDPL faced the same operational challenges as many utilities in developing markets: lack of visibility into its assets, human error, theft, and equipment failure. The first step in addressing all those issues—and losses of 53% to 60%—was NDPL performing a thorough accounting of its grid and the energy assets produced. ICT has been essential in enabling the utility to continue to implement changes during the past seven years.

NDPL used in-house expertise to develop an AMR system, but implemented it only at its industrial customers, which represented 60% of its consumer base. As a result, NDPL was able to make the smallest investment possible for the biggest impact.

Its capital efficient strategy included using customers to help it identify and precisely locate failures and faults on the grid. NDPL gained 24/7

feedback on the grid's functionality while having to make a relatively small investment in a system that enabled customers to communicate problems through SMS on mobile phones.

With cost in mind, NDPL also addressed power theft through a combination of preventative technologies and incentives to customers, thus increasing its customer base.

Cost-benefits analysis

NDPL invested Rs 1,700 crore ($362 million) over six years in technology and network upgrades. Its efforts resulted in a significant drop in energy losses and an increase in revenue.

The AMR system alone did away with former problem areas of billing errors, tampering of meters by unscrupulous consumers and fudging of meter readings, thus easing revenue flows from big ticket customers that comprised 60% of NDPL's consumer base.

The company reported AT&C losses in 2008 of 18.5%—a drop of over 65% since 2002. That helped the company exceed year-on-year targets, earning post-tax return on investment of an average 27% per year. The company reported in FY08 profit after tax of Rs 281.58 crore, with revenues showing an increase of 11.45% at Rs 2,287 crore. Since then, AT&C losses in NDPL areas have shown further decline to 14% as of March 31, 2010—a drop of 74% since 2002.

Emerging business models and their relevance to developing countries

NDPL is exploring opportunities to replicate its experience of distribution reforms in other places by taking consulting assignments for electricity boards in other Indian states, as well as overseas. NDPL has recently been retained as an IT consultant by Power Finance Corporation to assist other electricity boards in India.

NDPL is advising utilities and power providers on best practices in customer communications, transmission and distribution. The company is currently executing on a consultancy service to reduce losses at a public electricity corporation through the Republic of Yemen Ministry of Electricity and Energy. NDPL was also recently tapped for an IT consultancy under R-APDRP for Chattisgarh State Power Distribution Company Limited and Dakshin Haryana Bijli Vitran Nigam Limited. NDPL is serving as project manager and consultant to implement Geographical Information Systems at Tata Power Company Limited, and a consultant to deployment the CRM Module at Tata Power Company Limited. NDPL is providing support as a consultant to Haryana Distribution Companies (DHBVN & UHBVN) to establish a monitoring and evaluation framework for agricultural consumers.

Completed projects include the development of call center and consumer care centre for Paschimanchal Vidyut Vitran Nigam Limited (PVVNL – Noida Circle); advisory support for restructuring of transmission & distribution for Central Electricity Board (CEB) in Mauritius; and implementation the corporate restructuring of Nigeria

Electricity Power Authority (NEPA), now PHCN (Power Holding Company of Nigeria), Bureau of Public Enterprises (BPE), Abuja.

Example 3 – Smart Logistics

Software and hardware to help fleet drivers and transit agencies improve fuel efficiency

Driver behavior is universal. The driver's habits that increase fuel consumption of a public bus in Chicago would have a similar impact in Mumbai. The mistakes that make a truck driver in Germany more likely to get in an accident, also have the same result in China.

While much attention has been given to improving the supply chain with technology, the field of training drivers to perform their jobs more efficently and safely is still in its infancy. The next case study is not set in the developing world, but it has applications there that make the technology very promising. Indeed, the company profiled have plans to take their application to some developing countries.

Detailed description/ background

Driving behavior contributes up to 33% of fuel consumption due to subtle decisions that drivers make. In addition, driver behavior leads to over 90% of vehicle crashes, with an estimated annual cost of $200 billion in the U.S. on physical losses alone. General training courses have not proven an effective method for changing long-term driving behaviors, creating a market for driver-specific feedback and coaching. Trucking fleets, transit agencies, insurance companies and consumer groups are among the customers adopting new technology to measure, improve and sustain safe and efficient driving behavior.

