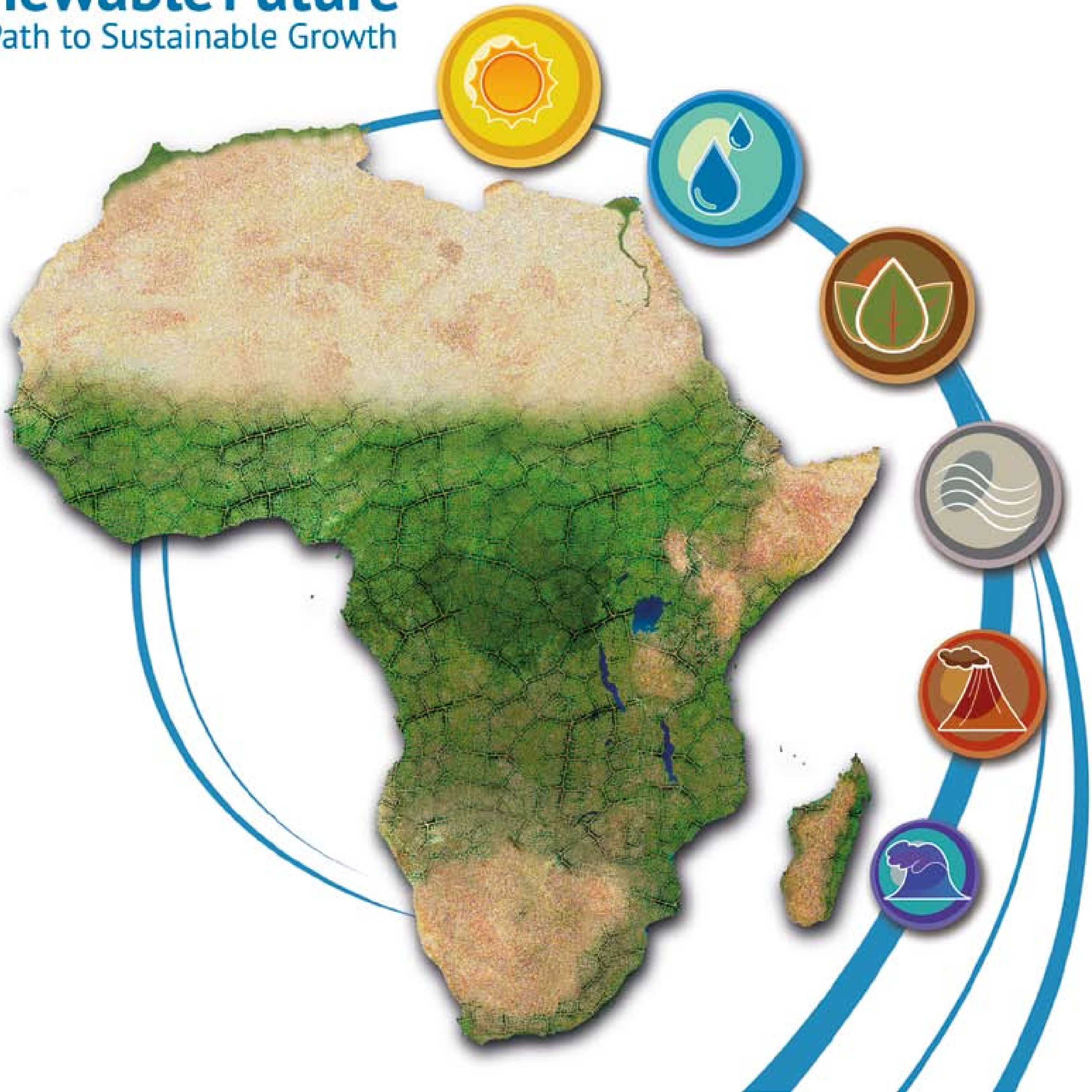
IRENA
International Renewable Energy Agency

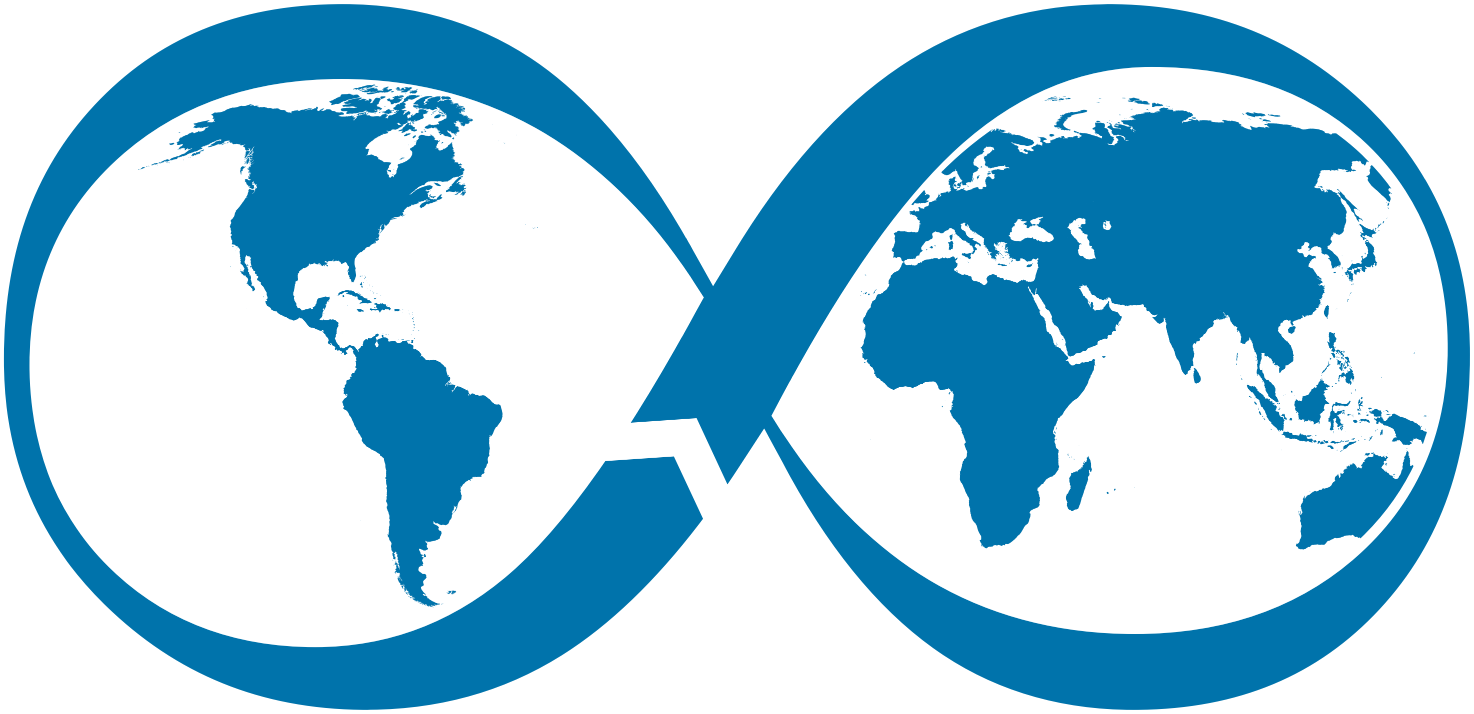
Africa's Renewable Future

The Path to Sustainable Growth



About IRENA

The International Renewable Energy Agency (IRENA) promotes the accelerated adoption and sustainable use of all forms of renewable energy. IRENA's founding members were inspired by the opportunities offered by renewable energy to enable sustainable development while addressing issues of energy access, security and volatility. Established in 2009, the intergovernmental organisation provides a global networking hub, advisory resource and unified voice for renewable energy.



Africa's Renewable Future

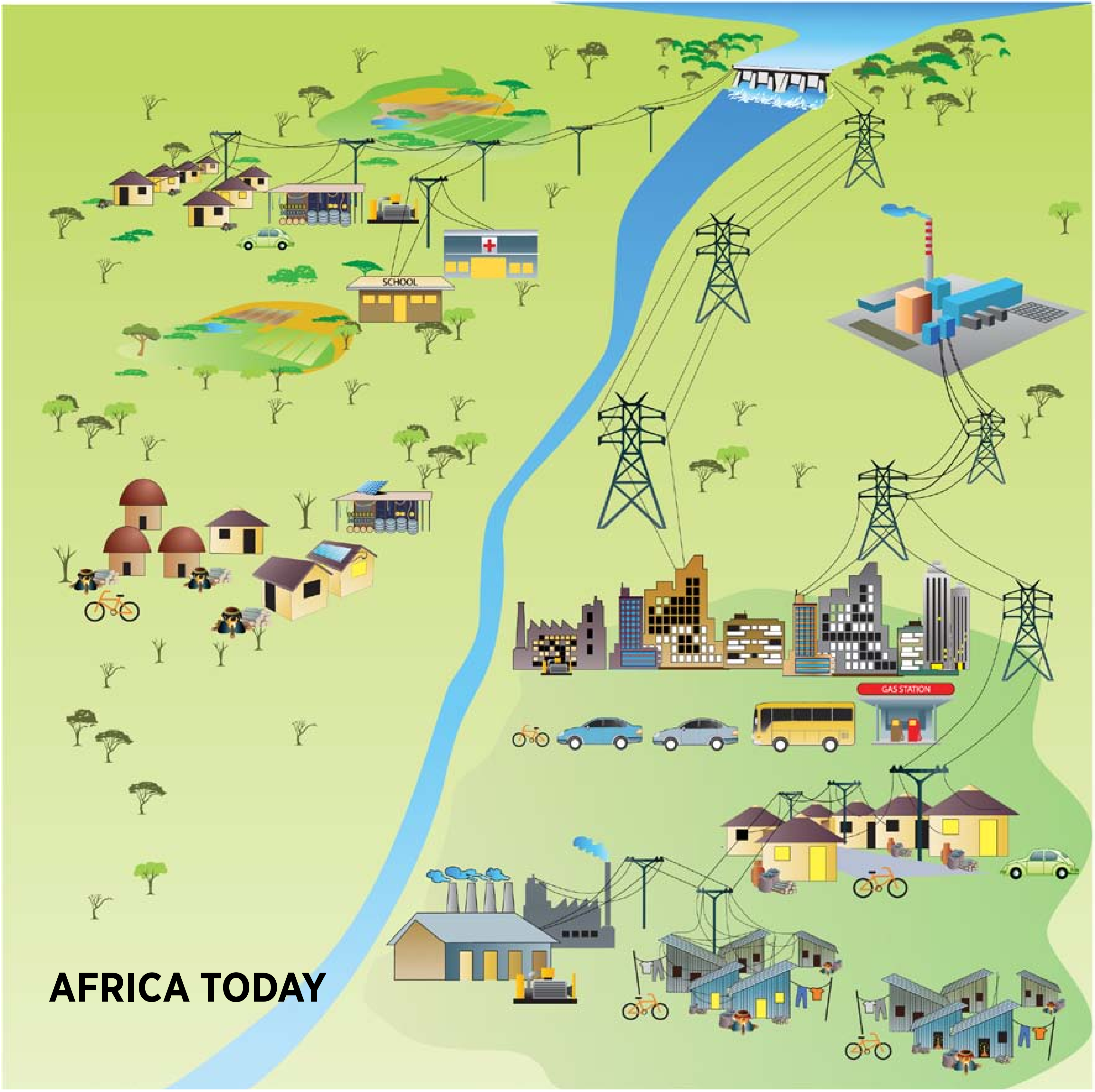
The Path to Sustainable Growth

Africa is undergoing a sustained period of economic growth and transformation. Its population is growing rapidly, and its economies are developing and diversifying. In order to be sustained, this growth will need to be fuelled by a massive investment in energy.

