8 ICT, Energy and Climate change

Embracing the Goals

SDG 7, to "ensure access to affordable, reliable, sustainable and modern energy for all," recognizes the crucial importance of universal access to sustainable energy and the de-carbonization of energy consumption. SDG 7 encompasses targets for universal energy access (target 7.1), renewable energy growth (target 7.2), energy efficiency improvements (target 7.3), international cooperation in sustainable energy infrastructure development (target 7.a), and technology upgrades and expansion of energy systems (target 7.b).

SDG target 7.1 recognizes that provision of energy access is critical for social and economic progress and calls for "universal access to affordable, reliable and modern energy services." Energy access enables services like powering medical equipment in hospitals, illuminating schools and businesses, cooking meals, turning on water pumps, powering computers and data centers, providing thermal comfort, and transporting people and goods around the world.

SDG 13 calls for taking urgent action to combat climate change and its impacts.

Facing the challenge

Access to energy is essential for human development and economic growth, yet over one billion people worldwide lack access to electricity—more than half in sub-Saharan Africa. As many as 2.8 billion do not have access to clean and safe cooking energy services,[233] and available alternatives such as kerosene and diesel have negative impacts on human health as well as the environment.[234] Not only do these energy access gaps need to be bridged, but it must be done in ways that minimize harm to human health, reduce global carbon emissions and help to combat climate change, in line with SDG 13.

The transportation sector in particular is a large consumer of energy, and accounts together with logistics for up to 40 percent of air pollution.[235] Transport infrastructure worldwide is under pressure due to rising population, environmental challenges and urbanization. By 2050, 7 out of 10 people will live in cities, which account for about 60 percent of global greenhouse gas emissions and 75 percent of global energy consumption, according to UN-Habitat.[236]

To address these challenges and achieve SDG7, easier access to affordable, cleaner, low-carbon energy sources is needed as well as major improvements in energy efficiency. ICT can help to deliver both. Moreover, existing lack of infrastructure in many parts of Africa and Asia creates an opportunity for such regions to leapfrog—via innovative technologies such as ICT and renewable power generation—to achieve universal energy access by 2030 and for building the foundation for low-carbon cities of the future.

8.1. Introduction

Securing sustainable universal energy access is not only about making greater use of renewables, but achieving better energy efficiency and lower energy consumption in the services delivered to consumers. If the global population were to adopt the same energy consumption patterns as developed countries—a Business-As-Usual energy scenario—economic growth would be unsustainable. The amount of greenhouse gases (GHGs) generated threaten the climate as depicted in IPCC 6GS scenario237 and jeopardize achievement of SDG 13 to combat climate change.

An historic agreement to combat climate change and unleash actions and investment towards a low-carbon, resilient and sustainable future was agreed by 195 nations on December 12, 2015. The aim is to keep a global temperature rise this century well below 2 degrees Celsius. Scientists believe that a greater increase in temperature would be very dangerous. The agreement even establishes, for the first time, that we should be aiming for 1.5°C, to protect island states, which are the most threatened by the rise in sea levels.[238]

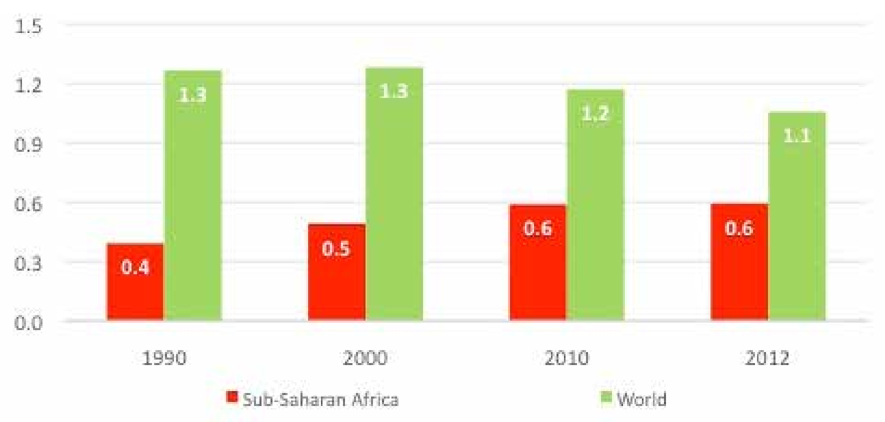
To provide energy sustainably to hundreds of millions of new users, address the cooking and heating needs of the world's least developed countries, ensure more efficient electricity delivery in developed markets, and support overall conversion to renewable power sources, harnessing new technology to deliver efficient, low-carbon solutions is crucial. ICT can help in three main ways—first, by catalyzing new business models for improving energy access and promoting uptake of renewables; second, by helping energy suppliers and other sectors to reap significant efficiency gains and manage consumer use; and third, by raising awareness and helping to drive the necessary behavior change to support a universal, low-carbon energy future.

Building new energy generation and distribution infrastructure would be cost-prohibitive. It would also impact achievement of other SDGs: cooking or heating with wood or coal, for example, is responsible for about 4 million premature deaths per year, undermining progress on SDG 3 on good health.[239]

SDG target 7.2 states that the world should "increase substantially the share of renewable energy in the global energy mix by 2030." With falling solar prices, wider-scale deployment is becoming a feasible substitute for high-carbon power sources. In addition to enabling new business models for provision of energy, ICT can help spur penetration of distributed renewable energy by allowing real-time measurement and control to help manage variables such as intermittent wind speed, solar irradiation and water flow.