Redwood Shores, California-based GreenRoad Technologies, Leeds, England-based Masternaut Three X, and San Luis Obispo, California-based Fleet Management Solutions are three companies that are deploying technology to address efficiency in this segment of the supply chain. We have chosen to look more closely at GreenRoad in this study to illustrate how ICT can have a beneficial impact in terms of energy usage and carbon in the world of transportation logistics – albeit in the developed world.

The technology is initially being adopted by medium and large fleets, which range from several hundred to thousands of vehicles, because fuel efficiency has a great impact on profitability. GreenRoad reports that it currently has 90 fleets as customers, in sectors such as trucking, public transit, telecommunications, service delivery, passenger transportation and public safety. Its announced customers include Ryder, Ericsson, FirstGroup, LeFleur Transportation, and the UK Ministry of Defence.

IDM Trucking Inc. is an employee-owned transportation company that hauls general household goods and beverages in dry vans for clients including small to large sized businesses in the U.S. mid-Atlantic region. In 2008, the company decided to self-install GreenRoad's

technology in all its vehicles. IDM says that some drivers initially expressed apprehension about the new addition to their vehicles and the possible distraction by a new screen, but became more comfortable after receiving the personalized feedback. Drivers saw improved mileage per gallon, resulting in annual fuel savings of $1,500 per vehicle. IDM's crash frequency dropped from 0.38 crashes per 1 million miles in 2008, to zero in 2009. Each crash eliminated reduced IDM's cost by an average of $16,500, based on National Highway Traffic Safety Administration cost per crash data. IDM's insurance rates also dropped as accidents decreased.

Another GreenRoad customer is Balfour Beatty Utility Solutions, an operating company of Balfour Beatty, a global engineering, construction, services and investment business. BBUS is one of the UK's leading utility solution providers, with a strong position in international markets. It works across the water, wastewater, gas and power industries, providing a range of services that contribute to the maintenance and provision of essential utility assets. BBUS was seeking to reduce its annual fuel bill of £12 million, and reduce risk to the public and its workforce as part of its Zero Harm initiative. The company started using GreenRoad software in late 2008, and deployed the technology to several BBUS depots, which reported a 60% reduction in risk and up to 10% in fuel savings. As a result, in May 2010, BBUS announced a three-year contract to roll out GreenRoad across its entire commercial fleet of 1,400 vehicles, including Light Commercial Vehicles (LCVs), Heavy Goods Vehicles (HGVs) and company cars.

Sheffield Insulations, the UK's leading distributor of insulation products, is part of the international SIG Group. Sheffield deployed GreenRoad's service in August 2009 across its fleet of HGVs and LCVs at its Ruislip depot that covers from West London to Surrey and Oxfordshire. By November 2009 the company had achieved a 24% reduction in the number of accidents over the same period in 2008 and a 9.7% reduction in fuel consumption.

Description of the ICT technology deployed

GreenRoad employs sensors to monitor up to 120 separate driving events in five categories: speed handling, cornering, land handling, braking, and acceleration. The technology analyzes a driver's maneuvers, recognizing unsafe or inefficient movements. The in-vehicle display provides immediate feedback and coaching to the driver, and seeks consistent patterns of behavior. The dashboard-installed box flashes green, yellow or red depending on the level of driving risk. The device uses a cellular modem to transmit the safety data back to servers, which use patented algorithms to evaluate overall driving risk and skills. A website provides real-time reports and analysis to managers, who can assess how driving habits can be improved and assess risk by driver, by organization or fleet-wide. The company says its technology can help drivers improve fuel economy 10% and reduce crash costs 50%.

The in-vehicle device is relatively low cost, taking advantage of commodity hardware components. The value-add is GreenRoad's

algorithms to understand what the vehicle is doing and how that impacts safety and efficiency.

The technology captures extreme behaviors, such as speeding and fast acceleration, but its value lies in that the technology also measures subtle habits that might not be immediately obvious. The most common finding affecting fuel efficiency is drivers exceeding the corporate speed policy (often established at 55 miles per hour to maximize fuel efficiency) by 3 or 4 miles per hour, which over time burns significantly more fuel.

Implementation issues / challenges

Technology focused on driver behavior is a new category of service, so education is crucial for market acceptance. Many companies and fleet managers are unaware of the impact that driver behavior has on fuel economy, instead focusing budgets on technology to improve vehicle or route efficiency. GreenRoad and other technology providers must educate their customers about potential savings, before even trying to differentiate their products from competitors'.