It is this report's contention that Africa has the potential and the ability to utilise its renewable resources to fuel the majority of its future growth with renewable energy. Doing so would be economically competitive with other solutions, would unlock economies of scale, and would offer substantial benefits in terms of equitable development, local value creation, energy security, and environmental sustainability.

Such an unprecedented transformation will not happen all by itself. It can only be made possible by a concerted effort by policy makers to develop enabling frameworks to spur investment and facilitate market development through sound policies and regional cooperation.

Africa's Renewable Future showcases examples where this effort is already happening and can be replicated – as well as how IRENA is uniquely positioned to contribute to that work.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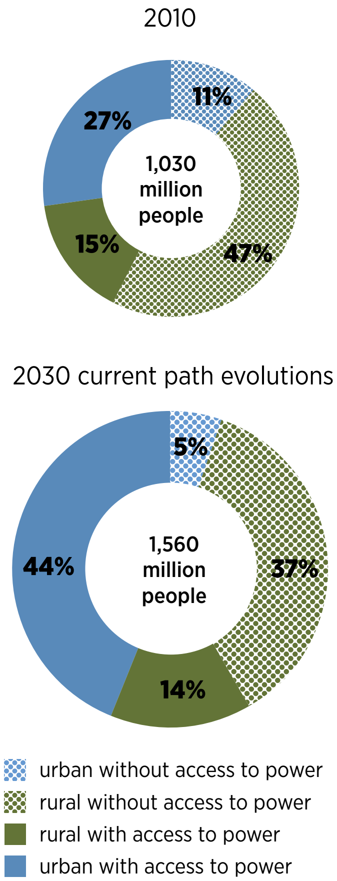
AFRICA TODAY

A Continent of Opportunity

Africa is undergoing unprecedented and sustained growth. By 2050, the continent will be home to at least 2 billion people – twice as many as today – with 40% living in rural areas.[1] In 2010, about 590 million African people (57% of the population) had no access to electricity, and 700 million (68% of the population) were living without clean cooking facilities. If these current energy access trends continue, in 2030 there will still be 655 million people in Africa (42% of the population) without access to power, and 866 million (56% of the population) without clean cooking facilities, depriving the majority of the population of the opportunity to pursue a healthy and productive life.

Figure 1: Comparison of rural and urban electricity access in 2010 and 2030, if current trends continue

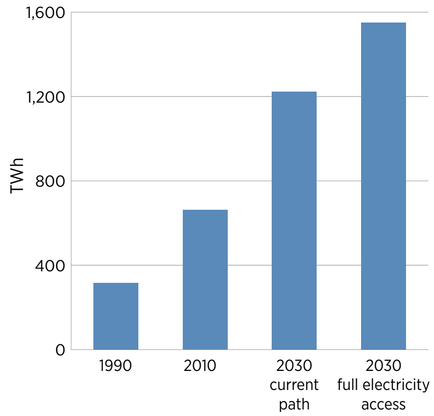


Source: IRENA analysis based on IEA: World Energy Outlook 2012; UN: World Population Prospects 2010 Revision

Africa's economies are growing currently at an average rate of 4% per year. Six of the world's ten fastest growing economies over the past decade were in sub-Saharan Africa. If this growth is maintained, Africa's GDP should increase roughly three-fold by 2030 and seven-fold by 2050. However, sustaining such growth will only be possible if fuelled by a much larger and better performing energy sector.

Africans currently consume only one quarter of the global average energy per capita, using a mix of hydropower, fossil fuels and biomass – mostly in traditional uses. As shown in Figure 2, providing full electricity access to all Africans would require only an additional 900 TWh over 20 years, an amount that corresponds to one year of current additional global power consumption.

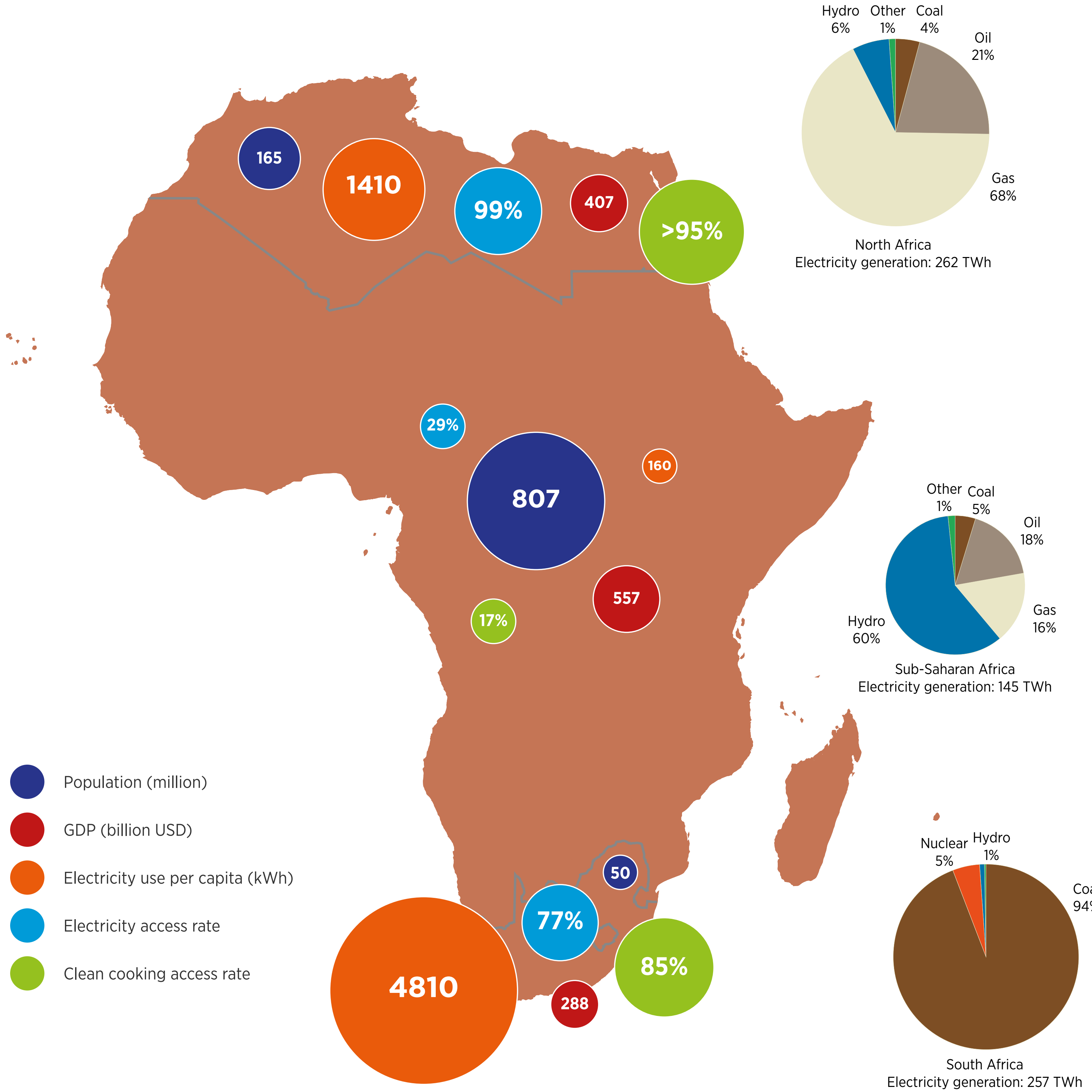
Figure 2: Comparison of current African power consumption trend vs. full access in 2030



Source: based on IEA: World Energy Outlook 2012 and IRENA analysis

Access to energy is a pre-requisite of economic and social development because virtually any productive activity needs energy as an input. Basic levels of electricity access (e.g. lighting, communication, healthcare, and education) provide substantial benefits for communities and households. Providing a basic level of electricity access with renewable sources is increasingly economically feasible (e.g. kerosene lighting systems at USD 4–15 per month cost households significantly more than the USD 2 per month to run a solar lighting systems).[2] However, sustained economic development requires a definition of electricity access, which asserts that energy levels should provide for basic services as well as for productive uses. If these services are based on renewable energy sources, positive environmental impacts can also be achieved.

Map 1: Key figures for North, sub-Saharan and South Africa



Source: IRENA analysis based on data from the International Energy Agency, the World Bank and the World Health Organization

Africa is a large and diverse continent. The level of economic and energy sector development differs widely across its 54 countries. Energy resources, whether fossil or renewable, are not distributed evenly. Therefore, every country confronts a different set of challenges. Countries rich in fossil fuels are faced with decisions of whether to use those resources domestically, or to export them and seek alternative energy sources at home. Countries which currently import fossil fuels need to decide to either continue on their current path, or strive for energy sufficiency through alternatives, such as renewables.

Decisions concerning the development of the African energy sector will have long-term implications for individual welfare, national economic development, and greenhouse gas emissions because investment in energy infrastructure spans several decades. Given recent technological advancements and cost reductions, the large-scale deployment of renewable energy offers African countries a cost-effective path to rapid, sustainable and equitable growth. This is in line with the aspirations of the United Nations Secretary-General's Sustainable Energy for All initiative.

SUSTAINABLE ENERGY FOR ALL AND IRENA'S ROLE AS THE RENEWABLE ENERGY HUB

In December 2010, the United Nations General Assembly (UNGA) declared 2012 the International Year of Sustainable Energy for All (SE4ALL), recognising that "...access to modern affordable energy services in developing countries is essential for the achievement of the internationally agreed development goals, including the Millennium Development Goals, and sustainable development, which would help to reduce poverty and to improve the conditions and standard of living for the majority of the world's population." The initiative seeks to engage governments, the private sector, and civil society partners worldwide, to achieve three major objectives by 2030:

- Ensuring universal access to modern energy services;
- Doubling the global rate of improvement in energy efficiency;
- Doubling the share of renewable energy in the global energy mix.

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On 5 December 2012 the UNGA's Second Committee approved a draft resolution on the "Promotion of new and renewable sources of energy", which declares the decade 2014-2023 to be the "United Nations Decade of Sustainable Energy for All".

IRENA Members expressed strong support for the Agency to be the "Hub for Renewable Energy" within the SE4ALL initiative. IRENA is currently developing a global Renewable Energy Roadmap (REMAP 2030) to double the share of renewable energy in the global energy mix by 2030.

Renewables-based energy growth is both viable and desirable for all three major energy sectors: electricity, heat, and transport. In addition, it can enable access to modern energy services for all.