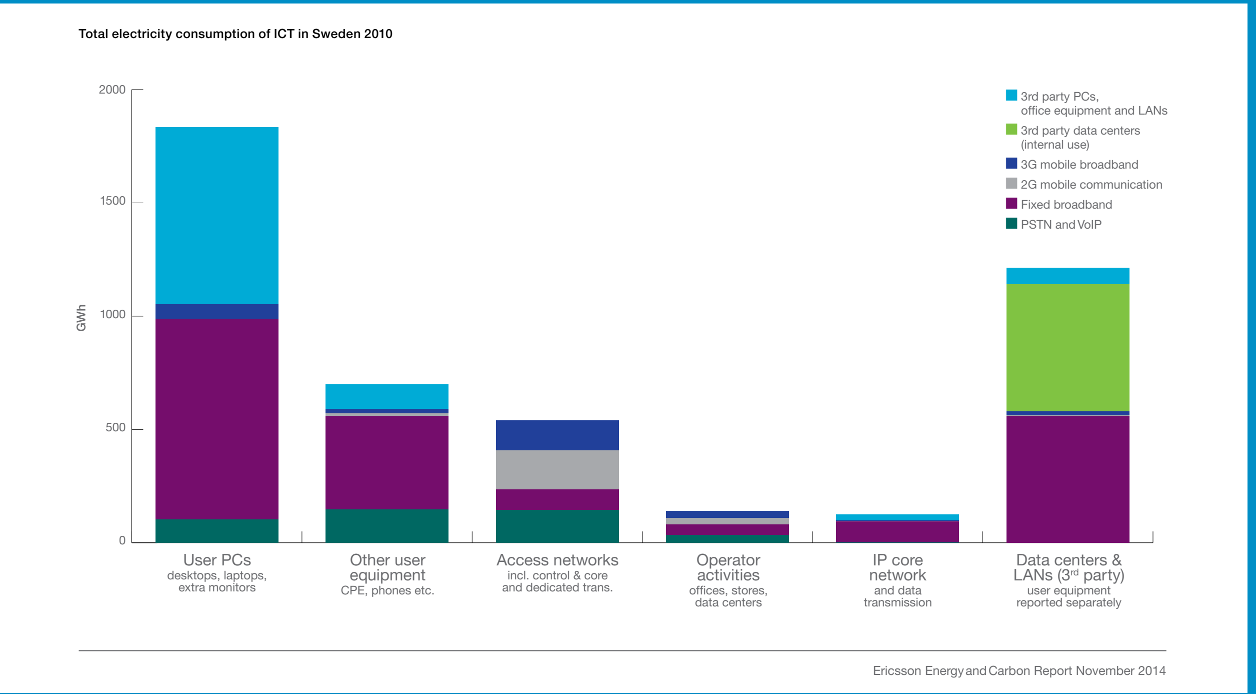
ICT can also play an important role in delivering SDG target 7.3, which sets out to "double the global rate of improvement in energy efficiency by 2030," yet at present some 70 percent of electricity is wasted before it reaches the end-user. This highlights enormous potential for ICT to make the whole electricity value chain 'smarter' and more efficient from extraction and production to distribution and use. As well as smarter operation of buildings, manufacturing facilities and

Figure 8.1. Number of people without access to electricity



Number of people without access to electricity and access to non-solid fuels.
Source: World Bank, Sustainable Energy for all (SE4ALL) database from WHO Global Household Energy database.

Case 8.1: Life-cyle impact of environmental impact of ICT[241]



In 2014, a national-level study of the lifecycle environmental impact of ICT was published with mobile operator TeliaSonera and KTH Royal Institute of Technology in Stockholm. This unique study was based on available statistical data from 2010. Results show that the ICT sector in Sweden consumed about 4,600 GWh of electricity in 2010. The main electricity-consuming categories were user PCs, data centers (servers) and other user equipment (customer premises equipment, CPE), as shown above. These areas also offer the largest potential for reducing electricity consumption.

The ICT sector comprises everything from end-user equipment to the access networks and data centers. The definition of 'ICT network' for this study included mobile and fixed-access networks (including broadband) to data transmission and the IP core network. User equipment was defined as everything from fixed and mobile phones to modems, computers and set-top boxes for IPTV. To provide a more complete picture, the enterprise networks as well as operators' own activities in terms of offices, stores, travel and vehicles were included. Lifecycle assessment data were collected for the vast majority of included products. The total GHG emissions of the ICT sector in Sweden amounted to approximately 1.5 Mtonnes CO_2ein 2010, corresponding to 1.2 percent of total Swedish GHG emissions.

appliances, growing connectivity between people, devices and the Internet-of-Things is paving the way for new paradigms in energy efficiency, as well as greater consumer awareness. Of course the ICT industry itself must also continuously improve its energy performance (see Case 8.1.).

Accelerating the shift to a low-carbon economy

Among the biggest contributions of ICT is its unique potential to enable other industrial sectors to reduce their environmental impact and improve sustainable urbanization. According to the Ericsson Mobility Report,[242] ICT solutions could help to reduce GHG emissions by up to 15 percent by 2030, amounting to around 10 gigatonnes of CO_2e—more than the current carbon footprint of the EU and US combined.

