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

## REPORT AND RECOMMENDATIONS

28 April 2010
New York

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# FOREWORD BY THE SECRETARY-GENERAL

This year, in September, world leaders will meet at the United Nations to assess progress on the

# ACKNOWLEDGEMENTS

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# LIST OF ABBREVIATIONS

| | |
|---|---|
| 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 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).

[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]

[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.**

For / , 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 Gsed on anm302 þhey prefer to inacility-eae.0767 fo6s donor co

[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

[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).

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, communicatio ns and productive usesŽ – 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 pro-

## 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

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
20 changing every car and light truck on Earth to a zero carbon dioxide emitter.[20]

### 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]

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]

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).

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-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**

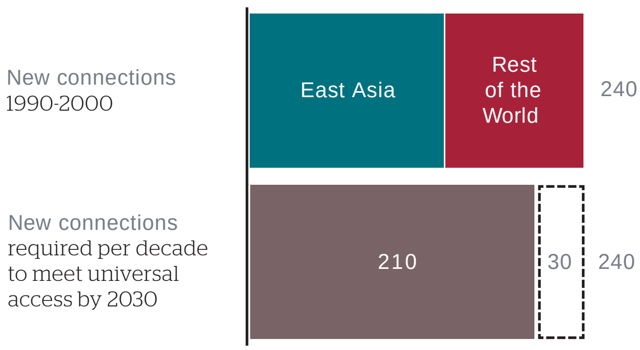
[26] **Increased electricity generating capacity and other energy related infrastructure for mechanical power is required**

[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 tha t 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

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.

- *G* . An extension of the existing transmission and distribution infrastructure to connect communities to power.
- *M -* . 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.
- *O -* . 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 a focus on reducing capital costs, / 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 cer-

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]

The private sector could play an important role in providing initial off-grid electricity supply. For 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.

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 t$CO_2$e/year.[56] At $15/t $CO_2$e 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.**

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

# 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]

[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

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

[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.

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.

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 (Lower-middle, Upper-middle and High income Industry; High income Buildings; High income Transport)

[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/tCO2e 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**

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** |

### 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

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**

- 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)**

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