UN-MDG regions and regional abbreviations appearing in sections 1–3 of chapters 3 and 4

REGION	ABBREVIATION	REGION	ABBREVIATION
Caucasus and Central Asia	CCA	Northern Africa	NAf
Eastern Asia	EA	North America	NAm
Eastern Europe	EE	Oceania	n.a.
Europe	EU	Southeastern Asia	SEA
Latin America and Caribbean	LAC	Southern Asia	SA
Middle East and North Africa	MEA	Sub-Saharan Africa	SSA
		Western Asia	WA

IEA regions appearing in section 4 of chapters 2–4:

REGION	REGION
Africa	Europe
Asia Oceania	Middle East
Developing Asia	North America
Eastern Europe/Eurasia	South America

IIASA regions and regional abbreviations appearing in section 4 of chapters 2–4

REGION	ABBREVIATION	REGION	ABBREVIATION
Central and Eastern Europe	EEU	North America	NAM
Centrally planned Asia and China	CPA	Pacific OECD	PAO
Former Soviet Union	FSU	Other Pacific Asia	PAS
Latin America and Caribbean	LAM	South Asia	SAS
Middle East and North Africa	MEA	Sub-Saharan Africa	AFR
		Western Europe	WEU

OVERVIEW

OVERVIEW

In declaring 2012 the "International Year of Sustainable Energy for All," the UN General Assembly established three global objectives to be accomplished by 2030: to ensure universal access to modern energy services,[1] to double the global rate of improvement in global energy efficiency, and to double the share of renewable energy in the global energy mix. Some 70 countries have formally embraced the Secretary General's initiative, while numerous corporations and agencies have pledged tens of billions of dollars to achieve its objectives. As 2012 drew to a close, the UN General Assembly announced a "Decade of Sustainable Energy for All" stretching from 2014 to 2024. The Secretary General provided a compelling rationale for SE4ALL in his announcement of the new program. For further information about the SE4ALL initiative, please go to www.sustainableenergyforall.org. The SE4ALL Global Tracking Framework full report, overview paper, executive summary and datasets can be downloaded from: www.worldbank.org/se4all.

The SE4ALL objectives are global objectives, applying to both developed and developing countries, with individual nations setting their own domestic targets in a way that is consistent with the overall spirit of the initiative. Because countries differ greatly in their ability to pursue each of the three objectives, some will make more rapid progress in one area while others will excel elsewhere, depending on their respective starting points and comparative advantages as well as on the resources and support that they are able to marshal.

The three SE4ALL objectives, though distinct, form an integrated whole. Because they are related and complementary, it is more feasible to achieve all three jointly than it would be to pursue any one of them individually. In particular, achievement of the energy efficiency objective would make the renewable energy objective more feasible by slowing the growth in global demand for energy. Tensions between the goals also exist, though they are less pronounced than the complementarities. One possible tension between the objectives is that the achievement of universal access to modern cooking solutions will tend to shift people from reliance on traditional biomass, a renewable source of energy, to greater reliance on non-solid fuels that are typically (though not always) based on fossil fuels.

To sustain momentum for the achievement of the SE4ALL objectives, a means of charting global progress over the years leading to 2030 is needed. The Global Tracking Framework described in this report provides a system for regular global reporting, based on rigorous—yet practical—technical measures. Although the technical definitions required for the framework pose significant methodological challenges, those challenges are no more complex than those faced when attempting to measure other aspects of development—such as poverty, human health, or access to clean water and sanitation—for which global progress has long been tracked.

For the time being, the SE4ALL tracking framework must draw upon readily available global databases, which vary in their usefulness for tracking the three central variables of interest. Over the medium term, the framework includes a concerted effort to improve these databases as part of the SE4ALL initiative (table O.1). This report lays out an agenda for the incremental improvement of available global energy databases in those areas likely to yield the highest value for tracking purposes.

While global tracking is very important, it can only help to portray the big picture. Appropriate country tracking is an essential complement to global tracking and will allow for a much richer portrait of energy sector developments. Global tracking and country tracking need to be undertaken in a consistent manner, and the Global Tracking Framework provides guidance that will be of interest to all countries participating in the SE4ALL initiative.

[1] The SE4ALL universal access goal will be achieved only if every person on the planet has access to modern energy services provided through electricity, clean cooking fuels, clean heating fuels, and energy for productive use and community services.

	IMMEDIATE	MEDIUM TERM
Global tracking	Proxy indicators already available for global tracking, with all data needs (past, present, and future) already fully met	Indicators that are essential for global tracking and that would require a feasible incremental investment in global energy data systems over the next five years
Country-level tracking	Not applicable	Indicators highly suitable for country-level tracking and desirable for global tracking

TABLE O.1 **A PHASED AND DIFFERENTIATED APPROACH TO SELECTING INDICATORS FOR TRACKING**

The SE4ALL Global Tracking team was able to construct global energy databases that cover a large group of countries—ranging from 181 for clean energy and 212 for modern energy services—that cover an upwards of 98 percent of the world's population (table O.2). The data on energy access (electrification and cooking fuels) draw primarily on household surveys, while those pertaining to renewable energy and energy efficiency are primarily from national energy balances. Indicators for individual countries can be found in the data annex to this report, as well as on-line through the World Bank's Open Data Platform: http://data.worldbank.org/data-catalog.

CATEGORY	DATA SOURCES	COUNTRY COVERAGE (% OF GLOBAL POPULATION)
Electrification	Global networks of household surveys plus some censuses	212 (100)
Cooking fuels	Global networks of household surveys plus some censuses	193 (99)
Energy intensity	IEA and UN for energy balances WDI for GDP and sectoral value added	181 (98)
Renewable energy	IEA and UN for energy balances REN 21, IRENA, and BNEF for complementary indicators	181 (98)

TABLE O.2 **OVERVIEW OF DATA SOURCES AND COUNTRY COVERAGE UNDER GLOBAL TRACKING**

NOTE: IEA = INTERNATIONAL ENERGY AGENCY; UN = UNITED NATIONS; REN 21 = RENEWABLE ENERGY NETWORK FOR THE 21ST CENTURY; IRENA = INTERNATIONAL RENEWABLE ENERGY AGENCY; BNEF = BLOOMBERG NEW ENERGY FINANCE; WDI = WORLD DEVELOPMENT INDICATORS (WORLD BANK); GDP= GROSS DOMESTIC PRODUCT.

The SE4ALL global tracking framework sets 2010 as the starting point against which the progress of the initiative will be measured. The framework provides an initial system for regular global reporting, based on indicators that are technically rigorous and at the same time feasible to compute from current global energy databases, and that offer scope for progressive improvement over time. For energy access, household survey evidence is used to determine the percentage of the population with an electricity connection and the percentage with access to non-solid fuels.[2] Solid fuels are defined to include both traditional biomass (wood, charcoal, agricultural and forest residues, dung, and so on), processed biomass (such as pellets and briquettes), and other solid fuels (such as coal and lignite). As a proxy for energy efficiency, the framework takes the compound annual growth rate of energy intensity of gross domestic product (GDP) measured in purchasing power parity (PPP) terms, complemented by supporting analysis of underlying factors as well as sectoral disaggregation. For renewable energy, the indicator is the share of total final

[2] *Non-solid fuels* include (i) liquid fuels (for example, kerosene, ethanol, and other biofuels), (ii) gaseous fuels (for example, natural gas, liquefied petroleum gas [LPG], biogas), and (iii) electricity.

energy consumption[3] deriving from all renewable sources (bioenergy, aerothermal, geothermal, hydro, ocean, solar, wind). Further methodological details and directions for future improvement are provided below and described extensively in the main report.

In addition to measuring progress at the global level, the report sheds light on the starting point for regional and income groupings. It also identifies two important categories of countries: high-impact countries, whose efforts will be particularly critical to the achievement of the objectives globally; and fast-moving countries, which are already making rapid progress toward the SE4ALL goals and may have valuable policy and implementation lessons to share.

Scenarios based on the various existing global energy models—such as the World Energy Model of the International Energy Agency (IEA) and the Global Energy Assessment (GEA) of the International Institute for Applied Systems Analysis (IIASA)—clarify the scale of the challenge involved in meeting the SE4ALL objectives. In particular, they illustrate the combinations of technological change, policy frameworks, and financing flows that will be needed to reach the objectives. They also shed light on the relationship between the three objectives, as well as the differential contributions to global targets across world regions based on respective comparative advantage.

Development of the Global Tracking Framework has been made possible through a unique partnership of international agencies active in the energy knowledge space. The steering group for the framework is co-chaired by the World Bank and its Energy Sector Management Assistance Program (ESMAP, a multidonor technical assistance trust fund administered by the World Bank) and the IEA. Members of the group are the Global Alliance for Clean Cookstoves (the Alliance), IIASA, the International Partnership for Energy Efficiency Cooperation (IPEEC), the International Renewable Energy Agency (IRENA), Practical Action, the Renewable Energy Network for the 21st Century (REN21), the United Nations Development Programme, UN–Energy, the United Nations Environment Programme, the United Nations Foundation, the United Nations Industrial Development Organization (UNIDO), the World Energy Council (WEC), and the World Health Organization (WHO). Experts from all of these agencies have collaborated intensively in the development of this report.

The report also benefited from two rounds of public consultation. The first round, which took place in October 2012, focused on the proposed methodology for global tracking. It was launched by a special session of the World Energy Council's Executive Assembly in Monaco. The second round, in February 2013, focused on data analysis. It was preceded by a consultation workshop held in conjunction with the World Future Energy Summit in Abu Dhabi in January 2013. The consultation documents reached more than a hundred organizations drawn from a broad cross-section of stakeholders and covering a wide geographic area. This report benefited greatly from the contributions of those organizations.

Achieving universal access to modern energy services

By some measures, progress on access to modern energy services was impressive over the 20 years between 1990 and 2010. The number of people with access to electricity increased by 1.7 billion, while the number of those with access to non-solid fuels for household cooking increased by 1.6 billion. Yet this expansion was offset by global population growth of 1.6 billion over the same period. As a result, the global electrification rate increased only modestly, from 76 to 83 percent, while the rate of access to non-solid fuels rose from 47 to 59 percent (figure O.1). In both cases, this represents an increase in access of about one percentage point of global population annually.

[3] Though technically energy cannot be consumed, in this report the term energy consumption means "quantity of energy applied", following the definition in ISO 50001:2011 and the future standard ISO 13273-1 Energy efficiency and renewable energy sources - Common international terminology Part 1: Energy Efficiency.

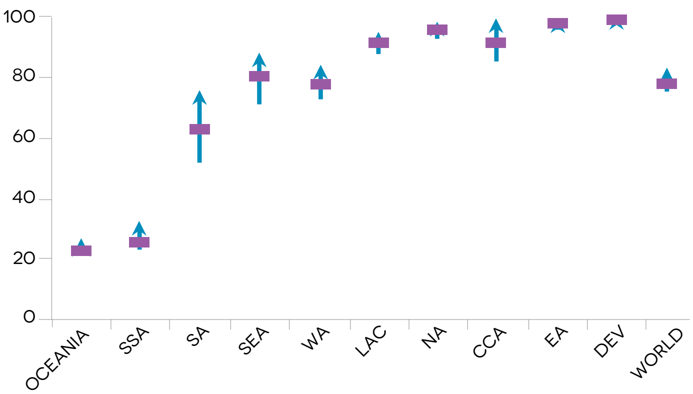

FIGURE O.1A **GLOBAL AND REGIONAL TRENDS IN ELECTRIFICATION 1990–2010, PERCENT**

FIGURE O.1B **GLOBAL AND REGIONAL TRENDS IN ACCESS TO NON-SOLID FUEL 1990–2010, PERCENT**

1990 2000 2010

SOURCE: WORLD BANK GLOBAL ELECTRIFICATION DATABASE, 2012. INDICATORS (WORLD BANK); WHO GLOBAL HOUSEHOLD ENERGY DATABASE, 2012.

NOTE: ACCESS NUMBERS IN MILLIONS OF PEOPLE. CCA = CAUCASUS AND CENTRAL ASIA; DEV = DEVELOPED COUNTRIES; EA = EASTERN ASIA; LAC = LATIN AMERICA AND CARIBBEAN; NA = NORTHERN AFRICA; SEA = SOUTH-EASTERN ASIA; SA = SOUTHERN ASIA; SSA = SUB-SAHARAN AFRICA; WA = WESTERN ASIA.

Starting point

The starting point for global electrification against which future progress will be measured is 83 percent in 2010. The SE4ALL global objective is 100 percent by 2030.

Electrification rates likely overestimate access to electricity. The reason is that some of those with access to an electricity connection receive a service of inadequate quantity, quality, or reliability of supply, which prevents them from reaping the full benefits of the service. A proxy for supply problems (albeit an imperfect one) is the average residential electricity consumption derived from the IEA World Energy Statistics and Balances (2012a). Globally, the average household electricity consumption was around 3,010 kilowatt-hours (kWh) per year in 2010. However, average household electricity consumption varies considerably ranging from over 6,000 kWh in developed countries to around 1,000 kWh in underserved regions of South Asia and Sub-Saharan Africa.

The starting point for access to non-solid fuels for household cooking against which future progress will be measured is 59 percent in 2010. The SE4ALL global objective is 100 percent by 2030.

Modern cooking solutions[4] are important because they curtail harmful indoor air pollution that leads to the loss of lives of 3.5 million people each year, mainly women and children; they also improve energy efficiency. Similar to electrification, rates of access to non-solid fuel do not fully capture access to modern cooking solutions. The reason for this is that an unknown and likely growing percentage of those without access to non-solid fuels may nonetheless be using acceptable cooking solutions based on processed biomass (such as fuel pellets) or other solid fuels paired with stoves exhibiting overall emissions rates at or near those of liquefied petroleum gas (LPG). At present, it is not possible to adequately measure the number of households in this situation. It is believed to be relatively small but is expected to grow over time as governments and donors place growing emphasis on more advanced biomass cookstoves as a relatively low-cost and accessible method of improving the safety and efficiency of cooking practices. These and other methodological challenges associated with the measurement of energy access are more fully described in box O.1.

[4] The term "modern cooking solutions" will be used throughout this document and includes solutions that involve electricity or gaseous fuels (including liquefied petroleum gas), or solid/liquid fuels paired with stoves exhibiting overall emissions rates at or near those of liquefied petroleum gas.

BOX O.1 Methodological challenges in defining and measuring energy access

There is no universally agreed-upon definition of energy access, and it can be a challenge to determine how best to capture issues such as the quantity, quality, and adequacy of service, as well as complementary issues such as informality and affordability. Because currently available global databases only support binary global tracking of energy access (that is, a household either has or does not have access, with no middle ground), this is the approach that will be used to determine the starting point for the SE4ALL Global Tracking Framework. Based on an exhaustive analysis of existing global household survey questionnaires, the following binary measures will be used:

- Electricity access is defined as availability of an electricity connection at home or the use of electricity as the primary source for lighting.
- Access to modern cooking solutions is defined as relying primarily on non-solid fuels for cooking.