ICT solutions are applicable across all sectors of the economy, from transportation and logistics to buildings and utilities, where innovations such as smart metering and smart grid communications can enable higher levels of renewable electricity and reduced household energy consumption. In applications ranging from homes and commercial buildings to parking and lighting, digital transformation can support energy efficiency and CO_2 reduction through intelligent sensors and controls that tailor energy consumption more precisely to demand. ICT also lowers operational costs and reduces complexity, making it easier for consumers to pay for energy and for utilities to receive payment.

ICT solutions could help to reduce GHG emissions by up to 15 percent by 2030, amounting to around 10 gigatonnes of CO_2e—more than the current carbon footprint of the EU and US combined.

Source: Ericsson Mobility Report, November 2015

Through ICT-enabled connectivity between commuters, logistics operators and transport infrastructure such as roads, rail and other public transport systems, more efficient traffic flows can help to ease congestion, avoiding the need for new transport infrastructure while providing efficient, safe and cost-effective transport of people and goods around the world.

Decoupling global GDP growth from energy consumption is key to achieving SDG 7 and its targets. The important role of ICT in ensuring sustainable and equitable access to energy was emphasized in 2011 in a UN initiative called Sustainable Energy for All (SE4All), launched to promote collaboration and partnership among governments, businesses and civil society. Emerging economies such as Russia, South Africa, China, Brazil have an opportunity to leapfrog to more sustainable energy development by drawing from successful initiatives in developed countries, increasing their energy intensity while at the same time spurring economic growth.

Monitoring energy consumption and energy efficiency, i.e., energy performance, is essential and it will be important to find new ways to measure progress, along with building greater societal awareness of the energy challenge to change habits and stimulate more efficient ways of using a scarce resource.

In short, to meet SDG 7, the energy sector must undergo a dramatic transformation in the way energy is delivered and utilized. Embracing ICT-enabled solutions can—and already is—playing a strong role in driving transformation of the energy sector and also supporting SDG 13.

Linkages to SDG 2, 6 and 11

SDG 2 which calls for ending hunger and includes areas such as increasing yield in agriculture and the whole food value chain, SDG 6 (Water and sanitation for all) and SDG 11, Sustainable cities and communities, are three additional SDGs which are closely connected to climate change. When parameters such as rate of evaporation vary a great deal globally, depending on temperature and relative humidity, distribution of precipitation in space and time is uneven, and therefore the amount of water available to replenish groundwater supplies will be impacted. Water and climate are also connected to the production of electricity from rivers and basins, among other water sources.

Cities are socio-economic powerhouses, generating over 80 percent of global GDP according to the World Bank. They also emit significant GHG emissions, rising from about 67 percent today to 74 percent by 2030 (International Energy Agency, 2008). If cities' investments include ICT then several SDG targets can be achieved simultaneously as outlined in a 2015 report by Ericsson and UN-Habitat,[243] "Information and Communication Technology for Urban Climate Action."

Sweden's Stockholm Royal Seaport, a sustainable urban district with the goal to be carbon neutral by 2030, is a prime example. It won the Sustainable Communities award in the C40 Cities Awards at COP 21. (Case 8.2)

8.2. ICT in action: Transforming the energy sector

Connectivity is transforming the energy sector. ICT delivers synergies across different technologies: sensing and control, automation of processes, energy storage, renewable energy generation, machine-to-human interactions, and efficient use of energy by consumers. Smart metering and smart grid communication are becoming essential for stability in the grid, particularly given the volatile nature of renewable energy sources, which benefit from greater measurement and communications in power networks than is typically needed with more predictable fossil fuel or nuclear power generation.

By using ICT to gather and act on information, smart grids give households greater control over their bills and environmental impact, and allow renewable energy sources to be better integrated into the power network. Real-time information enables providers to repair faults as they occur, and even to prevent them happening in the first place—hence addressing both SDG 7 and SDG 13.

This capability is already being demonstrated in today's 4G networks, and this will be enhanced by modern cellular networks that offer significantly higher throughput, lower laten-

Case 8.2: Energy-smart homes in Stockholm Royal Seaport

In 2015, a smart energy housing project with 150 new apartments was launched at the Stockholm Royal Seaport. Ericsson is part of a consortium of companies involved in the project, including Fortum, ABB, Electrolux and the Swedish Energy Agency and NCC, Erik Wallin and HEBA. The homes will be equipped with state-of-the-art energy technologies and connected appliances, so residents can monitor and control energy usage in real time. The aim is to develop smarter ways to use energy and reduce the total amount required.

Apartment residents will have much better overview of their energy use, while the companies will gain more knowledge about energy use in the building, which can help shape future development of smarter cities. The technology used in the apartments aims to make 'Demand Response' possible. Residents will visualize their electricity usage via a display alongside environmental and price signals and can allow the washing machine or tumble dryer to automatically run at a time of day when climate impact and/or price are lower. Residents will also receive a special electricity contract that supports this.

cy, and more data capacity compared to previous generations of mobile networks. This gives utilities more real-time control of their networks and meets the growing need to analyze data close to the collection point using private edge clouds.

8.3. New business models for energy access delivery

Multiple mini- grid installations around the world are successfully supplying rural communities with electricity from renewable or conventional power stations. These small energy systems usually include a generation site and connections to customers through a small electricity network. Mini-grid systems are important steps on the path to achieving SDG 7. The SE4All Global Tracking Framework 2015 estimates that half of the global rural population currently without energy access could be served with electricity via mini-grids.

