# ALTERNATIVES TO HYDROPOWER

FIVAS

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FIVAS – The Association for International Water Studies – is a Norwegian voluntary organization working to monitor the consequences of water projects and developments in the South. The organization seeks to prevent Norwegian participation in projects with major negative consequences for people and nature and works to promote fair and sustainable alternatives.

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**THE COVER:**
The wind energy park Schneebergerhof in Germany.
In the foreground thin film solar cells.
**PHOTO BY ARMIN KÜBELBECK, CC**

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# TABLE OF CONTENTS

# ALTERNATIVES TO HYDROPOWER

## INTRODUCTION

Our argument in this report is that hydropower falls short of being the renewable energy solution. The intrinsic problems of hydropower demands that we explore alternative avenues to supply modern renewable energy.

It has been well documented that large scale hydropower or mega dam projects have considerable consequences for the environment and groups of people living both upstream and downstream of hydropower installations. In many developing countries, dams are built without the full participation and consent of local inhabitants and without the proper environmental and social impact assessments. Local populations rarely receive the necessary compensation for their loss of habitat and livelihood. The subsequent energy that is produced by the dams often bypasses local populations and is sent to regional and national hubs where it is used predominantly to power industrial demands. In addition, the power produced is often too expensive for the majority of rural inhabitants. Or as stated by the REN21 Global status report for 2013:

*"The environmental and social impacts of hydro projects include: potential impacts on hydrological regimes, sediment transport, water quality, biological diversity, and land-use change, as well as the resettlement of people and effects on downstream water users, public health, and cultural heritage"*

P 37. SUSTAINABILITY SPOTLIGHT: HYDROPOWER

Despite the problematic nature of numerous projects hydropower is considered a boon by national governments. National governments are enticed by the onetime investments needed to secure the hydropower projects. The political significance of building a monumental dam also should not be underestimated. Even against mounting evidence that many hydropower plants around the world are underperforming and failing to meet design capacity, hydropower has



### TALKING ABOUT ELECTRICITY

#### *kW, MW and GW*

A kilowatt (kW) is a thousand of a Megawatt (MW). A Gigawatt (GW) is thousand Megawatt.

1 MW= 1000 Kw
1 GW= 1000 MW
1000 Gw = 1 TW

#### *The difference between kWh and kW*

When we quantify electric power we often talk about how much electric energy is consumed or produced. We measure electric energy as Kilowatt hour or kWh. Annual production is frequently listed in Terrawatt hours (TWh).

Watts, or Megawatts and Gigawatts, is a measure for effect. Installed capacity is measured in watts. In short this means how much electricity that can be produced each second.

#### *Some key expressions*

Installed capacity is the capacity of power generation that exists in a power plant or in a system. If a wind mill has a generator that can produce 50 kW and the wind mill is part of a wind park that has ten similar wind mills the installed capacity of the wind park is 500 kW or 0,5 MW.

Grid parity is when the production cost for electricity from a specific plant or technology is similar to or lower than the current prize for electric power in the national grid.

## INTERNATIONAL HYDROPOWER ASSOCIATION

Norway is a key supporter of the industry organization International Hydropower Association (IHA). IHA is promoting a standard for measuring sustainability called the Hydropower Sustainability Assessment Protocol (HSAP). The Protocol is criticized for its potential to sideline other agreed upon regulations and for being voluntary for the IHA Sustainability partners. Statkraft is one of the central partners that have piloted the protocol, and Norway have funded trials in developing countries.

READ MORE ABOUT THE CRITIZISM OF HSAP AT:
**INTERNATIONAL RIVERS**
(HTTP://WWW.INTERNATIONALRIVERS.ORG/CAMPAIGNS/THE-HYDROPOWER-SUSTAINABILITY-ASSESSMENT-PROTOCOL)
**THE INTERNATIONAL NETWORK ON DISPLACEMENT AND RESETTLEMENT**
(HTTP://INDR.ORG/?PAGE_ID=1763)

**FIGURE 1:**

Estimated Renewable Energy Share of Global Electricity Production, end-2012

| | |
|---|---|
| Fossils fuels and nuclear | 78,30% |
| Hydropower | 16,50% |
| Other renewables (non-hydro) | 5,20% |

SOURCE: RENEWABLE ENERGY POLICY NETWORK FOR THE 21ST CENTURY (2013): REN21'S RENEWABLES GLOBAL STATUS REPORT (GSR), AVAILABLE AT HTTP://WWW.REN21.NET/REN21ACTIVITIES/GLOBALSTATUSREPORT.ASPX

upheld its popularity. Large hydro has proven to be risky in the face of future climate changes, rainfall variability, uncertain river flows, failed projects, and poor socio-economic development outcomes for the vast majority of the populations living in these regions. Nevertheless power dynamics seems to favor these large scale installations.

