



WATER AND ENERGY

FACTS AND FIGURES

WWDR 2014

The United Nations World Water Development Report 2014

Water: Supply, demand and access

- Recent evidence shows that groundwater supplies are diminishing, with an estimated 20% of the world's aquifers being over-exploited, some massively so. Globally, total freshwater withdrawals (both surface water and groundwater) are believed to have increased by about 1% per year since the late 1980s, almost exclusively in developing countries. Annual freshwater withdrawals appear to have stabilized or even declined in the majority of the world's most highly developed countries, suggesting improvements in efficiency and increasing reliance on the importation of water intensive goods, including food (Gleick and Palaniappan, 2010).
- Global water demand in terms of water withdrawals is projected to increase by some 55% by 2050 because of growing demands from manufacturing, thermal power generation (mainly from the expansion of coal and gas powered plants), agriculture and domestic use (OECD, 2012a).
- 768 million people remain without access to an improved source of water and 2.5 billion remain without access to improved sanitation (WHO/UNICEF, 2013a). The High-level Panel on the Post-2015 Development Agenda has indicated that 2 billion people do not have access to safe water (UN, 2013). The number of people whose right to water is not satisfied is even greater, probably in the order of 3.5 billion (Onda et al., 2012).

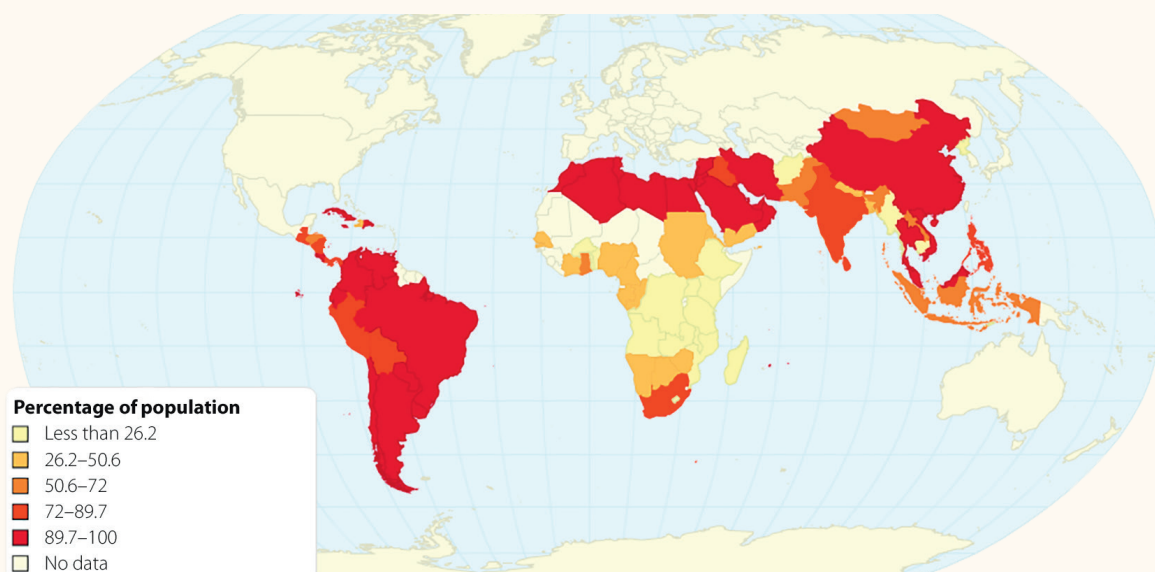
Energy: Supply, demand and access

- Thermal power plants (coal, natural gas, oil and nuclear) are responsible for roughly 80% of global electricity production.
- Globally, renewables (including hydropower) account for 13% of the primary energy used in the world.
- According to Kumar et al. (2011), the percentage of undeveloped technical potential for hydropower is believed to be highest in Africa (92%), followed by Asia (80%), Australasia/Oceania (80%) and Latin America (74%). However, only about two-thirds of estimated total technical potential is believed to be economically feasible (Aqua-Media International Ltd, 2012).
- In a study comparing various sources of renewable energy in terms of environmental and social impacts, wind power was found to be the most sustainable, mainly because of its low greenhouse gas (GHG) emissions and water consumption (Evans et al., 2009).
- During the period 2000–2010, electricity generation from wind grew by 27% and from solar photovoltaic (PV) by 42% per year on average (IEA, 2012a). Wind and solar power are expected to continue expand rapidly over the next 20 years (IEA, 2012a).
- Bioenergy refers to the renewable (primary) energy derived from biomass or biological sources, such as firewood, biofuels, agricultural by-products, charcoal, peat and dung. Bioenergy dominates, accounting for 77% of renewables (10% of the total), the majority of which comes from fuelwood (87% of bioenergy). More than two billion people in the world rely on firewood and charcoal for their daily energy needs (REN21, 2012).
- In 2010, the annual worldwide use of geothermal energy was reported to be 67 TWh for electricity and 122 TWh for direct use (Fridleifsson, 2012). Although this is a marginal quantity on the global scale, geothermal energy can make a substantial contribution to energy supply at local and national levels. A recent study consolidating decades of archived geological information in the USA shows that geothermal energy could offer 3,000 GW of added power – approximately ten times the capacity of the country’s coal power plants (Blackwell et al., 2011).