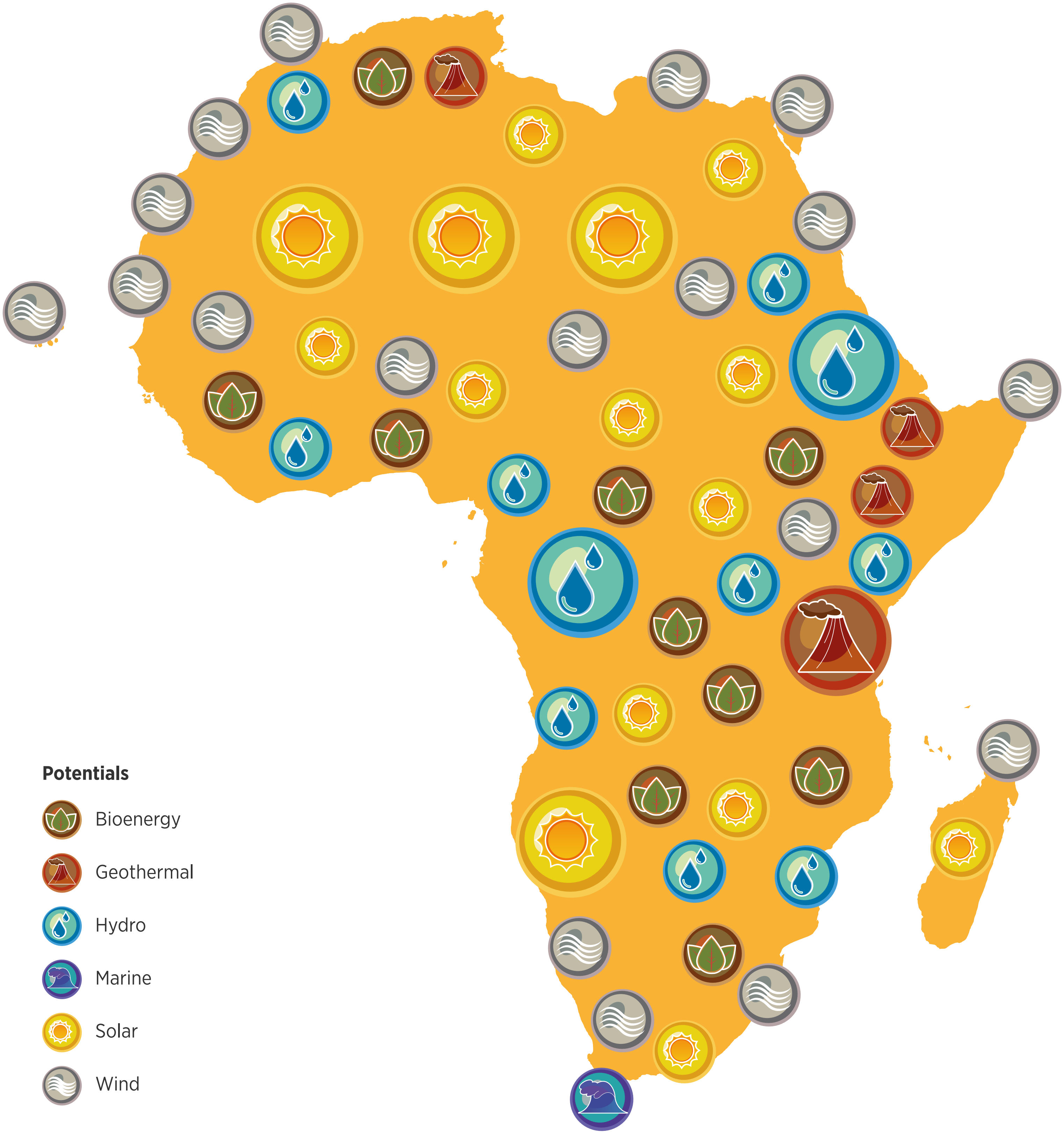
Africa's renewable energy power potential is substantially larger than the current and projected power consumption of the continent. Local geothermal, solar thermal and bioenergy resources have an important role to play in covering future heat demand. Domestic biofuels and renewable energy-based electrification of urban public transport can contribute significantly to transport needs.

To successfully harness these abundant resources, a better understanding and mapping of the available resources is needed to help governments establish ambitious yet realistic targets and effective supporting policies.

IRENA'S GLOBAL ATLAS: THE LARGEST REPOSITORY OF RENEWABLE ENERGY RESOURCE DATA

The IRENA-facilitated Global Atlas is the largest ever initiative undertaken to assess renewable energy potential on a global scale. Starting with wind and solar, it will progressively map all sources of renewable energy. The Internet-based platform is designed to raise awareness of technology opportunities, to optimise measurement campaigns of countries willing to further investigate their technical potential, and as a tool for companies exploring new markets. It provides high quality resource maps from leading technical institutes worldwide, and simplified models for evaluating the technical potential. The dataset is enriched by more detailed national atlases that are validated against measurement campaigns.

Map 2: Distribution of identified renewable energy potential in Africa



Source: IRENA analysis based on the Global Atlas

To date, almost half of African countries have undertaken national resource assessments for one or more renewable energy sources. Solar and wind assessments exist for at least 21 countries, biomass assessments in at least 14 countries, and geothermal assessments are on-going in seven countries. Centres of competence for renewable resource assessments (e.g. in universities) are emerging and there is a growing body of knowledge across African expert institutions. Connecting these institutions can facilitate the systematic development of national atlases and enable the design of specific deployment policies. Knowing the location, size and quality of the resource is not enough to trigger deployment. An attractive economic case is also essential, supported by targeted government policies to help developers and financiers get projects off the ground.

Renewable energy sources are indigenous and therefore enhance countries' energy self-sufficiency by limiting their dependence on fossil fuel imports. Energy self-sufficiency reduces countries' exposure to the price and supply volatility of importing energy, and mitigates the negative economic impact of volatility. The soaring cost of importing refined oil already constitutes a significant burden for African countries and can seriously hinder their economic growth. For example in 2010, African countries imported USD 18 billion worth of oil – more than the entire amount they received in foreign aid. In countries relying on imported fossil fuels for large-scale power generation, power prices are often high. Rural electricity is even more expensive if diesel-based. In addition, oil subsidies in Africa cost an estimated USD 50 billion every year.[3]

Renewable energy technologies are now the most economical solution for off-grid and mini-grid electrification in remote areas, as well as for grid extension in some cases of centralised grid supply with good renewable resources.

RENEWABLE ENERGY: THE MOST ECONOMICAL OPTION IN MANY CIRCUMSTANCES

Renewable power generation now represents almost half of new annual capacity additions globally. This massive up-scaling of deployment is unlocking the benefits of economies of scale and triggering a virtuous cycle of declining costs. In 2012, IRENA published five costing studies covering solar photovoltaics (PV), concentrating solar power (CSP), wind power, hydropower, and biomass for power generation. They showed that

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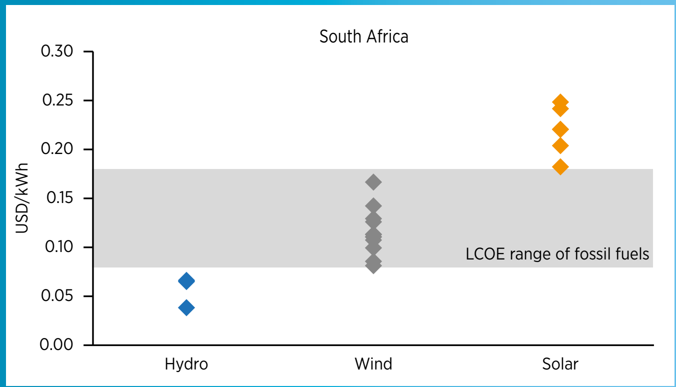
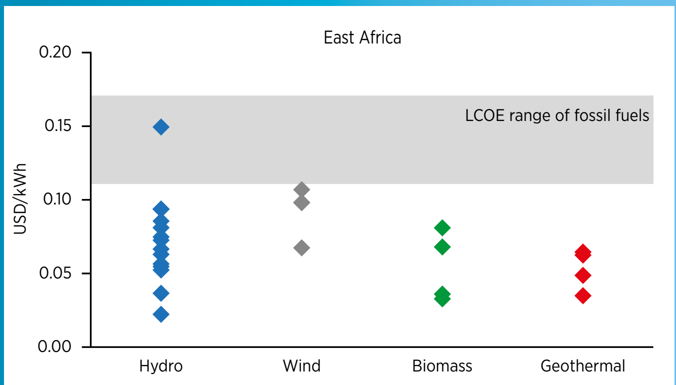
the Levelised Cost of Electricity (LCOE)* is declining for wind, solar PV, CSP and for some biomass technologies, while sustainable hydropower produced at good sites is the cheapest option to generate electricity. Across the spectrum, renewable energy technologies are becoming increasingly competitive with fossil fuel options.

In 2013, IRENA will accelerate the timely collection of data on existing costs and near-term future trends in collaboration with governments, industry associations, project developers, development banks and others, to help policy-makers and regulators adopt more ambitious and effective policies to promote renewables.

Figure 3: Levelised costs of electricity generation for selected grid-connected projects in South Africa and East Africa



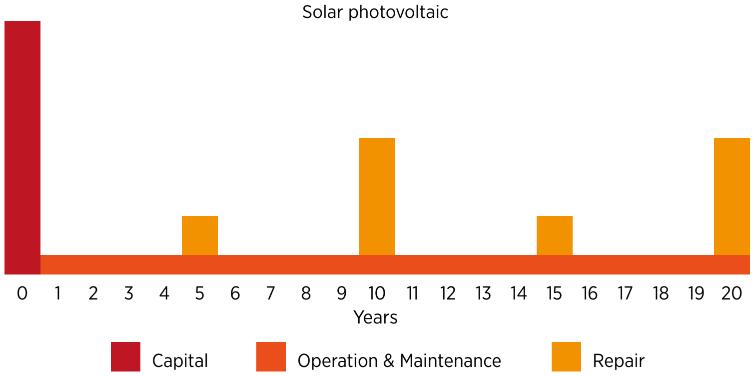


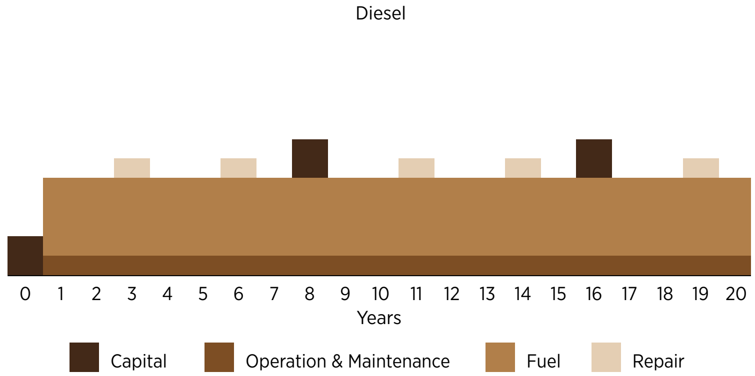
Source: IRENA analysis based on GIZ data

* Note: The LCOE of a given technology is the ratio of lifetime costs to lifetime electricity generation, both of which are discounted back to a common year using a discount rate that reflects the average cost of capital.

Despite a comparably better economic case, obtaining financing for renewable energy power plants is currently more difficult than for fossil-fuel plants. In part this is due to the relative lack of knowledge of renewable energy technologies. Because of this, and a lack of project experience, banks are often either reluctant to finance projects, or agree to finance but at premium rates. And while renewable energy projects are often cheaper in levelised terms, they tend to have higher up-front capital costs, requiring more specific financing schemes.

Figure 4: Comparison of lifetime costs of PV project with diesel generator (indicative distribution)





Source: IRENA

Investors, as well as the industry itself, need to understand and limit the risks of investing in renewable energy projects. They need long-term guarantees to ensure reasonable returns over the lifetime of the project, as some investments last for decades. Confidence in a robust and stable policy framework, as well as in long-term national objectives and targets backed up by sound market forecasts, also play a crucial role in their decisions. Policy makers have an essential role to play in addressing these non-economic barriers (i.e. institutional, regulatory, knowledge, information, infrastructure, technology and market) in order to develop an enabling environment for investors and entrepreneurs.