An important limitation of these binary measures is that they do not capture improvements in cookstoves that burn solid fuels, nor are they able to register progress in electrification through off-grid lighting products. In the case of electricity, the binary measure fails to take into account whether the connection provides an adequate and reliable service, which it may often fail to do.

A variety of data sources—primarily household surveys (including national censuses) and in a few cases, utility data—contribute to the measurement of access. Two global databases—one on electricity and another on non-solid fuel—have been compiled: the World Bank's Global Electrification Database and WHO's Global Household Energy Database. IEA data on energy access were also reviewed in the preparation of these databases. Both databases encompass three datapoints for each country—around 1990, around 2000, around 2010. Given that surveys were carried out infrequently, statistical models have been developed to estimate missing datapoints.

While the binary approach serves the immediate needs of global tracking, there is a growing consensus that measurements of energy access should be able to reflect a continuum of improvement. A candidate multi-tier metric put forward in this report for medium-term development under the SE4ALL initiative addresses many of the limitations of the binary measures described above:

For electricity, the recommended new metric measures the degree of access to electricity supply along various dimensions. This is complemented by a parallel multi-tier framework that captures the use of key electricity services.

For cooking, the candidate proposal measures access to modern cooking solutions by measuring the technical performance of the primary cooking solution (including both the fuel and the cookstove) and assessing how this solution fits in with households' daily life.

For medium term country tracking, the further development of the multi-tier metric can be substantially strengthened by rigorous piloting of questionnaires, certification, and consensus building in SE4ALL opt-in countries. The metric is flexible and allows for country-specific targets to be set to adequately account for varying energy challenges. For medium-term global tracking, a condensed version of the new metric would support a three-tier access framework requiring only marginal improvements in existing global data collection instruments.

The SE4ALL universal access goal will be achieved only if every person on the planet has access to modern energy services provided through electricity, clean cooking fuels, clean heating fuels, and energy for productive use and community services. Although global tracking of energy sources for heating, community services, and productive uses will not be possible in the immediate future, it is recommended that an approach to track them at the country level be developed in the medium term.

With respect to electricity, the global access deficit amounts to 1.2 billion people. Close to 85 percent of those who live without electricity (the "nonelectrified population") live in rural areas, and 87 percent are geographically concentrated in Sub-Saharan Africa and South Asia (figure O.2). For cooking, the access deficit amounts to 2.8 billion people who primarily rely on solid fuels. About 78 percent of that population lives in rural areas, and 96 percent are geographically concentrated in Sub-Saharan Africa, Eastern Asia, Southern Asia, and South-Eastern Asia.

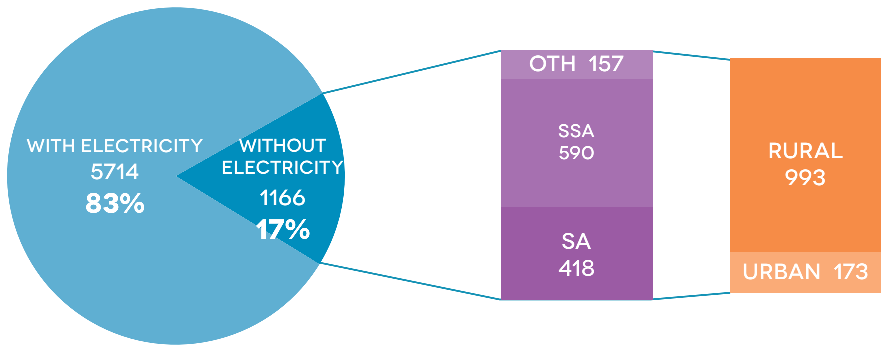

FIGURE O.2A **SOURCE OF ELECTRIFICATION ACCESS DEFICIT, 2010**

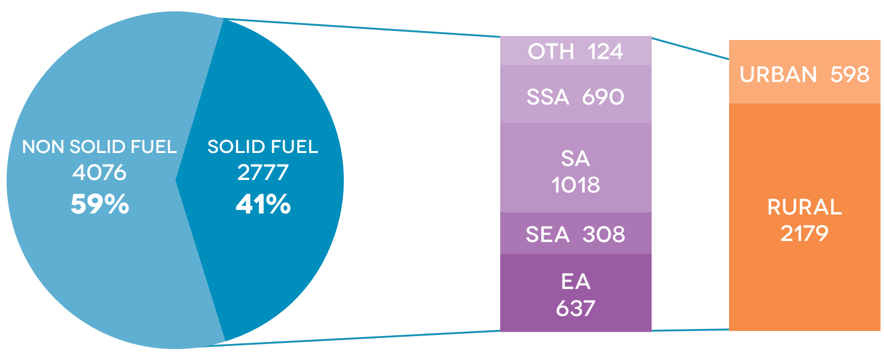

FIGURE O.2B **SOURCE OF NON–SOLID FUEL ACCESS DEFICIT, 2010**

SOURCE: WORLD BANK GLOBAL ELECTRIFICATION DATABASE, 2012; WHO GLOBAL HOUSEHOLD ENERGY DATABASE, 2012.
NOTE: ACCESS NUMBERS IN MILLIONS OF PEOPLE. EA = EASTERN ASIA; SEA = SOUTH–EASTERN ASIA; SA = SOUTHERN ASIA; SSA = SUB–SAHARAN AFRICA; OTH = OTHERS.

Most of the incremental electrification over the period 1990–2010 was in urban areas, where electrification increased by 1.7 percent of the population annually, about twice the rate in rural areas (0.8). However, even with this significant expansion, electrification only just kept pace with rapid urbanization in the same period, so that the overall urban electrification rate remained relatively stable, growing from 94 to 95 percent across the period. By contrast, more modest growth in rural populations allowed the electrification rate to increase more steeply, from 61 to 70 percent, despite a much lower level of electrification effort overall in the rural space. The rate of increase in access to non-solid fuel over the two decades was higher in urban areas, at around 1.7 percent of the population annually, with the overall urban access rate rising from 77 to 84 percent. Rural growth in non-solid fuel use was as low as 0.6 percent annually on average, while overall access in rural areas grew from 26 to 35 percent. Thus, most of the expansion in energy access between 1990 and 2010 was in urban areas, while most of the remaining deficit in 2010 was in rural areas (figure O.3).

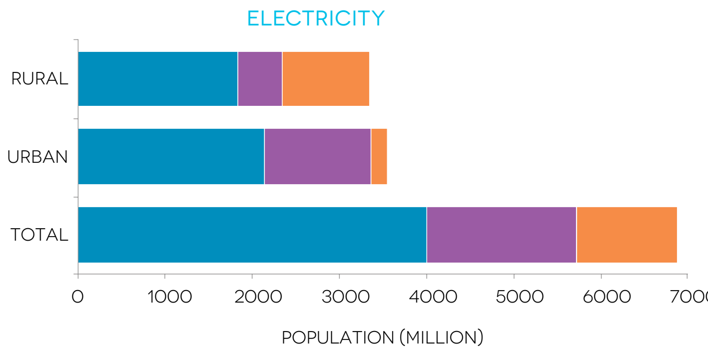

FIGURE O.3A **GLOBAL TRENDS IN ACCESS TO ELECTRICITY, 1990–2010, POPULATION MILLION**

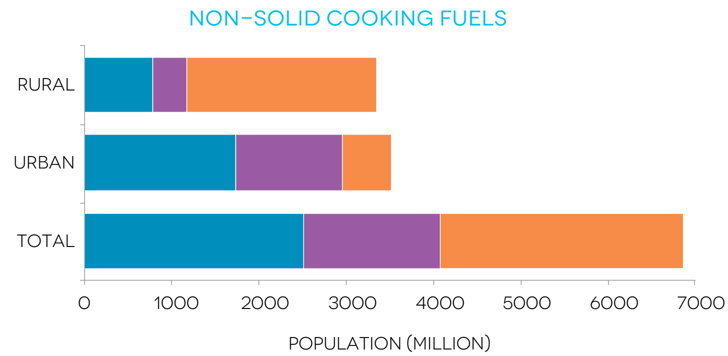

FIGURE O.3B **GLOBAL TRENDS IN ACCESS TO NON-SOLID FUEL, 1990–2010, POPULATION MILLION**

POPULATION WITH ACCESS IN 1990 | INCREMENTAL ACCESS IN 1990–2010 | POPULATION WITHOUT ACCESS IN 201

SOURCE: WORLD BANK GLOBAL ELECTRIFICATION DATABASE, 2012; WHO GLOBAL HOUSEHOLD ENERGY DATABASE, 2012.

High-impact countries

The achievement of universal access to modern energy will depend critically on the efforts of 20 high-impact countries. Together, these countries account for more than two-thirds of the population presently living without electricity (0.9 billion people) and more than four-fifths of the global population without access to non-solid fuels (2.4 billion people). This group of 20 countries is split between Africa and Asia (figure O.4). For electricity, India has by far the largest access deficit, exceeding 300 million people, while for non-solid cooking fuel India and China each have access deficits that exceed 600 million people.

The access challenge is particularly significant in Sub-Saharan Africa, which is the only region where the rate of progress on energy access fell behind population growth in 1990–2010, both for electricity and for non-solid fuels. Among the 20 countries with the highest deficits in access, 12 are in Sub-Saharan African countries; of those, eight report an access rate below 20 percent. Similarly, among the 20 countries with the lowest rates of use of non-solid fuel for cooking, nine are Sub-Saharan African countries, of which five have rates of access to non-solid fuel below 10 percent.

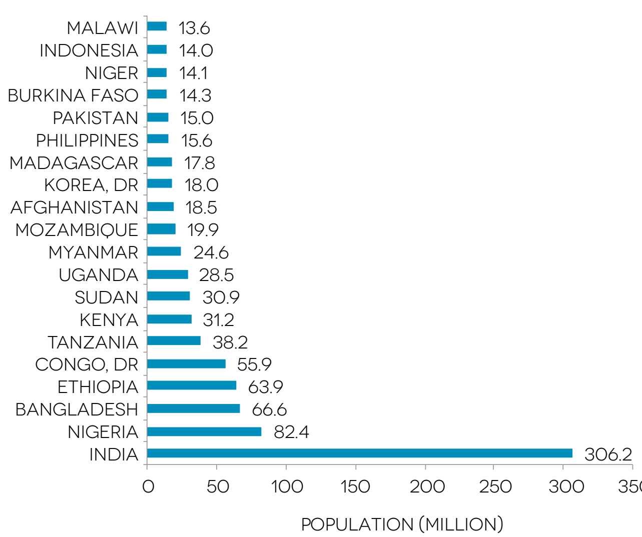

FIGURE O.4A **THE 20 COUNTRIES WITH THE HIGHEST DEFICIT IN ACCESS TO ELECTRICITY, 2010, POPULATION MILLION**

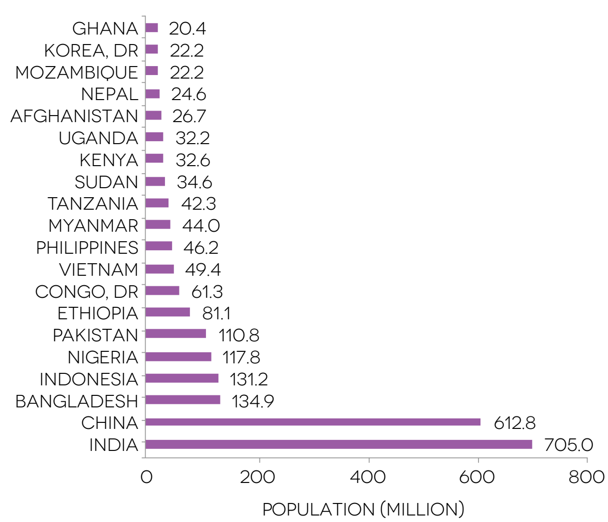

FIGURE O.4B **THE 20 COUNTRIES WITH THE HIGHEST DEFICIT IN ACCESS TO NON-SOLID FUEL, 2010, POPULATION MILLION**

SOURCE: WORLD BANK GLOBAL ELECTRIFICATION DATABASE, 2012; WHO GLOBAL HOUSEHOLD ENERGY DATABASE, 2012.
NOTE: DR = "DEMOCRATIC REPUBLIC OF."

Fast-moving countries

In charting a course to universal access, it will be important to learn from those countries that have successfully achieved universal energy access and those that have advanced the fastest toward this goal during the last two decades. The 20 countries that have made the most progress provided electricity to an additional 1.3 billion people in the past two decades. India has made particularly rapid progress, electrifying an average of 24 million annually since 1990, with an annual growth rate of 1.9 percent. Similarly, the 20 countries that have made the most progress on the cooking side—most of them in Asia—moved 1.2 billion people to non-solid fuel use. Whereas the global annual average increase in access was 1.2 percent for electrification and 1.1 percent for non-solid fuels, the countries making the most progress in scaling up energy access reached an additional 3–4 percent of their population each year (figures O.5 and O.6).

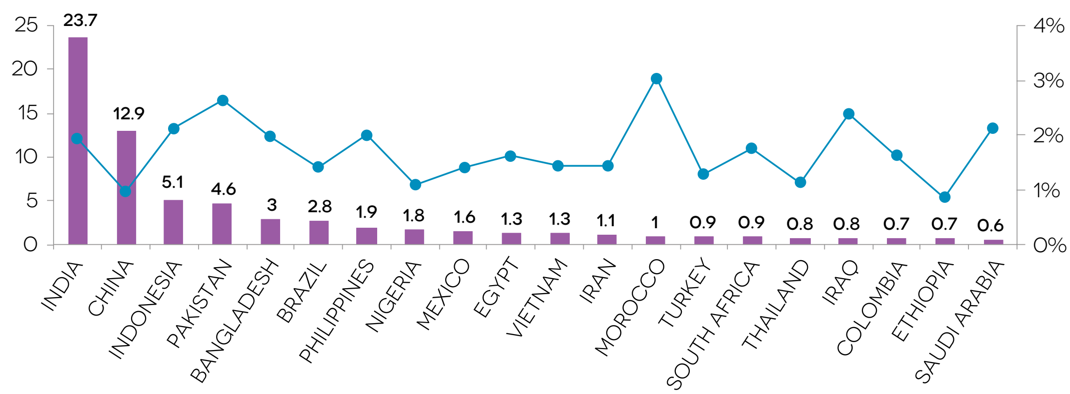

FIGURE O.5 **THE 20 COUNTRIES WITH THE GREATEST ANNUAL INCREASES IN ACCESS TO ELECTRICITY, 1990–2010**

ANNUAL INCREMENTAL ACCESS (MILLION PEOPLE) ANNUAL GROWTH IN ACCESS (%)

SOURCE: WORLD BANK GLOBAL ELECTRIFICATION DATABASE, 2012.