Climate change and the threat of environmental disaster have instigated a drive to reduce our dependence on fossil fuels, nuclear power and other traditional sources and seek out cleaner, more sustainable long-term renewable energy solutions. In response to this drive, a variety of technologies have been developed that can harness the power of the sun, wind, ocean currents and the earths heat. There is mounting evidence to suggest modern non-hydro renewable technologies have the capacity to meet a substantial proportion of our global electricity demand.

This report aims to show how so called new renewables could represent an alternative to hydropower expansion or other unsustainable energy. The report holds an introduction to a range of renewable energy technologies with a view on how they are used today and what prospects they hold.

## NORWAY AND ITS ROLE IN THE HYDROPOWER SECTOR

Norway has traditionally been a large contributor to the global hydropower sector, a knowledgeable and experienced player, capable of offering policy, finance and technical support services to various international hydropower institutions. Support can take the form of bilateral development cooperation, participation of Norwegian state-owned companies in the hydropower market and support for multilateral policy dialogues. This position comes with responsibilities however and Norway has not always managed to keep a clean track record. There are well-documented cases of Norwegian involvement in controversial hydropower projects around the world, from Brazil in South America to Ethiopia in East Africa. Political interests from a large group of hydropower producers, technology industry and a considerable mass of trained professionals within the public and private sphere present a strong force. Norway is a strong promoter of hydropower and is known for its support for multinational organization and regulation. We see it as Norway's role to monitor and set the standards for social and environmental performance

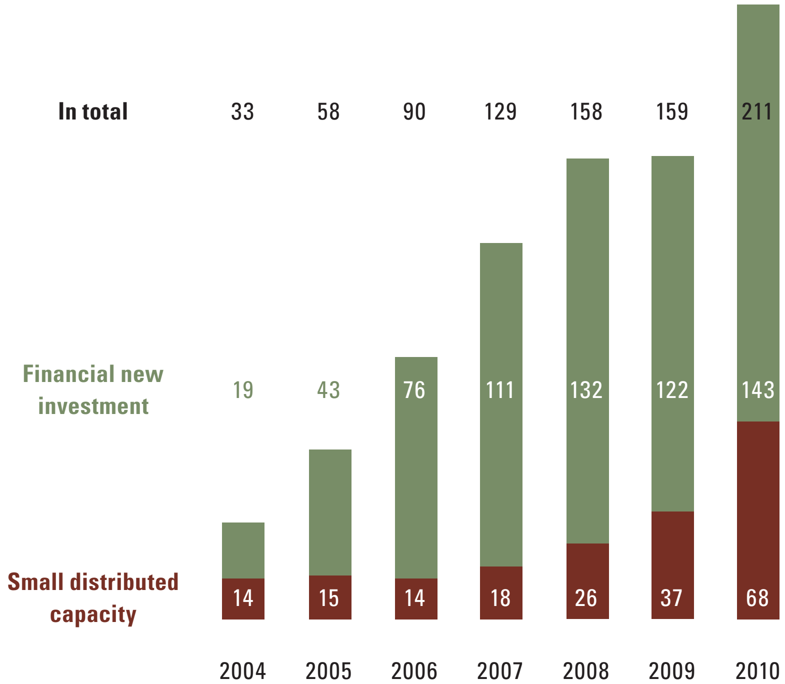



**FIGURE 2:** Global new investment in renewable energy (Billion USD)

SOURCE: BLOOMBERG NEW ENERGY FINANCE, UNEP SEFI, FRANKFURT SCHOOL, GLOBAL TRENDS IN RENEWABLE ENERGY INVESTMENT 2011.

in the hydropower sector as well as lead the way in transitioning to cleaner less controversial forms of support.[1]

## WHAT IS IN THE REPORT?

This report aims to explore how some of these "new" energy sources can meet the increasing need for electric energy and potentially offset further developments and investment in hydropower projects. The first part of the report provides a summary of global developments and trends in the renewable energy sector. Listing wind power, solar power – PV and CSP, bioenergy and geothermal power. The second part of the report is a review of how renewable energy is situated in the different regions of Africa, followed by a case study of energy challenges in Mozambique. In addition, off grid, small scale and less energy intensive development plans are given a focus because this region is characterized by large socioeconomic disparities. This disparity is very obvious when one considers access to clean energy and electricity.