RENEWABLES READINESS ASSESSMENTS: A COUNTRY-LED PROCESS TO CATALYSE ACTION

IRENA's Renewables Readiness Assessment (RRA) uses an inclusive approach to convene and empower the stakeholders who will help countries transition to a renewable energy. RRAs foster a national dialogue among key stakeholders to identify renewable energy drivers, comparative advantages, and areas for improvement in order to plan the up-scaling of renewable energy. The RRA methodology assesses each country's overall energy market, its renewable energy potential, existing policies and institutional structures, infrastructure synergies, technology feasibility and competitiveness of local manufacturing. To date, RRAs have taken place in seven African countries: Gambia, Ghana, Mozambique, Niger, Senegal, Swaziland, and Zambia.

The revenues of many African public utilities suffer due to the under-pricing of power, in line with the low purchasing power of the population; poor revenue collection; and high transmission and distribution losses. As a consequence, and in order to inject capital for infrastructure maintenance and expansion, many countries have opened their market to Independent Power Producers (IPPs). While tackling inefficiencies in the performance of public utilities remains a priority, stronger regulatory frameworks are needed to create a level-playing field for these IPPs. Governments are applying a range of policy instruments (e.g. fiscal incentives, regulations, access policies, and standardised power purchase agreements) to stimulate IPPs. However, these instruments are proving effective only within a stable policy environment.

TANZANIA: STANDARDISED POWER PURCHASE AGREEMENTS BOOST SMALL-SCALE RENEWABLE POWER

Renewable energy is economically viable in many remote rural areas of Africa, but to undertake projects investors and developers need a predictable business environment. Simple and streamlined power purchase arrangements, licenses and approvals, and technical standards for inter-connection to the grid are essential

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to attract investment. That is why the Government of Tanzania adopted a new Electricity Act in 2008, which is opening the sector up beyond the national utility, and introducing standardised Power Purchase Agreements (PPA) and power purchase tariffs to reduce transaction costs. Under the standard PPA, the buyer is obliged to purchase a certain amount of power, in return for which the seller agrees to follow interconnection guidelines and bear interconnection costs. Both have a legal obligation to keep financiers informed of progress; and the national utility coordinates the interconnection, production and payment process. Since the introduction of these standardised regulations in 2010, the national utility has undertaken standardised PPAs for 40 MW of small renewable energy power projects. These projects are now supplying the national grid with enough clean electricity to light 54,000 rural households.

Governments can use a portfolio of policy tools to support renewable technologies as they mature. Feed-in tariffs and feed-in premiums are standard power purchase agreements with a set price or premium – meaning the developer has a price guarantee for a fixed period of time. They are well established, especially in Europe, where costs of such schemes are typically passed onto electricity consumers. They have also been implemented in several African countries. However, local conditions must be favourable to the implementation of each specific instrument. In the case of feed-in tariffs or premiums in developing countries, the spending power of consumers is limited and requirements for new capacity are often much higher than in developed markets due to high economic and population growth.

Streamlining and standardising procedures can also be an important element of successful public policies. Recently, reverse-bid auctions and tendering mechanisms have resulted in competitive prices, while ensuring full government control over technology choice and project size. For large projects, where significant economies of scale can be achieved and which utilise technologies with site-specific risks, such as concentrating solar power and off-shore wind, the price-revealing function of auctions can result in notably lower prices. To maximise additional benefits, governments can also impose other criteria on auctioned projects, including environmental considerations and local manufacturing.

SUCCESSFUL TENDERING PROCESS IN MOROCCO

In 2010, Morocco introduced a new national framework for the deployment of renewable energy, establishing a target of 20% of renewable sources in electricity generation by 2020. A governing agency, the Moroccan Solar Energy Agency (MASEN), was established to manage the tendering process to achieve the solar energy target of 2,000 MW. The tendering process for the 500 MW plant in Ouarzazate, potentially the largest concentrating solar power project in the world (combined with some PV), consists of four phases.

The first phase was a tender for 160 MW, which concluded at the end of 2012. MASEN's role included initial environmental impact assessments and commissioning a pre-feasibility study that determined the type and size of the tendered CSP projects. MASEN also stipulated that 30% of the plant's equipment should come from the local industry, in order to bolster local training and job creation. The World Bank and other International Finance Institutions provided concessional low-interest loans to MASEN, as part of a public-private partnership between MASEN and the project consortium. The winning bid offered to produce electricity at MAD 1.6 (USD 0.189)/kWh – approximately one third lower than MASEN and the World Bank expected. A 25-year power purchase agreement with MASEN will be provided to the winning bid. Commissioning of this phase of the project is planned for 2014.

Governments play a crucial role in coordinating the development of infrastructure at the local, national and international level. Electrification and infrastructure programmes can help connect isolated grids to main grids – realising economies of scale and improving grid balancing and stability. Governments can bring about price convergence by cooperating to build regional long-distance grids, linking abundant and economical resources with centres of high demand. Estimates indicate that power trade at full potential can save African countries an estimated USD 2 billion in annual costs of power system operation and development.[4] Adding renewable energy into existing energy systems brings diversification and resilience.

AFRICA'S MINISTERIAL DECLARATIONS ON RENEWABLE ENERGY

In February 2009, the African Union Assembly of Heads of State and Government decided in Addis Ababa to develop renewable energy resources in order to provide clean, reliable, affordable and environmentally-friendly energy. African governments reaffirmed their political will in 2010, with the Maputo Declaration, which established the Conference of Energy Ministers of Africa (CEMA). In 2011, 46 African countries with the participation of 25 African energy ministers adopted the Abu Dhabi Communiqué on Renewable Energy for Accelerating Africa's Development, which called for the increased utilisation of Africa's renewable energy resources to accelerate development. Similarly, various subsidiary bodies of the African Union have committed to specific strategies and action plans for accelerating the deployment of renewable energy, such as the Programme for Infrastructure Development in Africa (PIDA).

In 2012, African Heads of State endorsed the Programme for Infrastructure Development for Africa (PIDA) including a pipeline of 15 priority energy projects amounting to a total budget of USD 40.5 billion, to be implemented between 2012 and 2020. The project portfolio, selected partly on the basis of the projects' ability to enhance cross-border energy market development, includes nine hydroelectricity generation projects, four transmission corridors, and two pipelines, one for oil and the other for gas. The four corridors include:

• the North-South transmission link, from Egypt to South Africa, with branches mostly into East Africa;
• the Central corridor, from Angola to South Africa, with branch lines into central and western Africa;
• a North African transmission link from Egypt to Morocco, with links via Libya, Tunisia and Algeria; and
• the West African Power Transmission Corridor, linking Ghana to Senegal, with branches.

The scale of the challenge is apparent in Map 3, which shows the real size of Africa compared to major countries: China, India and the United States.

The four planned power corridors will reinforce interconnections across the four established power pools in sub-Saharan Africa:

• The Southern African Power Pool, created in 1995 by 12 Southern Africa Development Community (SADC) countries;
• The West African Power Pool, launched in 2000 by 14 Economic Community of West African States (ECOWAS) countries;
• The Central African Power Pool, established in 2003 by 11 Economic Community of Central African States (ECCAS) countries;
• The East African Power Pool, launched in 2005 by East African countries member of the Common Market for Eastern and Southern Africa (COMESA) and the Nile Basin Initiative, including Egypt and Tanzania.

IRENA SCENARIOS AND STRATEGIES FOR AFRICA

IRENA has introduced a Renewable Scenario for Africa, examining the impact of policies that would actively promote the transition to a renewables-based electricity system by 2030. The scenario projects that the share of renewables in Africa can increase from 17% in 2009 to 50% in 2030, and nearly 75% by 2050. Total installed renewable capacity would grow from 28 GW in 2010 to around 800 GW by 2050, with solar photovoltaic accounting for 245 GW; wind 242 GW, hydropower 149 GW, concentrating solar power 94 GW, biomass 69 GW, and geothermal 8 GW. The Renewable Scenario factors in the objective of universal access to modern energy services by 2030, while substantially reducing longer-term costs compared to the business as usual scenario in 2050.

IRENA continues to work with African partners to enhance the Renewable Scenario with more detailed data and tools. In support of the scenario analysis, IRENA has developed a series of power system planning models for the Southern, Western and Eastern African Power Pools based on master plans in the region. These models can help with better investment planning and analysing the potential role of renewable energy technologies in the framework of overall power sector development.

Cross-border transmission can bring important benefits to countries dependent on fossil imports, or to countries with less abundant economical renewable resources. Power trade can be particularly helpful for countries with very small loads, where economies of scale are hard to obtain.

Map 3: Major transmission lines (simplified) in Africa

Source: IRENA, adapted from United Nations Cartographic Section map 4045 Rev.7, Environmental Systems Research Institute, Africa Infrastructure Country Diagnostic GIS data (the World Bank)

THE ETHIOPIA–DJIBOUTI INTERCONNECTOR: EAST AFRICA'S FIRST CROSS-BORDER POWER CONNECTION

Ethiopia's power system is based mostly on hydroelectricity and benefits from low production costs, while its neighbour Djibouti is highly dependent on oil and therefore exposed to substantial price volatility. Djibouti decided to look next door for alternatives.

In November 2002, the two countries agreed to connect their grids – allowing an installed capacity of 35 MW to be transported to Djibouti from Ethiopia through a 230 kV transmission line. In 2004, the African Development Bank agreed to finance the project. The double-circuit transmission line was completed in 2012 – the first cross-border power connection in East Africa. In addition to providing 33,000 people in Djibouti with cheaper power, the project also provides electricity access to rural communities in Ethiopia's border areas. Six health centres, catering to nearly 22,000 people, are slated to get power for refrigeration, and nearly 9,000 new consumers in 12 border towns will have electricity connections for the first time. By replacing 65% of its fossil fuel-generated electricity with electricity from Ethiopia's renewable sources, Djibouti is reducing both its electricity bill and its carbon footprint.

Interconnecting power grids are not limited to trading power with immediate neighbours. Cost-competitive and clean electricity can flow across several countries to supply centres of high demand. East Africa has significant renewable energy potential for grid integration, which can be used to power both its own growth, and help potentially meet rising power demand in Southern Africa, currently covered by unsustainable coal-fired generation.

THE EAST AND SOUTHERN AFRICA CLEAN ENERGY CORRIDOR: FUELLING GROWTH AND ENERGY SECURITY WITH COMPETITIVE POWER

East Africa is growing fast, as are its power needs. In the next two decades, electricity demand in the region is expected to quadruple. The power needs of South Africa are of a larger magnitude, are mostly fuelled by polluting coal-based generation and are also growing. Ethiopia, Kenya and Tanzania combined have identified about 15 GW of cost-effective geothermal potential and 40 GW of cost-effective hydro potential. Substantial wind potential also exists, of which 8 GW has already been identified as economically competitive. Moreover, typical costs of USD 0.03 to 0.08 per kWh for large-scale hydro, USD 0.05 to 0.10 for geothermal, and USD 0.05 to 0.14 for wind power are competitive with prevailing electric tariffs, which range from USD 0.06 to 0.17 in East Africa and are as high as USD 0.13 to 0.16 for most of Southern Africa.

A strong transmission grid linking east to south can move clean, low-cost renewable electricity from areas of abundance to areas of high-demand, while reducing current reliance on fossil fuels. But to drive the integration required by such a project would require greater legal, institutional, and technical capacity within regional power pools. IRENA will work with all major stakeholders to develop an action agenda for the East and Southern Africa Clean Energy Corridor, and will assist in raising the profile of cost-effective investments with governments, multilateral development banks, and financial institutions.

Large-scale renewable energy projects unlock economies of scale. They also improve energy diversification and shield countries from fossil fuel price volatility. Other benefits include direct and indirect job creation. Renewable energy pilot programmes supported by national governments and international partners can create a virtuous cycle where trained technicians become renewable energy entrepreneurs, creating new jobs and passing on their skills.