Mini-grid encompasses micro-grids (grid systems with less than 10kW of power capacity) and mini-grids (grid systems with 10kW-100kW of grid capacity). Renewable energy is usually the power source of choice as it tends to be the most affordable energy option for remote areas that are unconnected. Declining solar energy costs are also making solar energy more affordable, fuelling exponential growth in solar energy deployment. In the last five years[244] the price of solar panels has fallen by as much as 80 percent.

A major requirement for sustainability of mini-grid projects is effective management of the mini-grid operation.[245] Depending on the business model for the mini-grid operation, costs related to building, operating and maintaining the mini-grid are shared among different stakeholders in the system. ICT can enable operators to monitor performance and identify and troubleshoot problems remotely, reducing operational and maintenance costs. With a network of smart meters, a knowledgeable organization, e.g system manufacturer, can remotely help local entrepreneurs to solve problems as they arise.

Making billing simpler

Innovative prepaid metering and mobile payment systems are dramatically lowering transaction costs of meter reading and bill collections, and bringing transparency to 'last-mile' utility operations—just one example of how mobile financial services are improving delivery of services in multiple sectors (see Chapter 5, ICT and Financial Inclusion).

A number of successful mini-grid projects use a variety of ICT tools to collect revenues. This includes smart meters, a metering device that not only measures electricity consumption but can also enable communications between the customer and the meter operator enabling data collection and control. In addition to smart meters, some systems also integrate mobile payments into their revenue collection systems.

Mobile payments through ICT are dematerializing the way people pay for energy services. As discussed in Chapter 5 on Financial Inclusion, the number of mobile payments has grown exponentially in many developing regions in the last five years. Although cash payments in collection booths or through rural agents are possible in many mini-grid systems, mobile payments offer mini-grid operators the additional efficiency and affordability that are key factors for the sustainability of their operations.

Cost-effective metering

Mini-grid operators working with remote, rural communities are lowering operational costs for revenue collection by using a metered and billing system that includes smart meters, such as prepaid or pay-as-you-go (PAYG) meters. While mini-grids are poised to provide 50 percent of new connections, individual off-grid systems or household wind turbines will account for 25 percent of new connections.[246] Providers such as Azuri Technologies, Brighterlite, M-Kopa Solar (see Case 7.2), Mobisol and Simpa Networks are providing rural electrification to dozens of remote communities across several countries in Africa and Asia using ICT-based pay-as-you-go (PAYG) revenue collection processes.

The pay-as-you-go model allows customers and companies to remotely operate and manage off-grid projects. For customers, it means avoiding a long trip to an agent or office to top-up their accounts. For companies, it eliminates the risk of cash vanishing along the supply chain and enables collection of installments without complex and costly operations. Mobisol acknowledges that ICT-based mobile money payments are what make the company's business model possible: without basic ICT infrastructure in place, their enterprise could not exist.

Diversified consumer base

One way to mitigate the operational risk of a mini-grid is to diversify its consumer base, while ideally retaining one main 'anchor' customer, such as a hotel, hospital, or school that provides semi-stable revenue to the operation.[248]

Cellphone coverage in rural areas is often far more extensive than electric service coverage. Of some 3 million mobile-phone towers in operation in Africa, about 640,000 are located in rural off-grid areas[249] and many of these have to generate their own power. Omnigrid Micropower Company (OMC) in India has developed a model that provides electricity services to rural communities by using mobile-phone towers as 'anchor' customers. An estimated 150,000 of India's mobile telephone towers are located in off-grid areas, or areas with unreliable electricity supply, showing significant potential to scale this model and accelerate rural access to energy.

8.4 Renewable energy in the grid

Renewable energy generation is key to providing clean electricity for the low-carbon economy.[250] However, the variable nature and current technology limitations of renewable energy are major barriers to increasing its share in the world's energy consumption mix. ICT can help overcome the challenges of integrating renewable energy sources into existing energy systems by assisting energy utility operators to actively manage the variability of renewable energy generation. With active management, a large number of renewable energy generators can be connected to the grid without major electric network investment.

Case 8.3: In Africa, pay as you go with M-Kopa Solar[247]

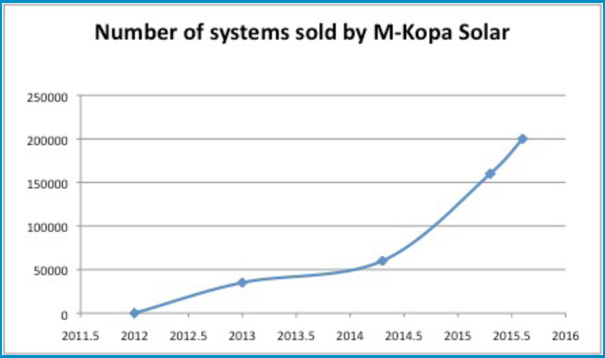
M-Kopa Solar is a successful Pay-As-You-Go (PAYG) energy provider in Africa. Commercially launched in 2012, it has sold more than 200,000 PAYG systems and sales are growing at a rate of 500 new systems a day.

Lessons learned

This success has been possible thanks to an ICT-enabled platform called M-KOPAnet.

M-Kopa systems have embedded GSM (Global System for Mobile) connectivity that enables them to collect revenues in real time through mobile money systems, monitor performance and regulate usage based on payments. The systems are affordable and small, with 8Wp (watt-peak), and can power three lights (two fixed and one portable), a mobile phone charger and a radio.