Although the service is highly automated, GreenRoad reports that it takes a fair amount of setup and education of fleet managers and drivers to maximize efficiency and safety. The company also offers ongoing support for its subscription-based product. With 90 employees, GreenRoad is focused on in a select few markets—the U.S., UK, Canada, Germany and Israel—but has ambitions to expand to India, China, Brazil and other developing markets when it can support the languages and training needs.

Initial setup can be a challenge because fleets involve hundreds of vehicles in many locations, all of which must be outfitted with the same hardware and software. Without careful coordination, the installation process can be extremely inefficient, taking additional time and delaying the company-wide implementation.

Classroom training has limited effectiveness because many drivers will revert back to habits. An environment of sustained change requires multiple forms of feedback, support, and targeted training. Finding the right combination can be challenging. Successful programs include alerting drivers while in vehicles, ranking drivers within companies, and conducting classroom training.

Lessons learned

Most of the issues that affect driver behavior and decision making are universal to drivers, regardless of size and type of vehicle, training, experience, job function, age, race and nationality. That has enabled GreenRoad to deploy the same technology to improve the operation of light vehicles, tractor trailers and city buses in different countries with the same results. However, some differences are pronounced, and GreenRoad developed algorithms that can assess the different driving needs of different contexts (a city bus driver versus one driving cargo cross-country).

GreenRoad has found that training is less effective when drivers and managers are not properly briefed in advance on what the new system is, what types of feedback it will give, and why the information is valuable. In order to do things differently, drivers must believe the feedback they are getting is credible. It helps to have endorsement or support from union leaders and senior drivers.

Positive reinforcement is as important as negative reinforcement. GreenRoad has seen that the majority of drivers engaged in a constructive and positive way will make changes, whereas if they perceive as something as a burden or as criticism, they are unlikely to sustain those changes. Positive feedback includes awards for safe and efficient driving, as well as a positive tone for coaching and feedback.

Cost-benefits analysis

GreenRoad's customers report savings on two fronts: reduced fuel consumption and fewer crashes (leading to less downtime, less equipment replacement, and lower insurance costs). Customers make a payment upfront to cover the cost of hardware, installation and training, as well as a subscription fee that can be charged monthly, quarterly, or annually that provides access to the service. The total cost per vehicle over three years is about $1,500. GreenRoad says the technology pays for itself in about six months, with a net savings of $1,000 to $4,000 per year per vehicle. There is currently no real economy of scale to be gained with larger deployments, so small and medium fleets see the payback in the same period as large fleet customers.

Emerging business models and their relevance to developing countries

GreenRoad has not deployed its technology in developing countries because of the cost to enter an unfamiliar market with language barriers. The issues that impact driver behavior are highly similar despite variables on location, job function or driver experience, so a safe projection is that the GreenRoad software and hardware would have applications in developing countries as well. The low upfront cost of its commoditized hardware means no significant upfront investment by customers—a plus when entering developing countries. The subscription-based model allows for the technology to produce cost savings greater than the price of the subscription, especially in markets in which vehicle safety is a major expense.

Conclusions

Energy efficiency has consistently been one of the top areas of technology attracting global venture capital for the last 18-24 months.[16] The market demand is there and is in tune with a tighter economy generally. Notwithstanding the climate change implications, energy efficiency investments stand up on their own, as they save owner/operators money. Current estimates point to a $170 billion per year investment opportunity[17] in energy efficiency, and an approximate 17% internal rate of return.

ICT has played a significant role in the last decades of improving economic productivity. It now has the opportunity to enable us to make further significant productivity improvements, helping us transform the world to a more sustainable, lower carbon and more resource-efficient future in the process.

The case studies to illustrate ICT in energy-efficiency enablement mode have been mainly drawn from the developed world. I think we should read into that two things. Firstly, ICT applications for energy efficiency are in their early growth phase; they have much distance to travel in terms of technological maturity, economies of scale and reliability. Secondly, most of the near-term focus is on the opportunity for investment returns in the capital-richer and more energy-intensive developed world where investment to de-leverage cost bases is a high priority to bring economies back in shape.

As the World Bank recognized in its own report, stimulating the invention and development of such ICT-based innovations for areas such as smart buildings, smart grid and smart logistics is critical for the developing world too.

However, energy efficiency wins will not be easy. There are plenty of policy, market and behavioral hurdles that need to be overcome to deliver the savings possible. The kind of ICT solutions I have illustrated in this report still need to be implemented at scale.

And it is implementation, rather than technological invention, which I think will prove the greatest challenge from here. Integration. Inter-operability. Standards. These all significant challenges for successful technical implementation, wherever in the world.