SOCIO-ECONOMIC VALUE OF RENEWABLE ENERGY

During 2012, IRENA produced several publications illustrating the additional benefits of renewable energy deployment, namely job creation, improvement of local skills and creation of income-generating activities. The renewable energy sector can become an integral part of local economies, integrated both through upstream supply chain, such as production of equipment components, and downstream energy-related services, such as maintenance. In 2013, IRENA will complete its analysis of the benefits of renewable energy, elaborating on job creation in all energy uses, extend it to broader value creation opportunities within an economy (impact on GDP, fiscal transfers, balance of trade, and local value creation) as well as the enabling policies required to maximise value creation from renewable energy deployment.

African countries can create local value along the chain of materials, components, construction, operation and maintenance required for renewable energy projects. These tasks represent the majority of jobs across the value chain for many renewable energy technologies. For hydropower projects, the civil works (which can be carried out with local resources) can represent up to 65% of the value chain. For geothermal projects, more than half of the investment costs can be sourced locally. For concentrating solar power (CSP) projects, the different technologies offer different short-term opportunities. The vacuum tubes and parabolic mirrors required in parabolic trough plants are produced in a few dedicated facilities in Europe and the US, and would require massive scale-up before considering local manufacturing. For solar towers, the other main CSP technology, the flat mirrors, mirror support structures, heliostats and the tower itself, can be produced locally in many countries. This enables up to 60% of the capital expenses for CSP solar towers to be sourced locally.

MOZAMBIQUE'S FUNAE: A BEST PRACTICE RURAL ELECTRIFICATION FUND

Mozambique's public fund, Fundo Nacional de Energia (FUNAE), was established in 1997 to promote sustainable rural electrification and rural access to modern

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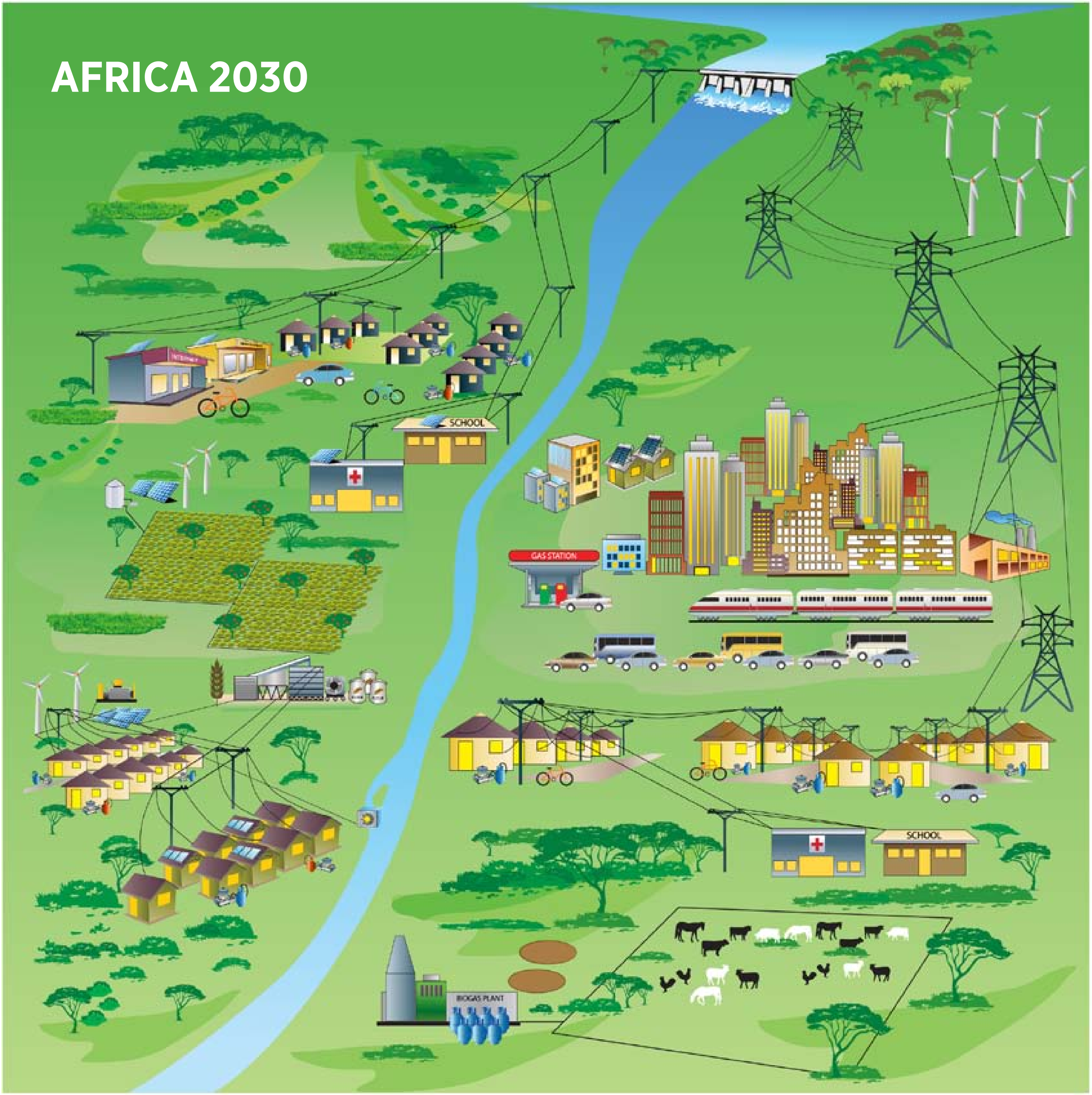
energy services. FUNAE has implemented numerous successful solar, wind and hydropower projects to bring access to modern energy services (e.g. water pumping, crop grinding, and communications) to schools, clinics, and communities. Thanks to these projects several hundred villages, schools and clinics now have access to electricity. Together with technology deployment, FUNAE has developed operation and maintenance capacity and has initiated a programme to train solar technicians in all provinces of the country. Inspired by the success of solar photovoltaics within the programme, FUNAE has helped to develop plans for a USD 13 million solar module manufacturing plant, aiming to sell solar modules in Mozambique and neighbouring countries. Construction of the plant in Beleluane, in the Maputo Province, started in April 2012 and was expected to be completed within a year.

Several renewable energy projects in Africa have also resulted in construction projects and the development of basic infrastructure, including roads, adding further to the local value of projects. Developing local capacities helps to reduce the cost of importing equipment, contributes to economic development, and opens up employment opportunities in research and development, manufacturing, construction, installation and maintenance, as well as engineering.

Attracting private investment in the local supply chain requires identifying components with a clear comparative advantage over imports. Market volumes need to be sufficient and secured by long-term contracts to justify local investments. Economies of scale can be enhanced by regional cooperation and the facilitation of inter-regional trade, but such cooperation requires the articulation of a shared regional vision to send a strong political signal to investors.

Any long-term vision for Africa needs to take account of two very different sets of challenges: those faced by African cities and those faced by rural areas. National governments and local authorities will have an important role to play in designing sound and integrated urban and rural policies to meet the growing demand for power, heat and transport of both urban and rural populations, as well as to ensure convergence in urban and rural living standards.

AFRICA 2030



A Renewable Future for Africa's Cities

The African urban population is projected to triple over the next 40 years.[5] These cities of the future will be powered by a mix of domestic fossil and renewable sources through stronger, more interconnected and more reliable grids than today. Interconnecting African countries through long-distance transmission, a process that is already underway, will help bring power from abundant renewable resources, mostly hydropower and wind but also geothermal and solar, to urban demand centres. These untapped resources are enormous compared to current energy needs and can be delivered at affordable costs.

UNTAPPED RESOURCES: PIDA HYDROPOWER PROJECTS TO BE IMPLEMENTED BY 2020

In 2012, at the 18th Summit of the African Union, African Heads of State endorsed a set of priority energy projects to be implemented by 2020 as part of the larger Programme for Infrastructure Development for Africa (PIDA). Nine hydropower projects were identified for this phase, amounting to more than 50 GW of potential capacity:

1) Great Millennium Renaissance dam in Ethiopia (5.25 GW)
2) Mphanda–Nkuwa project in Mozambique (1.5 GW)
3) Inga hydropower projects in the Democratic Republic of Congo (43.2 GW)
4) Hydropower component of the Lesotho Highlands Water Project Phase II (1.2 GW)
5) Sambangalou project on the Gambia River (64 MW)
6) Kaleta II in Guinea (117 MW)
7) Batoka Gorge project on the Zambia–Zimbabwe border (1.6 GW)
8) Ruzizi III project in Rwanda (145 MW)
9) Rusumo Falls development being pursued by Tanzania, Rwanda and Burundi (61 MW)

Continued policy innovation will be decisive to ensure the large-scale deployment of renewable energy sources. In several African countries, the power sector is already open to private sector participation, and additional power generating capacity is being secured in new ways. For large-scale projects, public-private partnerships are providing an effective means to structure collaboration, in which partners jointly plan and execute activities, distribute costs and risks, and share benefits. Governments benefit from the technical expertise and capital of private partners, while the private sector benefits from the reduced risk brought by the participation of

UGANDA'S BUJAGALI HYDROELECTRIC POWER PLANT: FINANCING THROUGH PUBLIC-PRIVATE PARTNERSHIPS

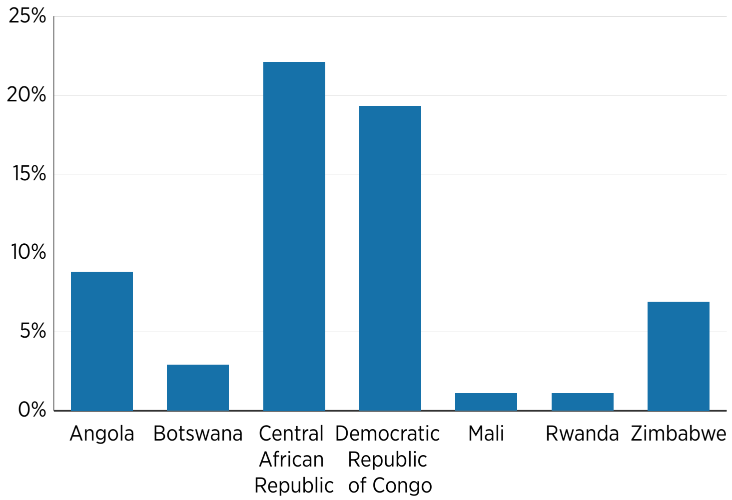
Despite being one of Africa's fastest growing economies, Uganda had one of the lowest electrification rates in the world. Only 2% of its rural population had access to electricity, and the country suffered from frequent rolling blackouts – requiring expensive emergency generation, costing USD 9 million per month. In 2007, to meet these shortfalls, the government decided the least cost option was a USD 860 million hydroelectric power plant in Bujagali, 8 km down the Nile from Lake Victoria. However, it needed financiers and large hydropower developers to implement the project.

The government established a public-private partnership called Bujagali Energy Limited, which would own the plant for a 30-year concessionary period before transferring it to Uganda. Multilateral lenders including the World Bank, the European Investment Bank, and the African Development Bank joined in with private financiers, such as South Africa's ABSA Capital and Standard Chartered Bank. Commissioning of the dam took place in August 2012. Today the 250 MW hydropower plant meets half of Uganda's energy needs. The project's construction created over 3,000 local jobs. Bujagali was registered in 2012 as a Clean Development Mechanism project, making it the largest ever registered in a Least Developed Country.

the State. Power consumption practices need to change too. For example, between 1992 and 2006 South Africa added an average of 350,000 new electricity connections per year and put itself at the forefront of smart-metering policies. Consumers were provided with an intelligent interface that monitors their electricity consumption patterns, and tailors electrical appliances usage to benefit from lower charges at certain times of the day.

