THE SECRETARY-GENERAL'S ADVISORY GROUP ON ENERGY AND CLIMATE CHANGE (AGECC)

Energy for a Sustainable Future

REPORT AND RECOMMENDATIONS

28 April 2010
New York

CONTENTS

FOREWORD BY THE SECRETARY-GENERAL

This year, in September, world leaders will meet at the United Nations to assess progress on the Millennium Development Goals and to chart a course of action for the period leading up to the agreed MDG deadline of 2015. Later in the year, government delegations will gather in Mexico to continue the process of working towards a comprehensive, robust and ambitious climate change agreement. Energy lies at the heart of both of these efforts. The decisions we take today on how we produce, consume and distribute energy will profoundly influence our ability to eradicate poverty and respond effectively to climate change.

Addressing these challenges is beyond the reach of governments alone. It will take the active engagement of all sectors of society: the private sector; local communities and civil society; international organizations and the world of academia and research. To that end, in 2009 I established a high-level Advisory Group on Energy and Climate Change, chaired by Kandeh Yumkella, Director-General of the United Nations Industrial Development Organization (UNIDO). Comprising representatives from business, the United Nations system and research institutions, its mandate was to provide recommendations on energy issues in the context of climate change and sustainable development. The Group also examined the role the United Nations system could play in achieving internationally-agreed climate goals.

The Advisory Group has identified two priorities – improving energy access and strengthening energy efficiency – as key areas for enhanced effort and international cooperation. Expanding access to affordable, clean energy is critical for realizing the MDGs and enabling sustainable development across much of the globe. Improving energy efficiency is paramount if we are to reduce greenhouse gas emissions. It can also support market competitiveness and green innovation.

I commend the Group's recommendations to a wide global audience and look forward to their rapid implementation.

Ban Ki-moon
Secretary-General of the United Nations

INTRODUCTION BY THE CHAIR

Energy is at the forefront of the global agenda. It is central to the issues of development, global security, environmental protection and achieving the MDGs. Profound changes are beginning to transform the way we supply, transform, deliver and use energy services – a trend that a revitalized global energy dialogue can reinforce, leading to a sustainable future for all with multiple co-benefits for development, human health, environment and climate change.

The United Nations system has responded to the challenges and opportunities in the energy system with numerous programmes and projects. The need for a strong and focused engagement is now clearer than ever before. Although there is no single United Nations entity with primary responsibility for energy, the establishment of UN-Energy as the interagency mechanism for coordination on these issues has allowed for a more focused system-wide approach.

The Secretary-General established the Advisory Group on Energy and Climate Change (AGECC) in June 2009 last year to advise him on the energy-related dimensions of the climate change negotiations. AGECC is a prime example of a multi-stakeholder partnership bringing together the UN system, including the World Bank, with the private sector and research institutions. Its work has benefited from a unique mix of policy orientation, technical expertise and business experience of leading figures in the field of energy. As chair of the Advisory Group, I deeply appreciate the enthusiastic participation and valuable contribution of all its members.

An important contribution of AGECC towards a sustainable energy future is this report. As the report makes clear, it is unacceptable that a third of humanity has no access to modern energy services and half of humanity has to rely on traditional biomass for meeting their basic needs. Eliminating energy poverty is of paramount importance in eradicating poverty. It is also essential to the achievement of the other Millennium Development Goals. At the same time, a vast potential for energy efficiency improvements across the energy supply and delivery chain remains largely untapped.

AGECC has therefore called for commitment and concerted action on two ambitious but achievable goals: universal access to modern energy services and improved energy efficiency. A global campaign can help raise awareness and galvanize countries and the international community into action. The United Nations system can catalyze this action by establishing a mechanism to track progress towards these goals and by providing the requisite support to strengthen national capacities to achieve them. Institutionally "embedding" the energy-related goals in the work of the United Nations system would help sustain efforts towards the achievement of the goals in the long term. UN-Energy is well positioned to be the hub for such collective engagement.

The Secretary-General has asked AGECC to continue its work and to put its collective weight behind the achievement of universal access to modern energy services and energy efficiency. In doing so, it will also contribute information and ideas to the work of the Secretary-General's High-Level Advisory Group on Climate Change Financing and the forthcoming High-Level Panel on Sustainable Development.

I continue to be energized by our collective endeavour under the leadership of the Secretary-General, and the enormous opportunities for positive change that lie before us.

Kandeh K. Yumkella
Chair

ACKNOWLEDGEMENTS

This report was prepared by the UN Secretary-General's Advisory Group on Energy and Climate Change (AGECC), which comprises of the following members:

- Kandeh K. Yumkella, Director General, **UNIDO**, Chair of **UN-Energy** and Chair of **AGECC**
- Tariq Banuri, Director, Division for Sustainable Development, **UNDESA**
- John Bryson, Former Chairman, Edison International, **USA**
- Suani Coelho, Coordinator, CENBIO-Brazilian Reference Center on Biomass, **Brazil**
- Yvo de Boer, Executive Secretary, **UNFCCC**
- José María Figueres, Former President of **Costa Rica**
- Carlos Slim Helú, Chairman, Fundación Carlos Slim, **Mexico**
- Dr. Sultan Ahmed Al Jaber, CEO, The Masdar Initiative, **UAE**
- Lars Josefsson, CEO, Vattenfall AB, **Sweden**
- Olav Kjørven, Assistant Administrator, UNDP, and Vice Chair, **UN-Energy**
- Sergey Koblov, Director, UNESCO Energy Centre, **Russian Federation**
- Helge Lund, CEO, Statoil, **Norway**
- Jacob Maroga, Former CEO, ESKOM, **South Africa**
- Alexander Mueller, Assistant Director-General, **FAO**
- Nebojsa Nakicenovic, Deputy Director, International Institute for Applied Systems Analysis, IIASA, **Austria**
- Jamal Saghir, Director, Energy, Water and Transport, **The World Bank Group**
- Shi Zhengrong, Chairman and CEO, Suntech Power Holdings, **China**
- Leena Srivastava, Executive Director, The Energy and Resources Institute, TERI, **India**
- Achim Steiner, Executive Director, **UNEP**
- Timothy Wirth, President, United Nations Foundation, **USA**

The AGECC would like to thank the many organizations and people who made important contributions to this report, through interviews, data and comments on various draft versions.

In particular, we would like to acknowledge a large volume of valuable feedback and inputs to the analysis presented in this report received from the Advisory Group members, and other reviewers and colleagues from ESKOM, IIASA, Statoil, Suntech Power, TERI, the United Nations Department for Economic and Social Affairs (UN DESA), the United Nations Development Programme (UNDP), the United Nations Environment Programme (UNEP), the United Nations Food and Agriculture Organization (FAO), the United Nations Foundation (UNF), the United Nations Framework Convention on Climate Change Secretariat (UNFCCC), the United Nations Industrial Development Organization (UNIDO), the United Nations Secretary-General's Climate Change Support Team (CCST), Vattenfall AB, and the World Bank

We would also like to thank McKinsey & Company, who provided data and analytical support.

LIST OF ABBREVIATIONS

Acronyms

ADB	Asian Development Bank
AGECC	Advisory Group on Energy and Climate Change
ASTAE	Asia Sustainable and Alternative Energy Program
Capex	Capital expenditure
CCS	Carbon capture and storage
CDM	Clean Development Mechanism
CFL	Compact fluorescent lamp
CIF	Climate Investment Funds
COP-15	15th Conference of the Parties
CTF	Clean Technology Fund
DTIE	Division of Technology, Industry and Economics
EGAT	Electricity Generating Authority of Thailand
ESMAP	Energy Sector Management Assistance Program
EUEI PDF	European Union Energy Initiative Partnership Dialogue Facility
FAO	United Nations Food and Agriculture Organization
GDP	Gross domestic product
GEF	Global Environment Facility
GHG	Greenhouse gas
GNESD	Global Network on Energy for Sustainable Development
GTZ	Gesellschaft für Technische Zusammenarbeit
IDA	International Development Association
IEA	International Energy Agency
IEEE	Institute of Electrical and Electronics Engineers
IPCC	Intergovernmental Panel on Climate Change
IRENA	International Renewable Energy Agency
ISO	International Organization for Standardization
LCGP	Low carbon growth plans
LED	Light emitting diode
LPG	Liquefied petroleum gas
MDG	Millennium development goal
MGI	McKinsey Global Institute
NAMA	National appropriate mitigation actions
NGO	Non-governmental organization
OECD	Organization for Economic Cooperation and Development
PPP	Public-private partnerships
R&D	Research and development
REDD	Reducing emissions from deforestation and degradation
REEEP	Renewable Energy and Energy Efficiency Partnership
SCF	Strategic Climate Funds
SHS	Solar household system

TERI	The Energy Resources Institute
UN	United Nations
UNDESA	United Nations Department for Economic and Social Affairs
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNF	United Nations Foundation
UNFCCC	United Nations Framework Convention on Climate Change
UNIDO	United Nations Industrial Development Organization
WEO	World Energy Outlook
WHO	World Health Organization

List of units

GWh	Gigawatt hours
kgoe	kilogrammes of oil equivalent
kWh	Kilowatt hours
m	Million
Mtoe	Million tons of oil equivalent
ppm	Parts per million
tCO2e	Tons of carbon dioxide equivalent

THE IMPORTANCE OF ENERGY

Energy is at the heart of most critical economic, environmental and developmental issues facing the world today. Clean, efficient, affordable and reliable energy services are indispensable for global prosperity. Developing countries in particular need to expand access to reliable and modern energy services if they are to reduce poverty and improve the health of their citizens, while at the same time increasing productivity, enhancing competitiveness and promoting economic growth. Current energy systems are inadequate to meet the needs of the world's poor and are jeopardizing the achievement of the Millennium Development Goals (MDGs). For instance, in the absence of reliable energy services, neither health clinics nor schools can function properly. Access to clean water and sanitation is constrained without effective pumping capacity. Food security is adversely affected, often with devastating impact on vulnerable populations.

Worldwide, approximately 3 billion people rely on traditional biomass for cooking and heating,[1] and about 1.5 billion have no access to electricity. Up to a billion more have access only to unreliable electricity networks. The "energy-poor" suffer the health consequences of inefficient combustion of solid fuels in inadequately ventilated buildings, as well as the economic consequences of insufficient power for productive income-generating activities and for other basic services such as health and education. In particular, women and girls in the developing world are disproportionately affected in this regard.

A well-performing energy system that improves efficient access to modern forms of energy[2] would strengthen the opportunities for the poorest few billion people on the planet to escape the worst impacts of poverty. Such a system is also essential for meeting wider development objectives. Economic growth goes hand in hand with increased access to modern energy services, especially in low- and middle-income countries transitioning through the phase of accelerated industrial development. A World Bank study[3] indicates that countries with underperforming energy systems may lose up to 1-2 per cent of growth potential annually as a result of electric power outages, over-investment in backup electricity generators, energy subsidies and losses, and inefficient use of scarce energy resources.

At the global level, the energy system – supply, transformation, delivery and use – is the dominant contributor to climate change, representing around 60 per cent of total current greenhouse gas (GHG) emissions. Current patterns of energy production and consumption are unsustainable and threaten the environment on both local and global scales. Emissions from the combustion of fossil fuels are major contributors to the unpredictable effects of climate change, and to urban air pollution and acidification of land and water. Reducing the carbon intensity of energy – that is, the amount of carbon[4] emitted per unit of energy consumed – is a key objective in reaching long-term climate goals. As long as the primary energy mix is biased towards fossil fuels, this would be difficult to achieve with currently available fossil fuel-based energy technologies. Given that the world economy is expected to double in size over the next twenty years, the world's consumption of energy will also increase significantly if energy supply, conversion and use continue to be inefficient. Energy system design, providing stronger incentives for reduced GHG emissions in supply and increased end-use efficiency, will therefore be critical for reducing the risk of irreversible, catastrophic climate change.

It is within this context that the UN Secretary-General's Advisory Group on Energy and Climate Change (AGECC) was convened to address the dual challenges of meeting the world's energy needs for development while contributing to a reduction in GHGs. AGECC carried out this task in a rapidly changing environment in which energy was often a key factor: the sensitivity of the global economy to energy price spikes; increased competition for scarce natural resources; and the need to accelerate progress towards achievement of the MDGs. The world's response to climate change will affect each of these issues. Pursuant to the Copenhagen Accord promulgated at the UNFCCC Conference of the Parties in December 2009, the Secretary-General has established a High-Level Advisory Group on Climate Change Financing. It is hoped that this report will be helpful to that and other similar initiatives.

[1] UNDP and WHO, 2009 estimates that over 3 billion people lack access to modern fuels for cooking and heating, while IEA 2009 estimates this number at 2.5 billion.

[2] Modern sources of energy include fuels such as natural gas, liquid petroleum gas (LPG), diesel and biofuels such as biodiesel and bioethanol. Technology, such as improved cooking stoves, can also enable cleaner and more efficient delivery of traditional fuels.

[3] World Bank, 2009b

[4] Carbon dioxide and the equivalent from other greenhouse gases

THE IMPERATIVE TO TRANSFORM NATIONAL ENERGY SYSTEMS

The central message of this report is that the international community must come together in a common effort to transform the global energy system over the coming decades, and that policy-makers and business leaders must place much greater emphasis on transforming the performance of national (and regional) energy systems over the coming decades. Low-, middle- and high-income countries all face major, albeit different, transformational challenges:

Low-income countries need to expand access to modern energy services substantially in order to meet the needs of the several billion people who experience severe energy poverty in terms of inadequate and unreliable access to energy services and reliance on traditional biomass. They need to do so in a way that is economically viable, sustainable, affordable and efficient, and that releases the least amount of GHGs.

Middle-income countries need to tackle energy system development in a way that enables them progressively to decouple growth from energy consumption through improved energy efficiency and reduce energy-related GHG emissions through gradually shifting toward the deployment of low-GHG emission technologies.

High-income countries' face unique challenges. As the large infrastructure investments made in the 1960s and 1970s begin to reach the end of their economic lives, they present opportunities to further decarbonize their energy sectors through new investments in lower-carbon generation capacity. In addition, they will need to reach a new level of performance in terms of energy use.

While different national economies may pursue these transformational paths in distinct ways, there are large potential synergies from international cooperation, joint strategies and the sharing and adaptation of emerging best practices. These include lessons learned from policies and regulations, capacity development, technical standards, best available technologies, financing and implementation approaches, and more coordinated, scaled-up research and development.