Figure 8.2. Number of homes connected with M-KOPA



Case 8.4: Affordable distributed energy in the UK

A pioneer installation of an ICT-based management system called Active Network Management started operations in 2009 in the Orkney Islands, UK. By 2012, 20 MW (megawatts) of renewable generation was connected to the island smart grid, with minimal electric network upgrades. The regional utility, Scottish and Southern Energy Power Distribution, estimated that an investment of GBP30 million would have been required to connect the 20 MW of energy.[251] The ICT-enabled solution cost just GBP0.5 million to implement. In 2013, the Orkney Islands started generating over 100 percent of their electricity through renewable resources. Currently, the renewable capacity installed is estimated to be over 55kW (kilowatts).

Whitelee Wind Farm (Renewable Energy in Scotland)

Creative Commons. https://commons.wikimedia.org/wiki/File:Whitelee_with_arran_in_the_background.jpg#filelinks

This successful application in the Orkney Islands is now being replicated by the utility operator, Scottish Power Energy Networks, with ARC (Accelerating Renewable Connections[252]) launched on the border between Scotland and England. The project uses ICT to collect data and identify areas with potential for more renewable connections. The UK was Europe's fastest-growing solar market in 2014, with significant further wind potential along the Scottish coast. The UK continues to works towards its Low Carbon Transition Plan to produce 30 percent of its electricity from renewable sources by 2020 and contribute to SDG target 7.2.

Although active management is enabled by ICT, the complete solution requires other policy inputs: Targets for renewable energy share, advanced commercial arrangements permitting reduction of power generation, enabling regulations in both the electricity and ICT spheres, and interoperability in the communications protocol so that operators can easily integrate their operations to the larger grid.

Enabling financing models for renewables

The previous section described how ICT can accelerate energy access growth and indirectly accelerate renewable energy penetration, since most mini-grids and off-grid projects include renewable energy generation. Renewable energy is becoming cost-competitive with other forms of electricity generation, especially in remote areas where constantly transporting fossil fuels is impractical.[253]

In the US and Europe, some companies offer solar photovoltaic generation equipment with no initial payment as long as customers commit to make payments over a 20-year agreement. These payments are lower than the cost of grid electricity replaced by the equipment. ICT monitoring of the system enables companies to monitor performance, meter the service, analyze power demand and quickly respond to problems. As a result, people are reducing their electricity bills and enjoying better service.

New financing models will become available in developing country settings thanks to ICT-enabled solutions such as mobile money for collecting payments and the ability to monitor the system and counter non-payment through disabling a system. Some models are tailored to give ownership to users after enough payments have been collected, transforming traditional energy customers into independent small power producers.

8.5. Managing energy and tackling climate change

Recent trends in developed economies show that use of ICT has led to decreasing amounts of energy consumption per capita while GDP continued to grow, according to the OECD.[254] ICT is also key to building consumer awareness and enabling advanced methods for improving energy efficiency.

ICT is providing individuals and organizations with innovative ways to monitor their energy consumption and its related cost. Data can be collected at multiple points and displayed in different ways, through smart-phones, home displays, computers, etc. so users can make informed decisions about their energy consumption. Along with displaying energy usage, variable tariffs can also incentivize behavior change.

Indirectly, ICT can promote efficient use of energy by enabling mini-grid and off-grid solutions that improve the quality and efficiency of both energy services and products offered to people in poverty. A LED lamp is much more efficient than a kerosene lamp or incandescent bulb, for example. This extra efficiency translates into the poor having to pay less to cover the same lighting needs.

Monitoring consumption and building awareness

Among the benefits of smart meters is that online portals can be accessed by users via in-home displays, mobile devices or personal computers, increasing users' awareness of their own energy consumption patterns. Sharing energy consumption measurements and analysis with energy consumers can spur greater engagement on increasing energy efficiency.

A great example of how utilities can embrace innovation in data analytics is the success E.ON UK is enjoying due to Opower's web-based solution. It provides personalized information about energy consumption, neighborhood comparisons and tailored tips on how to control energy usage. Through this solution, the utility has improved its customer relationships tenfold.[255]

Governments are realizing the potential of smart meters and a number of European countries are targeting large-scale (80 percent or more) smart meter rollouts by 2020. This includes the UK, Sweden, Denmark, Finland, Spain, France, Italy, Germany and several countries in Central and Eastern Europe. To maximize success and effectiveness, the technology must be accompanied by the right policy framework, public education campaigns and incentives.

Smart metering deployments today are increasingly supporting richer services including connected home and smart building services. Utilities are offering incentives to customers that allow utilities to temporarily control air conditioners or lights to reduce demand peaks when the energy grid is stressed. An ICT-enabled infrastructure is fostering collaboration among stakeholders to increase overall system efficiency.

Real-time energy management for buildings

Adopting cost-effective standards for a wider range of technologies could, by 2030, reduce global projected electricity consumption by buildings and industry by 14 percent, avoiding construction of more than 1,000 mid-size power plants.[256] During the last decade, ICT has been able to track manufacturing processes, so operation managers can identify energy inefficiencies and where systems could be replaced or upgraded with more efficient ones.[257] For example, smart buildings feature interconnected building systems (e.g. lighting, ventilation, heating, cooling, etc), so these systems can be automatically or manually controlled to maximize energy efficiency while still providing a comfortable and productive environment for building occupants. Another benefit of interconnected devices is the enhanced preventive maintenance of equipment, which increases its lifecycle.