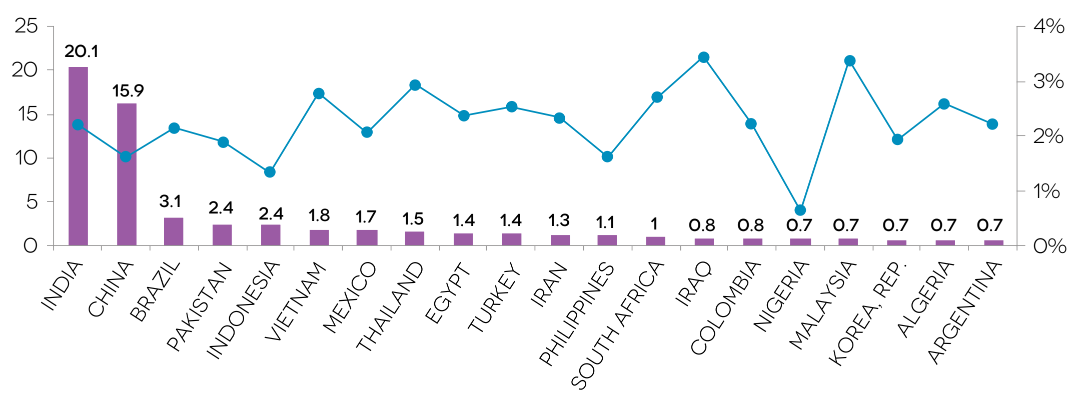

FIGURE O.6 **THE 20 COUNTRIES WITH THE GREATEST ANNUAL INCREASES IN ACCESS TO NON-SOLID FUELS, 1990–2010**

ANNUAL INCREMENTAL ACCESS (MILLION POEPLE) ANNUAL GROWTH IN ACCESS (%)

SOURCE: WHO GLOBAL HOUSEHOLD ENERGY DATABASE, 2012.

Scale of the challenge

If the global trends observed during the last two decades were to continue, the SE4ALL objective of universal access would not be met. The IEA's World Energy Outlook for 2012 (IEA 2012b) projects that under a New Policies Scenario that reflects existing and announced policy commitments, access rates would climb to just 88 percent by 2030, still leaving almost a billion people without access to electricity (figure O.7). Access to electricity would improve for all regions except Sub-Saharan Africa, which is expected soon to overtake developing Asia as the region with the largest electrification deficit. By comparison, the GEA projects 84 percent access to electricity by 2030 under business-as-usual assumptions.

The IEA projects that under the New Policies Scenario access to non-solid fuel would climb to 70 percent in 2030, leaving the number of people without access to non-solid fuels largely unchanged at 2.6 billion by the end of the period (figure O.7b). By comparison, the GEA projects 64 percent access to non-solid fuels by 2030 under business-as-usual assumptions.

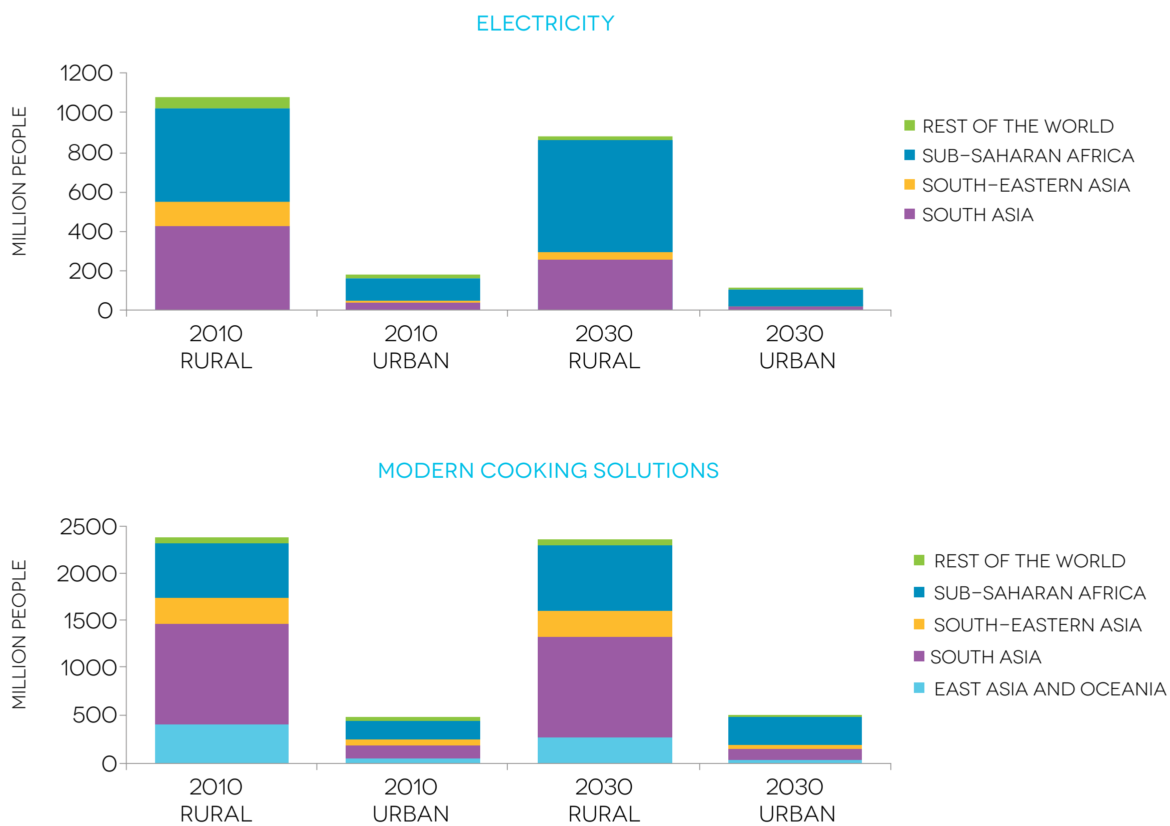

FIGURE O.7 **NUMBER OF PEOPLE WITHOUT ACCESS IN RURAL AND URBAN AREAS, BY REGION, 2010 AND 2030**

SOURCE: IEA 2012B.

Looking ahead, population growth over the next 20 years is expected to occur entirely in urban areas. Thus, while today's access deficit looks predominantly rural, considerable future electrification efforts in urban areas will be needed simply to keep electrification rates constant.

According to the IEA, achieving universal access to electricity by 2030 will require an average annual investment of $45 billion (compared to $9 billion estimated in 2009). More than 60 percent of the incremental investment required would have to be made in Sub-Saharan Africa and 36 percent in developing Asia. Universal access to modern cooking solutions by 2030 will require average annual investment of around $4.4 billion, a relatively small sum in global terms but a large increase compared with negligible current annual investments of about $0.1 billion.

IIASA's 2012 GEA provides estimates (based on different assumptions than those used by the IEA) of the cost of reaching universal access, which amount to $15 billion per year for electricity and $71 billion per year for modern cooking solutions. The higher estimate for modern cooking solutions is based on the assumption that providing universal access will not be feasible without fuel subsidies of around 50 percent for LPG, as well as microfinance (at an interest rate of 15 percent) to cover investments in improved cookstoves.

The IEA estimates that achievement of universal access for electricity and modern cooking solutions would add only about 1 percent to global primary energy demand over current trends. About half of that additional demand would likely be met by renewable energy and the other half by fossil fuels, including a switch to LPG for cooking. As a result, the impact of achieving universal access on global CO2 emissions is projected to be negligible, raising total emissions by around 0.6 percent in 2030.

Several barriers must be overcome to increase access to electrification and modern cooking solutions. A high level of commitment to the objective from the country's political leadership and the mainstreaming of a realistic energy access strategy into the nation's overall development and budget processes are important. So are capacity building for program implementation, a robust financial sector, a legal and regulatory framework that encourages investment, and active promotion of business opportunities to attract the private sector. In some cases, carefully designed and targeted subsidies may also be needed. Nonfinancial barriers to the expansion of access include poor monitoring systems and sociocultural prejudices.

Doubling the rate of improvement of energy efficiency

The energy intensity of the global economy (the ratio of the quantity of energy consumption per unit of economic output) fell substantially during the period 1990–2010, from 10.2 to 7.9 megajoules per U.S. dollar (2005 dollars at PPP).[5] This reduction in global energy intensity was driven by cumulative improvements in energy efficiency, offset by growth in activity, resulting in energy savings of 2,276 EJ over the 20-year period (figure O.8). Strong demographic and economic growth around the world caused global primary energy supply to continue to grow at a compound annual rate of 2 percent annually over the period, nonetheless improvements in energy intensity meant that global energy demand in 2010 was more than a third lower than it would otherwise have been.

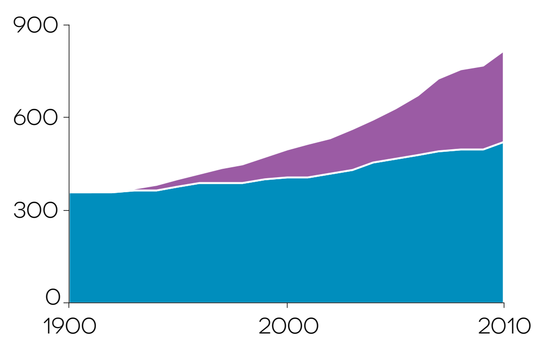

FIGURE O.8 **ENERGY SAVINGS OWING TO REALIZED IMPROVEMENTS IN ENERGY INTENSITY (EXAJOULES)**

PRIMARY ENERGY CONSUMPTION AVOIDED ENERGY CONSUMPTION

SOURCE: BASED ON WORLD DEVELOPMENT INDICATORS, WORLD BANK; IEA 2012A; UN ENERGY STATISTICS DATABASE.

5 Countries with a high level of energy intensity use more energy to create a unit of GDP than countries with lower levels of energy intensity. Throughout the report, energy intensity is measured in primary energy terms and GDP at PPP unless otherwise specified. More details on the accounting methodology and the terminology used can be found in the energy efficiency chapter of the report.

Starting point

Globally, energy intensity decreased at a compound annual growth rate (CAGR) of –1.3 percent over the 20 years between 1990 and 2010. The rate of improvement slowed considerably during the period 2000–2010, however, to a CAGR of –1.0, compared to –1.6 per year for 1990–2000 (figure O.9a).

With the starting point for measuring future progress in global energy efficiency under the SE4ALL, set as –1.3 percent, the SE4ALL global objective is therefore a CAGR in energy intensity of –2.6 percent for the period 2010–2030.[6]

Energy intensity is an imperfect proxy for underlying energy efficiency (defined as the ratio between useful output and the associated energy input). Indeed, the global rate of improvement of global energy intensity may over- or understate the progress made in underlying energy efficiency. This is because energy intensity is affected by other factors, such as shifts in the structure of the economy over time, typically from less energy-intensive agriculture to higher energy-intensive industry and then back toward lower energy -intensive services. A review of the methodological issues in measuring energy efficiency is presented in box O.2.

Statistical techniques that allow for the confounding effects of factors other than energy efficiency to be partially stripped out reveal that the adjusted energy intensity trend with a CAGR of –1.6 could be significantly higher than the unadjusted CAGR of –1.3 (figure O.9b). The effect of this adjustment is particularly evident for the period 2000–2010, when globalization led to a major structural shift toward industrialization in emerging economies, partially eclipsing their parallel efforts to improve energy efficiency.

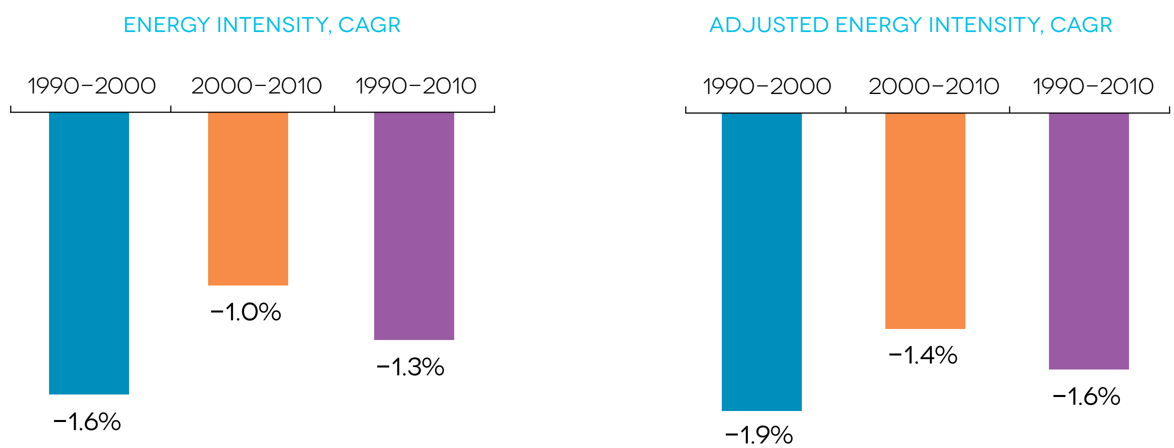

FIGURE O.9 **RATE OF IMPROVEMENT IN GLOBAL ENERGY INTENSITY, 1990–2010 (PPP TERMS)**

SOURCE: BASED ON WORLD DEVELOPMENT INDICATORS, WORLD BANK; IEA 2012A.
NOTE: PPP = PURCHASING POWER PARITY; CAGR = COMPOUND ANNUAL GROWTH RATE. "ADJUSTED ENERGY INTENSITY" IS A MEASURE DERIVED FROM THE DIVISIA DECOMPOSITION METHOD THAT CONTROLS FOR SHIFTS IN THE ACTIVITY LEVEL AND STRUCTURE OF THE ECONOMY.

[6] When measured in final energy terms, the compound annual growth rate is –1.5 percent for the period 1990–2010. Thus the goal is –3.0 percent on average for the next 20 years.

BOX O.2 Methodological challenges in defining and measuring energy efficiency

Energy efficiency is defined as the ratio between useful outputs and associated energy inputs. Rigorous measurement of this relationship is possible only at the level of individual technologies and processes, and the data needed for such measures are available only for a handful of countries. Even where data are available, they result in hundreds of indicators that cannot be readily used to summarize the situation at the national level.

For these reasons, energy intensity (typically measured as energy consumed per dollar of gross domestic product, GDP) has traditionally been used as a proxy for energy efficiency when making international comparisons. Energy intensity is an imperfect proxy for energy efficiency because it is affected not only by changes in the efficiency of underlying processes, but also by other factors such as changes in the volume and sectoral structure of GDP. These concerns can be partially addressed by statistical decomposition methods that allow confounding effects to be stripped out. Complementing national energy intensity indicators with sectoral ones also helps to provide a more nuanced picture of the energy efficiency situation.

Calculation of energy intensity metrics requires suitable measures for GDP and energy consumption. GDP can be expressed either in terms of market exchange rate or purchasing power parity (PPP). Market exchange rate measures may undervalue output in emerging economies because of the lower prevailing domestic price levels and thereby overstate the associated energy intensity. PPP measures are not as readily available as market exchange rate measures, because the associated correction factors are updated only every five years.

Energy consumption can be measured in either primary or final energy terms. While it may make sense to use primary energy for highly aggregated energy intensity measures (relative to GDP) because it captures intensity in both the production and use of energy, it is less meaningful to use it when measuring energy intensity at the sectoral or subsectoral level, where final energy consumption is more relevant.