By 2030, there is an opportunity for the world to be well on its way to a fundamental transformation of its energy system, allowing developing countries to leapfrog current systems in order to achieve access to cleaner, sustainable, affordable and reliable energy services. This change will require major shifts in regulatory regimes in almost every economy; vast incremental infrastructure investments (likely to be more than $1 trillion annually);[5] an accelerated development and deployment of multiple new energy technologies; and a fundamental behavioural shift in energy consumption. Major shifts in human and institutional capacity and governance will be required to make this happen. The transformation of energy systems will be uneven and, if poorly handled, has the potential to lead to a widening "energy gap" between advanced and least developed nations, and even to periodic energy security crises. But handled well – through a balanced framework of cooperation and competition – energy system transformation has the potential to be a source of sustainable wealth creation for the world's growing population while reducing the strain on its resources and climate.

[5] IEA, 2008b

While there are various possible areas of focus in the broader energy system, AGECC has chosen two specific areas that present immediately actionable opportunities with many co-benefits: energy access and energy efficiency.

TWO KEY GOALS: ENSURING UNIVERSAL ENERGY ACCESS, REDUCING GLOBAL ENERGY INTENSITY

AGECC calls on the United Nations system and its Member States to commit themselves to two complementary goals:

Ensure universal access to modern energy services by 2030. The global community should aim to provide access for the 2-3 billion people excluded from modern energy services, to a basic minimum threshold of modern energy services for both consumption and productive uses.[6] Access to these modern energy services must be reliable and affordable,[7] sustainable and, where feasible, from low-GHG-emitting energy sources. The aim of providing universal access should be to create improved conditions for economic take-off, contribute to attaining the MDGs, and enable the poorest of the poor to escape poverty. All countries have a role to play: the high-income countries can contribute by making this goal a development assistance priority and catalyzing financing; the middle-income countries can contribute by sharing relevant expertise, experience and replicable good practices; and the low-income countries can help create the right local institutional, regulatory and policy environment for investments to be made, including by the private sector.

Reduce global energy intensity[8] by 40 per cent by 2030. Developed and developing countries alike need to build and strengthen their capacity to implement effective policies, market-based mechanisms, business models, investment tools and regulations with regard to energy use. Achieving this goal will require the international community to harmonize technical standards for key energy-consuming products and equipment, to accelerate the transfer of know-how and good practices, and to catalyze increased private capital flows into investments in energy efficiency. The successful adoption of these measures would reduce global energy intensity by about 2.5 per cent per year – approximately double the historic rate.

Delivering these two goals is key to achieving the Millennium Development Goals, improving the quality and sustainability of macroeconomic growth, and helping to reduce carbon emissions over the next 20 years.

There are also important synergies between these two goals. Modern energy services are more efficient than biomass, and the acceleration of energy access will also contribute to a more rapid reduction in net energy intensity. Increased energy efficiency allows existing and new infrastructure to reach more people by freeing up capital resources to invest in enhanced access to modern energy services. Similarly, energy-efficient appliances and equipment make energy services more affordable for consumers – residential, commercial and industrial. While there is no agreement as yet on the minimum target for universal energy access, the initial steps do not entail significant climate impacts. For example, IEA's recommended threshold of 100 kWh per person per year, even if delivered through the current fossil fuel-dominated mix of generation technologies, will increase GHG emissions by only around 1.3 per cent above current levels. The impact of this increased energy consumption can be reduced through energy efficiency and a transition to a stronger reliance on cleaner sources of energy, including renewable energy and low-GHG emitting fossil fuel technologies, such as a shift from coal to natural gas. While each goal is worth pursuing independently, there will be clear synergies in pursuing them as part of an integrated strategy.

Although ambitious, these goals are **achievable**, partly because of technology innovations and emerging business models, and partly because of an ongoing shift in international funding priorities towards clean energy and other energy issues. There are also precedents for the widespread provision of both energy access (e.g., in China, Viet Nam and Brazil), and for dramatic improvements in energy efficiency (e.g., in Japan, Denmark, Sweden, California and China) that demonstrate the feasibility of achieving both goals.

[6] While UN-Energy is working on building consensus on an appropriate target for access to minimum energy services, this need not detain action. The lowest threshold is proposed by IEA, namely 100 kWh per of electricity and 100 kgoe of modern fuels (equivalent to roughly 1200 kWh) per person per year. This can be used as a starting target.

[7] Affordable in this context means that the cost to end users is compatible with their income levels and no higher than the cost of traditional fuels, in other words what they would be able and willing to pay for the increased quality of energy supply in the long run (though it may be necessary to provide temporary subsides to reach affordability in the shorter run before economic development accrues).

[8] Energy intensity is measured by the quantity of energy per unit of economic activity or output (GDP).

RECOMMENDED ACTIONS TO ACHIEVE THE GOALS

AGECC recommends the following actions toward achieving the two goals of ensuring universal energy access and of reducing global energy intensity:

1. A global campaign should be launched in support of "Energy for Sustainable Development."

This campaign would be focused on improving access to modern energy services and enhancing energy efficiency, as well as raising awareness about the essential role of clean energy in reaching the MDGs while addressing climate change, promoting economic growth and conserving natural resources and biodiversity. The campaign should ensure that energy is made an integral part of the MDG review process in 2010 as well as other major inter-governmental processes — including those on climate change, biodiversity, desertification, food security, and sustainable development. The campaign should encourage the United Nations and its Member States, other multilateral institutions, and the private and non-profit sectors to take the actions needed to achieve its goals.

2. All countries should prioritize the goals through the adoption of appropriate national strategies.

National strategies should create a predictable, long-term policy environment for investment and a road map for accelerating the establishment of the required human and institutional capacity and delivery mechanisms.

For high-income countries, this may entail: (a) national plans to benefit from the energy efficiency dividend; (b) increased investment in R&D; and (c) more focused commitments to support developing countries in helping to achieve their goals in the areas of both energy access and efficiency.

For middle-income countries, this may involve: (a) national plans to capture the energy efficiency opportunities as an integral part of their National Appropriate Mitigation Actions (NAMAs) and Low Carbon Growth Plans (LCGPs); (b) targeted interventions to reduce residual pockets of energy poverty; (c) a phased withdrawal of untargeted energy subsidies; and (d) technical support for the energy access and efficiency programmes of low-income countries.

For low-income countries, this may require: (a) national plans to accelerate the deployment and provision of modern energy services; (b) incorporation of these plans, if based on low-GHG emissions technologies, into their NAMAs/LCGPs; (c) re-orienting regulatory policy frameworks, including tariff structures and market regimes, to stimulate business innovation and private sector participation; (d) improvement in the design and careful targeting of energy subsidies; (e) further investment in the capabilities of public utilities; and (f) a phased introduction of low-GHG emitting technologies, as well as energy efficiency measures wherever feasible.

In a broader context, all countries have to work towards: (a) accelerated harmonization of technical standards for energy-using products and equipment; (b) increased R&D investments, especially in technologies that would reduce the cost and GHG intensity of energy services; and (c) trade-related measures that would support market expansion for products that increase energy efficiency or enhance access.

3. Finance, including innovative financial mechanisms and climate finance, should be made available by the international community.

A combination of financial support mechanisms and a significant increase in international finance – both bilateral and multilateral – will be needed to catalyze the existing public sector funding mechanisms and to leverage increased private sector investments, in order to meet the capital requirements needed for providing access to modern energy services and energy efficiency programmes in low- and middle- income countries.

For *universal access to modern energy services* to meet basic needs,[9] it is estimated that \$35-40 billion[10] of capital will be required on average per year to achieve basic universal access by 2030.

[9] Energy required for cooking, heating, lighting, communication, healthcare and education.

[10] \$35 billion per year for electricity access estimated by IEA, 2009, and \$2-3 billion per year for modern fuels access based on cost estimates from UNDP and ESMAP, 2005a

We estimate that around $15 billion of grants would need to be made available, mainly to cover the capital investment and capacity building required in least developed countries, where national energy investments are likely to focus on overcoming infrastructure backlogs and meeting suppressed demand in productive sectors. In addition, $20-25 billion of loan capital will be required for governments and the private sector above business-as-usual.[11]

For *energy efficiency*, our estimate is that on average $30-35 billion of capital is required for low-income countries and $140-170 billion for middle-income countries annually until 2030 above the IEA's reference case. In general, most energy-efficiency investments are cost-effective. In practice, however, costs of energy-efficiency are typically mostly front-loaded, with the benefits accruing over time, and low-income countries often have access to limited and expensive capital, which they prefer to invest in the cheapest (first-cost) options available to attain their energy goals. This is also a challenge for many consumers – residential, commercial and industrial – who look for investments with quick payback periods of typically 2-3 years. Financial support in terms of innovative financial structuring such as concessional loan finance, loan guarantees and other financial instruments, supplemented by other market mechanisms, helps to address the risks and barriers, and leverages private capital.

To support investment in energy access and efficiency, climate finance could be mobilized through two key strategies:

(a) Funds could be made available from the $30 billion "Fast Start Funding" committed in COP-15 under the Copenhagen Accord for 2010-2012, especially for strategy, policy and capacity development. This could be in line with the Global Environment Facility (GEF), or the newly-established, multi-lateral development bank-administered Climate Investment Funds (CIF) which already has donor commitments of $6 billion.[12] In the medium to long term, the Secretary-General's High-Level Advisory Group on Climate Change Financing could make it a priority to address the financing needs for energy efficiency and low-carbon energy access investments.

(b) In parallel, innovative use of carbon markets could expand the effectiveness of the Clean Development Mechanism and other market-based mechanisms as vehicles for the mobilization of incremental funds.

All support should aim at scaling up financial instruments that mitigate the risk of commercial lending for energy access and energy efficiency, and therefore leverage increased private sector participation over time.

4. Private-sector participation in achieving the goals should be emphasized and encouraged.

In the first instance, this will require the creation of long-term, predictable policy and regulatory frameworks to mobilize private capital. Within this context, major opportunities to enhance private participation may include:

(a) Implementing more public-private partnerships (PPPs) that have the potential to accelerate deployment of technologies that improve energy efficiency and/or enhance energy access (especially on the basis of low emissions). These could be akin to successful PPPs in the global public health arena and could catalyze a scaling up of funding for research, development, and commercial demonstration of low-carbon technologies, especially to close the energy access gap.

(b) The creation of new and innovative investment mechanisms to enable accelerated technology deployment with active private-sector participation – e.g., through a network of regional clean-energy technology centres to hasten the spread of locally appropriate energy technologies.

(c) An expansion of local lending capabilities to scale up investments in energy efficiency and access through local commercial banks and micro-finance institutions.

(d) Many countries have established regulatory and incentive frameworks for attracting private capital into the energy sector. These include a separation of regulatory, generational, transmission, and distribution functions; the announcement of capacity targets; transparent long term tariff offers; and coverage for political risk (but not for economic risk). Successful models could be transferred to other countries through South-South cooperation.

[11] This is based on an access level sufficient to meet basic human needs. As levels of infrastructure increase in order to allow for productive use, the loan capital requirements will increase, but the associated increased income generating capacity wil improve people's ability to pay for these services.

[12] CIF is a new source of financing to pilot projects to initiate transformational change towards low-carbon and climate-resilient development. The CIF funds, to be disbursed as grants, highly concessional loans, and/or risk mitigation instruments, are being administered through the multilateral development banks and the World Bank Group for quick and flexible implementation of country-led programmes and investments. CIFs consist of the Clean Technology Fund (CTF) and the Strategic Climate Fund (SCF). More details are available on http://www.climateinvestmentfunds.org/cif

(e) The existing systems could be adapted to the emerging challenges, e.g., by adding special incentives for off-grid areas, the deployment of renewables (feed-in tariffs), and R&D. Incentives for off-grid areas may include the expansion of local lending for energy efficiency and access through local banks and micro-finance institutions referred to under (c) above.[13]

(f) The envisaged technology mechanism under the UNFCCC could also be mobilized in this regard. One approach could be to increase private sector participation in the network of regional clean-energy technology centres to hasten the spread of locally-appropriate energy technologies

5. The United Nations system should make "Energy for Sustainable Development" a major institutional priority.

This may be achieved as follows:

(a) Facilitating energy access and improving energy efficiency should be integrated and mainstreamed into all relevant programmes and projects of the United Nations system, and Member States should be encouraged to do the same.

(b) Technical and financial support should be provided to help governments formulate appropriate plans, policies and regulations and develop local institutional capacities to enable their effective delivery, with a focus on "delivering as one" through United Nations country teams, supported and facilitated by UN-Energy.

(c) Existing knowledge networks should be mobilized and new ones built with partners outside the United Nations system to accelerate the transfer of best practices (with respect to modern energy system policies and regulations) by (i) mobilizing expertise across multilateral, public and private organizations; (ii) designing targeted, technical interventions;[14] (iii) providing a registry of donor projects to facilitate improved coordination; and (iv) creating and sharing diagnostic tools, technical software and know-how for policy-makers and practitioners. The UNEP-led Global Network on Energy for Sustainable Development (GNESD) provides a good example of knowledge creation and sharing on energy policy analysis.

(d) A monitoring and evaluation system for "Energy for Sustainable Development" should be created and coordinated to allow dynamic tracking of national (and sub-national, e.g., city) progress over time.

(e) A mechanism for regular global dialogue on "Energy for Sustainable Development" should be established, including a secretariat to manage the process.

(f) A strengthened UN-Energy framework could serve to spur progress toward a number of these objectives.

[13] Off-grid examples exist in Sri Lanka and Bangladesh where IDA and GEF have set up centrally-coordinated credit systems leveraging existing micro-finance institutions to create flexible payment options for solar household systems (ESMAP, 2008; Vipradas)

[14] For example, the Global Gas Flaring Reduction Initiative

ENERGY ACCESS

Overall Target and nature of the challenge

Universal access to modern energy services by 2030.

Defining energy access

One of the challenges facing the global development community is that there is no consensus on exactly what energy access means. It is useful to consider incremental levels of energy access and the benefits these can provide. For the sake of simplicity, one can consider three levels of access to energy (See Exhibit 1).

Exhibit 1 **Incremental levels of access to energy services**

Level 1
Basic human needs

Electricity for lighting, health, education, communication and community services (50-100 kWh per person per year)

Modern fuels and technologies for cooking and heating (50-100 kgoe of modern fuel or improved biomass cook stove)

Level 2
Productive uses

Electricity, modern fuels and other energy services to improve productivity e.g.