Power consumption in business and industry also needs to change. Today, unreliable power services mean that businesses and factories are frequently interrupted, reducing profits and requiring an array of back-up sources. These often come in the form of diesel generators, which are polluting and require costly fuel inputs. The distributed nature of renewable power generation can also help to alleviate the problem of power service unreliability. Power can be generated much closer to the point of consumption, thereby reducing the probability of service failure on transmission or distribution networks. When the policy framework of a country allows it, businesses can become power generators themselves, serving their own demand or even supporting the grid, for example with solar systems with batteries, which have lower lifecycle costs than diesel generators.

Figure 5: Losses due to electrical outages as percentage of annual sales (2010 and 2011 data)



Source: IRENA based on World Bank Enterprise Survey Data

For larger commercial and industrial applications, African urban communities can convert municipal and industrial waste into electricity and heat. Co-generation plants fuelled by waste provide power and heat services to industries that were the origin of the waste, creating a virtuous cycle of energy consumption. This option is suitable, for example, for waste from sugarcane production (bagasse, a waste by-product of sugarcane crushing), paper production (black liquor), or food production (e.g. waste from slaughterhouses, rice and coffee husks, coconut shells, etc.).

CO-GENERATION IN MAURITIUS: CLEAN POWER FROM INDUSTRY BY-PRODUCTS

The Mauritian Government has played a significant role in the development of bagasse co-generation through the passing of two instrumental laws: the 1985 Sugar Sector Package Deal Act and the 1988 Sugar Industry Efficiency Act. This legislation has improved the business environment of the sugar industry and provided tax incentives for investments in electricity generation. In 1991, the government and the sugar industry created the Bagasse Energy Development Programme to optimise the use of by-products of sugar production, in particular bagasse co-generation.

The heat and electricity from bagasse co-generation is used first to meet the energy requirements of the sugar factories. The co-generation plants then operate as independent power producers, selling their excess electricity to the grid through 20-year power purchase agreements with the public utility – the Central Electricity Board. In 2009, bagasse co-generation represented 20% of Mauritius' total electricity consumption, providing a number of benefits – including a reduced energy import bill, diversification of the electricity generation portfolio, and improved efficiency in the power sector. Generation from bagasse is expected to double by 2015 as a result of the commissioning of higher efficiency turbines, and will play a central role in meeting the country's goal of 35% of electricity generation from renewables by 2025.

Renewable energy also offers a compelling source of heat for Africa's cities. Smaller heat applications, which require relatively low temperature levels, such as water heating for households and the commercial sector, do not need electric boilers. Solar water heaters offer a mature and cost-competitive alternative, making power supplies available for activities that generate more value-added. Domestic solar water heaters have been successfully introduced in Asia and in southern and northern Africa, with eastern African efforts recently starting in Kenya. Small-scale heat pumps can also provide heat at competitive prices and can be adopted in places where land for their installation is available. Building standards can enable the rapid adoption of these technologies, which are economically viable for residential and commercial buildings.

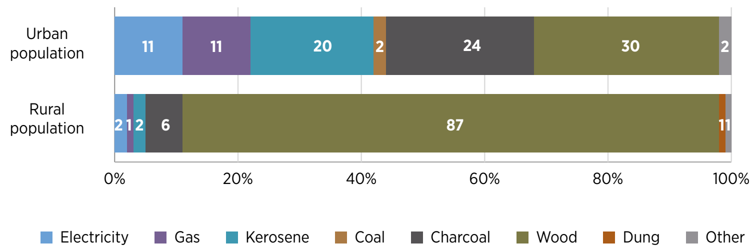
RENEWABLE WATER HEATING IN SOUTH AFRICA: SAVING ELECTRICITY AND CO_2

The South African Government has set a target of 10,000 GWh of renewable energy in final energy consumption by the end of 2013. Solar water heating as well as the use of residential heat pumps are contributing significantly to this goal. Electric water heaters can account for 30–50% of the electricity consumed by an average household. By implementing solar or heat pump technologies, a large part of household demand for electricity, currently generated mostly from coal, can be saved.

Since 2009, the South African Government has supported these technologies through schemes, in which a rebate is paid directly to consumers, provided the product, supplier and installers are registered in the programme. The rebate significantly reduces the cost of solar or heat pump systems, making water heating more affordable for a large segment of customers. As of January 2012, 180,000 applications had been received for the solar water heater rebate programme.

Due to climate conditions that range from mild to hot, a large part of heat demand in Africa is for domestic cooking. For the most part, people still rely on inefficient traditional fuels, such as wood and charcoal. In 2010, only 32% of African people had access to clean cooking facilities, although the situation differs significantly between urban and rural settings. In urban areas, 56% of the people have access to clean cooking facilities, while in rural areas, only 17% of the people do.

Figure 6: Share of population relying on different types of cooking fuels in sub-Saharan Africa in 2007



Note: Wood includes wood, wood chips, straw, and crop residues. Gas includes natural gas, LPG, biogas and ethanol. Coal includes coal dust and lignite. Kerosene includes kerosene and paraffin. Other includes other fuels, "no cooking in the house" and missing data.

Source: *The Energy Access Situation in Developing Countries*, United Nations Development Programme and World Health Organization, 2009

The widespread issue of using inefficient traditional fuel for cooking requires urgent solutions to avoid serious health and environmental implications (i.e. indoor air pollution and deforestation). Renewable energy-based solutions to improve cooking practices (e.g. improved cook stoves or biogas-based technologies, among others) are effective in reducing polluting fumes. In addition, improved cook stoves can save 35%–80% of wood or charcoal compared to traditional three-stone fires.

IMPROVED COOK STOVES IN MALI: SAVING LIVES, FORESTS AND MONEY WHILE CREATING JOBS

In Mali, over 90% of households meet their domestic energy needs with wood and charcoal, putting enormous pressure on national forests. Katènè Kadji, an Economic Interest Group created in 1996, is addressing this issue by manufacturing and distributing an improved cook stove. The "SEWA" stove uses 45% less charcoal, and significantly reduces carbon monoxide and carbon dioxide pollution – which kills more than 38,000 people per year in the country, mainly women and children. While more expensive than the alternatives, the stove has achieved a 47% market penetration rate in the capital, Bamako. The stoves' success is due to government support and to a marketing campaign that educated customers about the cook stoves' financial and health benefits. Thanks to its environmental benefits, in 2007 Katènè Kadji developed Mali's first Gold Standard (GS414) carbon credit project, which allowed it to reduce the stove's price by a third. More than 200 independent blacksmiths now manufacture SEWA stoves throughout the country.

Liquefied Petroleum Gas (LPG) is also widely utilised in cooking applications, providing a more efficient use of energy than traditional biomass. However, LPG operating costs are relatively high and are subject to global oil price volatility. LPG is a viable alternative when households are already making a financial payment for energy, like buying charcoal or wood, which is most common in semi-urban and urban areas.

Biogas-based technologies offer a renewable energy solution suitable for areas with a stable supply of organic waste, which can be found in both urban and rural settings. Biogas digesters come in different sizes and can serve a range of users, from individual households to municipalities. Cities can take advantage of landfills, sewage and other organic wastes to recuperate biogas.

"COWS TO KILOWATTS" PROJECT IN NIGERIA: BIOGAS AND FERTILISERS FROM SLAUGHTERHOUSE WASTE

The Bodija Abattoir in Ibadan, Nigeria, slaughters and processes more than 1,000 cows per day. In 2008, it inaugurated the award-winning "cows to kilowatts" scheme, designed in collaboration with a technology institute in Thailand. It makes use of slaughter-house waste to produce biogas for clean cooking fuel and power generation, as well as fertiliser for low-income farmers. Approximately 1,800 cubic metres of methane per day are used as household cooking gas to be sold locally to around 5,400 households each month at significantly lower cost than currently available sources of natural gas. The plant can also produce up to 1 MW of electricity. The left-over sludge from the reactor is used to create 1,500 litres of environmentally safe organic fertiliser for low-income farmers, reducing water pollution. The project has created local jobs and stimulated local industry. As abattoirs are common in most cities, the Bodija Abattoir biogas project is replicable across Africa, and can help build more sustainable towns and cities.

Transport is, and will remain, the most challenging sector to replace fossil fuels with renewable energy. Nonetheless, the sector is expected to develop rapidly as African economies grow, and as cities with over 1 million inhabitants (megacities) multiply. In 2025, there will be 50 megacities in Africa[5], and well-functioning public transport will be essential to reduce congestion and air pollution in all of them. Urban trains can be fully powered by renewable electricity, and buses can be fuelled by a mixture of liquefied gas and biogas. Biofuels can also play an increasing role, if produced sustainably without threatening food production.

MUMIAS SUGAR COMPANY LIMITED (MSCL), KENYA: FIVE REVENUE STREAMS INSTEAD OF ONE

Mumias Sugar Company produces approximately 60% of the sugar in the Kenyan market. The company used to generate just enough electricity and heat for its own use through the combustion of the bagasse waste by-product from sugarcane crushing. In 2008, Mumias developed a modern co-generation unit to produce renewable heat and power from bagasse, which today generates a surplus of 26 MW of electricity. This is sold to the Kenyan national grid, securing a second income stream for the company. Mumias gained a third revenue stream by registering the project as a Clean Development Mechanism (CDM) project, which produced 140,544.8 certified emission reduction credits between October 2008 and June 2011. In June 2012, the company commissioned a distillery plant with an annual capacity of 22 million litres, producing anhydrous alcohol for blending with petrol to produce gasohol for vehicles – adding a fourth revenue stream. The company now plans to register the distillery as a CDM project – bringing its total revenue streams to five.

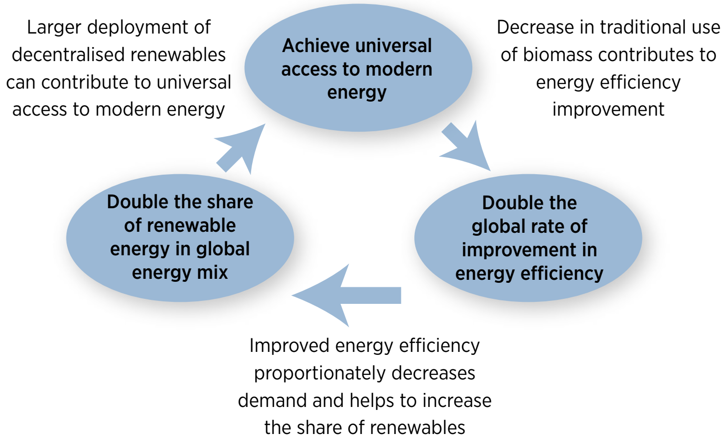
As highlighted in the examples above, renewable energy can significantly contribute to provide energy access in Africa's growing cities, strengthen power reliability, address local pollution, and improve the performance of businesses and industry.

A Renewable Future for Rural Africa

Despite rapid urbanisation, at least 40% of Africa's future population is expected to live in rural areas in 2050 and will need access to modern energy services. Africa's large agricultural sector and rural economy will continue to play an essential role in the continent's economic growth. Currently, large parts of rural Africa face specific energy challenges including lack of access to electricity and clean cooking facilities as well as low population densities and the distance to national grids.

If current African development trends continue, almost 600 million people in rural areas will still lack access to electricity in 2030, and an even larger number will lack access to clean cooking facilities. Bringing power to isolated communities is essential, not only to improve the quality of individual lives, but to kick-start businesses and industries. Distributed renewable energy technologies can contribute to meeting this challenge.