- According to the International Energy Agency (IEA)’s New Policies Scenario, global energy demand is expected to grow by more than one-third over the period to 2035, with China, India and the Middle East in particular accounting for about 60% of the increase (IEA, 2012a). Overall, 90% of the increase in demand will come from countries outside the Organisation for

1

Access to electricity in developing countries as a percentage of the population, 2011

FIGURE



Source: ChartsBin.com (<http://chartsbin.com/view/10471>, based on source cited therein [original data from IEA World Energy Outlook statistics at <http://www.iea.org/stats/index.asp>] (Accessed Oct 2013) and updated with data from the IEA World Energy Outlook 2013 Electricity Access Database (<http://www.worldenergyoutlook.org/media/weowebsite/energydevelopment/WEO2013Electricitydatabase.xlsx>) for India and Nicaragua.

Economic Co-operation and Development (OECD) (IEA, 2012a).

- Globally, electricity demand is expected to grow by roughly 70% by 2035. This growth will be almost entirely in non-OECD countries, with China and India accounting for more than half that growth.
- Hydroelectricity is currently the largest renewable source for power generation in the world, meeting 16% of global electricity needs in 2010 (IEA, 2012a). Its share in total electricity generation is expected to remain around 15% through 2035 (IEA, 2012a), keeping pace with the overall growth rate of power generation. Nearly 90% of the expected increase in hydropower production between 2010 and 2035 would be in non-OECD countries, where the remaining potential is higher and growth in electricity demand is strongest.
- More than 1.3 billion people worldwide still lack access to electricity, with more than 95% of them located in sub-Saharan Africa and developing Asia (Figure 1), and roughly 2.6 billion people rely on the traditional use of biomass for cooking (IEA, 2012a).

The water–energy nexus

- There are three billion people living on less than US\$2.50 per day. Major regional and global crises – climate, food, energy, financial – threatening the livelihood of many are interlinked through the water–energy nexus.
- Water resources have been considered by some to be a *public good* (though the economic definition of ‘public good’ does not apply to freshwater), with access to safe water and sanitation recognized as a *human right*. Neither concept ordinarily applies to energy.
- Women and girls bear most of the work burden associated with water and energy scarcity. Fetching water and collecting firewood adds to their time and seriously compromises their educational and employment opportunities, perpetuating the intergenerational transfer of poverty and disempowerment.
- The over-reliance on wood, straw, charcoal or dung for cooking and heating is detrimental to women and children’s health – they account for more than 85% of

the two million deaths each year attributed to cancer, respiratory infection and lung disease due to indoor air pollution (UNDP/WHO, 2009). Women and girls are also the most exposed to waterborne diseases (WWAP, 2012).

- The global size of the market for water treatment and distribution plant and equipment for domestic and industrial use is currently (2013) valued at US\$557 billion (Goldman Sachs, 2005; GWI, 2013). For a quick comparison, the annual global energy market is estimated at around \$6 trillion.¹