Availability of such solutions is not limited to developed countries. Azuri Technologies, a pioneer provider of small solar home systems in Africa, is now offering a Quad HomeSmart system for controlling appliances in Ghana, demonstrating that the technology can be tailored to developing country settings.

A scenario from IPCC 2014 suggests that the widespread implementation of state-of-the-art policies, building design and technologies, combined with behavior changes could deliver reductions in energy demand of over 50 percent from new and existing buildings compared to a Business-As-Usual (BAU) scenario. ICT-enabled remote control and management will be a key driver for achieving SDG target 7.3.

8.6. Government focus on the energy sector

ICT can improve decision-making processes for energy infrastructure. Extending electric grids has historically been the main way to provide access to energy in China, India and Kenya, and remains an important way to provide access to unserved populations after mini-grids. Off-grid connections will also remain crucial for scarcely populated areas where a mini-grid would not be cost-effective.[258]

Electrification practitioners compare costs for different options to identify the optimal solution, and consider information such as distance of villages to existing grids, estimated electricity demand, cost of materials and fuels, cost of operation and maintenance, population density, geography and land ownership. Although the calculations and methodology for comparing electrification options are well-known, manually gathering the required data inputs without ICT support is impractical, particularly in remote areas of developing countries. Moreover performing the analysis and comparison of electrification strategies for thousands of households could take months or years, and can be prohibitive for many countries.

ICT can greatly assist governments, investors and utilities in the planning stage of energy infrastructure development. Innovative ICT and geospatial tools can reduce costs and time in gathering and mapping energy system infrastructure, such as the grid lines, electrical equipment, and demand points not available in existing national databases. Also, ICT can shrink the computational time from months to days by using cloud-computing when running analysis of thousands of data points of geospatial and demographic information (via census, GIS, land-use and other data derived from satellite remote sensing) to calculate accurate estimates of electricity demand.

Expanding access to ICT at regional and local levels can expedite the data collection and computational processes described above and can avoid travel between local offices and headquarters as well as enhance training of personnel at local level.

Enhancing transparency in energy subsidies

Governments provide different types of subsidy to boost initiatives that promote their economic or social policy. In the case of energy, these subsidies are created to increase energy access, energy security, and de-carbonization of the economy, because these benefits are not adequately reflected in free market prices. For example, subsidies for fuel and electricity for agricultural use aim to keep farmers competitive; subsidies for Liquefied Petroleum Gas (LPG) attempt to increase access to modern cooking fuels for poor customers; and subsidies for deployment of renewable energy are intended to achieve emissions reductions.

Governments, especially those in developing countries, have limited budgets that should be wisely and carefully administrated. Although subsidies usually have good intentions, implementation can be flawed and costly to taxpayers and can interfere with commercially sustainable business models. However, managed well, timely subsidies can help to scale and to re-direct investments, for example, as with electric vehicles, in Norway, or renewable energy for households in Germany and Sweden. Sometimes subsidies fail to help targeted beneficiaries due to subsidy leakage—where unscrupulous citizens receive the benefit of a subsidy without being legally entitled to it. ICT can help with the efficient distribution of subsidies by tracking and monitoring delivery. Governments can use ICT-tools to ensure that budgets allocated to improving energy access or efficiency actually serve this purpose.[259]

8.7 Tackling supply reliability and losses in the grid

A report by the Asian Development Bank (2009) shows that lack of reliable electricity supply was by far the most binding constraint to doing business in Nigeria for more than 80 percent of the firms surveyed.

The situation is improving: for example in Africa, virtually every country has legally mandated regulators to set minimum quality-of-service standards and monitor and enforce these standards.

ICT advanced solutions can match generation supply and demand and integrate variable renewable sources and energy storage systems to control costs and ensure grid reliability. In developed countries, outages are not frequent, and if they occur they are short in duration because customers support investment in grid quality and reliability with their willingness to pay.[260] Recent experience in smart-metered mini-grid operation has shown that even the poor are willing to pay cost-reflective tariffs for what they consume, if they are provided reliable electricity.[261] In less developed areas, reliable electricity is needed to support income-generating activities that can pull people out of poverty.

ICT-enabled smart-grids allow real-time data to be collected from different nodes of the grid by using computer-based remote control and automation to operate the overall system. The expansion of smart grids worldwide is influenced by a growing number of customers requesting affordable and reliable supply and by operators looking to lower operational costs. Governments are encouraging this trend and should also set up enabling regulatory environments, requirements for interoperability of devices and provision of universal ICT access so that the benefits are realized by the general population. Smartgrid.gov and smartgrid.eu are examples of this trend.[262]

Smart grids including e-transportation systems can allow for storage of electricity to balance the grid and reduce peaks.

Enforcing revenue collection

Losses that are not due to technical failure are a serious and costly source of revenue loss for electricity grid operators. This loss ranges from single digit percentage of total revenues in developed countries (2 percent in Texas, USA, 1.5 percent in Vancouver, BC) up to 50 percent in some developing regions (South Asia, sub-Saharan Africa, and the former Soviet Union).[263]

Every year in India alone, losses are estimated to be in the billions of dollars. The gas industry in Bangladesh is also prone to metering losses. Energy revenue lost from illegal connections, unbilled consumption, and non-payment is difficult to quantify, but due to its impact on energy access decisions, this loss should be curtailed. It prevents utilities and governments from expanding energy access infrastructure, due to the risk of energy pilferage, therefore it indirectly impacts achievement of SDG Target 7.1.