Based on a careful analysis of these issues and of global data constraints, the SE4ALL Global Tracking Framework for energy efficiency will:

- Rely primarily on energy intensity indicators
- Use PPP measures for GDP and sectoral value-added
- Use primary energy supply for national indicators and final energy consumption for sectoral indicators
- Complement those indicators with energy intensity of supply and of the major demand sectors
- Provide a decomposition analysis to at least partially strip out confounding effects on energy intensity
- Use a five-year moving average for energy intensity trends to smooth out extraneous fluctuations

For the purposes of global tracking, data for the period 1990–2010 have been compiled from energy balances for 181 countries published by the International Energy Agency and the United Nations. These are complemented by data on national and sectoral value-added from the World Bank's World Development Indicators.

Looking ahead, significant international efforts are needed to improve the availability of energy input and output metrics across the main sectors of the economy to allow for more meaningful measures of energy efficiency.

Global final energy consumption can be broadly divided among the following major economic sectors: agriculture, industry, residential, transport, and services. For the purpose of initial global tracking, residential, transport, and services are aggregated into a single category of "other sectors" owing to data limitations. Industry is by far the most energy-intensive of these sectors, consuming around 6.8 megajoules per 2005 dollar in 2010, compared with 5.5 for "other sectors" (residential, transport, and services) and 2.1 for agriculture.[7] The most rapid progress in reducing energy intensity has come in the agricultural sector, which recorded a CAGR of –2.2 percent during 1990–2010 (figure O.10a). Although progress was significantly slower in the industry and other sectors, due to their much-higher levels of energy consumption they made far larger contributions to global energy savings than did agriculture during the same period (figure O.10b).

By contrast, the ratio of final to primary energy consumption, which provides a measure of the overall efficiency of conversion in the energy supply industry, actually deteriorated during the period 1990-2010, falling from 72 to 68 percent. This reflects relatively little improvement in the efficiency of the electricity supply industry over the same period. The efficiency of thermal generation (defined as the percentage of the energy content of fossil fuels that is converted to electricity during power generation) improved only slightly from 38 to 39 percent, while transmission and distribution losses remained almost stagnant at around 9 percent of energy produced. Gas supply losses fell a little more steeply, from 1.4 to 0.9 percent.

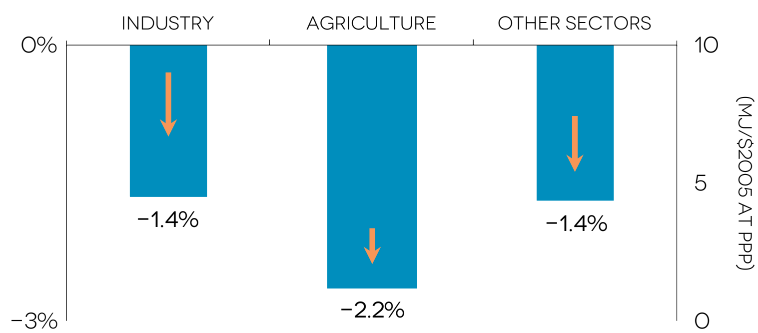

FIGURE O.10A **ENERGY INTENSITY TRENDS BY SECTOR (PPP TERMS)**

CAGR 1990–2010 (LEFT) | EI IN 1990 (RIGHT) | EI IN 2010 (RIGHT)

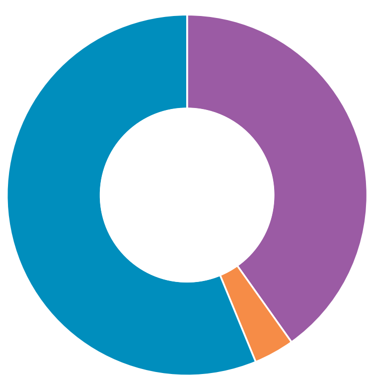

FIGURE O.10B **SHARE OF CUMULATIVE ENERGY SAVINGS BY SECTOR**

SOURCE: BASED ON WORLD DEVELOPMENT INDICATORS, WORLD BANK; IEA 2012A.
NOTE: "OTHER SECTORS" INCLUDE RESIDENTIAL, TRANSPORT, AND SERVICES. CAGR = COMPOUND ANNUAL GROWTH RATE; EI = ENERGY INTENSITY; PPP = PURCHASING POWER PARITY.

[7] Owing to data limitations, in this report the category "other sectors" includes transport, residential, services, and others. The medium- and long-term methodology considers them separately.

The rate of progress on energy intensity varied dramatically across world regions over the period 1990–2010. At one end of the spectrum, the Caucasus and Central Asia region achieved a CAGR of –3.2 percent while nonetheless remaining the region with the highest energy intensity (figure O.11a). At the other end, Western Asia (also known as the Middle East) was the only region to show a deteriorating trend in energy intensity, with a CAGR of +0.8 percent. Overall, 85 percent of the energy savings achieved between 1990 and 2010 were contributed by Eastern Asia and the developed countries (figure O.11b).

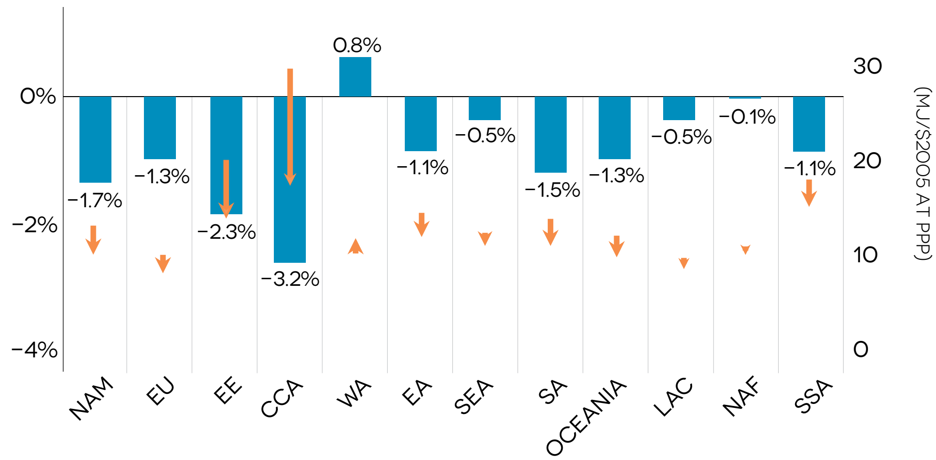

FIGURE O.11A **ENERGY INTENSITY TRENDS BY REGION (PPP TERMS)**

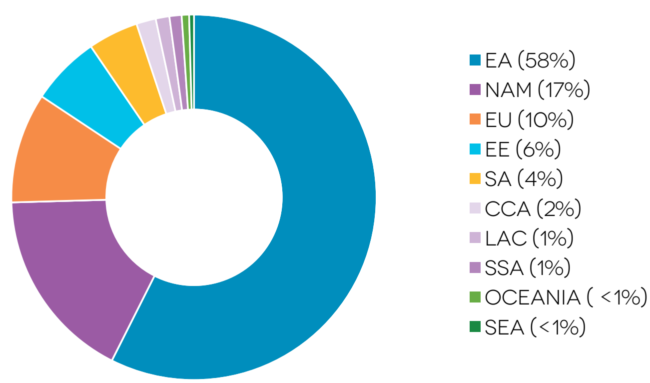

FIGURE O.11B **SHARE OF CUMULATIVE ENERGY SAVINGS BY REGION**

SOURCE: BASED ON WORLD DEVELOPMENT INDICATORS, WORLD BANK; IEA 2012A; UN ENERGY STATISTICS DATABASE.
NOTE: PPP = PURCHASING POWER PARITY; CAGR = COMPOUND ANNUAL GROWTH RATE; EI = ENERGY INTENSITY; NAM = NORTH AMERICA; EU = EUROPE; EE = EASTERN EUROPE; CCA = CAUCASUS AND CENTRAL ASIA; WA = WESTERN ASIA; EA = EASTERN ASIA; SEA = SOUTH-EASTERN ASIA; SA = SOUTHERN ASIA; LAC = LATIN AMERICA AND THE CARIBBEAN; NAF = NORTHERN AFRICA; SSA = SUB-SAHARAN AFRICA.

High-impact countries

Energy consumption is distributed unequally across countries, almost to the same degree as income. The 20 largest energy consumers account for 80 percent of primary energy consumption, with the two largest consumers (the United States and China) together accounting for 40 percent of the total (figure O.12). The achievement of the global objective of doubling the rate of improvement of energy efficiency will therefore depend critically on energy consumption patterns in these countries.

As of 2010, the high-income countries (with the exception of Saudi Arabia) show the lowest energy intensity relative to GDP. Nevertheless, energy consumption per capita varies hugely across this group, from 110 gigajoules per capita in Western Europe to 300 in North America. By contrast, the middle-income countries (with the exception of Russia and Kazakhstan) show much lower levels of per capita energy consumption but vary widely in their energy intensities. In particular, energy intensities in Latin America are comparable to those found in Western Europe, whereas in the Ukraine and Uzbekistan they are exceptionally high (figure O.13).

The gap between the world's most and least energy-intensive economies is wide—more than tenfold. At one extreme, the most energy-intensive countries—a heterogenous mix of the countries of the former Soviet Union and those of Sub-Saharan Africa—report intensities of 20–30 megajoules per 2005 PPP dollar (figure O.13). At the other extreme, the least energy-intensive countries—predominantly small island developing states with exceptionally high energy costs—report intensities of 2–4 megajoules per 2005 PPP dollar (figure O.14). Even among the 20 largest energy consuming countries, energy intensities range from more than 12 megajoules per 2005 PPP dollar in Ukraine, Russia, Saudi Arabia, South Africa, and China to less than 5 in the United Kingdom, Spain, Italy, Germany, and Japan.

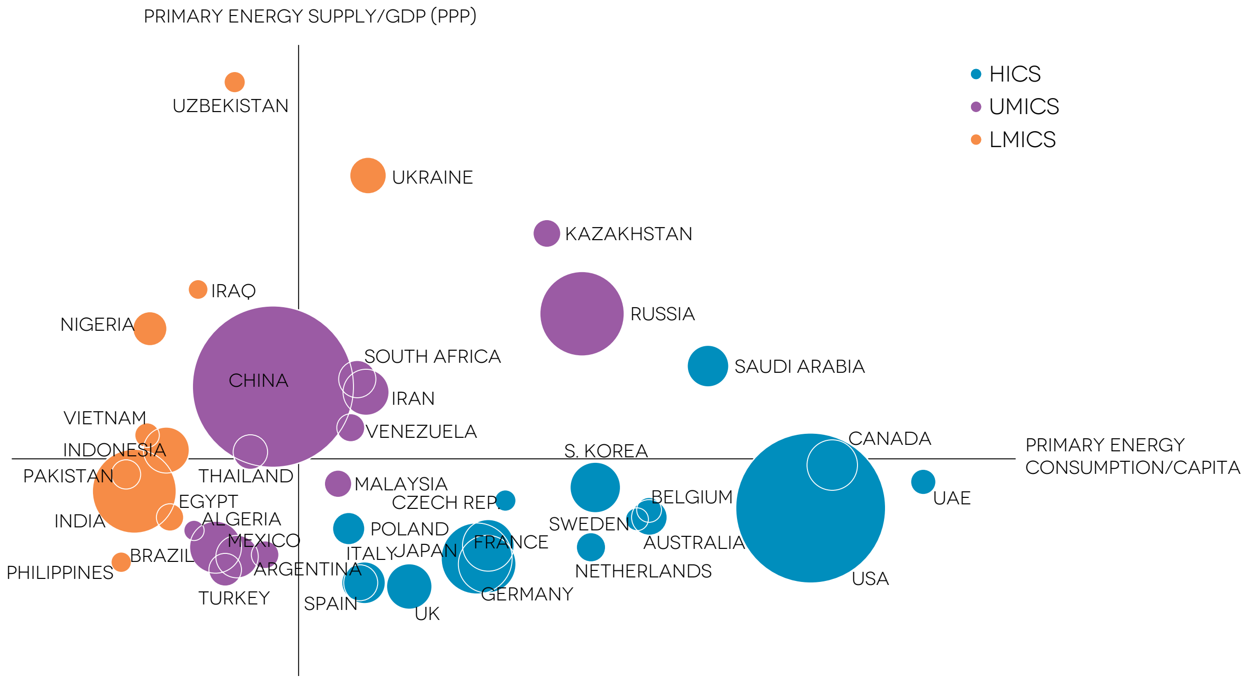

FIGURE O.12 **ENERGY INTENSITY (PPP) VS. ENERGY CONSUMPTION PER CAPITA IN 40 LARGEST ENERGY CONSUMERS, 2010**

SOURCE: BASED ON WORLD DEVELOPMENT INDICATORS, WORLD BANK; IEA 2012A.

NOTE: VALUES ARE NORMALIZED ALONG THE AVERAGE. BUBBLE SIZE REPRESENTS VOLUME OF PRIMARY ENERGY CONSUMPTION. PPP = PURCHASING POWER PARITY. GDP = GROSS DOMESTIC PRODUCT; PPP = PURCHASING POWER PARITY; HICS = HIGHER-INCOME COUNTRIES; UMICS = UPPER-MIDDLE-INCOME COUNTRIES; LMICS = LOWER-MIDDLE-INCOME COUNTRIES; UAE = UNITED ARAB EMIRATES.

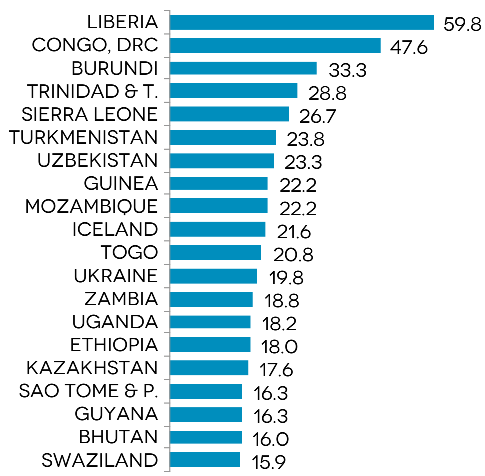

FIGURE O.13 **COUNTRIES WITH HIGHEST ENERGY INTENSITY LEVEL IN 2010 (MJ/$2005)**

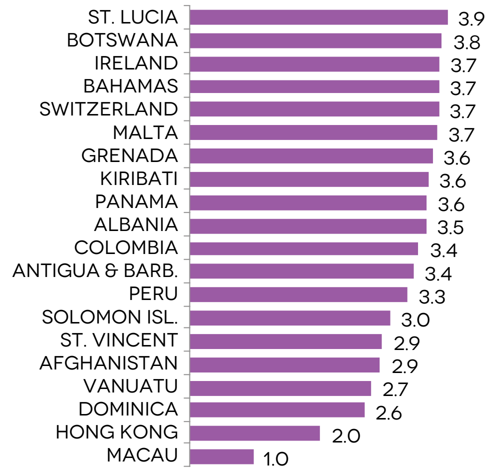

FIGURE O.14 **COUNTRIES WITH LOWEST ENERGY INTENSITY LEVEL IN 2010 (MJ/$2005)**

SOURCE: BASED ON WORLD DEVELOPMENT INDICATORS, WORLD BANK; IEA 2012A; UN ENERGY STATISTICS DATABASE.
NOTE: PPP = PURCHASING POWER PARITY; DR = "DEMOCRATIC REPUBLIC OF."