- Agriculture: water pumping for irrigation, fertilizer, mechanized tilling
- Commercial: agricultural processing, cottage industry
- Transport: fuel

Level 3
Modern society needs

Modern energy services for many more domestic appliances, increased requirements for cooling and heating (space and water), private transportation (electricity usage is around 2000 kWh per person per year)

SOURCE: IEA

Pending further analysis of the interlinkages between these uses, for the purposes of this report we have defined universal energy access as: **"access to clean, reliable and affordable energy services for cooking and heating, lighting, communications and productive uses"** – i.e., levels 1+2. Even a basic level of electricity access that includes lighting and allows for communication, healthcare and education can provide substantial benefits to a community or household, including cost savings. However, we have adopted a broader definition because access to sufficient energy for basic services and productive uses represents the level of energy access needed to improve livelihoods in the poorest countries and drive local economic development. "Affordable" in this context means that the cost to end-users is compatible with their income levels and no higher than the cost of traditional fuels, in other words what they would be able and willing to pay for the increased quality of energy supply.

In practice, achieving universal access to modern energy services by this definition will entail providing affordable access to a combination of energy services that can be classified in three headings:

- Electricity for lighting, communication and other household uses.
- Modern fuels and technologies for cooking and heating.
- Mechanical power[15] for productive use (e.g., irrigation, agricultural processing) could be provided through electricity or modern fuels (e.g., diesel, biofuels).

[15] In some cases, mechanical power may come directly from renewable sources, such as hydro; in most cases, however, this will require access to robust sources of electricity, over and above the power that would suffice for lighting and communication.

The importance of energy access

Universal access to modern energy services is fundamental to socio-economic development. Without access to modern fuels and electricity it is highly unlikely that any of the objectives of the Millennium Development Goals will be achieved (See Box 1).

Box 1 – The Millennium Development Goals

Goal 1: Eradicate extreme poverty and hunger
Goal 2: Achieve universal primary education
Goal 3: Promote gender equality and empower women
Goal 4: Reduce child mortality
Goal 5: Improve maternal health
Goal 6: Combat HIV/AIDS, malaria and other diseases
Goal 7: Ensure environmental sustainability
Goal 8: Develop a Global Partnership for Development

A lack of access to modern energy services hampers healthcare, gender equality, education, and poverty alleviation. For example, cooking on open fires and insufficiently ventilated and inefficient stoves that use biomass and coal-based fuels, results in an estimated 1.5 million premature deaths every year, disproportionately affecting women and children.[16] Many times this number of people suffer from debilitating respiratory infections. Women are further burdened by the long distances they need to travel to collect biomass for fuel – in extreme conditions, women in some areas of rural Tanzania walk 5-10km a day collecting and carrying firewood, with loads of over 30kgs.[17] It is also difficult for children relying on inefficient and poor-quality sources of lighting, such as candles and kerosene, to learn after dark.

The ability of poor communities to make productive use of their natural resources, time and human energy is severely hampered by the lack of mechanical power. Low-income households typically spend 7-15 per cent of their income on energy, but in countries where energy sources are more difficult to come by or prices are comparatively high, energy can account for as much as 30 per cent of the household's monthly expenditure.[18] In certain cases, there will be financial benefits from replacing traditional fuels with modern alternatives. Electric lighting in particular offers substantial cost savings over the most common alternatives (batteries, kerosene and candles).

In addition to these development aspirations, universal energy access is also important for the climate agenda. While universal access to basic levels of energy services will have a limited impact on greenhouse gas emissions (IEA estimates suggest that basic universal electricity access would add around 1.3 per cent to total global emissions in 2030),[19] increasing the level of energy provision and consumption for productive uses could substantially increase this. This underscores the importance of the accelerated deployment of low emissions technologies, where possible. This applies to both the supply side (including lower-emissions fossil fuel-based technologies) and the demand side, where energy-efficient end use devices reduce the amount of power consumed. Ensuring access to these technologies and developing new products and services geared to the needs of low-income communities is therefore critical.

In addition, in many cases there are environmental benefits to providing energy access, either through newer, lower-carbon-emitting technologies (e.g., solar LED lighting), or reducing deforestation by replacing charcoal with modern fuels (e.g., an estimated 20 per cent of deforestation in the Democratic Republic of the Congo is driven by demand for fuel wood and charcoal). The acknowledgement in the Copenhagen Accord of the importance of reducing emissions from deforestation and degradation (REDD) may create a link between carbon finance and energy access initiatives that reduce deforestation.

Furthermore, black carbon, a key component of soot from incomplete combustion of fossil fuels and biomass, represents a major part of global GHG emissions. About 26 per cent of black car-

16 UNDP & WHO, 2009

17 UNDP, 2008

18 World Bank, 2008a; Madubansi & Shackleton, 2006; Abdullah & Markandyab, 2009; ADB, 2005

19 IEA, 2009

bon comes from the residential sector – essentially from incomplete combustion in cooking stoves that burn fossil fuel and biomass. Solar ovens and improved efficiency stoves can achieve significant reductions in black carbon. The potential climate benefits are startling. Eliminating all black carbon emissions from cooking stoves over 20 years would be roughly equivalent to changing every car and light truck on Earth to a zero carbon dioxide emitter.[20]

[20] John C. Topping, Jr., in "How does black carbon change the climate debate?" – http://www.climate.org/PDF/climatealertautumn2009.pdf

Universal energy access is ambitious but achievable

Achieving universal energy access is an **ambitious** goal. The scale of the task is daunting and requires overcoming complex challenges in some of the poorest and most remote locations on the globe. Currently, more than 1.5 billion people have no access to electricity, and up to a billion more have access in name only because their power supply is highly unreliable. An estimated 2.5 to 3 billion people rely on biomass and transitional fuels (coal, kerosene) for cooking and heating.[21]

[21] IEA 2009 estimates 2.5 billion people lack access to modern fuels for cooking and heating, while UNDP & WHO, 2009 estimates that this number is over 3 billion people

If recent national trends in energy access continue, over the next 20 years an estimated 400 million people will gain access to electricity. Nonetheless, taking population growth projections into account, the number of people globally without access will stay roughly the same, and in many countries will actually increase. The geographical distribution of energy poverty will shift, with more people (both in absolute terms and proportionally) suffering from a lack of energy access in Sub-Saharan Africa, and a still significant proportion remaining without access in South Asia.[22]

[22] IEA, 2009

Ensuring universal access to modern energy services will thus involve providing new electricity connections to around 400 million households by 2030, and modern fuels and technologies to 700 to 800 million households over the same period.[23] For electricity, global access rates will need to increase by just over 2 per cent per year, while in Sub-Saharan Africa an increase of 8 per cent per year is needed (see Table 1).

[23] IEA, 2000; IEA, 2006; IEA, 2008; IEA electrification database; Global Insight WMM. Household numbers based on 5-6 people per household.

Table 1: Growth in electricity access required to achieve universal access by 2030

	World	Sub-Saharan Africa
1990 population with electricity access (m)	3.1	0.08
2008 population with electricity access (m)	5.2	0.23
2008 population without electricity access (m)	1.5	0.59
2030 population (m)	8.3	1.32
Annual growth rate in electrified population achieved since 1990 (%)	2.9%	6.0%
Annual growth rate in electrified population required to achieve universal access by 2030 (%)	2.1%	8.2%

Based on data from IEA global electrification database and Global Insight WMM

Providing universal energy access will pose a number of critical challenges related to gaps in national and local institutional capacity and governance required to produce, deliver, manage, operate and maintain these solutions (including strengthening the capabilities of public sector utilities to provide improved services for all their customers in a commercially viable manner and without political interference).

Additionally, accessing and allocating sufficient financing will be a major obstacle. In order to stimulate economic growth, many countries will naturally prioritize investment in power sector infrastructure for productive sectors (closing the existing supply gap or improving the existing power sector infrastructure) over providing basic energy access.[24] All around the globe, rural electrification is loss-making, and in the developing world this segment of the population is also often the poorest, with the lowest ability to pay. Subsidies are therefore often required to cover capital and, in some cases, operating costs. If the cost of the minimum energy package to end-

[24] World Bank. 2009b – World Bank Africa Infrastructure Country Diagnostic found that investment of $40 billion per year for the next 10 years is required to overcome the challenges currently facing the African power sector

users should be no more than a reasonable fraction of their income (say 10-20 per cent), it may be necessary to provide temporary subsides to reach affordability in the short-run before economic development accrues. This provides an additional reason why energy for productive uses is so critical: it increases the ability of end-users to pay for energy services, which is key to the long-term financial viability of such services – a virtuous circle.

At the same time, the goal of universal energy access is **achievable**, if the right elements are put in place. The capital investment required for basic access (roughly $35-40 billion per year[25] to 2030) represents only a small fraction (around 5 per cent) of the total global energy investment expected during this period. While more people need access to modern fuels, the capital costs of closing this gap are substantially lower than for electricity.

It is estimated that, on average, $40 billion annually is required through a mix of financial instruments. We estimate that grant funding of around $10-15 billion a year and loan capital of $20-25 billion a year will be needed, with the remainder being self-financed by developing countries. The incremental investment required to provide sufficient energy for productive uses[26] would be almost entirely for concessional loan capital rather than grant funding. This is because the additional energy capacity will provide people with opportunities for income generation and increase their ability to pay for services, thereby increasing the financial viability of the energy services.

Various sources of international funding and risk tools could be accessed to help finance capital and capacity building costs. These include ODA and other donor funding targeted at the achievement of the Millennium Development Goals; and climate-related finance, which under the Copenhagen Accord is intended to increase to $100 billion a year by 2020 (for both mitigation and adaptation). Existing energy programmes and funds (such as the Renewable Energy and Energy Efficiency Fund (REEF), the Climate Investment Funds of the World Bank and other Development Banks,[27] and GTZ's Energising Development) can be utilized to administer and distribute finance, but will need to be scaled up significantly. This will require governance structures that better balance the needs of donor countries for accountability and the needs of recipient countries for a stronger voice in how the funding is deployed. There are various successful examples of significant scale in the developing world that demonstrate that the technical, financing and operating challenges associated with expanding energy access can be met, even in the more difficult rural settings. As an example, more new household electricity connections were made in the 1990s than would be required in each of the next two decades to achieve universal access (see Exhibit 2). This extension occurred mainly in Asia (especially China, Viet Nam, and Thailand) but South Africa and Brazil also achieved notable successes in rural electrification.

While the challenge in the future will increasingly be that people who lack access will be more dispersed, more rural,[28] and have lower incomes, and will therefore require targeted subsidies in the face of a limited availability of resources to meet higher capital costs, the technologies and business practices required to overcome these obstacles already exist and are evolving rapidly.

The following sections discuss the technology options and associated challenges and costs, first for electricity and then for modern fuels and technologies.

Access to electricity

As discussed, it is useful to consider incremental levels of energy access and the benefits they can provide when planning electricity access programmes. Typically, electricity usage is initially limited to replacing other sources of fuel for purposes such as lighting, and for other low energy consumption devices such as for charging mobile phones. Other appliances that require more electricity to operate (such as televisions and refrigerators) are typically added as people can afford them.

However, access to sufficient power for productive use is the minimum required to achieve the objectives espoused in the MDGs, as it is this increase in productivity that can improve income generating opportunities. This is in turn key to improving the ability to pay for electricity services, thus improving the financial viability of these services.

[25] $35 billion per year for electricity access estimated by IEA, 2009 and $2-3 billion per year for modern fuels access based on cost estimates from UNDP and ESMAP, 2005a

[26] Increased electricity generating capacity and other energy related infrastructure for mechanical power is required

[27] For example the Clean Technology Fund, Pilot Program for Climate Resilience and Scaling Up Renewable Energy Program – see www.worldbank.org/cif

[28] It should be noted that increased urbanization with limited urban planning can result in limited access for these newly urbanized populations as well.

Exhibit 2 **Lessons from the 1990s indicate that the scale of universal electricity access challenge is not insurmountable**

Average number of households gaining access to electricity
Millions

Implementation had to be done with great speed and intensity:

In the early 90s, **China** was electrifying over 30 villages a day

Viet Nam granted almost 400 people access to electricity per hour for 15 years

South Africa made a new grid connection every 30 seconds, placed a pole in the correct position every 10 seconds and strung 200m of cable every minute

SOURCE: IEA WEO 2002, Eskom, World Bank Working papers

Access can be provided either at the community or household level. For example, **community level** access could initially be provided to health clinics, education facilities, and central recharging facilities that can be used for battery-powered devices such as LED lights or cell phones. Importantly, this corresponds to the priorities of many ODA and private donor organizations, as well as the commercial interests of private sector players, for example mobile phone operators.

Similarly, communal productive capacity could be created, for example to provide access to electricity or mechanical power for basic irrigation or for simple cottage industries such as basic manufacturing or agricultural processing.

In other cases, it may be quicker to provide some level of electricity access directly to **households**. These different levels and types of access are not necessarily sequential, and depend on the local context and priorities.

The scale and nature of the access gap and locations involved means that electricity will need to be provided through both centralized and decentralized energy technologies and systems, combining the following three general models.

- *Grid extension*. An extension of the existing transmission and distribution infrastructure to connect communities to power.
- *Mini-grid access*. Linking a local community to a small, central generating capacity, typically located in or close to the community. The power demand points are linked together in a small, low-voltage grid that may also have multiple smaller generating sources.
- *Off-grid access*. Generating capacity provides power for a single point of demand, typically a solar household system (SHS).

Grid extension

This is often the least-cost option in urban areas and in rural areas with high population densities. If pursued at the regional level, especially in Africa, it also offers the opportunity to tap into significant hydropower potential, providing low-cost clean energy.[29] A number of factors underpin successful grid extension, including strong government commitment, a clearly defined role for national utilities, sufficient central generating capacity to allow for the increase in demand, and

[29] World Bank, 2009b

a focus on reducing capital costs, *inter alia* by increasing the economies of scale of the connections.

For large-scale grid extension to be feasible, the system needs to be functioning well enough to support the additional capacity and demand and enable recovery of costs. In many developing countries this is not the case and would require a refurbishment of the existing infrastructure (generation and grids), improvement of the performance of the utilities through local capability building, implementing best practices for operational improvements (e.g., loss reduction programmes) and resolving fuel supply issues by ensuring the appropriate fuel supply chains and logistics infrastructure are established. In countries where electricity and primary energy prices are regulated and subsidized, steps would need to be taken towards establishing tariff structures reflective of costs. In addition, in some urban environments issues relating to land tenure and informality would need to be overcome, as authorities are wary of providing access to electricity if this may be viewed as indirectly acknowledging rights to land.

There are a number of compelling examples of successful large-scale grid extension.