ICT can enable effective distribution by transforming the monitoring that helps locate theft and the technical losses within distribution grids.[264] In addition, smart meters and ICT can enable accurate metering of user demand. The Electricity Company of Ghana (EGC) instituted an automated meter reading program and has already installed 350,000 smart units in order to reduce losses through meter tampering in Ghana. The Ugandan utility UMEME used data concentrators to detect where the most non-technical energy losses were coming from, and this initiative saved them USD1.5 million within a year.[265]

8.8. Enhanced transportation with ICT

The transportation sector is a large consumer of energy; in 2014 the total share of US energy used for transportation was 28 percent.[266] Transport and logistics are responsible for up to 40 percent of air pollution, and regulation is being implemented to reduce transport's impact on CO_2 , NO_x and other emissions.[267] The transport infrastructure of many nations are now coming under significant pressures due to urbanization, rising global population and environmental challenges.

Energy efficiency improvement in the sector is not only coming from new engine and motor technologies, but also from the proper management of transportation assets. ICT use in transportation could increase energy efficiency (and therefore accelerate access), as well as reduce carbon emissions.

Reducing transport impact in cities

In the world's fast-growing cities in particular, solutions such as Intelligent Transport Systems (ITS) are vital. ITS integrates connected cars, public transport, and logistics operations, bringing greater safety, efficiency, and sustainability to roads and railways. The EU defines an ITS as a system in which information and communication technologies are applied in the field of road transport, including infrastructure, vehicles and users, and in traffic management and mobility management, as well as for interfaces with other modes of transport.[268]

The manner in which transportation is 'delivered' needs to change. ICT plays both a fundamental and transformative role in the industry today. Use of technology may prove as effective as doubling or tripling the physical road capacity in some cities. Digital technologies, from modern control systems to sensor technologies, can create more capacity without requiring additional physical infrastructure.[269]

Autonomous vehicles

Autonomous cars or 'intelligent cars that assist drivers' can lead to dramatic reductions in vehicle weight and lower vehicle speeds without compromising time of travel in otherwise congested cities. This leads to greatly reduced energy consumption.[270] It also allows for greater human productivity and comfort, leading to higher economic benefits, and at the same time leverages scale-up of electric vehicles and reduces carbon emissions.

More efficiency throughout value chains

Such innovation would be impossible without the pervasive use of ICT that enables powerful sensing, computing and communications. Moreover the same level of consumer mobility experience can be provided through ICT with far fewer vehicles on the road. Service-based pay-per-use models for transportation could provide point-to-point transport (which is a similar experience to owning one's own car) without incurring the high costs of self-owned vehicles.

For developed countries, the link to transport and the links between home heating and power generation (energy transfer from power to heat or cooling) are increasingly becoming the focus of policymakers. Major CO_2 reductions are delivered when the economy can be dematerialized, e.g. by substituting services for products, or leapfrogging and changing entire value chains. Another example is to use renewable power within the transport sector, including charging of electric cars, and to heat and cool homes and buildings.

8.9. Issues and challenges

Ensuring that ICT can help the world move off the BAU path in enabling sustainable energy and achieving SDG 7 and SDG 13 by 2030, raises a number of issues and challenges, a few of which are addressed here.

Case 8.5. Connected buses in Curitiba, Brazil

The city of Curitiba in Brazil was the first in the world to connect public buses to a mobile-broadband network. A connected public-transport system makes for more efficient fuel usage and a corresponding reduction in CO_2e emissions.[271] Earlier studies on the bus system have shown that people will be attracted to public rather than private travel when provided with a more reliable bus service.

The Bus Rapid Transit (BRT) system adopted in Curitiba, which is used for 70 percent of all types of public and private commuting, produces approximately 200,000 tonnes of direct CO_2 emissions per year compared with 1,500,000 tonnes related to annual car travel in the city. The ICT portion of the BRT system adds about 500 tonnes of CO_2 emissions per year. This approach is now being implemented in Varna, Bulgaria (see Case 8.6.).

Case 8.6.: Integrated Urban Transport in Varna, Bulgaria

In January 2016, Varna, the third largest city in Bulgaria, launched an ambitious project for the modernization of its urban public transport system. It takes the success of Curitiba and evolves the approach to include traffic Management with traffic lights integration in order to provide priority to buses. This system supports better bus flow and speed with lower fuel consumption but also discourages the use of private cars in the city center.

The main objective of this project is the implementation of an Intelligent Transportation System (ITS) that fully supports the public bus operation, which includes 220 buses. The Varna ITS includes:

- An e-ticketing system.
- A system for automatic vehicle location.
- A real-time passenger information system.
- A traffic management system that provides priority to buses.
- A CCTV system at intersections and bus stops.
- Control rooms.

The ITS, being implemented by Ericsson, is designed to improve the quality and availability of transportation services; reduce traffic jams and increase the capacity and speed of public urban transport, while decreasing greenhouse gas emissions by optimizing bus routes. In addition, it will provide real-time financial management and control of ticketing revenue; the ability to offer new innovative ticketing plans and the safety of public transport.