## GLOBAL ELECTRICITY SHARES AND GROWTH FROM RENEWABLES

### *Political support and growth in investments*

It is seen as an important development goal to increase the produc-

## VARIABILITY

Renewable energy sources like wind and solar have well-known variability issues. As the production of electricity from wind mills or solar panels are dependent on the immediate availability of wind or sun rays, and since you cannot store the energy like with hydropower dams, the production will fluctuate with the weather. This variable nature has shown itself time and again as one of the major technical challenges when attempting to integrate renewable power into existing power grids. Small volumes of renewable power added to the grid will hardly be noticed and require little in the way of balancing by utilities. However, as the share grows and more power from renewables are delivered onto the grid, the balancing act becomes more difficult. There are various estimates as to how much variability a system can tolerate but it is agreed that with various investments in grid flexibility, hybrid systems, gas turbines, energy storage and demand management, much greater levels of penetration can be achieved.

Concentrated solar power (CSP) is one of the promising technologies when it comes to mitigating or avoiding variability issues. Storage times for CSP vary now from 4 to 8 hours after the sun goes down. Experts predict that as the technology matures over the longer term, storage capacities will increase.

Hybrid technologies include blending a renewable power source with a fossil fuel like gas. For instance biomass and coal offer good integration potential as the combustion processes used in both are very similar. Wind and solar combined with simple cycle natural gas turbines is also promising and could present an effective means of dealing with integration issues.

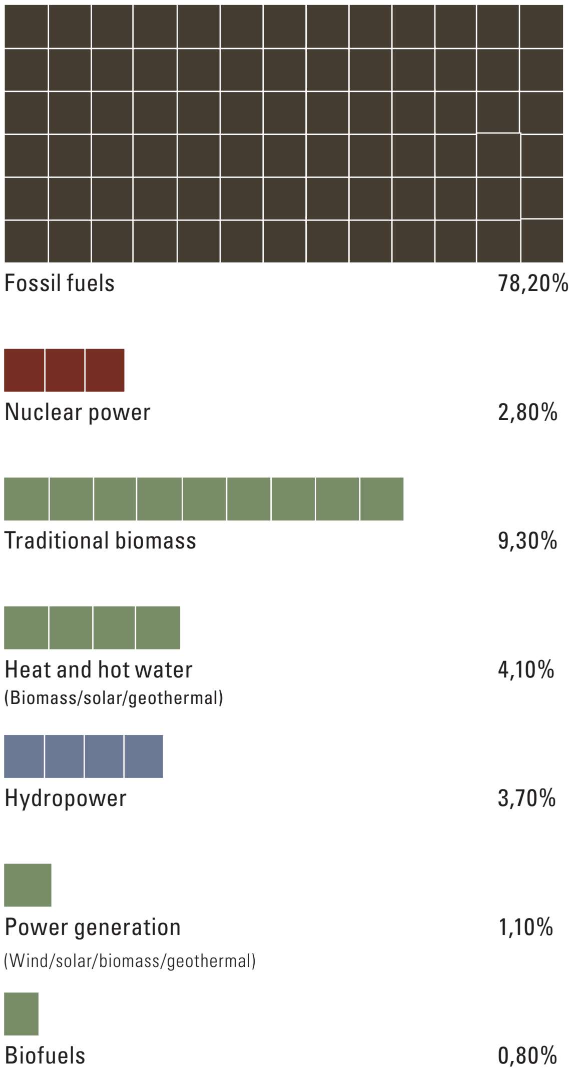



**FIGURE 3:** Estimated Renewable Energy Share of Global Energy Consumption, 2011

SOURCE: RENEWABLE ENERGY POLICY NETWORK FOR THE 21ST CENTURY (2013): REN21'S RENEWABLES GLOBAL STATUS REPORT (GSR), AVAILABLE AT HTTP://WWW.REN21.NET/REN21ACTIVITIES/GLOBALSTATUSREPORT.ASPX

tion of modern energy, especially electricity. Renewable, or sustainable, energy is at the pinnacle of international policymaking with international campaigns like the UN's SE4All (Sustainable energy for all). If we take a global perspective, renewables have taken major strides in contributing to national and regional electricity supply.