- China secured electricity access for almost 700 million people over the second half of the twentieth century to achieve electrification for over 98 per cent of the population by 2000. The plan focused on creating local enterprises. Key factors in China's success were the government's ability to mobilize contributions at the local level and the domestic production of low-cost components.[30]
- Viet Nam achieved extremely rapid electrification, expanding coverage from 3 per cent to 95 per cent of households in 35 years, and increasing connections at a rate of 13 per cent a year (see Box 2). Access to low-cost finance and insistence on cost recovery, through tariffs or from government budgets, were important in achieving its goals.
- In South Africa, excess generating capacity and the good condition of the existing grid formed the basis for Eskom to implement an intensive grid extension programme that achieved electrification of over 2.5 million households in less than seven years.[31]
- In Tunisia, the national government and the national utility committed to making a steady long-term rural electrification effort the national priority for over 30 years.[32]

[30] Jiahua et al., 2006 and IEA, 2010

[31] Stephen & Sokopo, 2006; Marquard et al., 2007

[32] ESMAP, 2005b; ESMAP, 2004

Box 2: Viet Nam – lessons on leveraging national, local and community level collaboration towards large scale electrification

Viet Nam has achieved very high rates of electrification. Access grew from 3 per cent to 95 per cent in 35 years. The most intensive growth period was from 1995-2008, during which time an average of 3.4 million people were provided with electricity access each year.

This was achieved largely through grid extension, driven (from 1995 onwards) by Electricity of Viet Nam (EVN). Existing infrastructure was severely underdeveloped, requiring a massive new build programme, which tripled the national installed capacity and involved the construction of a 500kV line stretching the length of the country. As a result, EVN had limited additional capacity also to develop the distribution grid, and relied heavily on local distribution utilities (LDUs), community cooperatives and service agents to erect, operate and maintain LV lines as well as managing invoicing and revenue collection. Recovery of operational costs from end-users was critical to success of the programme.

Capital was provided through a coordinated programme of government subsidies, provincial government funds, international loans and grants, and cross-subsidies. IDA helped the government to prepare a Master Plan for Rural Electrification, pulling together government, user and ODA financing into a single, coordinated programme.[19]

Despite the huge overall success, there are a number of challenges resulting from the intense pace of implementation – including limited capacity to ensure quality standards and provide sufficient capability-building to local participants. In certain regions, poor-quality grid infrastructure was installed and subsequent maintenance has been lacking. Grid refurbishment projects are underway and many of the community cooperatives have been incorporated into LDUs in an effort to reduce losses and improve revenue collection.

[33] World Bank, 2009a; World Bank/IDA, 2000; ASTAE, 2008

One environmental challenge is that large-scale grid-based electrification programmes have historically utilized predominantly fossil fuel-based generating technologies. This was certainly the case in China, where electrification was driven by a rapid expansion of coal-fired plants, and in South Africa, where the programme leveraged significant over-capacity that had already been installed. In the medium term, fossil fuels are likely to continue to play a major role. Deploying low-carbon-emitting fossil fuel technology solutions, such as natural gas, carbon capture and storage (CCS), high efficiency coal-fired stations, and exploring even newer technologies will therefore be critical to reduce emissions. Mechanisms both to reduce the costs of some of these technologies and to cover the additional costs often associated with cleaner technologies will need to be developed and implemented.

Mini-grid and off-grid solutions

In rural areas and settlements further from the grid, **mini-grid and off-grid solutions** may be more attractive, for a number of reasons. First, they can often be deployed more rapidly than grid solutions. Second, they do not rely on excess generation capacity. Third, there is often a significant potential local business- building and job creation opportunities from these solutions.

The levelized costs of these solutions relative to grid-based solutions depend on a number of factors, in particular the capital cost of the generation technology and distance from the existing grid. Renewable energy technologies, including small hydro, solar, wind and various types of bio-energy, are ideally suited to mini-grid and off-grid applications, especially in remote and dispersed rural areas. While the costs of non-hydro, renewable energy-based sources are typically somewhat higher than fossil fuel-based technologies, the learning curve associated with their increased deployment is resulting in increasing cost-competitiveness.

The key challenges related to both mini-grid and off-grid solutions include significant initial capital investments, the capabilities required to install and maintain these systems, and defining and implementing appropriate pricing systems. These have been successfully overcome in numerous developing countries. For instance, micro-finance and flexible payment options have helped overcome the lack of access to finance, which represents a significant barrier even where communities are able to afford a portion of the capital costs – in Sri Lanka and Bangladesh IDA and GEF set up centrally-coordinated credit systems leveraging existing micro-finance institutions to create flexible payment options for solar household systems (SHS) and village hydro power[34] (see Box 3). UNEP's work in establishing India's Solar Loan Programme (ISLP) and Tunisia's PROSOL[35] illustrates how subsidies, translated into favourable interest rates for loans and administered through local banks and SWH suppliers, can be used effectively to help customers overcome the barrier of high initial capital costs.

[34] ESMAP, 2008

[35] GEF & UNEP DTIE, 2004

Box 3: Sri Lanka – innovative financing mechanisms to overcome initial capital cost barriers and incentivise delivery

The centrepiece of the Renewable Energy for Rural Economic Development (RERED) Project in Sri Lanka is an IDA/GEF supported market-based credit programme available to participating credit institutions (PCIs), supported by a system of output-based, co-financed grants.

PCIs (commercial banks, MFIs, leasing companies) access credit at favourable rates. In turn, they offer shorter term sub-loans to households, community based organizations and private developers to finance SHS and village hydropower systems. The Administrative Unit of the Development Finance Corporation of Ceylon Bank manages the credit programme and monitors suppliers' compliance with technical and service standards.

The project also offers co-financed grants paid out once the pre-defined results are achieved. Such grants do not cover operations or maintenance costs and are provided to suppliers (rather than beneficiaries) on a declining scale to encourage the development of a commercial off-grid market.

With mini-grid systems specifically, there are sometimes addition challenges related to operating complexity and costs, including load balancing. In many cases, however, the value of aggregating supply in a mini-grid at the community level so that it is available for productive use during non-peak hours for household use will outweigh any additional costs. Mini-grids played an important part in Chinese rural electrification, and there are more recent success stories in Sri Lanka (see Box 3) and Mali.[36] In order to augment rural electrification, under a GEF funded Strategic Energy Programme for West Africa,[37] renewable energy powered mini-grids linking to productive uses are being established in eight countries.

There are several other important considerations:

- The long-term sustainability of mini-grid and off-grid programmes hinges on developing the capabilities of local participants[38] and ensuring local supply chains are in place.
- Another critical factor is ensuring that rigorous quality standards for equipment and installation are met (e.g., PVs on houses, distribution lines). In both China and Bangladesh, ad hoc inspections were carried out for off-grid technologies to ensure quality.[39]
- Specifically for mini-grids, ensuring that the technology is forward-compatible with later grid connections is important if mini-grids are viewed as an incremental step on the energy access pathway. This succeeded in China, where once-isolated local community grids have become interconnected as the national grid expanded to include them.[40]
- For mini-grid solutions, it is critical that consumers are charged relative to their level of consumption. In Sri Lanka this was overcome by using limiting power boards and charging end-users according to self-selected maximum supply capacities.[41]
- Finally, there is a need for awareness and confidence amongst end-users in the solution itself, and acceptance within the local community before implementation is also essential.[42]

The right mix of solutions

The critical question in electricity access is not which of these solutions should be adopted, but rather in what way a combination of these solutions should be adopted. The optimal choice for each country would be driven by the availability of resources, the regulatory and policy environment, the institutional and technical capacity, and the relative costs of each of these solutions. Each comes with its own set of advantages and challenges, and the highest impact will be achieved when grid, mini-grid and off-grid solutions are appropriately traded off and then combined to resolve the challenges in each different market.

The trade-off between grid solutions, mini-grid solutions and off-grid solutions needs to take into account several critical factors. These elements are not static, however, and decisions about them will need to consider their expected evolution. The following specific issues need to be considered:

- **Level of demand**: The level of energy access required is dependent on the needs of each community as well as contextual constraints, such as climatic conditions. This is also linked to the ability and willingness to pay.
- **Length of time for delivery**: Given the distributed nature of both the mini- and off-grid solutions, and the resulting reduction in other dependencies such as transmission rights-of-way and building new capacity, it will typically be possible to deliver these solutions more rapidly than a grid solution. Rather than relying on the incumbent utility to deliver the grid-based solution, services can be provided by private-sector players. The time benefit is especially relevant when there are shortages in generation capacity, as is the case throughout the developing world.
- **Cost of solutions**: The cost of technologies will differ according to local conditions and available natural resources, and so the least-cost fuel mix and technology options will also vary for any specific community. Different solutions will be cost-optimal for urban and rural communities. In urban areas and peri-urban areas close to an existing grid, the costs of extending the grid are relatively low, while high population densities create aggregated

[36] World Bank, 2009b

[37] GEF/UN Energy, 2010

[38] EUEI PDF

[39] ESMAP, 2008

[40] Jiahua et al., 2006

[41] Southwest Windpower

[42] Selco in India invested in extensive community awareness and education programmes to create an understanding of the benefits of solar power (Expert interviews and company website).

demand. Over time, the non-hydro renewable technologies associated with the off-grids and in particular the mini-grids are likely to have much higher learning curve benefits than the technologies associated with the grids, because they are new technologies. This makes mini- and off-grid solutions even more attractive options for the future.

- **Quality of access provided by technologies**: Grid-based solutions should (in theory) provide 24/7 access. However, depending on the generation base of the mini- or off-grid solutions, they are often unable to provide this access 24 hours a day, as the generation of wind and solar energy depends on weather conditions and battery storage is limited and expensive. Advances in battery storage technology (which are likely to be rapid due to the R&D investment in electric vehicles) will, however, improve this over time. The emergence of more energy-efficient appliances will also make off-grid and mini-grid solutions more acceptable

There could be considerable interim benefits from starting non-electrified households on a low-capacity supply for certain hours of the day as a step towards a longer-term solution.[43] In Peru, for example, the utility offered both solutions, inviting communities to choose between constant grid access in the future and the less-optimal solution providing more intermittent power much sooner. In most situations, consumers opted for more intermittent access earlier.[44]

[43] Venkataramanan & Marnay, 2008

[44] World Bank expert interviews

The private sector could play an important role in providing initial off-grid electricity supply. For example, mobile phone companies currently use diesel generators to provide power for their antennae in rural areas in Sub-Saharan Africa. By installing solar PV systems, mobile phone operators could be able to generate sufficient power for their requirements and excess capacity, which could be used to power the local health clinic or school. This could be utilized as a charging station for mobile phones, thus providing a commercial incentive for the mobile phone company to invest in the additional capacity.

It is also important to recognize the need for flexibility in the strategy for different countries. To this end, strategies should be tailored to each country to maximize local resources and satisfy specific local requirements.

For all types of electricity access, past successes show that no single institutional model reliably provides better success rates than others. Both large-scale vertically integrated utilities and smaller decentralized businesses can deliver the required solutions, using public, private and cooperative approaches,[45] depending on the strength of the existing utilities and local businesses. In all cases, however, a degree of central programme-level coordination is necessary.[46]

[45] Barnes, 2007

[46] ESMAP, 2008

Cost recovery is essential for the ongoing sustainability of services. Governments need to decide what tariff structures and cost recovery mechanisms (e.g., lifeline tariffs or cross-subsidies) to put in place based on the ability and willingness to pay, which will vary according to income levels and the availability of alternative energy sources in the different regions. For example, lifeline or free basic electricity allocations are set at 10kWh/month per connection in the Philippines; at 300kWh/month in Zambia; and at 50kWh/month in South Africa.[47]

[47] Komives et al, World Bank 2005; Eskom

Access to modern fuels and technologies

There are a wide variety of modern fuels, including natural gas, LPG, diesel and renewables such as biodiesel and bio-ethanol. There are also technology options that are required to make use of modern fuels or use traditional fuels more efficiently, such as improved cook stoves.

The suitability of these options depends on factors such as availability, applicability, acceptability and affordability, including access to finance to cover upfront investments. The declining availability of existing sources of fuel makes switching to modern alternatives a necessity in some places. For example, in many parts of India finding sufficient biomass for cooking is becoming increasingly difficult.

The acceptability of the modern alternative to the end-user is essential, as solutions will only gain traction if they meet users' preferences and needs. In many cases, existing methods meet multiple objectives, so providing a replacement that meets only one of these objectives will prove unacceptable. For example, in the South African rural electrification programme, some communities did not switch to electric cooking stoves even when these were provided for free, as they relied on the coal stoves not just for cooking, but also for heating.

The affordability and people's willingness to pay for modern fuels and technologies largely depends on whether and how much people currently pay for fuel. In many cases, modern fuels cost significantly more than people are currently paying or can afford. Furthermore, significant initial payments (e.g., for improved cook stoves or biogas digesters) and/or the need to buy in bulk (e.g., LPG) present major obstacles to the poor, who do not have access to credit.

Subsidies have been used in some cases to overcome affordability challenges (e.g., LPG programmes in Brazil and Senegal). The challenge with subsidies is that they place a significant strain on government resources, and may be unaffordable to many least developed countries. Furthermore, subsidies often end up providing limited benefit to the people who need them most.[48] They are best used only where necessary, in as targeted a manner as possible (e.g., in Brazil the general LPG subsidy was replaced with discounts as part of a conditional social payment programme – Bolsa Familia)[49].

To illustrate the challenges related to providing access to modern fuels and technologies, we have considered these requirements in the context of cooking needs, focusing on LPG, biogas and improved cook stoves. This does not represent the full range of needs or applications for modern fuels;[50] they have been chosen as examples of solutions that have been implemented at scale.

Liquefied Petroleum Gas (LPG)

LPG is widely utilized in cooking applications around the world, providing much more efficient use of energy than traditional biomass. The challenge is that operating costs are relatively high[51] (and subject to global oil price fluctuations). The use of LPG thus becomes a financially viable alternative only where households are already making a significant financial payment for energy (e.g., buying charcoal) or are able and willing to pay for a more efficient alternative. Depending on oil prices and local availability, liquefied natural gas (LNG), dimethyl ether (DME) and ethanol gel could provide viable and cleaner alternatives to LPG.[52] LPG and its alternatives will therefore often be viable in urban areas, where roughly 20 per cent of people without access to modern fuels are located. In addition, the operational delivery of LPG-type solutions in urban areas is typically viable because population densities and available infrastructure make distribution easier than in rural areas.

Still, large-scale LPG programmes in Brazil and Senegal demonstrate that these rural distribution challenges can be overcome, at the same time creating local jobs and livelihoods. Assuming that up to a quarter of the rural population without access to modern fuels could afford to pay for their cooking fuel requirements, LPG (along with its alternatives) may represent a viable option for 25-40 per cent of the global population without access to modern fuels. The sustained impact of this solution is limited, however, by that fact that prices are linked to global oil prices. In Brazil, for example, recent increases in fuel prices resulted in the reversal of the trend of replacing traditional fuels with LPG.

This option should be prioritized where charcoal production is resulting in deforestation and degradation. Even though LPG does produce CO2 emissions, these are dwarfed by the reduction in GHG emissions related to changes in land use, and carbon finance could thus be utilized to cover the additional costs.