Water and energy

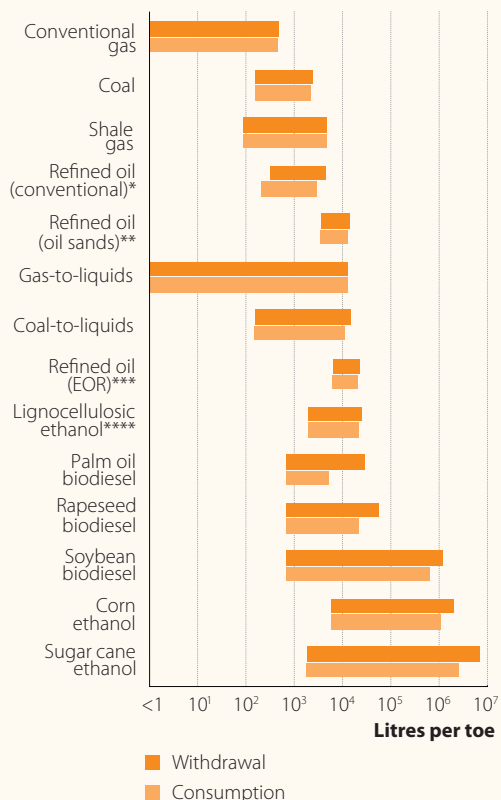
- Energy accounts for a significant fraction of a country’s water use (both consumptive use and non-consumptive). The IEA estimates global water withdrawals for energy production in 2010 at 583 billion m³ (representing some 15% of the world’s total withdrawals or roughly 75% of all industrial water withdrawals), of which 66 billion m³ was consumed (IEA, 2012a). By 2035, according to the IEA’s New Policies Scenario, withdrawals would increase by 20%, whereas consumption would increase by 85%.
- 90% of global power generation is water intensive. There is an increasing risk of conflict between power generation, other water users and environmental considerations.
- Water is used to produce fuels in the extractive industries in a variety of ways, each requiring different quantities of water (Figure 2).
- Approximately 15–18 billion m³ of freshwater resources are contaminated by fossil fuel production per year, with significant implications for ecosystems and the communities that depend on the water for drinking or to support their livelihoods. At the global level, climate change introduced by combustion of fossil fuels will have major, long-term impacts on water availability and quality across the planet (Allen et al., 2012).
- The thermal power sector, responsible for roughly 80% of global electricity production, is a large user of water; in Europe, it is responsible for 43% of total freshwater withdrawals (Rübelke and Vögele, 2011) and accounts

¹ ‘Energy is a \$6 trillion global market’, quote attributed to then US Commerce Secretary Gary Locke on a visit to China in May 2010 (Shirouzu, 2010).

for more than 50% of national water withdrawals in several countries (Eurostat, 2010). The thermal power sector is also the single largest user of water in the USA, responsible for nearly half of all water withdrawals, ahead of even agriculture (Kenny et al., 2009). In China, water withdrawals for power plant cooling exceed 100 billion m³ annually, which is more than 10% of the national cap (700 billion m³) (Bloomberg, 2013). In developing countries, relative water use by the power sector is generally lower, the agriculture sector is generally higher.

FIGURE 2

Water withdrawals and consumption vary for fuel production



* The minimum is for primary recovery; the maximum is for secondary recovery. ** The minimum is for in-situ production, the maximum is for surface mining. *** Includes carbon dioxide injection, steam injection and alkaline injection and in-situ combustion. **** Excludes water use for crop residues allocated to food production.

Note: toe, tonne of oil equivalent (1 toe = 11.63 MWh = 41.9 GJ). Ranges shown are for 'source-to-carrier' primary energy production, which includes withdrawals and consumption for extraction, processing and transport. Water use for biofuels production varies considerably because of differences in irrigation needs among regions and crops; the minimum for each crop represents non-irrigated crops whose only water requirements are for processing into fuels. EOR, enhanced oil recovery. For numeric ranges, see <http://www.worldenergyoutlook.org>.

Source: IEA (2012a, fig. 17.3, p. 507, based on sources cited therein). World Energy Outlook 2012 © OECD/IEA.

- Electricity costs are estimated at 5% to 30% of the total operating cost of water and wastewater utilities (World Bank, 2012b), but in some developing countries such as India and Bangladesh, it is as high as 40% of the total operating cost (Van Den Berg and Danilenko, 2011).
- Desalinated water involves the use of at least 75.2 TWh/year, which is about 0.4% of global electricity consumption (IRENA, 2012a).
- The amount of energy required to provide 1 m³ water safe for human consumption can vary from 0.37 kWh/m³ to 8.5 kWh/m³ depending on the water source (Figure 3).
- Unconventional oil (e.g. oil/tar sands) and gas production (e.g. 'fracking') are generally more water intensive than conventional oil and gas production.