21.7% of global electricity production was supplied by renewables by the end of 2012 (fig 1). The largest portion of this was produced by hydropower, accounting for 16.5%. Recent years have seen a huge growth in renewable electricity production. Most remarkable is maybe that 50% of all net additions to electric generating capacity in 2012 came from renewables! A proportion of 20 some percent is not outstanding, but there has been a veritable surge in new money flowing into renewable energy. Of the investment of 244 billion USD almost half was invested in developing countries. Investments in renewable energy have grown almost exponential in the '00 (graph 2), a growth that has continued despite global financial crises. Modern renewables like wind and solar power continue to penetrate deeper into existing traditional electricity markets. The solar industry accounted for more than 57% of the investments in 2012 alone and wind power was the second biggest attractor with almost 33%. The incline in investments in new renewables has still not sidelined hydropower completely. Hydropower made up 30 GW of new additions to power supply in 2012. Solar PV only made up 29.4, and wind made up almost 45 GW.*

As the newer technologies like wind and solar grow and penetrate conventional grids problems can arise as to the variable nature of some renewable sources.

## REGIONAL RENEWABLE SHARES AT A GLANCE

### *EU*

In 2010 close to 20% of EUs electricity production came from renewable energy sources. Countries like Denmark and Germany have aims of renewable energy making up 100% and 60% of their energy supply respectively. The growth in overall renewable energy within EU was some 70% in previous decennium. In 2012, a staggering 70% of all electricity additions in the EU were renewable![2] This is a huge growth and mostly came from windmills and solar PV. By the end of 2012,

* The most common solar panel is a Solar PV, or photovoltaic, -panel. There is more about solar power on page 10.

non-hydro renewables made up more than one-fifth of the EUs total generating capacity.

One major factor driving this growth is the sale of green electricity that customers can choose to buy. Green energy purchasing is highest in Germany and Finland, but large markets also exist in other EU countries like Austria, Belgium, the UK and The Netherlands. Outside of the EU, Japan and the US have established green power markets.

### *North America*

In the United States, while still low, renewable energy shares continue to grow, and this is certainly the case for non-hydro renewables. The renewable share of electricity production in 2012 was slightly over 11%. Renewables like wind, solar and biofuels now provide more power than nuclear and more electricity than oil. Hydropower is by far the biggest with close to 60% of renewable energy production in 2012. Wind energy production has grown by a factor of 16 in the last decade, while solar has grown 5 times as large[3]. Total wind power capacity in the states grew from less than a gigawatt to 65 GW in 2012. And in 2012, wind added most electric capacity of all renewables for the first time. Hydropower output declined in 2012 while other renewables increased their output.

One report attributes the growth to lowered prices for technology, market investment, voluntary buying of green energy by consumers and companies and tax incentives.[4]

# A CLOSER LOOK AT THE DIFFERENT RENEWABLES

## COST

The cost of electricity production varies between different technologies. Of course it also varies within the technologies, according to size, complexity and other factors. Cost is often described as US cents per kWh (or dollars per MWh). When calculating the cost both fuel or inputs and maintenance is considered, as well as the costs of capital. However the cost of transporting the power from the generation site to the central grid is often not included in calculations. This could be a substantial factor for many renewable energy projects.

Open energy information, a contributory project, estimates the leveled cost of a range of different energy sources, renewable and non-renewable. The estimates vary from 1 to 15 cent/kWh, and some as high 28 cent/kWh for the median projects.

As we can see hydro power is by far the most cost effective in the median project. However most large hydro installments in developing countries incur higher costs than 2 cent/kWh.