Figure 7: Virtuous cycle of SE4ALL goals



Rural renewable energy development requires dedicated policies. Large-scale power plants appropriate for an urban environment are not necessarily suited to power remote, low density areas. The present scale of rural demand often does not justify the cost of grid expansion, but mini-grids and stand-alone off-grid solutions can offer a viable alternative. Public policies focused on mini-grid and off-grid solutions can create a favourable environment for rural entrepreneurs to become small power producers, and help meet rural electrification needs. Technical solutions should be grid-compatible as over time mini-grids can be expanded and even integrated with the central grid.

GHANAIAN SOLAR: SHARING INFORMATION BETWEEN ENTREPRENEURS

Wilkinsolar is a Ghanaian social enterprise, which develops solar systems for people not connected to the electricity grid. Since 2004, the enterprise has developed and sold solar-powered lanterns to replace more expensive and unhealthy kerosene lanterns. The company found its customers were also looking for energy solutions to charge their mobile phones and listen to the radio, so has developed products to meet these needs. In 2012, the company attended a South-South Clean Energy Enterprise Technique Transfer seminar in Bangalore, organised by IRENA to build capacity in solar entrepreneurs. At the event Wilkinsolar was introduced to India's social enterprise SELCO and went on to visit the company's CEO in Bangalore. SELCO India has installed solar light systems in 125,000 houses and has played a significant role in improving the living conditions of households in rural India, especially in the state of Karnataka. Wilkinsolar learned from SELCO's customer-driven approach, general operations, state of the art accounting systems, and end-user finance programs, and this year saw its highest sales since it started operations: 1,570 solar home systems and over 6,000 solar lanterns as of mid-2012.

Most African rural communities are characterised by low population densities resulting in high connection costs. Demand is mostly for household and agricultural use, and rural customers often have more limited financial resources. In such a setting, entrepreneurs can play a crucial role in meeting rural, decentralised demand. However, they can only operate in a suitable business environment, which needs to be established by governments.

THE INTERNATIONAL OFF-GRID RENEWABLE ENERGY CONFERENCE (IOREC): KEY CONCLUSIONS

The IOREC, organised by IRENA along with the ECOWAS Regional Centre for Renewable Energy and Energy Efficiency and the Alliance for Rural Electrification, was held in Accra, Ghana in November 2012. The conference was attended by over 350 delegates from

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80 countries, including representatives from rural electrification agencies and Ministries in charge of renewable energy development from around 30 African countries.

The main conclusions of the conference included:

- Off-grid renewables-based solutions should be an integral component of sound national electrification strategies. They have the potential to fill the demand-supply gap and can supplement the grid to achieve rural electrification goals.
- Dedicated off-grid support policies should create enabling regulatory frameworks to drive rural electrification.
- Market distortions, such as fossil fuel subsidies (e.g. kerosene or diesel subsidies) hamper the uptake of off-grid renewable energy, despite its cost-competitiveness.
- Local banks can extend access to credit for households and businesses, allowing the adoption of cleaner technologies, and supporting related services such as maintenance.
- Governments should create awareness of the benefits associated with off-grid renewable technologies, highlighting their importance for productive uses and their favourable life-cycle costs.
- Capacity building, which facilitates uptake of off-grid renewable energy systems, should be supported for all actors along the rural electrification value chain – public institutions, financing agencies, communities, private sector, etc.

There are three main options to bring electricity access to remote rural areas. The first option is to extend the national grid. Under certain circumstances, grid extension may be the least-cost option. However, in other cases where villages are located far from the national grid, the high cost of extending the transmission grid makes many of these projects unfeasible. In these cases, a mini-grid may be the least-cost option where local renewable resources are located close to a certain level of demand concentration. A mini-grid can power household use and local businesses with almost the same quality and services as the national grid. In the case of isolated households with limited electricity demand, the third option is that of individual energy systems (i.e. solar home systems, wind home systems or pico-hydro systems).

The development of mini-grids can be optimised by using a combination of renewable energy technologies. The reliability of mini-grids based on one renewable technology can be improved by being complemented with batteries, which help reduce the impact of seasonal or weather-related variability. Batteries add stability to the system by storing the energy for peak consumption when there is insufficient production from renewable sources (i.e. to offset the lack of solar power during night-time hours). Since batteries are still relatively expensive, the use of existing diesel systems as back-up can be the most practical solution in some locations to ensure reliable performance of mini-grids. When renewable resources are abundant they help save substantial amounts of fuel, while diesel generators can serve as a back-up when renewable options are not available (e.g. at night for solar PV panels).

MALI DECENTRALISED SOLAR-DIESEL HYBRID PLANT: SAVING ONE-THIRD OF FUEL COSTS

Most rural areas of landlocked Mali are not connected to the national grid – and are instead supplied by decentralised diesel-based generation plants. Faced with rising prices, in January 2011 the rural community of Ouelessebougou, 80 km south of Bamako, partnered with the national utility and a private solar company, ZED Mali-SA, to build, install and operate a supplementary 216 kW peak solar PV plant. The solar arrays of the plant provide electricity during daylight hours, while also charging a bank of 73 batteries, which take over for a few hours when the sun sets. Together, these sources of energy provide electricity for an average 18 hours a day. The thermal generator only needs to provide electricity for six hours during the night, when load is at its lowest. The solar plant has the best performance during the hot and sunny season, for six to eight months a year, and has reduced yearly fuel costs for the thermal plant by one-third. The Government of Mali and the national utility are currently considering introducing hybrid systems throughout the country.

Africa possesses substantial unexploited potential for small, mini and micro hydro energy generation, which can be very economical. Where it is technically feasible, it can constitute the key option for rural electrification, or can be combined with other sources, like solar and wind power. Bringing power to communities enables many productive uses, improving incomes as well as living conditions in remote or isolated communities.

NIGERIA'S WAYA SMALL HYDRO SYSTEM: RURAL POWER SPURS LOCAL INDUSTRY

The Waya small hydropower project was originally designed in 2001 to irrigate 2,000 hectares of agricultural land in Bauchi, northern Nigeria. In 2003, it was chosen as one of two small pilot hydropower demonstration projects, funded by UNIDO and China, to provide electricity to rural communities. Designed, managed and operated locally, today it provides 24/7 electricity to 2,250 people. "We don't have to go to town to grind our maize now," says 38-year old Umar Abdullahi. "We have over nine grinding machines in our area that can take care of our villages and beyond." Aishatu Sani, a housewife, said that since her husband bought a grinding machine they earn between 3,000–4,000 naira (USD 20–25) per day, which helps them to buy food and clothes for their children.

Productive uses of renewable energy in rural areas include water treatment (desalination), water supply (pumping), heating (drying of foods products), and cooling (refrigeration of agricultural and medicinal goods and products).

In North Africa, desalination supplies water for irrigation, industrial and municipal use. Desalination is a very energy intensive process; therefore the cost of desalination is largely determined by the energy costs. Using renewable energy sources such as wind, solar and hybrid systems is a more suitable option than using fossil fuels, in particular for countries where national fossil fuel resources are limited (such as Tunisia and Morocco). To supply water in Africa, there is an opportunity to deploy both solar electric-driven water pumps and wind mechanical-driven water pumps on a larger scale. It is estimated that South Africa alone has over 300,000 wind pumps[6] and several thousand pumps have also been installed in other sub-Saharan African countries, with a capacity in the order of tens of MW. These pump systems are most suited to providing irrigation for fruit farms, which require trickle or drip irrigation. Recent solar panel cost reductions have also broadened the range of economical applications for solar water pumps.

Despite falling technology costs, bringing renewable energy to rural communities remains challenging. This is partly due to the financing structure of renewable energy projects, which is largely up-front capital costs. Local banks can play an important role by offering financial products better adapted to the cash flows of rural communities. Also, to make appropriate financing decisions, banks need to understand the specificities of the technologies they are financing, and the issues related to their installation and maintenance.

GHANA APEX BANK

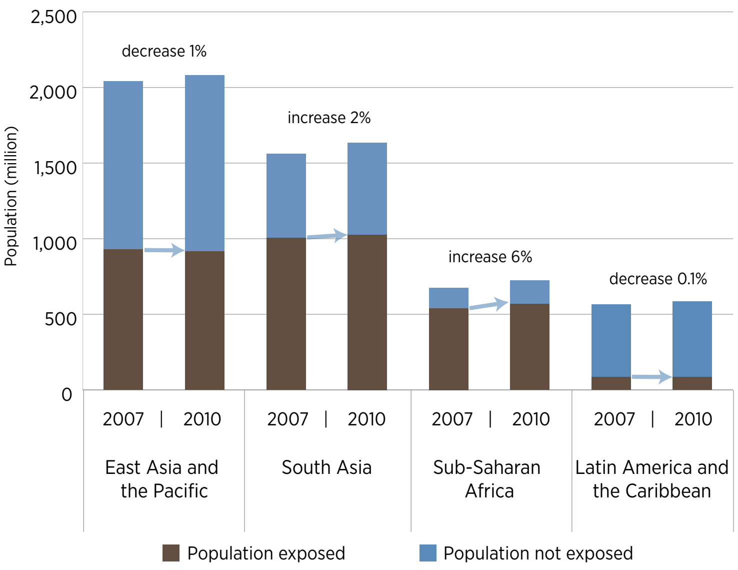
The ARB Apex Bank is the implementing agency of the Ghana Energy Development and Access Project. The bank acts as a mini-central bank by lending capital to a network of rural and community banks across Ghana, which in turn provide financing for solar home systems to rural households. The project targets 1 million households without access to power that will not be reached through grid extensions in the next 5–10 years. The financing scheme has three components – a grant subsidy (30–50%), a 10% customer down payment, and a loan from Apex Bank. Since its start in 2008, the project has steadily gained momentum, and as of November 2012 more than 9,000 household systems had been installed. After a slow start, momentum grew when the bank adapted its services to suit rural households by implementing flexible loan repayment models (six months to three years) based on customer cash-flow. It also built capacity within the bank to understand the technology, and started installation inspections prior to disbursement of funds to suppliers. The bank is working towards its target of 15,000 systems by 2013, benefiting over 90,000 people.

Bringing power to rural Africa constitutes a substantial challenge but it is exacerbated by the even greater challenge of providing clean cooking facilities. Indoor air pollution from solid fuel usage kills 2.4 million people[7] globally every year making it the second most prevalent environmental cause of death after waterborne diseases[8]. While many countries have reduced their population's reliance on solid fuels, sub-Saharan African countries saw a significant increase between 2007 and 2010 of 6% in their populations' level of exposure.

By 2030, all African households can transition to modern uses of biomass as envisioned in the SE4ALL Global Action Agenda (i.e. modern cooking appliances and fuels including biogas and biofuels)[9], enabling women and children to

reallocate the time spent on wood collection to social, educational and productive activities, bringing further future benefits.

Figure 8: Population exposed to solid fuels use for cooking



Source: IRENA analysis based on World Health Organization Global Household Energy Database and World Bank population data

Several solutions to the clean cooking challenge are available. Improved cook stoves are a feasible alternative as they provide multiple benefits: they double or triple the thermal efficiency of traditional fuels, reduce the harmful effects of poor ventilation, and may also provide some co-heating.