Biogas

There is a strong case for biogas where people own sufficient livestock: the dung from two cows typically suffices to meet the cooking requirements of a household. As the fuel is produced on site, there are limited distribution challenges or costs beyond the delivery of the equipment. Even though a higher initial investment is required than for the other options (and access to finance therefore needs to be provided), the absence of ongoing fuel costs mean that the annualized cost over the lifetime of the equipment is significantly lower than that for non-

[48] World Bank, 2001; ESMAP, 2004; Barnes, 2007

[49] Lucon et al., 2004

[50] For more modern fuel applications see Practical Action Consulting, 2009

[51] Based on a cooking energy requirement of 50kgoe per person per year (IEA, 2009) and a market price of LPG of $0.7/kg, a 5 member household would have LPG cooking costs in the region of $150 annually (around 45kg LPG provides 50kgoe). This would represent around 10% of total household expenditure for households below the poverty line.

[52] IEA, 2006

renewable modern fuels (LPG, ethanol gel).[53] Replacing LPG with biogas in Thailand resulted in savings per household of more than $70 per year. This is most relevant in some rural and peri-urban settings, but this solution is more suited to South Asia as livestock in Africa are typically free roaming.[54]

Nonetheless, the market for biogas could feasibly represent a solution for up to 20 per cent[55] of the people without modern fuel access. Examples in Nepal (see Box 4) and Viet Nam have shown how rapidly this solution can be scaled up. Furthermore, this option reduces greenhouse gas emissions by capturing and burning methane, and carbon finance could therefore be used to cover part or all of the costs. In Nepal, it is estimated that each installation avoids 4.6 tCO_2e/year.[56] At $15/t CO_2e a $250 installation could pay for itself in less than four years.

Box 4: Nepal – significant scale up of biogas plant installations

Nepal installed over 170,000 biogas plants, benefiting more than a million people, in a 13-year programme during the 1980s and 1990s. Over 90 per cent of these are still in operation today.

This intensive programme was supported by the development of a local private sector biogas manufacturing and construction capacity, as well as training and certification facilities to ensure that quality standards were maintained. Between 35 and 50 per cent of the capital costs were subsidized through grants from international donors such as the German development finance institution Kreditanstalt für Wiederaufbau (KfW). Loan capital was made available for the remaining capital costs.[57]

Improved cook stoves

For people who lack access to sufficient livestock and biomass for biogas production and who are unable or unwilling to pay for LPG/natural gas solutions, one further option is to improve the efficiency with which they burn biomass. Here improved cook stoves (ICS) offer a feasible alternative. These stoves provide numerous advantages: they double or triple the thermal efficiency of traditional fuels, reduce the harmful effects of poor ventilation, and may also provide some co-heating. They ameliorate a number of serious health and environmental problems caused by current practices. More efficient stoves are relatively inexpensive ($15-60 per unit/$3-12 per person).[58] However, experience has shown that higher-quality, more durable models (with associated higher costs) stand a much better chance of sustained impact.

While the success of ICS programmes has often been limited, this appears to be a consequence of poor or ill-conceived business models and inattention to financing realities, rather than any fundamental problem with the concept. For example in Nepal, the limited success was largely ascribed to the fact that there was insufficient promotion, education, monitoring and follow-up. Furthermore, prefabricated models were distributed through a prolonged and difficult transportation process to remote mountainous areas, leading to significant levels of breakage.[59]

For all the modern fuels and technology solutions, increased levels of understanding of their benefits and proper use are essential to ensure uptake. In addition, the development of local capabilities to maintain new technologies (e.g., stoves, biogas digesters) is crucial to success. This should be viewed not as an obstacle but as an opportunity for the creation of sustainable livelihoods. In addition, policy and regulatory frameworks are critical triggers for scaling up investments in renewable energy projects.[60]

Based on the options laid out above and modern fuels projects around the developing world, providing universal access to modern fuels and technologies by 2030 would require an initial investment of $2-3 billion a year[61] (see Table 2). This includes an estimate of both equipment and programme costs.

53 Limmeechokchai and Chawana, 2004

54 Biogas for a Better Life, 2007

55 The market has been sized at 18.5m installations in Africa (SNV Biogas for a Better Life, 2007), which would benefit 15-20% of the population lacking access, based on figures (IEA 2009). It is estimated that the potential in Asia would be slightly higher.

56 Bajgain & Shakya (2005)

57 *Ibid.*

58 UNDP expert interviews, ESMAP 2005a

59 Shrestha et al., 2003; Basnyat and Shrestha, 2003

60 UNIDO/Africa Union, 2008

61 Based on the cost estimates from UNDP and examples from UNDP, World Bank and ESMAP, 2005a

Table 2: Capital costs for providing universal access to modern fuels for cooking by 2030

	LPG	Biogas	Improved Cook Stoves
Target population	Urban population with access to fuel distribution channels	Rural population with access to sufficient biomass (e.g., dung)	Rural population lacking sufficient biomass for biogas
Proportion of population (%)	25-40	~20	40-55
Capital costs ($/capita)	10-15	30-40	10-20
Total capital costs for universal access ($ bn)	7-17	11-22	11-31
Total capital costs	$39-64 billion ($2-3 billion per year)		

Based on cost estimates from ESMAP 2005 and UNDP-supported projects[62]

What is required for success?

Based on the lessons learned from programmes around the world to provide access to electricity and modern fuels, a number of building blocks for universal energy access emerge as requirements, at both national and international levels. These will all rely on the mobilization of resources and support at appropriate levels from a range of actors in different countries. In particular:

- **Policy support from governments**: Governments need to prioritize energy access, set aggressive national targets for universal access, and put in place plans and the enabling environment to deliver them. Successful large-scale electrification programmes are underpinned by government targets and priorities that inform a rigorous planning process. The necessary policies, programmatic capabilities, tariff structures and incentives to support these targets and participation from the private sector also need to be put in place. These policies will need to be translated rapidly into regulations and legislation. This process should be supported by multilateral organizations, international agencies such as the IEA and IRENA, and non-profit organizations.
- **Access to financing**: The international community needs to provide financial support to developing countries for meeting the global universal energy access and energy efficiency goals proposed by AGECC. The IEA's reference case estimates that it is possible to provide electricity access sufficient to meet the objectives of the MDGs to the vast majority of the world's energy poor in the next 20 years, for an average capital investment of around $35 billion per year.[63]

Based on a set of assumptions[64] and using the IEA's reference case for universal energy access provision to provide an understanding of where this funding needs to be sourced from, we estimate that most (55-70 per cent) of the capital costs could be recovered through end-user tariffs (including cross-subsidies, for example as was used in China and South Africa), and could therefore be funded through loan finance. The remainder would need to be funded through international grants (20-30 per cent) and government budgets (10-15 per cent). For example, Kenya charges a 2-5 per cent levy on the national utility's revenues towards a rural electrification fund to subsidize grid extension and SHS projects.[65]

This equates to concessional finance of $20-25 billion per year to provide loan capital to banks and microfinance institutions to fund capital requirements. Approximately $5-7 billion of this would be passed directly to end-users to enable them to meet the upfront costs of energy access. In addition, $15-18 billion is likely to be required by government, utilities and private developers as loans that could be recovered through future revenues (largely as cross-subsidies). Of this amount, some $3-5 billion per year will need to be made available from the national budgets of lower-middle-income countries that are implementing energy access programmes, while the remaining $10-15 billion per year would need to be provided by international donors. These

[62] Including GEF Small Grants Programme, the Multifunctional Platform Programme and the UNEP/AREED Programme.

[63] IEA, 2009

[64] Some high level assumptions have been made to allow us to estimate the amount of loan capital and subsidies needed to fund a global energy access campaign requiring investment of $35-40 billion per year. The estimates are based on the IEA 2009 reference case for universal energy access – the technology split is 70% for grid extension, 27% for mini-grid solutions and less than 5% for off-grid options. The fuel mix is 35% renewables, 65% conventional technologies, based on the IEA developing countries split. Four major channels for obtaining capital have been considered. The first two involve recovering the cost from end-users through tariffs (including cross-subsidies) or up-front payments by the beneficiaries. Both options would require financing, and therefore make up the loan portion of the funding strategy. The next two channels cover the subsidized capital costs and could come from either national budgets (e.g., funded through taxes) or international grants. It is assumed that governments of low income countries will not be able to cover any of their investment costs, while governments of lower middle income countries could cover up to two thirds of the required subsidies through public revenues. For grid extension, it is further assumed that the majority of the cost (70-90%) will need to be recovered through the tariff structure. A small portion of connection costs may be recovered directly from end-users and the rest will come from subsidies, covering connection costs for the poorest population segments and some renewable generation investments. Finally, the programme costs will need to be subsidized entirely, funded by governments and grants.

[65] Kenya Environment Donors, 2005; KPLC, 2007

financing requirements could be partially met from the international climate finance and ODA earmarked for the achievement of the MDGs. It is expected that international finance institutions will have a major role to play in distributing this finance, which will require scaling up existing funding mechanisms, and the development of additional, creative financing mechanisms, like for example the GET FiT programme suggested by Deutsche Bank (See Box 5).

Box 5 – GET FiT from Deutsche Bank Climate Change Advisors:

The Global Energy Transfer Feed-in Tariff (GET FiT) Program, developed by Deutsche Bank Climate Change Advisors, is a concept to specifically support both renewable energy scale-up and energy access in the developing world through the creation of new international public-private partnerships. GET FiT would combine a fund of public money directed for renewable energy incentives with risk mitigation strategies and coordinated technical assistance to address project development and financing barriers.

GET FiT would partner with developing countries seeking to establish feed-in tariff policies, and with international partners to address a variety of risks and barriers faced by all renewable stakeholders, including development risk, off-take and counterparty risks, political risk, market risk, reinsurance risk and currency risk. GET FiT would provide premium payments, passed through the national governments and utilities to independent power producers (IPPs). The utility would pay at least the market rate to the IPP, and there would be minimal additional burden on the electricity ratepayer. The transfer payments of the GET FiT premium to the IPP could be guaranteed by the national government, or by the GET FiT Programme, depending on the national context and creditworthiness of the involved parties. An international sponsor would provide an ultimate guarantee for the GET FiT payments. Political risk insurance entities, (e.g. MIGA, OPIC, private sector providers, etc.) could play a role in mitigating sovereign risk, and could also backstop governments' guarantees of renewable energy payment where necessary.

This stabilization of revenue streams would attract significant amounts of private sector capital from both domestic and international sources to build renewable energy projects. The payments would be adjusted to reflect market conditions over time and chart a pathway to grid parity. Based on a preliminary analysis by DBCCA, a \$3bn commitment under the GET FiT scheme could facilitate over 1 GW of newly installed on-grid and off-grid renewable energy capacity, with the associated abatement of 100 million tons of CO_2 emissions over funded projects' lifetimes.

- **Capacity development**: Resolving the challenges related to access to financing, and reducing the costs of energy access and end use appliances, will not be sufficient to improve energy access without complementary efforts to develop the capabilities and capacities of local institutions for the provision of delivery, quality monitoring, finance, and operations and maintenance services. Such capacity development is needed in both the public and private sectors, and at all levels – national, sub-national and community – and should leverage and build on the expertise and knowledge base that has been developed by multilateral institutions and international agencies.
- **Utility performance**: Improving the performance of public utilities will be critical for the success of expanding the grid and achieving the universal access target, since utilities in developing countries often have technical losses four or five times higher than their counterparts in developed countries. Expertise from the private sector in the developed and developing world should be leveraged to drive these utility improvements.

Providing global energy access is not a luxury, but a necessity. Lack of access to modern energy services is one of the main factors that constrains development for the poorest populations. Providing access to reliable and affordable energy services is critical for development, and increasing the reliance on clean energy sources for energy access is also important for the climate agenda. Access solutions will vary by geography, by setting and over time. There are many successful examples of access expansion to demonstrate that the ambitious goal of universal energy access by 2030 is achievable.

ENERGY EFFICIENCY

Overall Target and nature of the challenge

Reduce global energy intensity by 40 per cent by 2030.[66]

There is a strong correlation between energy consumption and economic growth, and the term "energy intensity" provides a way of understanding the evolution of this relationship. Energy intensity is the amount of energy used per unit of economic output (Gross Domestic Product).

Energy intensity can be reduced in two ways:

- First, higher energy efficiency can reduce the energy consumed to produce the same level of energy services (e.g., a more efficient bulb produces the same light output for less energy input).
- Second, the economic structure of individual markets can shift from high energy intensive activities such as manufacturing to low energy intensive activities and sectors such as services, while maintaining, or even increasing, total GDP.[67]

Since 1990, global energy intensity has decreased at a rate of about 1.3 per cent per year due to both structural effects and physical energy efficiency improvements (see Table 3).

Table 3– Global energy intensity 1990-2007

	1990	2007	Average annual change 1990-2007 (%)
GDP ($bn, real 2005 at market exchange rates)	29,930	49,300	3.0%
Final energy consumption (Mtoe)	6,293	8,286	1.6%
Energy intensity (toe per $k)	0.21	0.17	(1.3%)

In the future it is clear that a step change in the rate of energy intensity reduction will be required.

Energy efficiency is the key to driving the required incremental reduction in energy intensity. It has come to prominence in recent decades as one of the few "no-regret" policies that can offer a solution across challenges as diverse as climate change, energy security, industrial competitiveness, human welfare and economic development. While it offers no net downside to energy-consuming nations, the opportunities have proved very difficult to capture. In recent decades, however, some developed countries and regions such as Japan, Denmark and California have been able to partially decouple economic growth from energy growth, in part due to major and sustained energy efficiency efforts.

Capturing all cost-effective[68] energy efficiency measures could reduce the growth in global energy consumption to 2030 from the 2,700-3,700 Mtoe forecast to 700-1700 Mtoe (see Exhibit 3). This would represent a reduction in energy consumption growth of some 55 to 75 per cent from the business-as-usual case. It would also have a significant effect in emissions: energy efficiency opportunities make up about a third of the total low-cost opportunities based on currently available technology to reduce GHG emissions globally.[69] (Forestry and agriculture, and a move to low-carbon energy supply, represent the balance of the opportunity.)