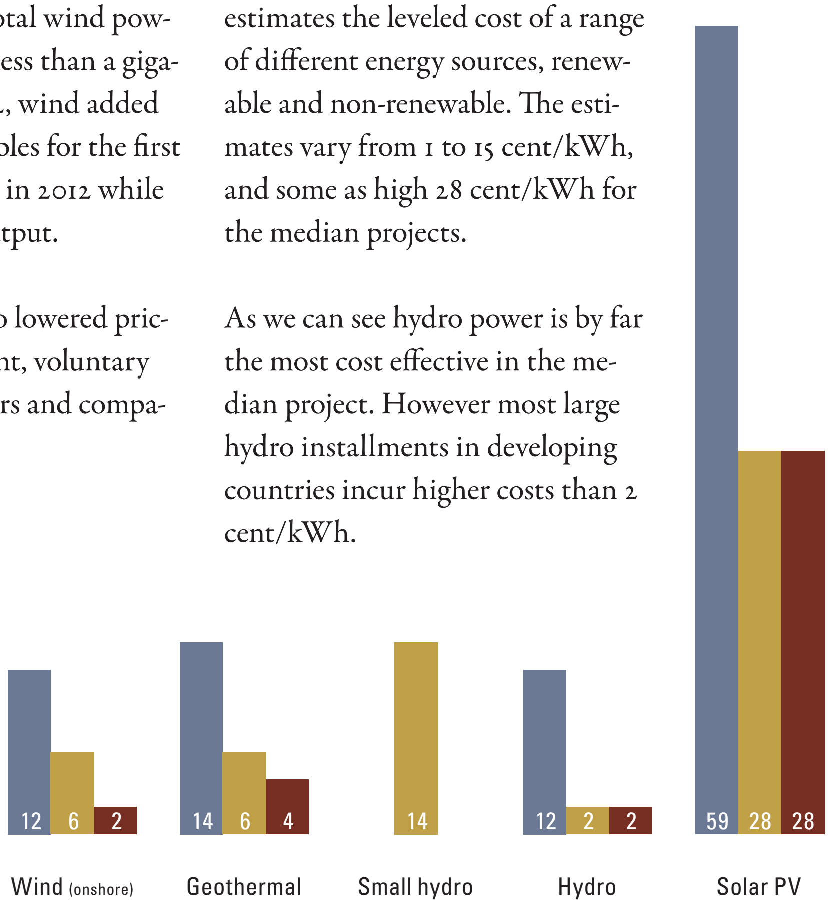



**FIGURE 4:** Leveled cost of energy as cents/kWh

Maximum
Median
Minimum

SOURCE: SOURCE OPEN EL 2013, HTTP://EN.OPENEI.ORG/APPS/TCDB/ RENDERED ON HTTP://EN.WIKIPEDIA.ORG/WIKI/COST_OF_ELECTRICITY_BY_SOURCE

## WIND POWER

Wind energy technology has evolved significantly over the last 3 decades as the technology continues on a path towards technological maturity. Tower heights are now as high as 135 meters and turbines are larger than ever with outputs per unit averaging 1.8 MW (2012). Total wind power capacity in 2013 was 318 GW.

China was making up almost half of all new installed capacity in 2013.[5] From 2007 to 2012 annual growth in installed capacity averaged 25%.[6] This saw a dip in 2013 with growth amounting to 12.4%. According to sustainablebusiness.com the reduction can be subscribed to lower production in the United States due to uncertainty of supportive policy. [7]

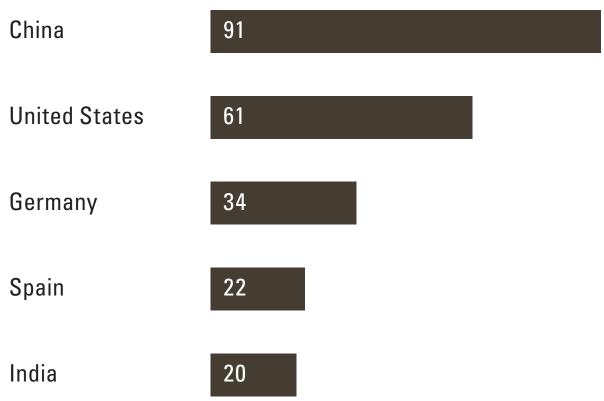
Offshore power is still small with 90% of it being produced in Northern Europe where a total output of 5 GW is in 10 countries. China with 0.4 GW offshore wind energy is biggest outside Europe (2012) and on par with Europe's second biggest offshore producer Denmark. The UK reached 2.9 GW with addition of its 630 MW project The London Array. [8]

### *Current shares*

The share of electricity produced by wind power is still small with 2.6-3% of global electricity production in 2012.[9] However with the exponential growth wind power has it is expected to grow significantly towards 2020 and 2030. Projections range from wind power covering 9% of global electricity consumption in 2030 in the lower estimates and close to 25% in 2030 for the higher ones.[10]

Europe is the region where wind power has the strongest position. In the four countries Denmark, Portugal, Spain and Ireland, between 10 and 20% of national electricity demand has already been successfully supplied by wind power.