Location matters too. The energy-efficiency challenges vary, developed to developing, north to south, hot to cold.

Although energy-use patterns are surprisingly similar across the globe, it's impossible to develop single international solutions for energy efficiency. Energy efficiency strategies in developed countries mostly focus on retrofitting existing buildings and reforming existing networks, be they electricity grids or logistics/transportation supply chains. In

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[16] *2009 annual review and 4Q09 investment monitor*. Cleantech Group. February 2010

[17] http://www.felj.org/docs/elj302/15growing-the-energy-efficiency-market091020.pdf

contrast, the priorities for the developing world and the use of ICT will be quite different:

- 2 billion more people will live in cities in 20 years, mostly in the developing world. A priority for energy efficiency in buildings, therefore, must be how to design low-energy intensity into where new construction is going to occur – namely, in the new cities and buildings of the developing world
    - Automated, networked, smart buildings may be realistic prospects in some urbanised areas of some developing countries, but the realities of energy efficiency in buildings for the majority of the developing world will centre on the most basic of basics – better lighting, for example
    - Solutions and providers must adapt to different situations. Brazil and China are very different from Haiti and Tanzania, for example
- Many countries do not start with a grid to make smart, and those that do may be overawed by the scale and cost of the upgrade challenge
    - For the 'grid-less', is this, on its own, such a disadvantage? One bright spot for the developing world is that its lack of electricity infrastructure isn't such a huge relative disadvantage by itself, as many of the deployed transmission lines and substations in North America and Europe are ill-equipped to support the smart grid. The U.S., for example, has hundreds of thousands of transmission lines that pre-date the year 2000, and less than 700 miles of interstate transmission added since then. The complexity of overhaul is complicated by there being more than 500 owners of the U.S. transmission lines, whereas ownership is more centralized in most other countries.[18]
    - This is where governments and supra-national development organizations could become critical since they are in positions to accelerate or underwrite the build-out of smarter, but perhaps more decentralized, grids. Is it easier when you start with very little, analogous to the by-passing of fixed-line telephony for a mobile network? I am sure the World Bank is well aware that most smart grid programs, in Korea, China and US for example, are driven by "green deal" stimulus funds.
- As discovered in this study, in many ways the development of ICT applications in smart logistics is least developed. There is, at least on the face of my work, the least innovation activity stimulated here in the developed world. And yet, with the population growth continuing in the developing world, and the existence of mobile phone networks as a basis for communication, it may be that this is a field where adaptation could occur faster, where economic productivity could be

[18] http://www.ferc.gov/eventcalendar/Files/20080731102123-Chairmantestimony.pdf

increased, of which energy-efficiency is but one of the measures of enhanced ability to do more with less.

And lastly, but perhaps most important of all, business models matter too. Who pays and who benefits goes to the heart of whether something will happen and something is sustainable. What our case studies consistently show is the identification of a situation where upfront capital investment into some ICT-based solution (be that a networked lighting system, a sensor network in a building, or software to maximize fuel efficiency) holds the promise of lowering total costs of 'ownership and maintenance' over a period of time. But, to capture the energy savings, the user might need to tolerate upfront investment and payback periods, something that can be a psychological barrier in the developed world in these capital-constrained times and simply unachievable in many cases in the developing world.

This is where innovating with new business and finance models comes in.

The emergent business models in energy efficiency are analogous to how software discovered 'software as a service' in the early 2000s. It is now a popular business model with businesses and consumers alike. Essentially, it offered a choice. As opposed to having to buy software licenses upfront and servers and other software to support usage, the service model creates a monthly subscription. Quite simply, for the model to work, the subscription cost needs to be lower than the savings achieved by the service. Energy Efficiency can be such a service:

- This approach is evident in the GreenRoad case study
- D.light, through its partnership with a microfinance provider, was in effect trying to "package up" the same model, by offering a loan on the upfront capital cost, thereby enabling the user to realize the 'business as usual' savings
- It has also been evident in the approach of energy services companies (ESCOs) for many years

Other analogies are found in the printer and the mobile phone world. Printers are relatively cheap hardware; the money is made in the sale of higher-margin ink which is an ongoing, regular cost. Similarly, with mobile phones. By embedding the costs of the handset within the monthly subscription (be that a fixed price or pay as you go), the mobile phone industry overcame a barrier to market adoption: it flattened the initial upfront capital hurdle.