In all scenarios, energy demand continues to grow: energy intensity improvements are overshadowed by economic growth. Moreover, an improvement of energy efficiency can also act as an incentive to raise consumption. One reason is that because of energy efficiency improvements, energy services may become cheaper. For example, a more fuel-efficient car may result in more driving. A second reason, especially relevant for developing countries, is that certain forms of energy are supply-constrained (see also the previous discussion on energy access). For

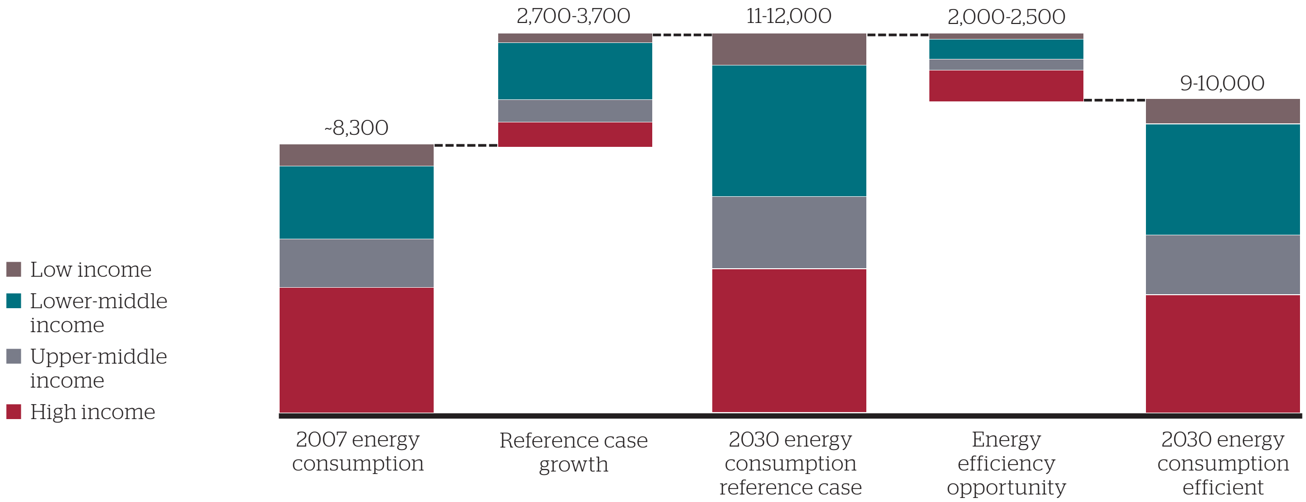
[66] Energy intensity is defined here as final energy consumption over GDP (in constant 2005 terms, at market exchange rates). Final energy consumption – that is, energy measured at end use – excludes conversion efficiencies in processes such as power generation and refining.

[67] McKinsey Global Institute, 2008

[68] All energy efficiency measures costing less than $90/tCO2 in the McKinsey Global GHG abatement cost curve v2.0 (McKinsey, 2009)

[69] All GHG abatement measures costing below $90/t CO2 in the McKinsey Global GHG Abatement Cost Curve v2.0 (McKinsey, 2009). With substantially increased R&D and deployment, there is reason to have at least some optimism that additional low cost means of reducing GHG emissions will be developed and made widely available for implementation in the next two or three decades.

Exhibit 3 **Global final energy consumption**
Mtoe



SOURCE: IEA; Global Insight; McKinsey Global GHG Abatement Cost Curve v2.0; McKinsey analysis

example in case the latent demand for electricity exceeds the supply, electricity savings because of more efficient equipment can open up the opportunity to use additional electricity-consuming equipment, and the net electricity savings effect is nullified. The combination of the two mechanisms is called the rebound effect. Measurements in developed countries suggest rebound effects in the order of 10-20 per cent of the energy saving, but for developing countries the rebound effects may be more substantial. While the energy savings and carbon saving effect may be partially offset by the rebound, an increase in energy efficiency will result in clear improvements in terms of access, welfare and economic growth.

The vast majority of energy demand growth is expected to come from lower-middle-income countries such as China and India, driven by rapid industrialization and an increasingly wealthy population with a rising demand for cars, household appliances and other energy-consuming products. The energy efficiency savings potential, however, is split almost evenly between high-income countries and the rest of the world, mostly due to the retrofitting opportunities on the large existing stock of infrastructure in the developed world.

In most countries, the untapped potential for improvements is available across both supply and demand. A significant opportunity exists in the power sector in the developing world to improve generation efficiency and reduce transmission and distribution losses, and thereby reduce the amount of primary energy (e.g., coal, gas, oil) consumed for the same output.[70] In many ways, the supply side potential is easier to capture in the short- to medium-term, as there are fewer institutional barriers. Improving power sector efficiency is also directly linked to improving energy access, as discussed above.

On the demand side, there are opportunities across all sectors of the economy to improve energy efficiency by reducing final energy consumption, with the largest opportunities in industry, buildings and transport. For instance, a UNIDO project funded by the Global Environment Facility (GEF)[71] on motor systems energy efficiency in China yielded on average 23 per cent improvement with a payback period of well below two years. For the purposes of this report, the potential for energy efficiency has been estimated by looking at more than 80 individual measures across all sectors of the economy.[72] If best available technologies were applied worldwide today, the largest potential savings exist in buildings (in the order of 1500 to 2000 Mtoe in primary energy) and power generation (around 1000 Mtoe), followed by industry (600 to 900 Mtoe) and transport (on the order of 500 Mtoe).[73]

[70] The potential is estimated by looking at more than 80 individual measures that are economically positive; McKinsey, 2009; IEA 2009

[71] This achievement has resulted in a major UNIDO-GEF programme that now covers twelve countries, and it has served as a worldwide call for systems optimization. See UNIDO, 2005

[72] McKinsey, 2009

[73] IEA, 2008b; UNIDO analysis

Demand-side energy efficiency improvement potential above business-as-usual in 2030[a]
2030, 100%=1,900-2,100 Mtoe

Exhibit 4

Sectors	Country groups: Low income	Lower-middle income	Upper-middle income	High income	Total
Industry[b]	-5	15-20	-10	15-20	40-50
Buildings[c]	1-5	5-10	5-10	15-20	30-40
Transport	-1	-5	1-5	-10	-20
Total	5-10	-30	15-20	40-50	100

■ Largest opportunity

[a] All opportunities costing $90/t CO_2e; electricity is not converted to primary energy equivalents; electricity sector efficiencies are excluded
[b] Includes heating and refineries
[c] Includes household and commercial heating and insulation, appliances and lighting

SOURCE: IEA; McKinsey Global GHG Abatement Cost Curve v2.0; McKinsey analysis

If the full identified low-cost[74] energy efficiency improvement potential were captured by 2030, global energy intensity would decrease by 2.2-2.7 per cent per year. This compares with the IEA reference case of 1.3-1.7 per cent,[75] which is similar or slightly higher than the historic rate. Since this potential is estimated on the basis of currently available technologies, the actual figure could prove to be even larger, taking into account future breakthrough technologies or behavioural change, which could provide substantial additional gains in efficiency.

Based on certain reference case energy efficiency improvement assumptions, in 2030 the remaining opportunity that can be captured in high income countries is spread across industry, buildings and transport, but industry would represent the largest opportunity in the developing world[76] (see Exhibit 4). On the supply side, the power sector mix is projected to change significantly, and substantial efficiency gains will occur due to this change of the mix and the higher efficiency of new plant. To some extent the different energy intensity can be explained through a net export flow of energy intensive commodities from developing to developed countries. In addition, exchange rates play a role; measurements based on purchasing power parity give a different picture than those based on the market exchange rates used here.

To reach the global target of a 2.2-2.7 per cent reduction in energy intensity, developed countries need to reduce their energy intensity by 2.2-2.4 per cent a year on average (almost double the historic rate of 1.2 per cent between 1990 and 2007). Developing countries need to reduce energy intensity by around 4 per cent a year. This is an increase of more than 50 per cent from their historic 2.5 per cent improvement, which is higher than the developed world because of the rapid industrialization and economic growth in some major developing countries. China and India, for example, have had energy intensity improvement rates of 6.4 and 3.6 per cent respectively since 1990. While these numbers cannot be directly extrapolated to the rest of the world, these data do suggest that rapid progress is possible on a large scale.

The type of response towards these goals will differ by sector (see Box 6). In many sectors the nature of the opportunity is similar for both developed and developing countries. For example, there are similar initiatives to improve the efficiency of lighting and appliances, and the fuel efficiency of the vehicle fleet all around the world. In sectors with long-life assets, however, it differs.

[74] Defined as opportunities costing less than $90/t$CO_2e$ in the McKinsey GHG Abatement Cost Curve v2.0

[75] IEA, 2008a; IEA, 2009

[76] McKinsey, 2009

In developing countries, much of the energy efficiency potential in buildings, industry and power is associated with greenfield opportunities (i.e., new buildings, new industrial stock). There is a need to move quickly on these infrastructure opportunities: continuing energy-inefficient expansion can lock in infrastructure that will require high energy consumption and carbon emissions for 40 years or more. While retrofit opportunities do exist, they tend to be more expensive. Furthermore, opportunities in the developing world are heavily concentrated in industry, the primary driver of its economic growth.

In developed countries, the energy efficiency opportunities in the near term focus more around retrofitting and upgrading existing infrastructure, or accelerating the retirement of the least efficient assets and replacing them with more efficient ones. Although this is more expensive than capturing the opportunity at the point of construction, it is nonetheless vital if the enormous energy consumption of the developed world is to be tackled. New-build opportunities exist here as well, though this is largely from replacing assets reaching the end of their working life.

Box 6 – Energy efficiency improvement encompasses many different activities across various different sectors:

- Energy efficiency measures in **industry** include switching away from energy- intensive materials (e.g., clinker substitution in cement), improved maintenance, using efficient burners, and cogenerating power by using waste heat from industrial processes. National policies that set targets and standards have resulted in significantly higher industrial efficiency in Japan and the Netherlands than most other countries.[77] Awareness, training and performance management to change the mindsets of management and staff is also crucial. Special attention should be focused on small and medium-size enterprises and on systems approaches that go beyond the process or technology level.
- The biggest opportunities in **building** energy savings are improvements to insulation and design (e.g., windows, shell) and efficiency of heating, ventilation and air conditioning (HVAC) systems (e.g. district heating). Denmark[78] and China[79] are examples of countries where significant savings have been achieved through the effective introduction of building codes and standards.
- For short- to medium-life assets such as **appliances and lighting**, the focus is on switching to more efficient devices such as appliances with low standby power consumption, and CFLs and LEDs rather than incandescent lighting. Making lighting more energy-efficient is often the first efficiency measure undertaken due to the low cost and ease of capture (e.g., as in Bangladesh, Bolivia, China, Cuba, Ethiopia, India, Mexico, Philippines, Rwanda, South Africa, Sri Lanka, Thailand, Uganda, and Viet Nam). Several developing countries have also successfully introduced standards for various appliances, including chillers (Thailand, India, Philippines), electric motors (China), refrigerators (Brazil, Mexico) and air conditioners (Thailand).
- Similarly, in the **transport** sector, a mix of energy-efficient vehicles provides significant potential, *inter alia* by improving the fuel consumption of the vehicle fleet through improved fuels and engine technology as well as the increased use of all-electric and hybrid electric vehicles. Integrated traffic planning and modern public transportation systems can create significant energy efficiency gains, while concurrently addressing congestion and air pollution. This is especially relevant in rapidly-growing urban areas in developing countries. Bogotá, in Colombia, is a good example. The city created special lanes for buses, introduced a more effective pricing system, and replaced the oldest buses with more efficient models. The project led to a reduced number of buses while maintaining the level of service, and lower fuel consumption per passenger-mile. As a consequence, the project was partly financed by CDM credits.
- The **power** sector can significantly increase its energy efficiency through implementation of currently available improvements in many forms of power generation, and in improved electric grids that enhance reliability and reduce transmission and distribution line losses.[80] Reducing these line losses requires both improved maintenance and significant capital investment.[81] This is a particularly important opportunity in the developing world, where losses are typically significantly higher. (Transmission and distribution losses of 35-50 per cent are not unusual in the developing world, compared with 6-8 per cent in developed markets.)

[77] UN-Energy, 2009

[78] Marsh et al., 2009

[79] World Bank, undated

[80] Technical losses mainly due to archaic infrastructure nearing the end of its useful life, lack of proper maintenance and overloaded systems. Commercial losses include electricity theft and losses resulting from ineffective billing and collection.

[81] World Bank, 2009b

Low-income countries represent a relatively small part of the absolute global energy efficiency potential, but still need to get onto the right track and benefit from positive spillover effects from the better-off countries, particularly from standards, learning curves and economies of scale. Critically, improved energy efficiency will assist in providing energy access to more people by making existing capacity stretch further – thereby reducing the total need for investment in new capacity, and keeping energy costs lower.

The analysis and recommendations that follow focus on the developing world, since this is where the UN, the World Bank and donors have a particularly important role to play. It is of course critical that the developed world also takes action to improve energy efficiency. In addition, developed countries can serve as role models and as promoters of energy-efficient measures. They are also likely to shoulder a large part of the cost burden of technology development for energy-efficient products and systems.

Benefits of capturing the energy efficiency opportunity

Much of the recent attention to energy efficiency has its origins in the need to reduce carbon emissions; energy efficiency opportunities make up about a third of the total low cost opportunities to reduce GHG emissions globally.[82] A large number of currently available energy efficiency opportunities are characterized as having "negative cost": in other words, the savings from reduced energy consumption over the lifetime of the investment exceed the initial cost. It is estimated that the total financial savings, or avoided energy cost, of this efficiency opportunity is $250-325 billion a year in 2030.[83]

Additional benefits include the environmental benefit – a reduction of 12-17 per cent of total global GHG emissions in 2030 versus a baseline scenario, which is around a third of the low-cost GHG abatement opportunity[84] – and the economic benefit of reducing the risk of price volatility as a result of demand outstripping supply. When coupled with other low-cost abatement actions such as renewable power and reduced deforestation, this path is compatible with a 450 ppm stabilization scenario.[85]

In addition to the benefits shared by the global community, countries that succeed in increasing energy efficiency can also reap a number of direct benefits at different levels:

- **Governments**. Energy efficiency can ease infrastructure bottlenecks by avoiding or delaying capital-intensive investments in new power supply without affecting economic growth. This is especially important in developing countries, where there are energy supply shortages and significant capital constraints. The IEA estimates savings of $1 trillion in avoided energy infrastructure investment to 2030 if the available energy efficiency potential is captured.[86] Reducing peak load through load management can reduce generation costs. Reducing overall generation through energy efficiency reduces fuel imports (primarily oil and gas), which lowers import dependence, reduces import bills and overall energy costs, and improves the competitiveness of the economy.[87] In sectors with energy subsidies, energy efficiency helps mitigate the burden on the government budget. In terms of project economics, energy efficiency options almost always have positive financial returns and are almost always cheaper than installing new supply.
- **Consumers**. Energy efficiency allows lower energy consumption for the same end-use energy services, which lowers energy costs for consumers – industrial, commercial and residential. This leads to higher affordability, which is particularly important for low-income groups, and creates a more attractive environment for tariff reform. Efficient lighting alone, as shown in Table 4, could save more than $1 a month per household. This would be even more for households that currently rely on kerosene and candles for lighting (the average non-electrified household in South Africa, for example, spends $5-6 per month on lighting).[88] At the same time, reducing energy demand leads to higher system reliability, which in turn lowers outage costs and raises productivity and income.