Fast-moving countries

In doubling the rate of energy efficiency improvement globally, it will be important to learn from those countries that made the most rapid progress toward this goal during the 20 years between 1990 and 2010. While the global CAGR of energy intensity was only –1.3 percent over the period 1990–2010, 20 countries achieved rates of –4.0 percent or greater (figure O.15). The countries making the most rapid progress on energy intensity often started out with particularly high levels of energy intensity—notably China, the countries of the former Soviet Union, and several countries in Sub-Saharan Africa (figure O.16). By far the largest absolute energy savings have been made by China, where energy efficiency efforts have yielded savings equivalent in magnitude to the energy used by the country over the same time frame. Savings in the United States, the European Union, and India have also been globally significant.

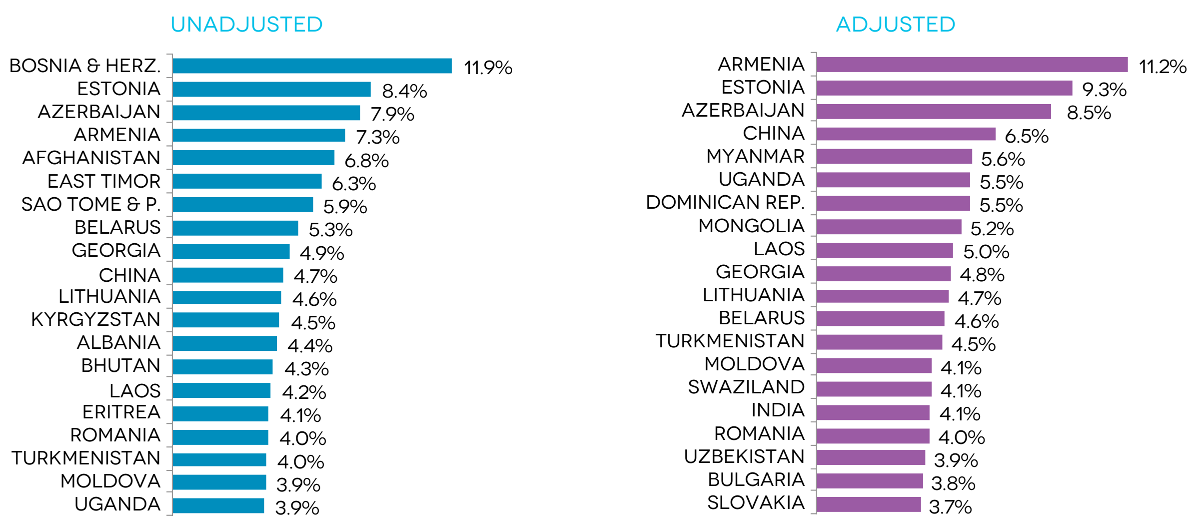

FIGURE O.15 **REDUCTIONS IN ENERGY INTENSITY OF 20 FASTEST-MOVING COUNTRIES, CAGR, 1990–2010 (PPP TERMS)**

SOURCE: BASED ON WORLD DEVELOPMENT INDICATORS, WORLD BANK; IEA 2012A; UN ENERGY STATISTICS DATABASE.
NOTE: CAGR = COMPOUND ANNUAL GROWTH RATE. "ADJUSTED ENERGY INTENSITY" IS A MEASURE DERIVED FROM THE DIVISIA DECOMPOSITION METHOD THAT CONTROLS FOR SHIFTS IN THE ACTIVITY LEVEL AND STRUCTURE OF THE ECONOMY.

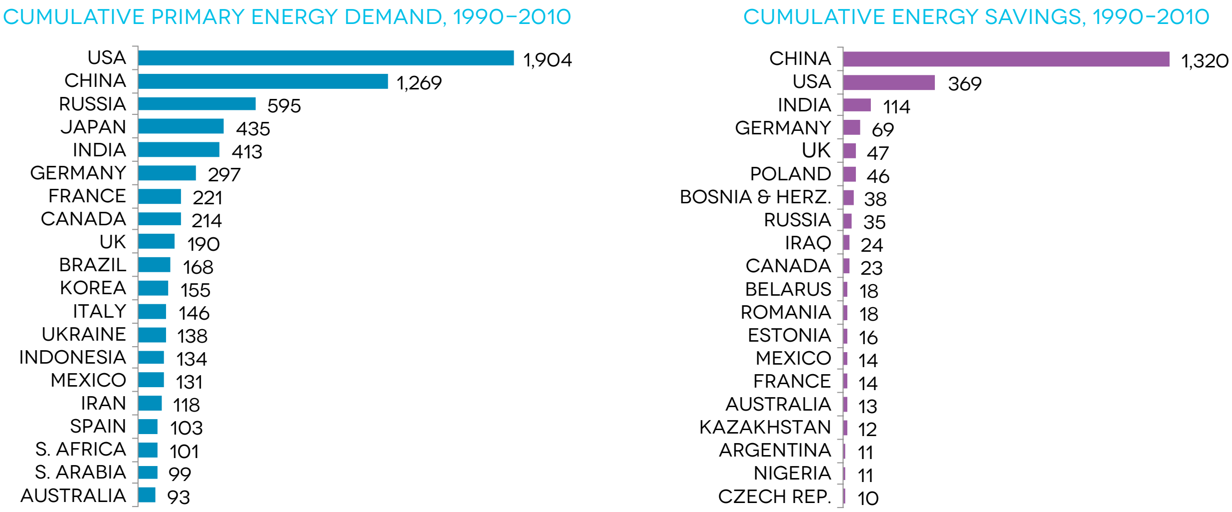

FIGURE O.16 **LARGEST CUMULATIVE CONSUMERS OF PRIMARY ENERGY, AND CUMULATIVE ENERGY SAVINGS AS A RESULT OF REDUCTIONS IN ENERGY INTENSITY, 1990–2010 (EXAJOULES)**

SOURCE: BASED ON WORLD DEVELOPMENT INDICATORS, WORLD BANK; IEA 2012A; UN ENERGY STATISTICS DATABASE.
NOTE: BOSNIA & = BOSNIA & HERZEGOVINA.

Scale of the challenge

Looking ahead, analysis from the IEA's World Energy Outlook 2012 indicates that energy efficiency policies currently in effect or planned around the world would take advantage of just a third of all economically viable energy efficiency measures. The current or planned uptake of available measures is highest in the industrial sector at 44 percent, followed by transport at 37 percent, power generation at 21 percent, and buildings at 18 percent.

Recent analysis shows that the existing potential for cost-effective improvements in energy efficiency goes far beyond what will be captured through current and planned policies (referred to as the New Policies Scenario in figure O.17; IEA 2012b). Under an Efficient World Scenario that exploits all cost-effective improvements, it would be possible to improve energy intensity by an average CAGR of –2.8 percent through 2030, more than double historic rates and even somewhat beyond the SE4ALL objective. About 80 percent of the energy savings that are achievable under this scenario would result from measures taken by energy consumers in end-use sectors, with much of the remaining 20 percent attributable to fuel switching and supply-side efficiency measures. By far the largest potential for energy efficiency improvements is to be found in developing Asia.

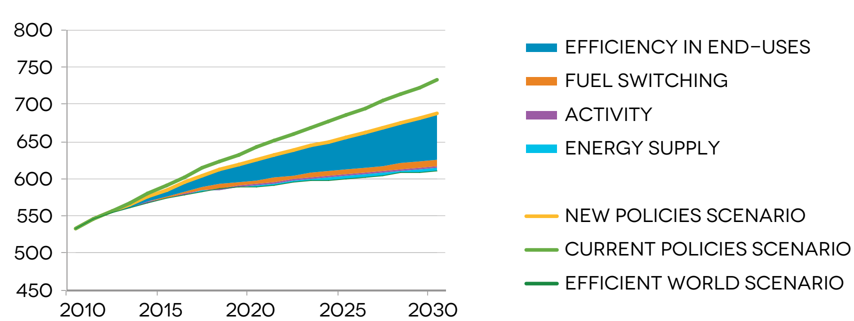

FIGURE O.17 **CHANGE IN GLOBAL PRIMARY ENERGY DEMAND BY MEASURE BETWEEN IEA EFFICIENT WORLD SCENARIO AND IEA NEW POLICIES SCENARIO, 2010–2030 (EXAJOULES)**

SOURCE: IEA 2012B.

The Efficient World Scenario would slow the CAGR of global energy demand to 0.6 percent through 2030, compared with an anticipated 1.3 percent under current and planned policies. It should be noted that even the Efficient World Scenario does not bring about an overall decline in global energy demand over the period 2010–2030.

Mobilizing these improvements would call for cumulative additional investments of close to $400 billion annually through 2030, more than triple historic levels. These investments—although high—would offer the prospect of rapid payback, giving a boost to the global economy of $11.4 trillion over the same period. As in the case of renewable energy, achieving change on this scale is contingent on the adoption of a strong set of energy policy measures, including the phasing out of fossil-fuel subsidies, the provision of price signals for carbon emissions, and the adoption of strict energy efficiency standards.

IIASA's GEA presents six scenarios that meet all three SE4ALL objectives while also meeting the requirement to limit global temperature increases to 2°C. All six of these scenarios require CAGRs for energy intensity on the order of –3.0 percent annually. Achieving the global objective would entail CAGRs for energy intensity in the range of –4.0 to –6.0 percent for Asia and the former Soviet Union (figure O.18).

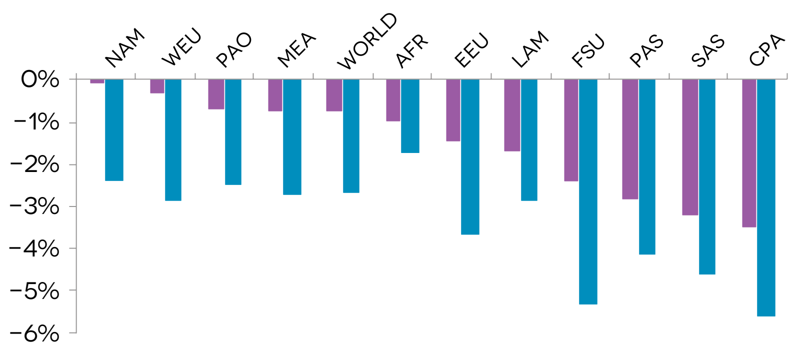

FIGURE O.18 **ANNUAL RATE OF IMPROVEMENT IN PRIMARY ENERGY INTENSITY: IIASA GLOBAL ENERGY ASSESSMENT BASELINE VS. SE4ALL SCENARIO, CAGR, 2010–2030**

■ BASELINE ■ SE4ALL

SOURCE: IIASA (2012).
NOTE: ON THE CHART ABOVE GDP IS MEASURED AT MARKET EXCHANGE RATE AND PRIMARY ENERGY IS MEASURED USING DIRECT EQUIVALENT METHOD AS OPPOSED TO THE PHYSICAL CONTENT METHOD USED ELSEWHERE. CAGR = COMPOUND ANNUAL GROWTH RATE. NAM = NORTH AMERICA; WEU = WESTERN EUROPE; PAO = PACIFIC OECD; MEA = MIDDLE EAST AND NORTH AFRICA; AFR = SUB-SAHARAN AFRICA; EEU = EASTERN EUROPE; LAM = LATIN AMERICA; FSU = FORMER SOVIET UNION; PAS = PACIFIC ASIA; SAS = SOUTH ASIA; CPA = CENTRALLY PLANNED ASIA.

Doubling the share of renewable energy in the global energy mix

The amount of energy provided from renewable sources for electricity, heating, and transportation has expanded rapidly since 1990, and particularly since 2000, with a compound annual growth rate (CAGR) of 1.5 percent during 1990–2000 and 2.4 percent during 2000–2010.[8] Global consumption of renewable energy grew from 40 exajoules (EJ) in 1990 to almost 60 EJ in 2010 (figure O.19). Yet as the consumption of energy from renewable sources rose, global TFEC grew at a comparable pace of 1.1 percent during 1990–2000 and 2.0 percent during 2000–2010. As a result, the share of renewable energy in the total final energy consumption remained relatively stable, growing from 16.6 percent in 1990 to 18.0 percent in 2010.

[8] Nuclear energy is not considered renewable.

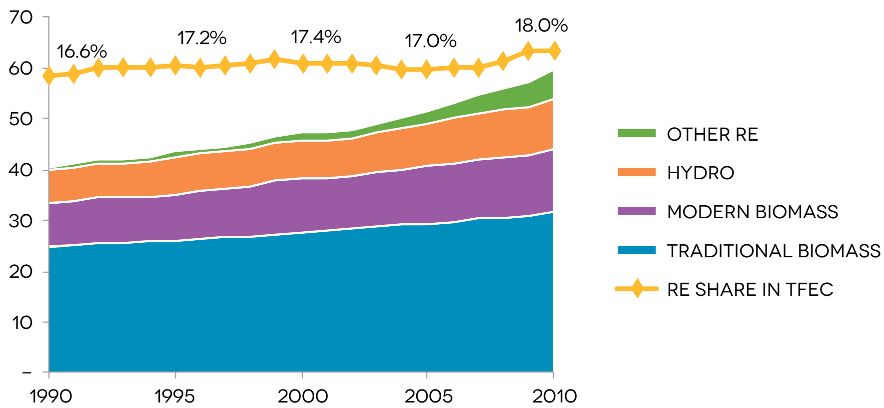

FIGURE O.19 **WORLD CONSUMPTION OF RENEWABLE ENERGY (EXAJOULES) AND SHARE OF RENEWABLE ENERGY IN TFEC (%)**

SOURCE: IEA 2012A.
NOTE: TFEC = TOTAL FINAL ENERGY CONSUMPTION; RE = RENEWABLE ENERGY.

Focusing specifically on electricity, power generation from renewable sources increased from 2,300 terawatt-hours (TWh) in 1990 to 4,160 TWh in 2010. The increase in electricity generation from renewable sources is equivalent to the combined electricity output of Russia and India in 2010. Global electricity generation almost doubled in the 20-year period, growing from 11,800 TWh in 1990 to 21,400 TWh in 2010, which is equivalent to the combined electricity generation of China, the United States, and India in 2010. As of 2011, renewable energy sources accounted for more than 20 percent of global power generated, 25 percent of global installed power generation capacity, and half of newly installed power generation capacity added that year. More than 80 percent of all renewable electricity generated globally was from hydropower.

The starting point

The starting point for the share of renewable energy in total final energy consumption against which future progress will be measured is estimated to be at most 18 percent of TFEC in 2010, reflecting uncertainties over whether some types of renewable energy usage (notably traditional biomass) meet sustainability criteria (figure O.20). The implied SE4ALL global objective is up to 36 percent by 2030.