In the latter case, complexities had to be overcome in the value chain. How much does the handset manufacturer benefit, how much the operator, how much the provider of applications or content for the handsets? What savings over time should be passed onto the end user? Similarly, as energy efficiency grows up, such questions will need to be resolved. There are potentially many stakeholders in most energy efficiency situations with revenue and cost interests. This basic point is illustrated in a current housing project in Egypt. It was reported to me that, in this project, the builder, the electricity company, and Internet Service Provider (ISP) are collaborating and are using Broadband on

Power Line (BPL) to provide broadband connectivity to the occupants but also using the same medium to provide smart buildings and smart grid solutions. Who pays and who benefits in situations like these?

There are no simple answers, but for ICT solutions for energy efficiency to thrive, such questions do need to be resolved. And nowhere more so than in the developing world where access to upfront capital is a significant barrier.

Recommendations

This study, illustrative rather than comprehensive, suggests the World Bank Group would be well-advised to concentrate on the following:

Build on what works, what is sufficiently developed, and what is realistic today.

Energy efficiency is a long-term game and whilst we can write about and visualize all these solutions, only some are in reach today, even fewer for the developed world.

The D.light case study powerfully reinforces the message that energy efficiency for many millions will not be futuristic or 'smart' (i.e. connected to a broadband backbone) but stand-alone and distributed, and serving basics today like the ability to see at night. How about concentrating on what is realistic and impactful today?

Building codes in the developed world are the norm and ever more complex. For the developing world, the ambition can be more limited. Yes, to some minimum requirements for building codes (with new construction), but how about concentrating on just one or two areas such as efficiency standards for appliances?

Concentrate on the enablers

As I said before, year by year, ICT will enable many solutions for energy-efficiency, much of which will start with a developed world focus but some of which will be quickly adaptable.

However, getting such applications into use will present many challenges, areas in which the World Bank Group is well-placed to assist. Three keys places that came out of the case studies:

- Education and Training – ICT applications and new technologies represent change in all parts of the world, but even more so in parts of the developing world where people are not exposed to ICT on a daily basis.
- The availability of finance (micro-finance) – Even where the return on investment is a no-brainer, the ability to finance the upfront investment may be too large a barrier. If facilities are available that support the business models, energy efficiency can work in the developing world. Most business models in ICT revolve around an upfront investment and a subscription to pay for a service. To work, this requires integrated finance

mechanisms that enable the lending of capital (to cover the upfront investment) and the repayments (via the subscription).

- Aggregation – The Energy Efficiency landscape is typified by a large number of small projects, and probably nowhere more so than in the developing world. I would recommend the World Bank Group look at how it could help aggregate individual projects into a larger and more cohesive investable model.

Notes from the author

There were two significant challenges in completing this study.

One was time. The timetable was short and the ability to interact and adapt in line with WBG feedback was limited. The danger was always not hitting the timeline and as that was always said to be immoveable, that has been a priority in my work scheduling.

The second is data availability. It is tempting to think that more time would have improved data availability. That is true, only to a certain extent. What has become apparent in doing the study is that the evidence “bank” on ICT solutions in energy efficiency is still relatively limited. This phase of innovation is still in its infancy; there are many interesting developments and pilot projects, but we are some way short of a treasure trove of large-scale projects with multiple-year track records, with precise and auditable costs/benefits. Today, the key data source is primary interviews. Can one identify the project owners/operators? Are they willing to divulge information (why? what is their incentive for doing so)? If so, in what time-frame? With more time, more information and more case studies could have been done, but it would constitute an evolution of the study, not a comprehensive revolution.

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Various interviews were conducted in June 2010 for the purposes of this report, including the following:

- Amit Chatterjee, CEO of Hara, and Michel Gelobter, chief green officer of Hara
- Akhil Pendrey, chief executive of New Delhi Power Ltd.,
- Leonardo Borgini of D.light Design
- Dan Steere, CEO of GreenRoad,

Various technology company websites were reviewed including those who appear in this report:

http://www.aduratech.com/

http://www.beyondsolar.org/

http://www.dlightdesign.com/home_global.php

http://www.enocean.com/

http://www.farmworks.com/

http://www.greenroad.com/

http://www.hara.com/

http://corporate.helveta.com/index.html

http://www.landisgyr.com

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http://www.micelectronics.com/

http://www.ndpl.com/

http://www.rltec.com

http://www.routematch.com/