Energy efficiency can also generate significant employment from additional business activities in the manufacturing and service sectors, such as appliance substitution, public lighting, and other programmes.

[82] McKinsey, 2009. Including abatement measures costing below USD 90/t CO2 in the McKinsey Global GHG Abatement Cost Curve v2.0.

[83] Based on the McKinsey Global GHG Abatement Cost Curve v2.0 (McKinsey, 2009). It is important, however, to balance this view of the opportunity against the many barriers and distortions that can lessen the financial benefit and make it hard to capture. Marginal Abatement Cost curves typically take a "societal" perspective in order to show relative costs in a way that is appropriate for long-term planning and capital allocation. This means taking a risk-free, low cost of capital, and excluding the impact of energy taxes and subsidies, green incentives, and other policies that, when seen at a national level, are transfers rather than a real economic cost.

[84] McKinsey, 2009

[85] According to the IPCC, scientific evidence suggests that a scenario where GHG (CO2e) concentrations stabilize at 450ppm gives a 40–60 per cent probability to limit global warming to 2 degrees Celsius.

[86] IEA, 2009

[87] Based on the McKinsey Global GHG Abatement Cost Curve v2.0 (McKinsey, 2009), the energy savings for fuel-importing countries from oil alone of fully capturing this efficiency opportunity would be worth $180-200 billion globally in 2030 at a very conservative $60 oil price.

[88] Madubansi & Shackleton, 2006

[89] Per light bulb for 4 hours per day

[90] Based on 4 lights on for 4 hours per day and electricity cost of $0.05 kWh

[91] Based on findings and bulk costs, excluding programme costs of ~50$c per lamp, from ESMAP case studies in Vietnam, Uganda, Rwanda, Ethiopia, Bangladesh and Philippines. (ESMAP 2009)

[92] At present more than $300 billion is spent every year in subsidizing carbon-intensive fossil fuels in the 20 largest non-OECD countries. IEA, 2007/ 2008

Table 4 – Cost and energy consumption of lighting technologies

Lighting Technology	Unit cost ($)	Life span (hours)	Capacity (W)	Annual consumption[89] (kWh)	Monthly household lighting cost[90] ($)
Incandescent	0.5	1,000	60	88	1.7
CFL[91]	0.9-1.1	6,000-10,000	13-15	19-22	0.4-0.5
LED	40	50,000	7	10	0.6

Barriers to capture

However, it is important to balance this view of the benefits against the many barriers and distortions that can lessen the financial gain and make energy efficiency hard to capture. When one moves away from the societal perspective used to calculate the overall energy efficiency opportunity, and adopts a sector or household view, these barriers become clearly evident. The cost of capital, taxes and subsidies all matter in determining the attractiveness of an investment, and transaction costs such as programme and administrative costs can significantly reduce the potential savings on offer. In many countries, energy subsidies distort price signals and present a substantial disincentive to invest in energy efficiency.[92]

There are a number of other major obstacles that apply across both the developed and developing world, though their relative importance varies.

- **Capital constraints** are a particular issue in the developing world. This factor alone impedes, for example, the construction of new power infrastructure that could greatly increase generation efficiency. At a household level too, more efficient appliances are often out of reach due to the higher upfront cost, even if it represents a cost saving over time. This is often compounded by bureaucracy limiting access to financing.
- **A lack of awareness and understanding** of energy efficiency opportunities can limit action on the part of end-users and lead to reticence of lending institutions to fund energy efficiency initiatives.
- **The unavailability of energy efficient technologies** is a major barrier in developing markets and low-income consumers – energy efficient technologies are often targeted only at high-end consumers.
- **The limited appeal of energy efficient technologies**, for example due to poor design or limited features, can deter investment.
- **Agency issues and split incentives** mean that in many cases, the financial benefits of energy efficiency do not accrue to the decision maker. For example, landlords have no incentive to invest in energy-efficient buildings when the benefits go to the tenant, and appliance manufacturers will not adopt efficient technologies unless consumers show themselves willing to pay for them.
- **The lack of capabilities and capacity** in many developing countries to design and implement the required regulations, financing mechanisms and energy efficiency measures is a further obstacle. Even given sufficient capital, many players would currently not be able to capture the full range of available efficiency savings, because they lack the necessary implementation capabilities.

Overcoming barriers

Barriers can be overcome by a combination of establishing appropriate regulation and standards, setting the right pricing points, easing access to finance, building capability and undertaking informational campaigns:

- **Policy and regulation**. When it comes to practical implementation, experience shows that changing the behaviour of households, businesses and individuals requires a combination of an appropriate regulatory environment and financial incentives. A broad set of policies is required to set standards, reduce transaction costs, align incentives, monitor performance and otherwise overcome market failures.

Codes and standards are a very effective tool. National energy management standards, which have proven successful in OECD countries in delivering significant energy efficiency gains in industry, buildings and transport, can bring worldwide benefits.[93] However, effective tracking and monitoring of the implementation of such standards is critical to success. Energy efficiency codes and standards for lighting and home appliances represent some of the fastest and most easily-realized opportunities, as demonstrated by their being the first resort for countries experiencing an energy crisis, such as Cuba and Ghana. The financial incentive can also be large, as the value of energy saved is high relative to the initial investment cost (more than eight times in some cases). Because light bulbs and appliances typically have a short lifespan, moreover, a focus on standards for new products permeates rapidly through the installed base, capturing most of the opportunity without need for retrofitting.

International action on standards can provide momentum by creating the necessary scale to encourage the private sector to invest in research and development to drive down the costs of more efficient technologies. This will have huge positive spillover effects, benefiting countries that would on their own be unable to drive the initiatives in a cost-effective way. The Lighting Initiative, initiated by the IEA in OECD countries and subsequently by the GEF in non-OECD countries, provides an example of this. As part of this initiative, several countries have banned incandescent light bulbs already, and others have committed to do so over the next two-to-five years. The support of major manufacturers (such as Philips and Osram) has been key to the success of this initiative.

Codes and standards are also an important driver of fuel efficiency improvements for vehicles and energy efficiency improvements in buildings, as shown by the example of Denmark in Box 7.

[93] International Organization for Standardization (ISO) and UNIDO are jointly working with Member States to promote and support the development of international ISO energy management standards (ISO 50001) for Industry (UNIDO /SAC, 2008). UNIDO/Standards Administration of China Report (2008) Towards an international energy management standard. Final report. Vienna/Beijing.

Box 7 – Building codes in Denmark[94]

Denmark is a leader in increasing the energy efficiency of buildings, having more than halved energy consumption for heating buildings since the 1970s. Following the 1973 oil crisis, Denmark implemented national energy efficiency campaigns. One of the main components has been the adoption of progressively stricter building codes and standards for new buildings, and energy efficiency labelling for buildings. Programmes were also established to replace inefficient heating systems and windows for existing building stock.

Total heat consumption per unit of floor area was reduced by ~60 per cent between 1975 and 2005. Ongoing government-provided training for construction companies and a high degree of awareness of the benefits of energy efficiency amongst the general population were among the factors cited as fundamental to the success of the program.

[94] Danish Energy Agency, Marsh et al., 2010

For industry and utilities, energy management standards can play a key role. Many countries have developed their own national energy management standards. These are now being internationally harmonized though the new upcoming ISO 50 001 standard (Box 8).

Financial incentives, in the form of regulations and tariffs, are often required to catalyze action. Finding the pricing point of energy at which an efficiency initiative will gain traction is critical. Much work has been done by the World Bank and others to find ways to reduce or phase out subsidies without making poor households worse off. This policy alone would have a dramatic impact on energy use. Some countries, particularly in the developed world, apply energy taxes, and these go some way to increasing the attractiveness of energy efficiency investments, often cancelling out the economically inefficient disincentive created by transaction costs or high costs of capital.

Other financial incentives may also be required; including access to concessional finance to help overcome cost barriers or performance-based incentives. Changing financial incentives for utilities – to allow them to earn a competitive rate of return on investments in efficiency – is particularly important, as demonstrated by successful utility demand-side management (DSM) initiatives around the world.[95] Here, regulators mandate utilities to undertake DSM, with energy efficiency costs recovered through utility bills. The benefits of involving utilities in the design and implementation of energy efficiency initiatives include the low capital cost of utilities, facilitating access to capital, and economies of scale from relationships with manufacturers.

[95] For example, from 1993-2000 Thailand's generating utility, EGAT, invested $60 million and saved 566MW and 3,140GWh/year. From 2000-04, Brazilian power utilities invested almost $200 million, which saved 500MW and 1,500GWh/year (World Bank).

Box 8 – ISO 50001 Energy Management Standard

National energy management standards have proven successful in OECD countries in delivering significant energy efficiency gains in industry, buildings and transport. Recent evaluations of national industrial energy efficiency programmes showed that the implementation of energy management systems mostly succeeded in changing management culture towards energy and achieved average incremental energy intensity reductions of 1.0-2.0% per year, doubling the business-as-usual rate of efficiency improvement of industrial companies.

Recognizing the potential for strengthening national policy frameworks for climate change mitigation and industry competitiveness in developing countries and countries with economies in transition, ISO and UNIDO have jointly started in 2007 to promote and support the development of an international ISO energy management standard for Industry, by raising awareness of policy-makers, standards authorities and industry; supporting the participation of emerging and developing economies in the ISO process; contributing to preliminary harmonization work; and channeling the views of industry into the process.

The international ISO 50001 – Energy Management Standard is scheduled for release during the 1st half of 2011. ISO 50001 will be applicable to all organizations, of any size and sectors but in particular industry, utilities, commercial buildings and transport. ISO 50001 will specify requirements applicable to energy supply and energy uses and consumption, including design and procurement practices for energy using equipment, systems, processes, and personnel. The implementation of energy management systems in compliance with ISO 50001 and its inherent requirement for continual improvement will lead to an accelerated adoption of energy efficiency best practices and technologies, GHGs emission and cost reductions, and productivity and competitiveness enhancement.

The uptake of ISO 50001 will be driven also by Governments and companies seeking an internationally recognized response to international climate agreements, national cap and trade programmes, carbon or energy taxes, corporate sustainability/responsibility programmes and measures to increase the market value of “green manufacturing”. Large global corporations will demand participation by their suppliers as is already happening for quality, environment and lean manufacturing. It has been estimated that ISO 50001 could have an impact on as much as 60 per cent of global energy use.

Utility DSM has its beginnings in North American regulatory initiatives (see Box 9), but many developing countries – including Argentina, Brazil, India, Mexico, Pakistan, Philippines, South Africa, Sri Lanka, Thailand, Uruguay and Viet Nam – have subsequently implemented DSM programmes in local electric utilities, with associated financial incentives.

Box 9 – California Utility Demand Side Management[96]

Following the major oil price spikes of the 1970s, Californian regulators took transforming steps to make utilities the principal providers and facilitators of energy efficiency in their customers’ businesses and homes. To achieve this, they changed the utilities’ business model in two important ways. First, they de-coupled the utilities’ earnings opportunities from the sale of electricity or natural gas. The result was that utilities were no longer incentivized to increase sales – and there was no penalty for reduced sales. Second, the regulators directed the utilities to invest in customer efficiency improvements to the full extent to which those investments were lower on a life cycle cost basis than the traditional investments in utility power generation, transmission and distribution. The total cost of these programmes is reimbursed to the utilities from tariffs paid by all customers. The effect of making the utilities major supporters of customer efficiency is that their customers are provided the lowest cost means of meeting their energy needs. At the same time, the programmes support environmental and national security policy goals.

Over the thirty years since the adoption of these initiatives, the programmes have continued to become more productive through experience and learning. Today, the utilities incentivize and support customer efficiency investments in many ways including direct cash payments (which are often provided for major customized investments such as large industrial, commercial and university system investments); rebates for efficient lighting, air conditioning, appliances, and

[96] Based on expert interviews

more standardized efficiency systems for retail, commercial and agricultural customers; and through contracting with installers of efficiency measures for lower-income residences.

The impact has been impressive:

- **Electricity savings of 40,000 GWh (total consumption) annually and 12,000 MW (peak) overall.**
- **Per capita electricity usage has remained stable since the mid-1970s, while nationwide per capita usage outside California has increased by approximately 40 per cent.**
- **Utility spending on efficiency was about $770 million in 2008.**

- **Access to finance**. Given the substantial capital requirements, a critical factor for success is access to finance. To date, a wide range of financing mechanisms has been used around the world, often in conjunction with multilateral financing through the GEF and carbon markets, to enable energy efficient investments. These include credit lines, revolving funds, special purpose funds (including equity, mezzanine), partial credit guarantees and loss reserves, and special purpose vehicles. There are a number of international funds providing financing for energy efficiency initiatives, such as the Renewable Energy and Energy Efficiency Fund set up by UNDP and a number of Climate Investment Funds set up by the Word Bank Group.

There are also several examples of successful public-private partnerships for providing access to capital to the end-user, such as partnerships with banks. In Thailand, banks provided the distribution infrastructure for deploying government funds, thereby reducing bureaucracy. The government provided zero interest loans (mainly funded from taxes on petroleum products) to banks, who passed them on as low interest loans to end-users or energy service companies (ESCOs)

- **Institutional capability and capacity development**. Delivering the energy efficiency opportunity will require capabilities to be developed across a variety of public and private sector stakeholders, including policy makers, regulators and enforcement officials, utilities, and implementers. Beside the initiatives undertaken by the United Nations agencies and World Bank, such as ESMAP, ASTEA and AFREA, specialized NGOs funded by private donors have also provided critical policy support and capability development for the public sector.[97]

  Energy Service Companies (ESCOs) play an important role in providing capacity to implement energy efficiency measures in some countries (see Box 10). These are specialized, for-profit companies designed to overcome a number of the existing barriers to energy efficiency investments while taking on risks related to project performance, and sometimes also credit.

- **Informational programmes**. Education and transparency regarding the benefits of energy saving is also important. This is typically achieved through awareness campaigns targeting the private sector and end-users, followed by more specific measures such as labelling, upon which consumers can base their decisions. The success of Denmark's energy efficiency initiatives is attributed in large part to the awareness and public discussion of the topic that resulted from the 1974 oil crisis. In Cuba, campaigns targeting the youth have proven to be extremely effective in raising awareness and changing behaviour around energy use.