**FIGURE 5:** Wind power capacity in GW




SOURCE: GLOBAL WIND ENERGY COUNCIL, 2013 (HTTP://WWW.EC.NET/WP-CONTENT/UPLOADS/2014/02/EC-PRSTATS-2013_EN.PDF)

By the end of 2012, wind accounted for 11.4% of total EU electric capacity, with Germany remaining the largest consumer there. Denmark established more ambitious goals of a 35% renewable share of final energy by 2020, wind generation to account for 50% of total electricity consumption by 2020. [11]

In the Americas the United States were producing 4% of its electricity by wind power in 2013. China is one of the world's major renewable energy producers and have an installed production capacity for wind power second only to EU as a region in 2013. Numbers for total generation in China are elusive, but until 2010 China was frequently listed with wind power contributing less than 1% of total electricity production.

### *Installed capacity and current developments in the global south*

Most countries in the global south appear far down the list when it comes to installed capacity. Egypt with 550 MW and Thailand with 223 MW (2013) are two of the higher ranking. South Africa is hardly making the list on installed capacity, but have in a turn to renewable power awarded contracts for 787 MW of wind power, which will generate capacity to a number of companies. [12]

The Lake Turkana Wind project is projected to have an installed capacity of 310 MW, which make up a fifth of current capacity in Kenya. The realization could bring Kenya high up on the list of wind power penetration in the market. The Norwegian development finance institution Norfund invested in the project in 2011, however the project reportedly still has problems to get under way in 2013. The lack of roads capable of moving entrepreneurial machinery obstructs the work, also the Kenyan government has not announced work to construct the needed transmission lines for the project. [13]

## *Predicted growth*

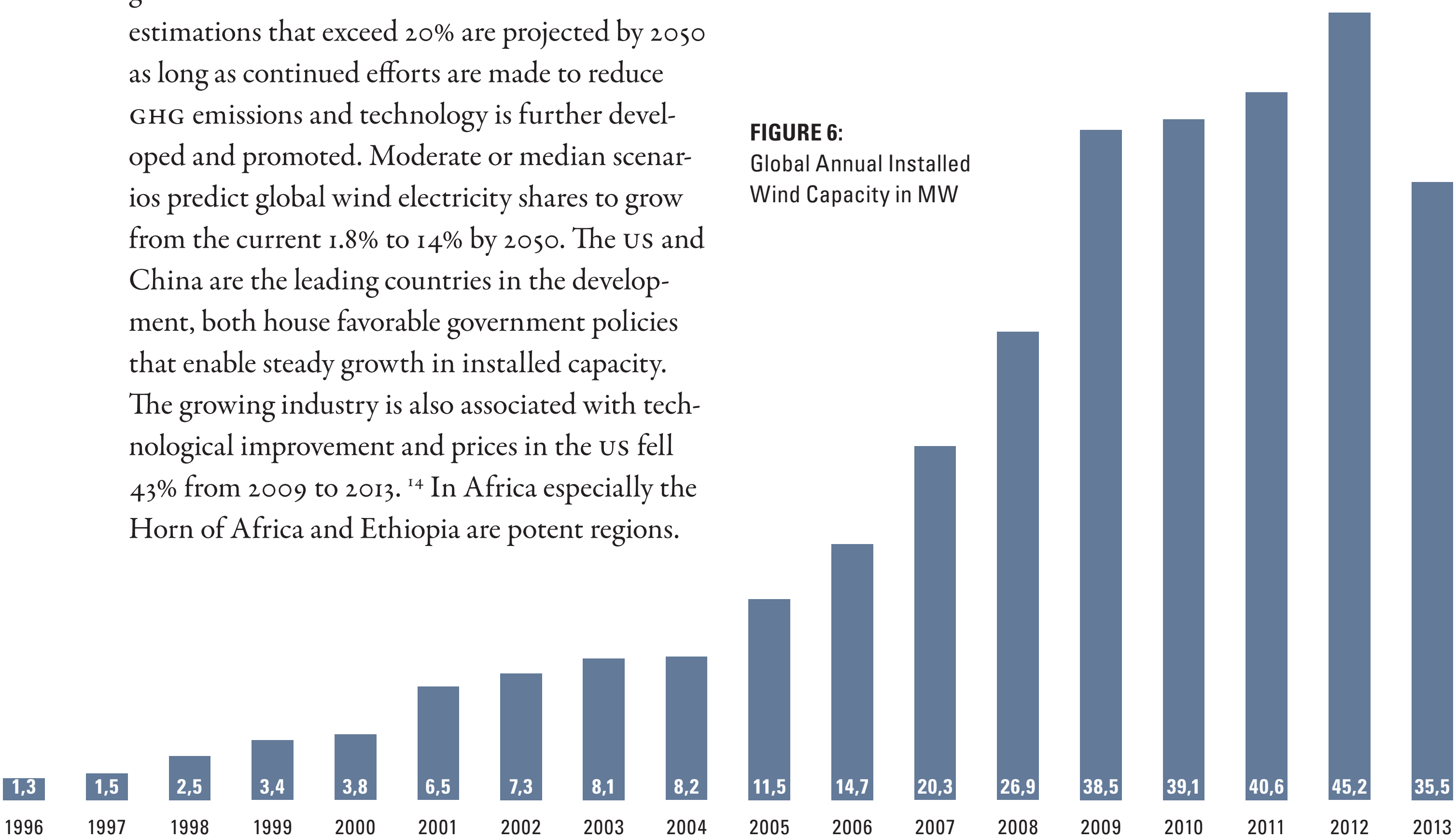
Globally wind has the potential of producing enough clean energy to meet GHG emission reduction targets both for 2020 and 2050. The potential for wind energy in many developing and emerging countries is substantial. Dependent on the current energy situation wind power could be a cost effective alternative to sources such as diesel generators or other renewable alternatives. Global estimations that exceed 20% are projected by 2050 as long as continued efforts are made to reduce GHG emissions and technology is further developed and promoted. Moderate or median scenarios predict global wind electricity shares to grow from the current 1.8% to 14% by 2050. The US and China are the leading countries in the development, both house favorable government policies that enable steady growth in installed capacity. The growing industry is also associated with technological improvement and prices in the US fell 43% from 2009 to 2013. [14] In Africa especially the Horn of Africa and Ethiopia are potent regions. Also vast regions of the Sahel ranging from Sudan to Morocco have high wind power potential.