It is estimated that traditional biomass accounts for about half of the renewable energy total, although data on these traditional usages are imprecise, and the sustainability of these sources cannot be reliably gauged.[9] A further quarter of the renewable energy total relates to modern forms of bioenergy, and most of the remainder is hydropower. Remaining forms of renewable energy—including wind, solar, geothermal, waste, and marine—together contribute barely 1 percent of global energy consumption, though they have been growing at an exponential rate. For example, wind power grew at a CAGR of 25.0 percent and solar at 11.4 percent, compared with a growth rate of slightly over 1 percent for traditional biomass (figure O.21).

An examination of the methodological issues of measuring the renewable energy share can be found in box O.3.

[9] The UN Food and Agriculture Organization defines traditional biomass as "woodfuels, agricultural by-products, and dung burned for cooking and heating purposes." In developing countries, traditional biomass is still widely harvested and used in an unsustainable and unsafe way. It is mostly traded informally and non-commercially. So-called modern biomass, by contrast, is produced in a sustainable manner from solid wastes and residues from agriculture and forestry.

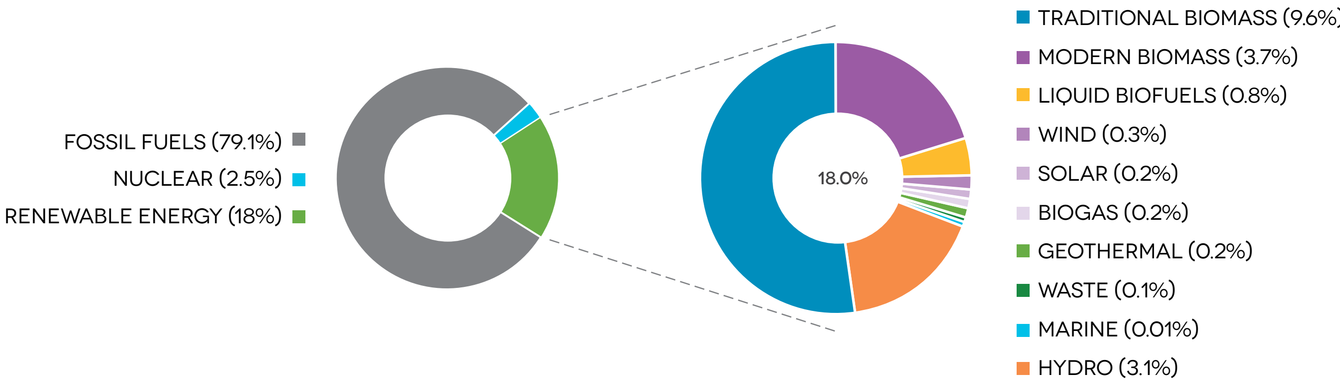

FIGURE O.20 **SHARE OF RENEWABLE ENERGY IN GLOBAL TFEC, 2010**

SOURCE: IEA 2012A.
NOTE: TFEC = TOTAL FINAL ENERGY CONSUMPTION;

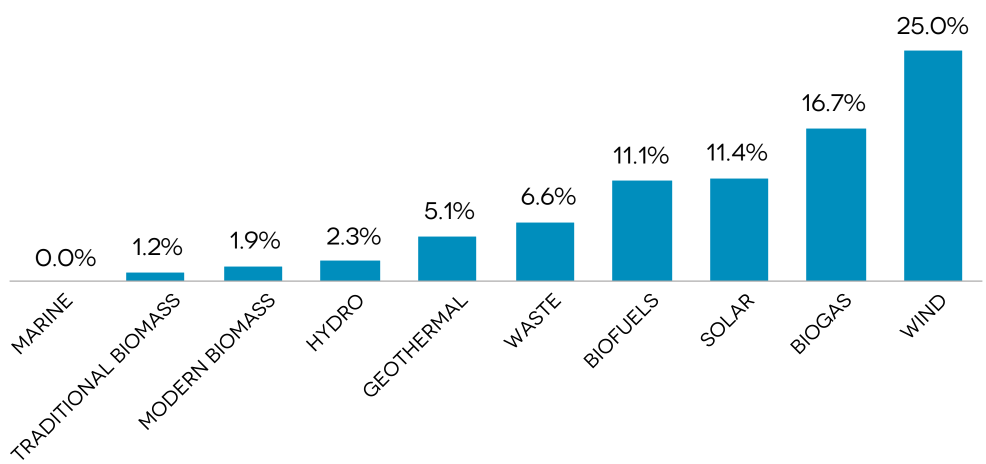

FIGURE O.21 **COMPOUND ANNUAL GROWTH RATES (CAGRS) BY RENEWABLE ENERGY SOURCE, 1990–2010**

SOURCE: IEA 2012A.

Box O.3 Methodological challenges in defining and measuring renewable energy

There are various definitional and methodological challenges in measuring and tracking the share of renewable energy in the global energy mix used for heating, electricity, and transportation.

First, while there is a broad consensus among international organizations and government agencies on what constitutes renewable energy, their legal and formal definitions vary slightly in the type of resources included and the sustainability considerations taken into account. For the purposes of the SE4ALL Global Tracking Framework, it is important that the definition of renewable energy should be specific about the range of sources to be included, should embrace the notion of natural replenishment, and should espouse sustainability. But the data and agreed-upon definitions needed to determine whether renewable energy—notably biomass—has been sustainably produced are not currently available. Therefore, it is proposed that, as an interim measure for immediate tracking purposes, renewable energy should be defined and tracked without the application of specific sustainability criteria. Accordingly, its broad definition is as follows:

"Renewable energy is energy from natural sources that are replenished at a faster rate than they are consumed, including hydro, bioenergy, geothermal, aerothermal, solar, wind, and ocean."

Second, an important methodological choice is whether tracking should be undertaken at the primary level of the energy balance or on the basis of final energy. Power generation from fossil fuels leads to substantial energy losses in conversion, leading to a discrepancy between primary energy, or fuel input, and final energy, or useful energy output. Since renewable energy sources do not have fuel inputs, they are only reported in final energy terms; expressing them in primary terms would require the use of somewhat arbitrary conversion factors.

Third, the high aggregation levels and data gaps in certain categories of available data repositories still limit the analysis. Data gaps have also been identified in the areas of distributed generation and off-grid electricity services. An additional challenge is related to measuring the heat output from certain renewable sources of energy such as heat pumps and solar water heaters. These missing components of renewable energy are relatively small in scale at present but are expected to grow significantly through 2030, making it increasingly important to develop methodologies and systems for capturing the associated data.

For the purposes of global tracking, data for the period 1990–2010 have been compiled from energy balances for 181 countries published by the International Energy Agency and the United Nations. Those data will be complemented by indicators on: (i) policy targets for renewable energy and adoption of relevant policy measures; (ii) technology costs for each of the renewable energy technologies; and (iii) total investment in renewable energy from the Renewable Energy Network 21, the International Renewable Energy Agency, and Bloomberg New Energy Finance, respectively.

Looking ahead, significant international efforts are needed to improve data collection methodologies and bridge identified data gaps. In particular, there is a need to develop internationally agreed-upon standards for sustainability for each of the main technologies, which can then be used to assess the degree to which deployment meets the highest sustainability standards. This is particularly critical in the case of biomass, where traditional harvesting practices can be associated with deforestation.

Looking across regions, it is striking that lower-income regions, such as Africa and Asia, have the highest shares of renewable energy, ranging from 20 to 60 percent. These shares declined significantly in 1990–2010, however, in part due to decreased reliance on traditional biomass for cooking and wider adoption of non-solid cooking fuels (figure O.22). By contrast, higher-income regions such as Europe and America present much lower shares of renewable energy (in the range of 10 to 15 percent), although those shares grew steadily over the two decades. Overall, Africa and Asia alone accounted for about two-thirds of global share of renewable energy in TFEC in 2010, while Europe and North America together contributed about 20 percent (figure O.23).

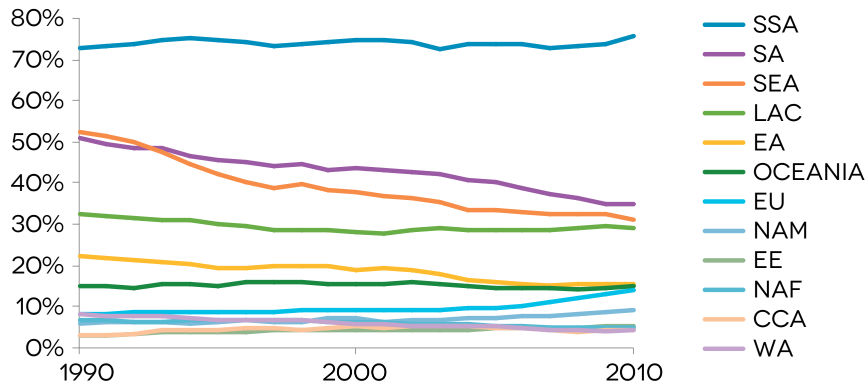

FIGURE O.22 **EVOLVING RENEWABLE ENERGY SHARE BY REGION, 1990–2010 (PERCENTAGE OF TOTAL FINAL ENERGY CONSUMPTION)**

SOURCE: IEA 2012A.
NOTE: TFEC = TOTAL FINAL ENERGY CONSUMPTION; RE = RENEWABLE ENERGY. CCA = CAUCASUS AND CENTRAL ASIA; EA = EASTERN ASIA; LAC = LATIN AMERICA AND CARIBBEAN; NAF = NORTHERN AFRICA; SEA = SOUTH-EASTERN ASIA; SA = SOUTHERN ASIA; SSA = SUB-SAHARAN AFRICA; WA = WESTERN ASIA; EU = EUROPE.

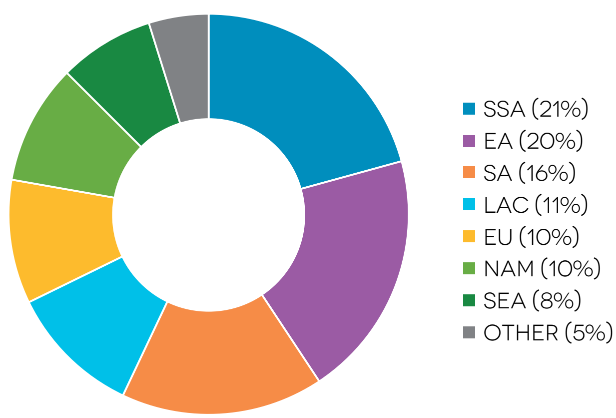

FIGURE O.23 **REGIONAL CONTRIBUTIONS TO GLOBAL RENEWABLE ENERGY 2010 (PERCENTAGE CONTRIBUTION TO THE GLOBAL SHARE OF RENEWABLE ENERGY IN TFEC)**

SOURCE: IEA 2012A.
NOTE: CCA = CAUCASUS AND CENTRAL ASIA; EA = EASTERN ASIA; LAC = LATIN AMERICA AND CARIBBEAN; NAF = NORTHERN AFRICA; SEA = SOUTH-EASTERN ASIA; SA = SOUTHERN ASIA; SSA = SUB-SAHARAN AFRICA; WA = WESTERN ASIA; EU = EUROPE; OTHER = ALL OTHER REGIONS.

If we confine attention to power generation only, the regional picture for the share of renewable energy in the electricity mix looks quite different. Latin America and Caribbean emerges as the region with by far the highest share of renewable energy in the electricity generation portfolio of 56 percent, which is more than twice the level in the next highest regions – Caucuses and Central Asia, Europe, Oceania and Sub-Saharan Africa – all of them above 20 percent. Globally, 80 percent of renewable electricity generation is found evenly spread across just four regions: East Asia, Europe, Latin America and Caribbean and North America.

High-impact opportunities

Substantial potential exists for further tapping of renewable energy sources. Studies have consistently found that the technical potential for renewable energy use around the globe is substantially higher than projected global energy demand in 2050. The technical potential for solar energy is the highest among the renewable energy sources, but there is also substantial untapped potential for biomass, geothermal, hydro, wind, and ocean energy. Available data suggest that most of this technical potential is located in the developing world. For instance, at least 75 percent of the world's unexploited hydropower potential is found in Africa, Asia, and South America, and about 65 percent of total geothermal potential is found in countries that are not members of the Organisation for Economic Co-operation and Development (OECD). The solar belt—that is, the tropical latitudes that have the highest solar irradiance across the globe—endows many developing countries with a high potential for solar-based power generation and heating.

Despite the major technical potential of renewable energy, large-scale adoption will ultimately depend on economic factors. The costs of renewable energy—particularly wind and solar—have been falling steeply and are expected to fall further as the scale of production increases. As a result, renewable energy sources—in particular hydropower, wind, and geothermal—are increasingly competitive in many environments, while solar energy is becoming competitive in some environments. Nevertheless, it is still challenging for renewable energy to compete financially with conventional fossil-fuel alternatives, particularly given that the local and global environmental impact of these conventional sources of energy is not fully reflected in costs. The further integration of renewable energy sources into the public electricity supply system also calls for more proactive expansion of both transmission grids and back-up capacity for handling higher levels of variability in the production of wind and solar energy and this further adds to the associated cost. The relatively high capital costs of renewable energy, even when overall lifecycle costs may be lower, adds further to the financing challenge.

Fast-moving countries

Over the 20 years between 1990 and 2010, renewable energy technologies matured and became more widely adopted. Both developed and developing countries are increasingly motivated by the social benefits offered by renewable energy, including enhanced energy security, reduced greenhouse gas emissions and local environmental impacts, increased economic and industrial development, and more options for reliable and modern energy access. Today, about 120 countries—more than half of them developing countries—have a national target related to renewable energy. Moreover, 88 countries have introduced price- or quantity-based incentives for renewable energy. Just over half of those countries are in the developing world.

Almost 80 percent of renewable energy other than traditional biomass has been produced and consumed by high-income and emerging economies, most notably China, the United States, Brazil, Germany, India, Italy, and Spain (figure O.24). The technology of focus differs from case to case, with China focusing mainly on hydropower; the United States on liquid biofuels; Brazil, Germany, and India on modern biomass; and Spain on wind power. Those countries moving most rapidly, such as China and Germany, experienced average annual rates of growth of 8–12 percent in 1990–2010. As of 2010, the countries with the highest shares of renewable energy (excluding traditional biomass) were Norway, Sweden, and Tajikistan, where the shares were about 50 percent (figure O.25). Many other emerging countries—among them Argentina, Mexico, Turkey, Indonesia, Philippines, and a few African countries—are starting to show progress in adopting policies to scale up renewables.