IMPROVED COOK STOVES IN NIGER: MORE EFFICIENT USE OF BIOMASS RESOURCES

In 2009, ATPF ("Aménagement de Terroirs et Productions Forestières") a local NGO started promoting forest management in five villages in south-west Niger, near the Dosso wildlife reserve. The region regularly suffers from drought and has a scarcity of natural resources. To preserve dwindling woodstocks, ATPF disseminates improved cook stoves, which use 50 to 65% less wood than traditional three-stone fires. These improved cook stoves are made with local, inexpensive materials using simple techniques. The NGO also launched a campaign to explain the stoves' fuel-saving benefits, and trains women to build them. Over two years, more than 7,000 stoves have been built in the five pilot villages. The project will be expanded to another 24 villages over the next three years.

Similar to urban environments, biogas can be a viable and clean cooking option in rural areas. Feedstock to biodigesters differs in urban and rural environments. In rural environments biogas solutions can be based on agricultural waste or waste from livestock production.

TURNING WASTE INTO RURAL ENERGY: RWANDA BIOGAS

More than 80% of Rwanda's energy comes from solid biomass, which is either burned as is, or turned into charcoal. Such use of biomass is inefficient. To help preserve its biomass resources, the Government of Rwanda is promoting biogas as an alternative fuel for cooking and lighting in households and public institutions. Bio-slurry, a by-product of biogas production, can be used to replace inorganic fertilisers in agriculture. In 1998 the Energy, Water and Sanitation Authority began scaling-up biogas production for cooking and sanitation in schools and prisons. In 2009, it launched an additional programme for domestic cooking and lighting in places without access to electricity. Initially supported by the Government of the Netherlands, since 2012 the programme has been fully transferred to the Government of Rwanda. Every Rwandan with at least two cows is encouraged to build a biogas plant.

Rural heat demand is not limited to household cooking, and its importance will grow as the continent develops. Some agricultural applications require heat supply, and innovative solutions for utilising agro-waste as a feedstock for heat production already exist in several countries. The productive uses of heat and waste heat will also gain im-

portance in rural settings. Efficient drying, cooling and refrigeration systems can save major losses currently caused by the deterioration of agricultural goods and products. In sub-Saharan Africa, grain losses due to poor storage are currently estimated at about USD 4 billion per year.[10] Open air sun drying is common throughout Africa, but modern food preservation technologies are increasingly available. The most promising renewable energy food preservation technologies are solar and geothermal drying.

Modern food-drying technologies have several advantages, including reducing the exposure of products to insects, dirt, birds, mice, and rain. Modern drying also reduces drying time, enabling farmers to get their products to markets faster and cheaper. It also reduces losses related to perishable crops like fruits and vegetables, while boosting the quality of cash crops. Solar drying technologies, which can include direct dryers, indirect dryers, and forced circulation dryers, have been successfully piloted in Africa. Geothermal energy has been successfully employed for fish drying in Iceland, and the technology can equally be applied to Africa's fishing industries. Kenya already uses geothermal heat in greenhouses for flower production.

GEOTHERMAL GREENHOUSES IN KENYA: PRODUCTIVE USES OF HEAT

Oserian is the largest flower farm in Kenya, employing 4,500 people and exporting up to a million flowers per day to Europe and North America. Its flowers are grown over 200 hectares of land, including 50 hectares of greenhouses that make use of geothermal heat.

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Geothermal steam is run through heat exchangers that heat fresh water, which is then circulated through the greenhouses in pipes to raise the ambient temperature of the air, and thereby accelerate the flowers' growth while also warding off pests. In parallel, steam is run through a 2 MW power plant to generate electricity for the complex, which runs the geothermal steam system. The use of low-carbon geothermal steam means that the life-cycle carbon emissions of Oserian flowers are much lower of those grown in greenhouses elsewhere.

Renewable energy-based rural transport options, similar to urban options, remain relatively modest, but sustainable production of bioethanol and biodiesel can be a cost-competitive option in many rural settings. Biodiesel can be used directly in agricultural machines, as well as to supply existing diesel generators for rural electrification.

FASO AND MALI BIOCARBURANT: BIOFUELS FOR TRANSPORT AND DIVERSIFIED FARMERS' INCOME

Faso Biocarburant and Mali Biocarburant are two biofuel companies that work with over 8,000 smallholder farmers in Mali and Burkina Faso. These farmers grow

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jatropha, a non-edible oil crop mostly used for the production of biodiesel for diesel engines (i.e. cars, industrial machines and generators). Its seed cake, which is a waste by-product of biodiesel production, can be used as a rich organic fertiliser. The farmers sell their jathopha to the company, and are also partial shareholders: they benefit both from the sale of biodiesel and from dividends of the company. Growing and selling jatropha enables farmers to diversify their sources of income and improves their food security. By selling the carbon credits Mali Biocarburant and Faso Biocarburant generate, this became the first project in Africa to give smallholder farmers access to carbon offset financing.

The provision of modern energy services can help to create a virtuous cycle of economic development in African countries. Cities are major drivers of economic growth, creating wealth and sizeable demand for rural and agricultural products, thereby enabling the shift from subsistence to commercial agriculture. In rural areas, higher agricultural productivity enables diversification of non-agricultural, income-generating activities (e.g. food processing, construction, businesses and services).[11] Economic integration of rural and urban areas is essential to sustain Africa's growth and to promote the convergence of living standards for all Africans tomorrow.

THE ROAD TO A RENEWABLE FUTURE

Africa's population is set to double by 2050 and its energy needs will grow even faster. If current growth rates are maintained Africa's GDP will increase seven-fold by 2050. Providing full electricity access to all Africans will require at least a doubling of total electricity production by 2030 from current levels. The continent's vast untapped renewable energy resources can supply the majority of this future energy demand and are suited to supply both concentrated, high-load urban centres and remote, dispersed rural areas.

Investing in renewable energy in Africa makes good business sense. With world-class solar and hydropower resources, complemented by bioenergy, wind, geothermal and marine resources in some regions, Africa has the opportunity to leapfrog to modern renewable energy. Renewable energy technologies are now the most economical solution for off-grid and mini-grid electrification in remote areas, as well as for grid extension in some cases of centralised grid supply with good renewable resources. Notably, on average, solar photovoltaic module costs have fallen by more than 60% over the last two years to below USD 1/Watt.

African governments are embracing renewable energy to fuel the sustainable growth of their economies. A number of recent Ministerial declarations attest to the strong political commitment and far-sighted vision of African decision-makers, which are being articulated through dedicated regional and national institutions and plans.

Renewable resources are plentiful, demand is growing, technology costs are falling and the political will has never been stronger. The moment is right for a rapid scale-up of renewable energy in Africa.

Governments must provide leadership to create the enabling framework for private investors in Africa's energy sector. Streamlining and standardising procedures is an essential element of successful public policies to promote a sound business environment. In the power sector, improving the governance structure, operational performance and financial viability of national utilities is an important pre-condition to deploy renewable energy at scale.

Local entrepreneurs will be essential for African countries to have electricity access and modern cooking for all by 2030. They already help in meeting both urban and rural demand for energy products and services. Renewable energy champions should be encouraged by governments and their business models should be promoted and replicated. The potential markets are huge, for example, residential solar heat appliances and solar PV panels can improve energy services for millions of African customers.

Expanding regional grid integration and power trade can unlock economies of scale and connect abundant and low-cost renewable energy resources to urban poles of growth. Power trade at full potential can save African countries an estimated USD 2 billion in annual costs of power system operation and development. Regional planning, harmonisation of standards and procedures, equitable commercial terms and coordination at power pools level are all essential elements of successful regional integration.

Off-grid solutions are of particular importance in Africa and deserve dedicated public policies and innovative financing mechanisms to accelerate their deployment. While they represent a small portion of total demand, they enable productive uses and increase incomes. They are crucial to reach universal access by 2030, which can improve the living conditions of millions in remote areas of Africa.

The availability of local financing plays a decisive role in the development of local markets. Commercial banks and financial intermediaries need to be better informed about renewable energy technologies and project profiles. Public financing, either from African governments, international or regional development banks, can be leveraged to reduce financial risk perception by commercial banks.

Ambitious regional grid integration projects such as the East and Southern Africa Clean Energy Corridor have the potential to significantly transform the African energy landscape. Such projects must be backed by strong political commitment and a sound technical rationale. Emerging examples show that public-private partnerships, enabled by sound policies and government leadership, can mobilise significant levels of financing.

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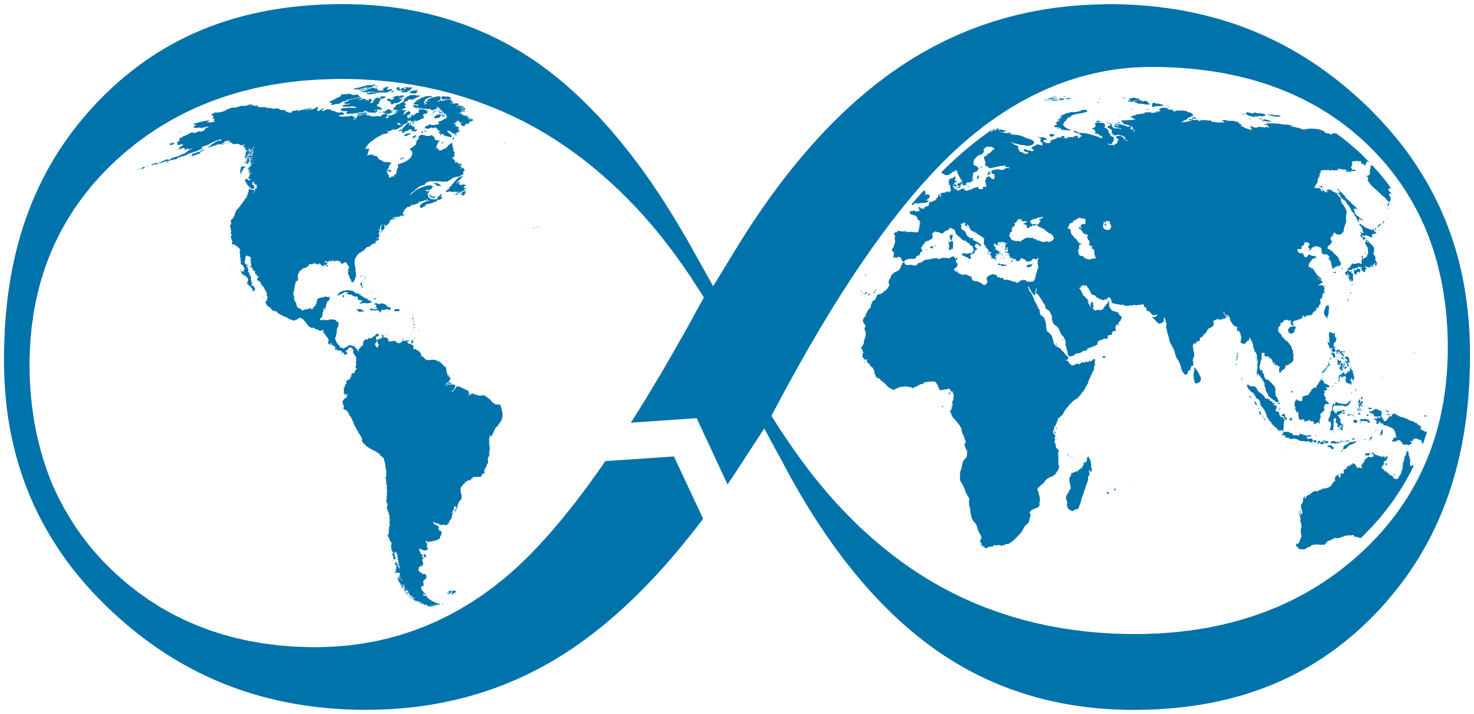

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