Current installed capacity is still marginal in Africa, however the growth is exponential. As you can see from the figure above middle income countries make up most of the installed capacity and development plans. However, as entrepreneurs get a foot hold in Africa south of Sahara the potential for spreading to other countries in the region are increasing.

## *Technical aspects*

The size of wind power turbines is continuously increasing and so is the output of single turbines. The turbines are biggest in Northern Europe at over 3 MW and smaller in India and China at 1.2 and 1.6 MW. Offshore turbines are the biggest with an average size of 4 MW. Parallel with the growth in turbine size, new wind farms are increasing in size and total installed capacity.

**FIGURE 6:**
Global Annual Installed Wind Capacity in MW



### *Availability*

Most regions of the world have significant wind resources to be able to make serious contributions to local and regional energy mixes. [15] However the wind resources are restricted to distinct geographical locations and some countries have very little or no potential. Also the geographical factor makes transportation of the energy an issue. Technological know-how and detailed mapping of wind resources are also at need in many regions.

### *Economic constraints associated with the cost of wind energy*

Wind energy is quite close to commercial maturity with some regional examples of unsubsidized wind power being competitive with other conventional sources of energy. The competitiveness of wind power is also dependent on what other forms of energy is available. Wind is generally more costly than large scale hydropower, but could be cheaper than other renewable sources and fossil driven thermal plants. Production scale will also affect unit price.

Wind turbine manufacturers have increased in numbers in recent years with major growth in BRIC countries China, India and Brazil. These manufacturers compete with each other for concessions and are stimulating local and regional wind energy markets.

### *Operational integration*

Wind energy provides a variable output over time. The wind does not blow the same all the time and can vary over short time spans (a day) to much longer time spans. Based on the way current electricity systems are set up, there are technical challenges when trying to blend wind energy into the conventional energy mix. Wind energy, because of its variability, requires a different kind of grid system, a restructuring of the conventional system to tolerate the newcomer. Until this happens, wind penetration will be limited.

### *Social acceptance and environmental impacts*

Pollution from the wind energy sector is low compared to the energy obtained over the lifetime of a windmill. Wind farms can however lead to some detrimental impacts on local bird life, human activities and natural ecosystems. Careful planning with proper controls and environmental impact assessments can limit the harm caused.