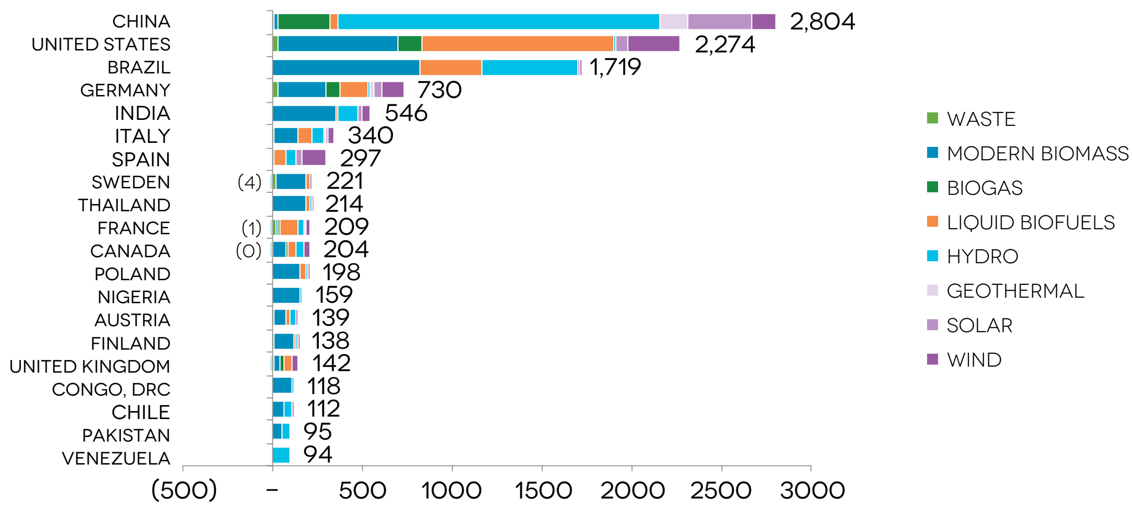

FIGURE O.24 **VOLUME OF INCREMENTAL CONSUMPTION OF RENEWABLE ENERGY (EXCLUDING TRADITIONAL BIOMASS), 1990–2010 (PETAJOULES)**

SOURCE: IEA 2012A.
NOTE: "INCREMENTAL CONSUMPTION" INDICATES ADDITIONAL CONSUMPTION OF RENEWABLE ENERGY OVER AND ABOVE THE LEVEL OF CONSUMPTION IN 1990. DRC = DEMOCRATIC REPUBLIC OF CONGO.

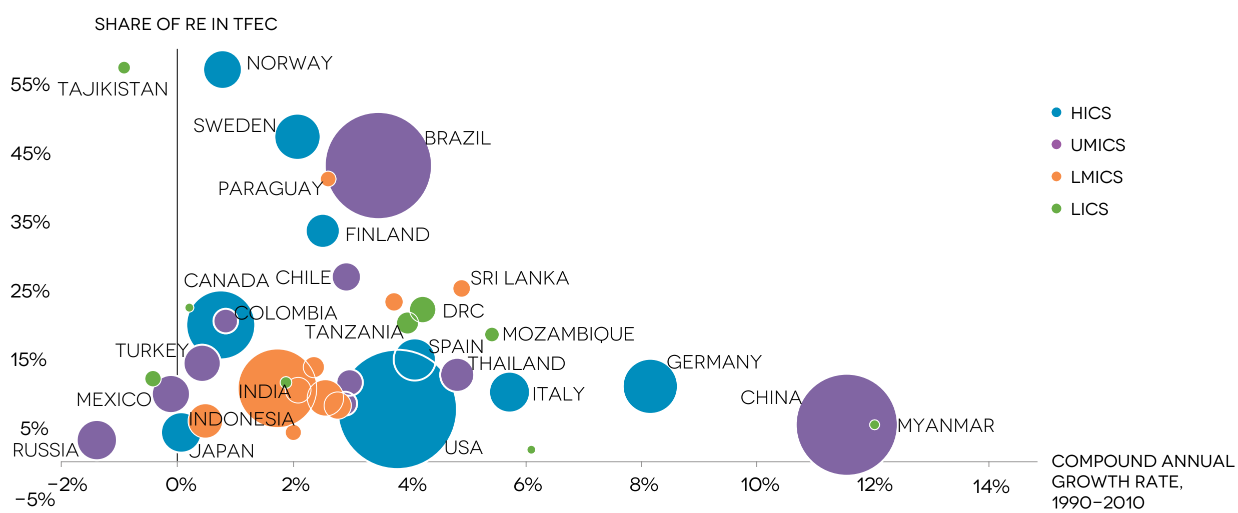

FIGURE O.25 **SHARE OF RENEWABLE ENERGY IN TOTAL FINAL ENERGY CONSUMPTION AND COMPOUND ANNUAL GROWTH RATE IN CONSUMPTION OF RENEWABLE ENERGY, 2000–10**

SOURCE: IEA 2012A.
NOTE: TFEC = TOTAL FINAL ENERGY CONSUMPTION; CAGR = COMPOUND ANNUAL GROWTH RATE; RE = RENEWABLE ENERGY. FIGURE EXCLUDES TRADITIONAL BIOMASS, BUT INCLUDES THE USE OF MODERN BIOMASS. CONGO AND TANZANIA APPEAR DUE TO THEIR HIGH USE OF MODERN BIOMASS IN THE INDUSTRIAL SECTOR. NEGATIVE CAGRS SHOWN DENOTE A REDUCTION IN THE USE OF NON-TRADITIONAL SOLID BIOMASS (MOST NOTABLY IN INDUSTRY) IN TURKEY, MEXICO, AND INDONESIA. UNLABELED BUBBLES REPRESENT COUNTRIES WITH A LOW SHARE OF RE IN TFEC AND A LOW CAGR.

Scale of the challenge

If current trends were to continue, the expansion of renewable energy would barely keep pace with the projected expansion of global energy demand. Consequently, the expected renewable energy share in 2030 would be no greater than 19.4 percent—barely one percentage point higher than it is today.

Furthermore, if current overall growth in energy demand continues, renewable energy consumption would have to triple, growing at an annual rate of 5.9 percent—or two and a half times the current growth rate—in order meet the target of doubling by 2030. Given that traditional biomass (representing about half of renewable energy use in 2010) is not expected to expand greatly, the annual growth rate for other forms of renewable energy would have to be in double digits.

By contrast, if overall energy demand were to stabilize (due to greater energy efficiency, for example), doubling the renewable energy contribution would require an annual growth rate of 3.5 percent, or a 50 percent increase over the levels observed in 1990–2010. This analysis highlights the critical linkage between the SE4ALL objectives for renewable energy and energy efficiency.

Several agencies and organizations have modeled scenarios of the evolution of renewable energy. These vary greatly in terms of their methodologies (that is, forecasting versus goal-seeking) as well as their assumptions about the prevailing policy environment. A review of energy modeling scenarios by the Intergovernmental Panel on Climate Change finds that more than half of 116 scenarios indicate a renewable energy share in total primary energy supply of less than 17 percent by 2030, with the highest cases projecting a renewable energy share of 43 percent (figure O.26). Those scenarios in which renewable energy shares rise above the 30 percent mark typically assume a strong package of policy measures, such as elimination of fossil -fuel subsidies, imposition of carbon pricing, aggressive pursuit of energy efficiency, sustained support for research and development of emerging renewable technologies, and the advent of advanced transport fuels and technologies.

Achieving the SE4ALL renewable energy objective within a supportive policy environment will call for sustained global investments in the range of $250 to $400 billion per year, depending on the pace of growth in energy demand. Financing for renewable energy rose exponentially in 2000–2010, reaching $277 billion in 2011. Only the last four years of this period, however, saw an investment exceeding the bottom of the required range; the total investment over the ten-year period amounted to an annual average of just $120 billion.

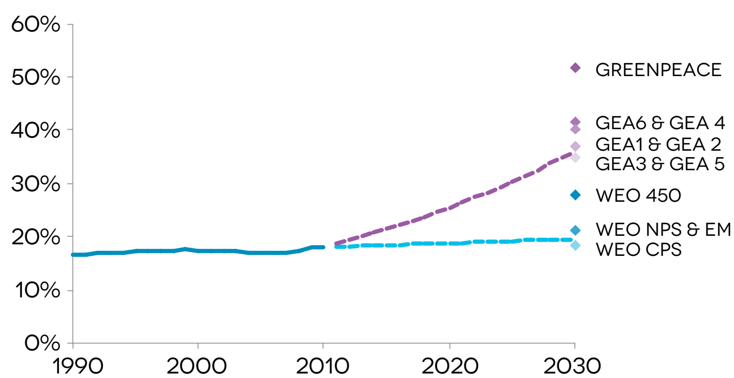

FIGURE O.26 **PROJECTIONS OF SHARE OF RENEWABLE ENERGY IN TFEC, 1990–2030**

% RE – HISTORICAL   % RE – TRENDS CONTINUED   % RE – SE4ALL TARGET GROWTH RATE

SOURCE: IEA (2012B): GREENPEACE INTERNATIONAL (2012); IIASA (2012); EXXONMOBIL (2012).
NOTE: TFEC = TOTAL FINAL ENERGY CONSUMPTION; RE = RENEWABLE ENERGY; WEO = WORLD ENERGY OUTLOOK; GEA = GLOBAL ENERGY ASSESSMENT; NPS = NEW POLICIES SCENARIO (IEA); CPS = CURRENT POLICIES SCENARIO (IEA); EM = EXXONMOBIL; SEFA = SUSTAINABLE ENERGY FOR ALL (SE4ALL).

The way forward

On the basis of the Global Tracking Framework, it is possible to establish the following starting points against which progress will be measured under the SE4ALL initiative: the rate of access to electricity and primary non-solid fuel will have to increase from 83 and 59 percent in 2010, respectively, to 100 percent by 2030; the rate of improvement of energy intensity will need to double from –1.3 percent in 1990–2010 to –2.6 percent in 2010–30; and the share of renewable energy in the global energy mix will need to double from an estimated 18 percent in 2010 to up to 36 percent by 2030 (table O.3).

	OBJECTIVE 1		OBJECTIVE 2	OBJECTIVE 3
	Universal access to modern energy services		Doubling global rate of improvement of energy efficiency	Doubling share of renewable energy in global energy mix
Proxy indicator	Percentage of population with electricity access	Percentage of population with primary reliance on non-solid fuels	Rate of improvement in energy intensity*	Renewable energy share in TFEC
Historic reference 1990	76	47	–1.3	16.6
Starting point 2010	83	59		18.0
Objective for 2030	100	100	–2.6	36.0

TABLE O.3 **SE4ALL HISTORIC REFERENCES, STARTING POINTS, AND GLOBAL OBJECTIVES (%)**

SOURCE: AUTHORS.
NOTE: TFEC = TOTAL FINAL ENERGY CONSUMPTION
*Measured in primary energy terms and GDP at purchasing power parity

While progress in all countries is important, achievement of the global SE4ALL objectives will depend critically on progress in the 20 high-impact countries that have a particularly large weight in aggregate global performance. Two overlapping groups of 20 high-impact countries in Asia and Africa account for about two-thirds of the global electrification deficit and four-fifths of the global deficit in access to non-solid fuels (figure O.27). Meeting the universal access objective globally will depend to a considerable extent on the progress that can be supported in these countries. A third group of 20 high-income and emerging economies accounts for four-fifths of global energy consumption. Therefore, the efforts of those high-impact countries to accelerate improvements in energy efficiency and develop renewable energy will ultimately determine the global achievement of the corresponding targets.

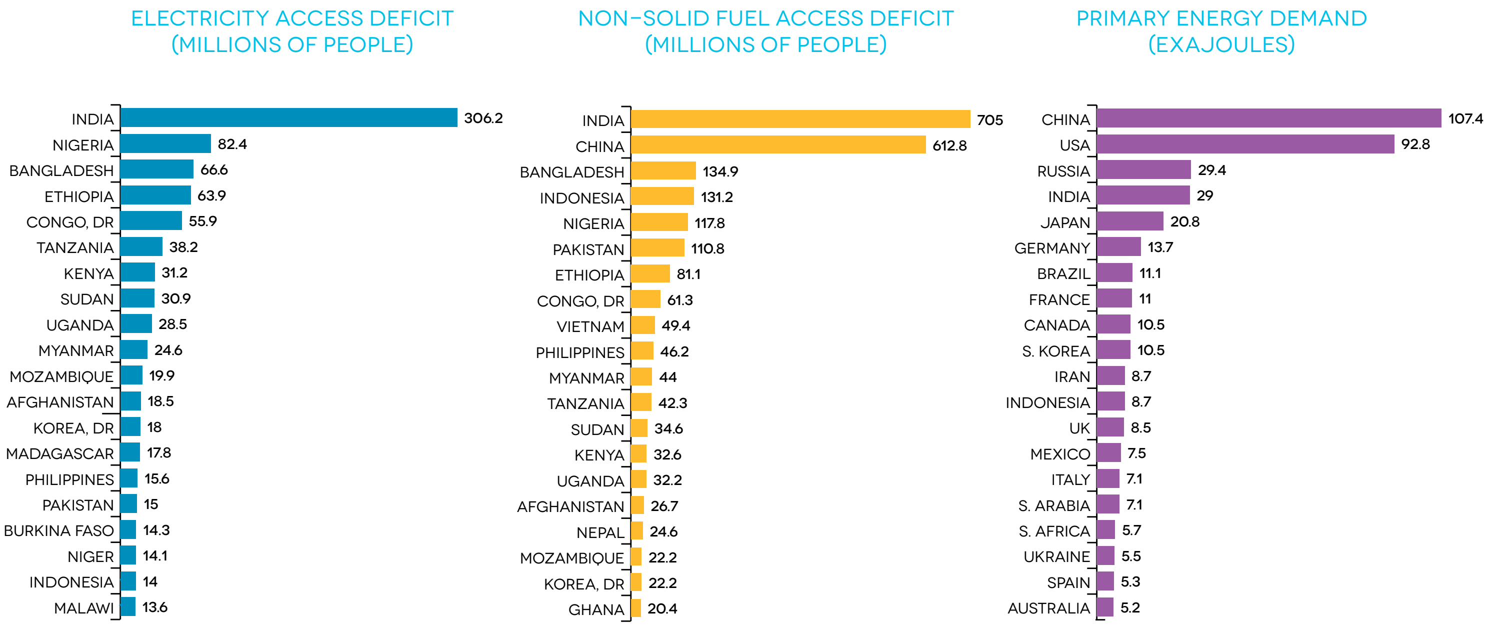

FIGURE O.27 **OVERVIEW OF HIGH-IMPACT COUNTRIES**

SOURCE: IEA, WB GLOBAL ELECTRIFICATION DATABASE, WHO GLOBAL HOUSEHOLD ENERGY DATABASE.
NOTE: DR = "DEMOCRATIC REPUBLIC OF."

In charting a course toward the achievement of the SE4ALL objectives, it will also be important to learn from the experience of the fast-moving countries that made the most progress during the 20 years between 1990 and 2010 (figure O.28). China and (to a lesser extent) India stand out as both high-impact and fast-moving countries on all three aspects of energy sector development.