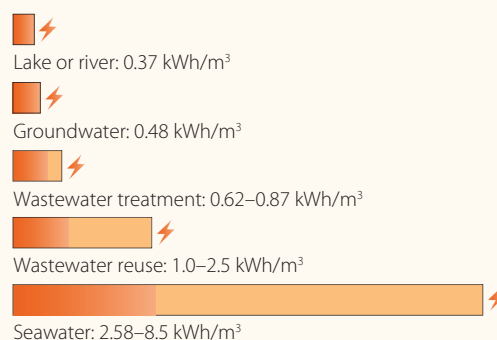
Thematic perspectives

Agriculture

- Agriculture currently uses 11% of the world's land surface, and irrigated agriculture uses 70% of all water withdrawals on a global scale. Without improved efficiencies, agricultural water consumption is expected to increase by about 20% globally by 2050 (WWAP, 2012).

FIGURE 3

Amount of energy required to provide 1 m³ water safe for human consumption from various water sources



Note: This diagram does not incorporate critical elements such as the distance the water is transported or the level of efficiency, which vary greatly from site to site.

Source: WBSCD (2009, fig. 5, p. 14, based on source cited therein).

- An estimated 870 million people are undernourished due to a lack of food or a lack of access to food (FAO, 2013a). Demographic projections suggest that world population will increase by a third – to 9.3 billion – by 2050 (UNDESA, 2012). Estimates suggest that global food production will need to increase by as much as 60% by 2050 to meet demand (FAO, 2012).
- The food production and supply chain accounts for about 30% of total global energy consumption (FAO, 2011b).
- The demand for agricultural feedstock for biofuels is the largest source of new demand for agricultural production in decades, and it was a major factor behind the 2007–2008 spike in world commodity prices. For example, FAO (2011c) estimates that biofuels accounted for about one-third of the maize price increase. This raises concerns about the implications that global biofuels production may have on food security in developing countries.
- In 2010, traditional biomass represented 9.6% of global final energy consumption, whereas modern biofuels represent only 0.8% of global final energy consumption (Banerjee et al., 2013). However, with the dramatic increase of biofuel production since 2000 (Figure 4), the contribution of biofuels to energy supply is expected to grow rapidly, with beneficial impacts including reduction in GHGs, improved energy security and potential new income sources for farmers (de Fraiture et al., 2008).

- Generally, biofuels require more water per unit energy than extracted fuels because of the water needed for photosynthesis. Biomass production for energy will compete with food crops for scarce land and water resources, already a major constraint on agricultural production in many parts of the world. China and India, the world's two largest producers and consumers of many agricultural commodities, already face severe water limitations in agricultural production, yet both have initiated programmes to boost biofuel production (de Fraiture et al., 2008).

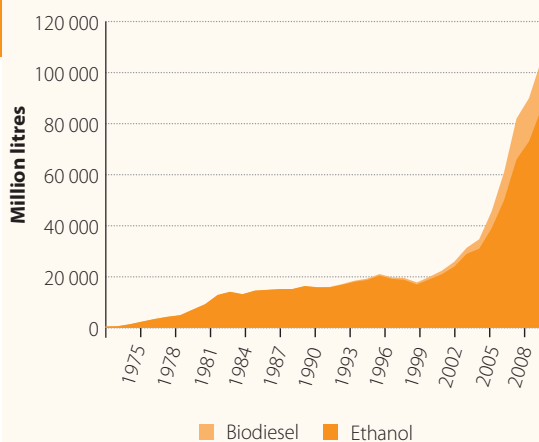
Cities

- Between 2011 and 2050, it is estimated that the urban population will increase by 2.6 billion (UNDESA, 2012). Almost all of this increase will be in cities located in developing countries, while the urban population in developed countries will remain close to constant (UN-Habitat, 2012).
- Cities are home to just over 50% of the global population, but they consume 60% to 80% of the commercial energy and emit about 75% of the GHGs (IEA, 2008b; UNEP, 2011b).
- Water and energy consumption in cities can be reduced during early stages of urban planning through development of compact settlements and investment in systems for integrated urban water management, such as conservation of water sources, use of multiple water sources – including rainwater harvesting, stormwater management and wastewater reuse – and treatment of water as needed rather than treatment of all water to a potable standard.
- It is estimated that more than 80% of used water worldwide – and up to 90% in developing countries – is neither collected nor treated (WWAP, 2012), threatening human and environmental health.
- Wastewater is becoming recognized as a potential source of energy. Water supply companies in several countries are working towards becoming energy neutral by generating energy from wastewater that equals the amount of energy consumed in their other operations.

Industry

- 60% of the world's industrial energy consumption is estimated to occur in developing countries and transitional economies (UNIDO, 2010).

4 **World ethanol and biodiesel production, 1975–2010**



Source: Shrank and Farahmand (2011, fig. 1, from source cited therein).