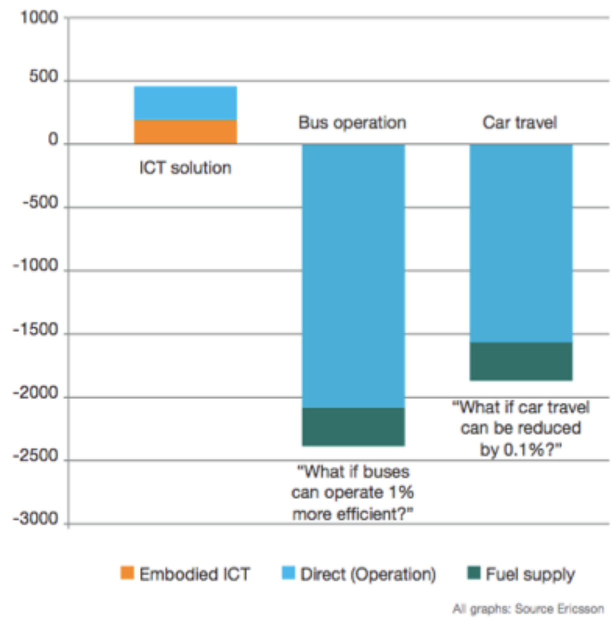
All the different elements of the transport ecosystem will be connected—vehicles and the supporting infrastructure, like roads, traffic lights and bus stops—through wireless sensors. The citizens of Varna who use mass urban public transport are expected to benefit in quality of life, including increased level of service, quality and accessibility of transport, including for people with disabilities. The estimated quantified benefits from a climate perspective are reduced emissions of greenhouse gases of 7,136 tonnes per year, the equivalent of 1,518 cars per year. This figure refers to the estimated benefits from the full implementation—including introduction of new Euro 6 buses.

1. **People-centered approach:** inclusion of ICT in energy systems should keep people and communities in mind. For example, remote controlled devices should involve people so they can make informed decisions about their energy consumption or at least access information when desired.

2. **Data privacy:** Measures must be taken to safeguard data privacy from smart meters to address emerging consumer concerns and meet European smart meter regulations. For example, the Trans-Atlantic Consumer Dialogue (TACD),[272] a coalition of consumer groups in Europe and North America, adopted a report on privacy and electrical services in Brussels in 2016. The Smart Meter White Paper[273] warns that the "dramatic increase in the granularity of data available and frequency of collection of household energy consumption means that the smallest detail of household life can be revealed."[274]

3. **Cybersecurity:** Solutions to strengthen cybersecurity measures are needed to ensure that the new interconnected energy infrastructure is not exposed to hackers. Malicious

Figure 8.3. Potential Saving from ICT, Curiba (tonnes CO_2e)



individuals can create blackouts if networks are not protected. Encryption and the use of dedicated communication protocols can reduce this risk. This concern is addressed further in Chapter 9, Issues and Challenges.

4. **Industry transformation:** To fully realize the potential of ICT in the area of energy and climate requires industry transformation to a low-carbon economy, including infrastructure for electric vehicles and addressing shifts in the value chain to facilitate dematerialization as well as taking into account urban and rural transportation realities. Finally, industry transformation requires an enabling platform for new business models to thrive.

8.10 Conclusions

Our energy systems are rapidly evolving, driven in large part by the inclusion of ICT to enable improved monitoring, control and management of these systems through the dramatic cost reduction of distributed renewable energy generation systems. As a result, new and alternative energy services are becoming more affordable, efficient, reliable and sustainable. This energy revolution is creating green tech jobs, promoting economic growth, reducing greenhouse gas emissions, fostering economic growth, enabling sustainable urbanization and improving energy security for countries that lack domestic fossil fuel resources. However, this revolution is not occurring evenly around the world due to differences in income, policy, ICT availability and human capacity.

The inclusion of ICT in energy systems can accelerate the rate of access to affordable, sustainable and modern energy services for people in different parts of the world. ICT is already helping to modernize electricity grids by increasing grid efficiency, cost effectiveness and integrating feed-in renewable energy resources. Other demonstrated advantages of using ICT in energy systems include improving energy subsidy distribution, enabling financing of clean energy technology and reducing the cost of revenue for energy services With an appropriate mix of programs and policy recommendations, ICT-enabled energy services can be scaled to achieve the SDGs. After the UNFCC Paris climate meeting, it is also time for action. The implementation of ICT as a technology to reduce GHGs is vital.

8.11 Recommendations

SDG 7 calls for universal coverage of modern energy services (electricity and clean cooking fuels) and major gains in energy efficiency. SDG 13 calls for the decarbonization of national energy systems as well as for change throughout value chains. For both goals, ICT will be vital for success, supporting the technical and business backbone of a clean-energy system. Key measures include:

(1) Promotion of mini-grid and off-grid solutions through private entrepreneurship. New companies will benefit from cloud-based monitoring, cashless payments, and prepayment business models.

(2) Detailed planning of coverage, costs, and reliability for incorporating intermittent renewable energy into low-cost energy systems.

(3) Minimum standards on electricity supply for grid operators to facilitate basic standards of service for renewable providers.

(4) ICT-based training and education for personnel in e-Energy services.

(5) Online tools to help households manage their electricity usage.

(6) Monitoring and managing of energy consumption through smart metering and the Internet of Things.

(7) Smart grid solutions as a fundamental building block for the low-carbon economies of the future.

(8) Secure that national targets on climate change and energy performance are matched with National Broadband Plans and set to support urban and rural implementation.