The most important insight from the various energy efficiency initiatives mentioned above is that achieving energy efficiency improvements on the scale needed will require an integrated approach, with multilateral organizations, governments, industry and the public sector working in parallel. Implementing one or two of the success factors is insufficient: a broad, coordinated approach where multiple barriers are addressed simultaneously is needed to achieve the "critical mass" needed to shift behaviour. Successful initiatives usually require a combination of policy measures enabled through regulation, standards and incentives, as well as financing, capability building and informational programs.

[97] For example the International Council on Clean Transportation

Box 10 – Energy Service Companies (ESCOs)

The ESCO market in the US has grown steadily from its inception in the 1980s and since 2004 has experienced 22 per cent annual market growth, surpassing $4 billion in 2007.

A number of developing countries have made strides to promote ESCO markets, including Brazil, Bulgaria, China, Croatia, India, Poland, Thailand, Tunisia, Turkey, Uruguay, and Viet Nam. The Chinese ESCO industry, which began to be developed in the mid-1990s, has grown fast and its total energy efficiency investment reached about $3 billion in 2009; this growth has been driven both by heavy initial international support, and by top level government support that helped gain the understanding, acceptance and trust of China's business, financial and regulatory communities.

While this instrument works well for the buildings and municipal sector, experience with industry has been mixed. Moreover, the feasibility of ESCOs is also determined by the prevailing market conditions and regulatory regime. This notwithstanding, ESCOs should be considered as an important instrument within overall broad policy instrument portfolio.

Chinese energy efficiency building codes (see Box 11) highlight the importance of effective management systems and capacity for monitoring and enforcement, in addition to regulation. On the other hand, Ghana's lighting initiative provides salutary lessons on the pitfalls to avoid. Faced with an energy crisis, Ghana tried to move to low-energy lighting, but managed to capture only half of the target potential. Success was limited by lack of market research to understand the technical requirements (in this case of bayonet versus screw fitting), inadequate training for programme implementation teams, and insufficient awareness of CFL technology on the part of end-users.

Box 11 – Building codes in China

The Chinese Ministry of Construction regulates a highly fragmented industry, which over the past decade has built roughly half of new construction in the entire world. China issued its first building code in 1986, but most were not made mandatory until the late 1990s and early 2000s. However, due to lack of enforcement, compliance with building codes was extremely low. To combat this, a national code was issued by the central government in 2007, which established a streamlined urban construction management system in which real estate developers were made responsible for complying with the building codes and enforcement procedures were made mandatory for provincial governments. By this time, the market for energy efficient materials and components had matured substantially, thereby improving availability. Recent government inspections indicate that in a few dozen large cities about 80 per cent of new residential buildings completed in 2008 complied with the applicable building codes, compared with about 20 per cent in 2005 and only 6 per cent in 2000.[98]

[98] World Bank, undated

What is required to capture the potential?

Achieving energy efficiency improvements on the scale needed will require an integrated approach, with multilateral organizations, governments, industry and the public sector working in parallel:

- At the national level, governments need to set energy efficiency targets, develop strategies to deliver these as part of the energy planning process, and create an environment that enables delivery.
- At the international level, the United Nations should encourage countries to commit to targets and develop strategies to meet them. Energy efficiency requires careful planning and a sustained push if it is to be successful. Unless there is a global call for targets, many governments are likely to deprioritize the energy efficiency agenda and overlook the potential benefits.
- Multilateral institutions (MLIs) need to develop best practice knowledge based on leading national standards and regulation for energy efficiency programmes. Several MLIs and privately-funded NGOs are already providing this type of support, but this could be further improved through coordination and alignment of different countries around single global standards.

- The private sector could be encouraged to place more emphasis on R&D on energy-efficient products in order to improve technology, product concept and economics.
- Utilities can be made major providers and facilitators of customer energy efficiency through regulatory mandates and decoupling efficiency improvements from their income opportunities.
- Increased financial resources need to be made available from both public and private sources to fund the additional capital expenditures required for developing countries to meet their higher energy efficiency target over the next two decades. This capital investment amounts to an average of $250-300 billion a year for developing countries to 2030.[99] Assuming that lower-income countries (largely made up of China and India) and upper-middle income countries are able to meet their energy efficiency financing requirements internally, the available funding to meet the financing needs of the low-income countries, where lack of funding is most critical, would need to ramp up from $10-15 billion initially to $45-50 billion per year by 2030. Given the short payback period of many investments (less than five years), loan repayments could quickly be rolled over to fund other projects.

Put simply, energy efficiency can save money and reduce carbon emissions while maintaining economic output. It should therefore be a major global priority. There are roles for multinational institutions, governments, industry and civil society to play in overcoming barriers to action in the short term. Action is needed now so that developing nations are not locked into inefficient infrastructure for a generation by short-sighted decisions taken today.

[99] McKinsey, 2009. (An additional $200-250 billion a year will be required in developed countries)

REFERENCES

- Abdullah, S. & Markandyab, A. 2009. Rural electrification programmes in Kenya: Policy conclusion from a valuation study. *University of Bath*
- ADB (Asian Development Bank). 2005. Republic of the Fiji Islands: Rural Electrification Project. *Technical Assistance Consultant's Report*
- ASTAE (Asia Sustainable and Alternative Energy Program). 2008. The Last Mile. *World Bank Vietnamese Electrification Program Video*
- Bajgain, S. & Shakya, I. 2005. The Nepal Biogas Support Program: A successful model of Private-Public Partnership for Rural Household Energy supply
- Barnes, D. F. 2007. The Challenge of Rural Electrification: Strategies for Developing Countries. ESMAP and RFF (UNDP/World Bank Energy Sector Management Assistance Program and Resources for the Future)
- Basnyat, M. B. & Shrestha, S. K. 2003 Government Policy and Strategies of Improved Cook Stove for Dissemination in Nepal. *Alternate Energy Promotion Centre*
- Biogas for a Better Life. 2007. Ter Heegte, F. & Sonder, K. Domestic biogas in Africa: a first assessment of the potential and need; *SNV Biogas Practice Team*
- ESMAP (UNDP/World Bank Energy Sector Management Assistance Program). 2009. Limaye, D. R., Sarkar, A. & Singh, J. Large-Scale Residential Energy Efficiency Programmes Based on CFLs: Approaches, Design Issues, and Lessons Learned. *World Bank*
- ESMAP (UNDP/World Bank Energy Sector Management Assistance Program). 2008. Govindarajalu, C., Elahi, R. & Najendran, J. Electricity Beyond the Grid: Innovative Programmes in Bangladesh and Sri Lanka. *ESMAP Knowledge Exchange Series. World Bank*
- ESMAP (UNDP/World Bank Energy Sector Management Assistance Program). 2005a. Modi, V. MacDade, S. Lallement, D. & Saghir, J. Energy Services for the Millennium Development Goals. *The Millennium Project. World Bank*
- ESMAP (UNDP/World Bank Energy Sector Management Assistance Program). 2005b. Rural Electrification in Tunisia: National Commitment, Efficient Implementation and Sound Finances. *World Bank/UNDP joint report*
- ESMAP (UNDP/World Bank Energy Sector Management Assistance Program). 2004. Barnes, D. & Foley, G. Rural Electrification in the Developing World: A summary of lessons from successful programmes. *World Bank*
- EUEI PDF (European Union Energy Initiative Partnership Dialogue Facility). Strategy on scaling up access to modern energy services in order to achieve the MDGs. *GTZ and UNDP Publication*
- GEF & UNEP DTIE (Global Environment Facility and United Nations Environment Programme Division of Technology, Industry and Economics). 2004. MacLean, J. C. & Siegel, J. M. Financing Mechanisms and Public/Private Risk Sharing Instruments for Financing Small Scale Renewable Energy Equipment and Projects. *United Nations Publication*
- GEF/UN-Energy Report. 2010. Strategic Programme for West Africa – Energy Component. Presented at the Ministerial level Consultations held at Cotonou, Benin. *GEF / UN-Energy Report (under publication)*
- IEA (International Energy Agency). 2010. Niez, A. Comparative study on rural electrification policies in emerging economies – Keys to successful policies. *IEA Information Paper*

- IEA (International Energy Agency). 2009. Energy Technology Transitions for Industry. Organization for Economic Cooperation and Development (OECD)/IEA
- IEA (International Energy Agency). 2009. World Energy Outlook 2009. Organization for Economic Cooperation and Development (OECD)/IEA
- IEA (International Energy Agency). 2008a. World Energy Outlook 2008. Organization for Economic Cooperation and Development (OECD)/IEA
- IEA (International Energy Agency). 2008b. Energy Technology Perspectives 2008. Organization for Economic Cooperation and Development (OECD)/IEA
- IEA (International Energy Agency). 2008. Energy Technology Perspectives 2008. Organization for Economic Cooperation and Development (OECD)/IEA
- IEA (International Energy Agency). 2007. Tracking Industrial Energy Efficiency and CO2 Emissions. Organization for Economic Cooperation and Development (OECD)/IEAIEA (International Energy Agency). 2006. World Energy Outlook 2006. Organization for Economic Cooperation and Development (OECD)/IEA
- IEA (International Energy Agency). 2000. World Energy Outlook 2000. Organization for Economic Cooperation and Development (OECD)/IEA
- Informal Working Group on Interim Finance for REDD. 2009. Report of the informal working group on interim finance for REDD+ (IWG-IFR). *Discussion document*
- Jiahua, P., Wuyuan, P., Meng, L., Xiangyang, W., Zerriffi, H., Elias, B., Zhang, C. & Victor, D. 2006. Rural Electrification in China 1950-2004: Historical processes and key driving forces. *Stanford University Working Paper*
- Kenya Environment Donors. 2005. Joint donor statement for the Kenya consultative group meeting energy sector. *Consultative Group Meeting*
- KPLC (Kenya Power and Lighting Company). 2007. Odhiambo, G. O. *Workshop on Rural Electrification presentation*
- Limmeechokchai and Chawana, 2004. Implication of Biogas Potential in Thailand: The Case Study of Livestock Farm, The Joint International Conference on "Sustainable Energy and Environment (SEE)", 1-3 December 2004, Hua Hin, Thailand
- Lucon, O., Coelho, S.T., & Goldemberg, J. 2004. LPG in Brazil: lessons and challenges. *Energy for Sustainable Development*, Volume 8 (3)
- Madubansi, M. & Shackleton, C. M. 2006. Changing energy profiles and consumption patterns following electrification in five rural villages, South Africa. *Energy Policy*, 34 (18): 4081-4092
- Marquard, A., Bekker, B., Eberhard, A. & Gaunt, T. 2007. South Africa's Electrification Programme – an overview and assessment. *Management Programme in Infrastructure Reform and Regulation Graduate School of Business University of Cape Town*
- Marsh, R., Larsen, V. G. & Kragh, M. 2010. Housing and energy in Denmark: past, present and future challenges. *Building Research & Information*, 38(1): 92-106.
- McKinsey & Company. 2009. Pathways to a Low-Carbon Economy. *Version 2 of the Global Greenhouse Gas Abatement Cost Curve*
- McKinsey Global Institute (MGI). 2007. Curbing Global Energy Demand Growth: The Energy Productivity Opportunity. *MGI publication*
- McKinsey Global Institute (MGI). 2008. Fueling sustainable development: The energy productivity solution. *MGI publication*
- Practical Action Consulting 2009. Small-Scale Bioenergy Initiatives: Brief description and preliminary lessons on livelihood impacts from case studies in Asia, Latin America and Africa. Prepared for PISCES and FAO by Practical Action Consulting, January 2009

- Shrestha, S. K., Thapa, R. & Bajracharya, K. 2003. National Improved Cook Stove Dissemination in the Mid-Hills of Nepal: Experiences, Opportunities and Lesson learnt; *Asia Regional Cook Stove Programme.*
- Southwest Windpower. Wind Power Improves Islanders' Quality of Life. *Sri Lanka case study*
- Stephen, R. & Sokopo, I. 2006. Eskom Rural Electrification Experience – Lessons Learnt. *Eskom presentation to UPDEA*
- UNDP (United Nations Development Programme). 2008. Watkins, K. Human Development Report – Fighting Climate Change: Human Solidarity in a Divided World, 2007/8
- UNDP & WHO (United Nations Development Programme and World Health Organization). 2009. The Energy Access Situation in Developing Countries – A review focusing on least developed countries and SSA. *Sustainable Energy Programme Environment and Energy Group Report*
- UN-Energy. 2009. Policies and Measures to Realize Industrial Energy Efficiency and Mitigate Climate Change.
- UNIDO. 2005. Motor system energy conservation programme (China). Final report. Vienna.
- UNIDO/Standards Administration of China. 2008. Towards an international energy management standard. Final report. Vienna/Beijing.
- UNIDO/Africa Union Report 2008. Scaling up Renewable Energy in Africa: Action Plan adopted by the International Conference on Renewable energy in Africa, April 2008, Dakar, Senegal
- Venkataramanan, G. & Marnay, C. 2008. A large role for microgrids – are microgrids a viable paradigm for electricity supply expansion. *IEEE power and energy magazine*
- Vipradas, M. C. Sri Lanka Off Grid Electrification. *REEEP (Renewable Energy and Energy Efficiency Partnership)*
- World Bank. 2009a. Hung, V. T. Vietnam Rural Electrification Program. *World Bank presentation in Mozambique*
- World Bank. 2009b. Africa's infrastructure, a time for transformation. *World Bank Africa Infrastructure Country Diagnostic*
- World Bank. 2009c. Climate Change and the World Bank Group – Phase I: An Evaluation of World Bank Win-Win Energy Policy Reforms. *World Bank and IEG (Independent Evaluation Group) Report*
- World Bank. 2008a. Sarkar, A. Large Scale CFL Deployment Programs: Mainstreaming Carbon Finance and CDM. *Phase Out 2008 presentation*
- World Bank. 2008b. Costing Power Infrastructure Investment Needs in Southern and Eastern Africa. *Econ Pöyry Report*
- World Bank. 2008c. Rosnes, O. & Vennemo, H. Africa Infrastructure Country Diagnostic – Powering Up: Costing Power Infrastructure Investment Needs in Southern and Eastern Africa. *Econ Pöyry Report*
- World Bank. 2005. Komives, K. Foster, V. Halpern, J. & Wodon, Q. Water, Electricity and the Poor: Who benefits from utility subsidies? *The International Bank for Reconstruction and Development/World Bank*
- World Bank. 2001. West Africa LPG Market Development Study. World Bank and World LP Gas Association
- World Bank/IDA (International Development Association). 2000. Vietnam Rural Energy Project Information. *World Bank Projects and Operations Database*
- World Bank. Undated. China: Implementing Building Energy Efficiency Codes. *World Bank Note*