- World energy consumption increased by 186% between 1973 and 2010 and for the same period industry's use increased by 157% (IEA, 2012c).
- The opportunities in energy savings in industry translate to a potential 26% improvement worldwide based on benchmark data, and more than 75% in developing countries or economies in transition. This would result in a saving of 3% to 4% in total cost of production (UNIDO, 2010).
- The industrial (including energy) and domestic sectors account for 20% and 10% of total freshwater withdrawals globally, respectively, although these figures vary considerably across countries.
- The increasing development of renewable energy sources is spurred by the Renewable Energy Directive,² which lays down legally binding targets; notably, a 20% share of renewable energy in the European Union by 2020.
- Thermoelectric power plants produce 91% of total electricity in the USA and 78% in Europe.
- In Western Europe and the USA, roughly 50% of water is abstracted for energy production as cooling water, and the majority of this is discharged to water bodies at a higher temperature (EEA, 2009).
- With climate change, an increase in and spread of water scarcity and stress is predicted to affect about half the river basins in the European Union by 2030 (EC, 2012c).

Infrastructure

- Estimates suggest that developing countries will require US\$1.1 trillion in annual expenditure through 2015 to meet growing demand for infrastructure (World Bank, 2011). This is more than double their \$500 billion annual spending (Qureshi, 2011).
- For developing countries alone, it has been estimated that US\$103 billion per year is required to finance water, sanitation and wastewater treatment through 2015 (Yepes, 2008). Middle income countries such as Brazil, China and India are all already committing considerable resources to develop their infrastructure.
- Regarding energy infrastructure, the IEA has estimated that nearly US\$1 trillion in cumulative investment (\$49 billion per year) will be needed to achieve universal energy access by 2030 (IEA, 2012a). It also concludes that in a business-as-usual scenario, one billion people will remain without access to electricity by 2030.

Regional perspectives

Europe and North America

- In Europe and in North America, some 65% and 61%, respectively, of hydropower generation potential is estimated to have been already developed (IEA-EC, n.d.).
- In 2008, hydropower generated 16% of Europe's electricity; there are currently more than 7,000 large dams and a number of large reservoirs in Europe (EEA, 2009).

Asia and the Pacific

- The Asia-Pacific region is home to 61% of the world's people and its population is expected to reach five billion by 2050 (UNESCAP, 2011).
- Asia's per capita freshwater availability remains half of the global average (FAO, 2011e), and almost 380 million people do not have access to safe drinking water (UNESCAP, 2013). The ability to address issues of water availability and distribution will play an important role in the region's capacity to grow and develop.
- The Asian Development Bank forecasts a massive rise in energy consumption in the Asia-Pacific region: from barely one-third of global consumption to 51–56% by 2035 (ADB, 2013).³
- In Asia, where 46% of the global primary energy is produced (UNESCAP, 2011), coal is the most prevalent energy product, with China and India together extracting more than half of the world's total output (World Coal Association, 2011). Asia's demand for coal is projected to increase by 47% in coming years (IEA, 2010).
- There is a growing market for renewable sources such as biofuel. Indonesia and Malaysia are the top two global producers of palm oil (InfraInsights, 2013), and China

2 Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources.

3 The Asian Development Bank's Asia-Pacific region excludes the Russian Federation.

is the third largest producer of biofuels overall in the world (European Biofuels Technology Platform, 2009). China was the dominant country for investments in renewable energy in 2012, with commitments rising to US\$67 billion – a 22% increase from 2011 (Frankfurt School-UNEP Centre/BNEF, 2013).

- Although it provides a cleaner energy source and is a potentially strong economic driver, the biofuel industry has large water requirements that could exceed capacity in some regions.
- Existing and potential hotspots in Asian transboundary river basins develop where issues and challenges for both energy and water have political and socio-economic implications at local and basin levels. Areas of conflict include the Aral Sea and the Ganges-Brahmaputra River, Indus River and Mekong River basins.

The Arab region

- With the exception of Iraq and Lebanon, the low to middle income countries in the Arab region have an annual per capita share of renewable water resources that falls below the water poverty line (UNESCWA, 2013a) and they are struggling to achieve energy security. Many of these countries are seeking to reorient their energy mix towards renewable energy sources to meet growing demand for water and energy services.
- Unaccounted-for water in Arab countries is estimated to vary between 15% and 60%, whereas the best practice rate ranges from less than 10% for new systems to 25% for older systems (World Bank, 2009). The high percentage of water losses in Arab countries is coupled with high energy losses, which further increases the cost of service provision. This challenge is all the more true when water is sourced from desalination plants.