In the case of electrification and cooking, even the most rapidly moving countries have not expanded access by more than 3–4 percentage points annually. In the case of energy efficiency, the countries with the most rapid improvements in energy intensity have seen CAGRs of minus 4–8 percent annually. In the case of renewable energy, the most rapidly moving countries experienced CAGRs of 10–20 percent (excluding traditional biomass).

AVERAGE ANNUAL RATE OF IMPROVEMENT (%)	GLOBAL AVERAGE	FAST MOVING COUNTRIES
Electrification	1.2	2.5 to 3.7
Non-solid fuel use	1.1	2.2 to 4.0
Energy intensity	1.3	3.9 to 11.9
Renewable energy [w/o trad. biomass]	3.0	7.0 to 18.2

TABLE O.4 **FAST MOVING COUNTRIES RELATIVE TO GLOBAL AVERAGE, AVERAGE ANNUAL RATE OF IMPROVEMENT (%)**

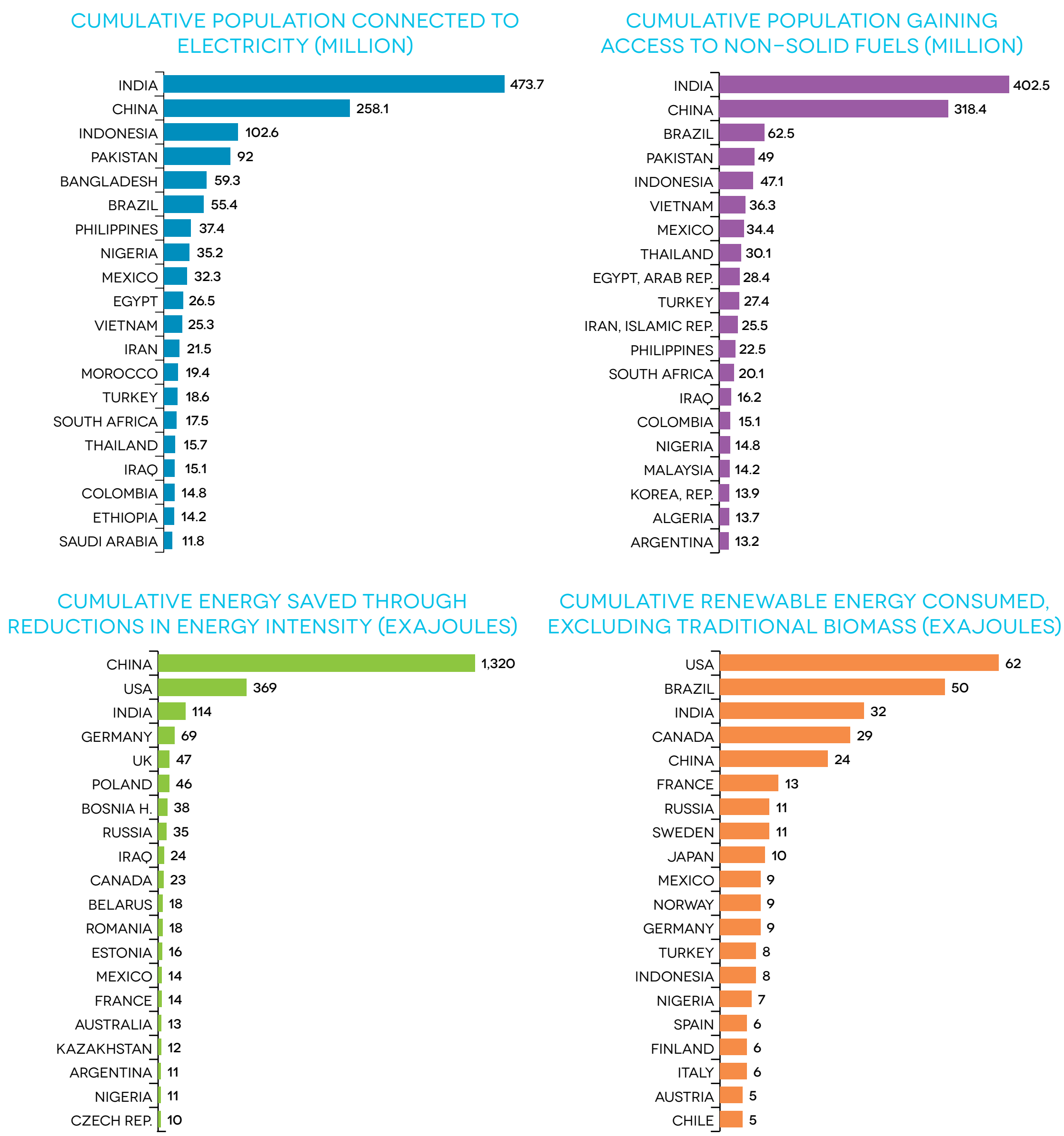

FIGURE O.28 **OVERVIEW OF FAST MOVING COUNTRIES (1990–2010)**

SOURCE: IEA, UN, WB GLOBAL ELECTRIFICATION DATABASE, WHO GLOBAL HOUSEHOLD ENERGY DATABASE.
NOTE: BOSNIA H. = BOSNIA AND HERZEGOVINA.

Global energy model scenarios enable us to gauge the scale of the global challenge of achieving the SE4ALL objectives. Based on these scenarios, it is clear that business as usual will not suffice (table O.4). With regard to universal access, business as usual would leave 12–16 percent and 31–36 percent of the world's population in 2030 without electricity and non-solid fuels, respectively. Implementing all currently available energy efficiency measures with reasonable payback periods would be enough to meet or even exceed the SE4ALL objective. However, numerous barriers prevent wider adoption of many of those measures, so that the current uptake ranges from around 20 percent for power generation and building construction to around 40 percent for manufacturing and transportation. Furthermore, few scenarios point to renewable energy shares above 30 percent by 2030.

Existing global investment in the areas covered by the three SE4ALL objectives was estimated at around $400 billion in 2010 (table O.5). The additional annual investments required to achieve the three objectives are tentatively estimated to be at least $600–800 billion—a doubling or tripling of current levels. The bulk of those investments is associated with the renewable energy and energy efficiency objectives, with access-related expenditures representing a relatively small share (10–20 percent) of the incremental costs.

The global energy models also help to clarify the kinds of policy measures that would be needed to reach the Secretary General's three sustainable energy objectives. The WEO and GEA coincide in highlighting the importance of phasing out fossil-fuel subsidies, adopting measures to provide price signals for carbon, embracing stringent technology standards for energy efficiency, and carefully designing and targeting subsidies to increase access.

In addition, global models help to clarify the likely pattern of efforts to achieve the SE4ALL objectives across geographical regions based on starting points, potential for improvement, and comparative advantage. On energy access, greatest efforts are needed in Sub-Saharan Africa and South Asia. For energy efficiency, the highest rates of improvement are projected at around –4 percent annually in Asia (particularly China) and the countries of the former Soviet Union. For renewable energy, Latin America and Sub-Saharan Africa (with its strong reliance on traditional biomass) emerge as the regions projected to reach the highest share of renewable energy in 2030—in excess of 50 percent, compared to the 20–40 percent range in much of the rest of the world (table O.6).

	OBJECTIVE 1		OBJECTIVE 2	OBJECTIVE 3
	Universal access to modern energy services		Doubling global rate of improvement of energy efficiency	Doubling share of renewable energy in global mix
Percentage in 2030	Population with electricity access	Population with primary reliance on non-solid fuels	Global rate of improvement in energy intensity*	Renewable energy share in total final energy consumption
IEA scenarios				
New policies	88	69	–2.3	20
Efficient world	88	69	–2.8	22
450	n.a.	n.a.	–2.9	27
GEA scenarios				
Baseline	84	64	–1.0	12
GEA Pathways	100	100	–3.0 to –3.2	34 to 41
2^0 Celsius	n.a.	n.a.	–1.8 to –3.2	23 to 41

TABLE O.5 **OVERVIEW OF PROJECTED OUTCOMES FOR 2030 FROM IEA WORLD ENERGY OUTLOOK AND IIASA GLOBAL ENERGY ASSESSMENT**

SOURCE: IEA (2012) AND IIASA (2012).
n.a. = NOT APPLICABLE.

* IEA scenarios are presented in primary energy terms while GEA scenarios in final energy terms (GDP at purchasing power parity in both cases)

	OBJECTIVE 1		OBJECTIVE 2	OBJECTIVE 3	
Average annual investment 2010–30 (US$ billion)	Universal access to modern energy services		Doubling global rate of improvement of energy efficiency	Doubling share of renewable energy in global mix	Total
	Electrification	Cooking	Energy efficiency	Renewable energy	
Actual for 2010	9.0	0.1	180	228	417.1
Additional from WEO	45.0	4.4	393	>>174	>>616.4*
Additional from GEA	15.0	71.0	259–365	259–406	604–858**

TABLE O.6 **OVERVIEW OF PROJECTED ANNUAL INVESTMENT NEEDS FOR 2010–2030 FROM WORLD ENERGY OUTLOOK AND GLOBAL ENERGY ASSESSMENT**

SOURCE: IEA (2012) AND IIASA (2012).

* WEO estimates are taken to be those closest to the corresponding SE4ALL objective: the Energy for All Scenario in the case of universal access, the Efficient World Scenario in the case of energy efficiency, and the 450 Scenario in the case of renewable energy. The 450 Scenario corresponds to a 27 percent renewable energy share, which is significantly below the SE4ALL objective. The Efficient World Scenario corresponds to a –2.8 percent CAGR for global energy intensity, which is significantly above the SE4ALL objective.

** GEA estimates that a further $716–910 billion would be needed annually for complementary infrastructure and broader energy sector investments not directly associated with the three objectives.

	OBJECTIVE 1				OBJECTIVE 2		OBJECTIVE 3	
	Universal access to modern energy services				Doubling global rate of improvement of energy efficiency		Doubling share of renewable energy in global mix	
	Percentage of population with electricity access		Percentage of population with primary reliance on non-solid fuels		Rate of improvement in energy intensity*		Renewable energy share in total final energy consumption	
	2010	SE4ALL	2010	SE4ALL	1990–2010	SE4ALL	2010	SE4ALL
Sub-Saharan Africa	32	100	19	100	1.1	2.2–2.4	56	60–73
Centrally Planned Asia	98	100	54	100	5.2	3.6–3.9	17	27–31
Central and Eastern Europe	100	100	90	100	3.1	2.6–3.0	8	28–36
Former Soviet Union	100	100	95	100	2.4	3.7–4.3	6	27–48
Latin America and Caribbean	95	100	86	100	0.7	2.6–3.0	25	49–57
Middle East and North Africa	95	100	99	100	-0.9	1.8–2.1	3	13–17
North America	100	100	100	100	1.7	2.4–2.6	8	26–34
Pacific OECD	100	100	100	100	0.7	2.9–3.4	6	30–41
Other Pacific Asia	89	100	57	100	1.2	3.6–4.0	18	30–37
South Asia	74	100	38	100	2.9	2.7–2.9	47	25–32
Western Europe	100	100	100	100	1.1	3.2–3.5	11	27–43
World	83	100	59	100	1.5	3.0–3.2	17	34–41

TABLE O.7 **GLOBAL ENERGY ASSESSMENT: REGIONAL PROJECTIONS UNDER SE4ALL SCENARIOS**

SOURCE: IIASA (2012). ACCESS TO ELECTRICITY FOR 2010 IS FROM WB GLOBAL ELECTRIFICATION DATABASE, 2012. ACCESS TO NON-SOLID FUEL FOR 2010 IS FROM WHO GLOBAL HOUSEHOLD ENERGY DATABASE, 2012.

* Measured in final energy terms and GDP at purchasing power parity

Moreover, the global energy models clarify how the three SE4ALL objectives interact with one another and contribute to addressing global concerns, such as climate change. The IEA finds that energy efficiency and renewable energy are mutually reinforcing—neither one on its own is sufficient to contain global warming to 2°C. Furthermore, achieving universal access to modern energy would lead to a negligible increase—only 0.6 percent—of global carbon dioxide emissions. The GEA estimates that the probability of limiting global warming to 2°C increases to between 66 and 90 percent when the SE4ALL objectives for renewable energy and energy efficiency are simultaneously met, higher than if either objective was met individually (Rogelj and others 2013). The achievement of the universal access objective for modern cooking, which would increase reliance on typically fossil-fuel-based and non-solid fuels for cooking, would have a small offsetting effect, reducing the share of renewable energy in the global mix by some two percentage points, with a negligible impact on the probability of achieving the 2°C target.

In conclusion, the Global Tracking Framework has constructed a robust data platform capable of monitoring global progress toward the SE4ALL objectives on an immediate basis, subject to improvement over time. Looking ahead, the consortium of agencies that has produced this report recommends a biannual update on the status of the three SE4ALL objectives that will build on this framework.

While the methodology here developed provides an adequate basis for basic global tracking, there are a number of significant information improvements that would be desirable to implement in the medium term. To effectively monitor progress through 2030 incremental investments in energy data systems will be essential over the next five years, both at the global and national levels. These represent relatively cost-effective high-impact improvements, whose implementation would be contingent on the availability of financial resources. For energy access, the focus will be to go beyond binary measures to a multi-tier framework that better captures the quantity and quality of electricity supplied, as well as the efficiency, safety, and convenience of the cookstoves that are used for cooking, including those that make use of biomass. For energy efficiency, the main concern is to strengthen country capacity to produce more disaggregated data on sectoral and subsectoral energy consumption that are fully integrated with associated output measures from the key energy consuming sectors. In the case of renewable energy, the main priority will be to improve the ability to gauge the sustainability of different forms of renewable energy, and most particularly the use of traditional biomass. These are all required to ensure that high-performing policies are developed that effectively target tangible results. Developing the capability of countries to develop and respond to such improved indicators is in itself a significant task.

Finally, given the scale of the challenge inherent in meeting the three SE4ALL objectives for energy, it is clear that a combination of bold policy measures with a supportive regulatory and institutional environment is required to support the requisite ramp-up of delivery capacity and financial flows to the sector. A detailed analysis of the policy environment at the country level lies beyond the immediate scope of this Global Tracking Framework, which has focused on the monitoring of global progress toward outcomes. Such an analysis, however, would be an important focus for future work in support of the SE4ALL initiative.

	RECOMMENDED TARGETING OF EFFORT OVER NEXT FIVE YEARS
Energy access	Work to improve energy questionnaires for global networks of household surveys. Pilot country-level surveys to provide more precise and informative multi-tier measures of access to electricity and clean cooking Develop suitable access measures for heating.
Energy efficiency	Integrate data systems on energy use and associated output measures. Strengthen country capacity to collect data on sectoral (and ideally subsectoral process) intensities. Improve data on physical activity drivers (traffic volumes, number of households, floor space, etc.). Improve data on energy efficiency targets, policies, and investments.
Renewable energy	Improve data and definitions for bio-energy and sustainability. Capture renewable energy used in distributed generation. Capture renewable energy used off-grid and in micro-grids. Promote a more harmonized approach to target-setting.

TABLE O.8 **MEDIUM–TERM AGENDA FOR THE IMPROVEMENT OF GLOBAL ENERGY DATABASES**

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