Latin America and the Caribbean

- Latin America and the Caribbean has the second largest hydropower technical potential of all regions in the world – about 20% (of which almost 40% is in Brazil) or approximately 700 GW. Less than one-quarter of this is developed (IEA, 2012b; OLADE, 2013).
- At present the region has almost 160 GW installed capacity. As a result, hydropower provides some 65% of all electricity generated (even more in Brazil, Colombia, Costa Rica, Paraguay and Venezuela); in comparison, the world average is just 16% (IEA, 2012b).

- In comparison with other developing regions, Latin America and the Caribbean is well advanced in the provision of water supply and sanitation services: 94% of its population has access to improved water sources and 82% to improved sanitation facilities (WHO/UNICEF, 2013b).
- With more efficient operation, many water utilities would be able to reduce energy costs by 10% to 40% (Rosas, 2011), and even more (up to 75%) in wastewater treatment – savings that could help expand service coverage to the poor, improve service quality, and make bills more affordable for customers.

Africa

- Sub-Saharan Africa is the least electrified of all major world regions, with 57% of its population without access to electricity in 2011 (IEA, 2012a).
- Because sub-Saharan Africa's population is predominantly rural (70%) (World Bank, n.d.a), achieving rural energy security is a prerequisite for equitable and sustainable development. Electrification in rural areas stands as low as 7.5%.
- Sub-Saharan Africa is characterized by low consumption of commercial energy and high dependence on traditional fuels. The majority of the rural population relies on traditional energy supplies, mainly unprocessed biomass, the burning of which causes significant pollution and health concerns.
- Sub-Saharan Africa is the only region in which the absolute number of people without access to electricity is increasing. It is estimated that without major policy action and increased investment in the electricity sector, 650 million people will be living without electricity in sub-Saharan Africa in 2030 compared with some 500 million today (IEA, 2011b).
- Hydroelectric power supplies 32% of Africa's energy (UNEP, 2012). Although endowed with considerable hydropower potential, African countries have developed only a small fraction of it – about 8%.
- Africa currently faces an infrastructure funding gap of US\$31 billion a year, mainly in power (World Bank, 2010d).

Data challenges

- Traditional statistics assessing the relative water intensity of major water uses (domestic, industry, agriculture) are often unsatisfactory when one is interested in the final goal of allocating water resources to different sectors. They are especially unsatisfactory regarding energy, which appears to account for 75% of all industrial withdrawals.
- Lack of data puts water resources management at a political disadvantage in terms of priority decision-making. While energy may be perceived as 'big business', the central role of water in socio-economic development remains under-acknowledged (WWAP, 2012). As a result, many of the decisions made and implementation mechanisms adopted with respect to energy (e.g. improved efficiency, economic growth, enhanced service coverage, benefitting the impoverished) fail to take proper account of the impact of these actions on water resources or the different benefits to other water users.

Enabling environment for change and responses

- With an annual investment of US\$198 billion globally on average over the next 40 years, water use can be made more efficient, enabling increased agricultural, biofuel and industrial production (UNEP, 2011*b*).
- Investing US\$170 billion annually in energy efficiency worldwide could produce energy savings of up to \$900 billion per year (SE4ALL, 2012), and each additional \$1 spent on energy efficiency in electrical equipment, appliances and buildings avoids more than \$2, on average, in energy supply investments (US EIA, 2010*a*).

- It has been suggested that more than half of the water demand and water-related energy consumption in some cities in the USA could be saved just by implementing simple water conservation measures, such as leakage prevention, efficient water appliances and xeriscaping. Further measures include collecting, treating and reusing stormwater for low-risk purposes such as garden watering and building cleaning and maintenance.
- Energy audits to identify and reduce water and energy losses and enhance energy efficiency can result in substantial energy and financial savings, with savings of between 10% and 40% reported.
- Global fossil fuel consumption subsidies totalled US\$523 billion in 2011, which was almost 30% higher than in 2010 (IEA, 2012*a*). Financial support for renewable energy, by comparison, amounted to only \$88 billion in 2011, and increased by another 24% in 2012 – mainly due to the expansion of solar PV in the European Union (IEA, 2012*a*). Although this progress is encouraging, support for the development of renewable energy will need to increase dramatically in comparison to support for fossil fuels in order to make a significant change in the global energy mix and, by association, to water demand.

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