## SOLAR POWER

Solar energy is transformed into electricity by two main technologies, Photovoltaic technology or solar PV and concentrated solar power or CSP. Photovoltaic technology uses solar cells collected in solar panels. CSP technology uses mirrors or lenses to concentrate sun rays and heat up a medium, such as water. The water then usually drives a steam turbine. The world's largest solar PV project is the Agua Caliente Solar Project in Arizona with an installed capacity of 250 MW, expected to reach 397 MW in 2014. While the largest solar CSP to date is the Solar Energy Generating Systems in California with 354 MW. Some solar projects under construction are planning capacity above 500 MW, however it is not only large scale installations that are increasing. “Onsite” small systems producing power where it is used is an increasing phenomenon.

### *Solar PV*

Solar power is reportedly the biggest industry in mainland China. Production of solar panels quadrupled between 2009 and 2011, surpassing global demand. The earth receives 174 petawatt of incoming solar radiation. Harnessing this directly is of course an immense power source. Many have probably seen the info graphics of the area needed for solar panels to produce the global demand of electric energy, a tiny spec in the Sahara or a small part of inland Australia. As efficiency grow the panels make more energy per square meter. Efficiency in the last half of previous decade was around 8% while efficiency today on average is 15%. Understandably the challenge lies in the cost of production. In recent years the costs have been reduced dramatically, it fell by 60% from 2008 to 2011 only, and the cost of systems are now reaching grid parity in several countries.*

An estimated 31 GW of new capacity was added during 2012. China being the fastest grower has had an exponential increase in new capacity, installing 5 GW of new capacity in 2012, increasing total capacity to 8.3 GW. China was expected to get more than 6 GW of added capacity online in 2013. Europe is still on top of the list with approximately 70 GW installed capacity (2012). [16] Germany has the highest installed capacity with a total of 35 GW installed capacity on 2013, adding approximately 7.5 GW. China with 8.3 GW surpassed the United States for the third spot in 2012 outranked only by Italy and Germany. Further down the list India reportedly had an installed capacity of 1.8 GW in 2012. The EU added 22 GW in 2012 which was the first market decline since 2000 and reflected reduced incentives and policy uncertainty, chiefly in Italy.[17] Global capacity for solar PV was estimated to 100 GW in 2012 or about a third of global wind capacity

## *Current shares*

In Germany the current share of electricity from solar power is 3%, in the US solar PV only makes up 0,23% of the annual electricity production. Solar energy accounted for 0.5% of global electricity production in 2011. The pacific territory of Okelau became the first country to be 100% supplied by photovoltaic electricity in 2012. Solar energy is still an expensive alternative for large scale on grid solutions. Still there have been a tremendous growth in the industry, and as opposed to in the nineties the on grid market is now the main market for solar development.

* Grid parity occurs when production cost of solar (or other) electricity is similar to or lower than the price of energy delivered on the grid.

## *Growth*

The increase in use of PV has been exponential in recent years, driven mainly by Japan after the Fukushima nuclear disaster, and EU growth especially in Germany as it strides to meet its 2020 emission targets. To highlight this amazing rate of growth, in 2012, the world added 29.4 GW representing a third of total global capacity (Ren21, 2013). Strong growth was also seen in leading markets US and China.

The cost of solar panels is still a threshold for a large scale introduction into national distribution nets. However in California, which is one of the most advanced markets, large scale solar farms are able to produce electricity at grid parity. China is also a huge driver of the development in the field and have had the largest relative growth in capacity for the last years. Chinese companies have also started building projects in developing countries, an area where solar power so far has little penetration. As for other renewable technologies the spread has thus far been strongly related to national economic incentives, rather than insolation.

As economies of scale are emerging in the solar industry the costs have lowered. The price of inputs such as crystalline silicon and thin film both dropped dramatically in 2012. The price drop lowered the price on solar panels but also put a crunch on companies. Together with an aggressive buildup of companies in 2010-2011 and reduced margins this led to 2012 being a tough year for producers. Many went out of business and there has been a consolidation of the market.

## *Integration & Variability*

Structure and management issues are creating barriers to the technologies growth.1 After the issue of price also the issue of energy storing or timing is important. Storing electricity is inefficient and expensive, electric energy should therefore be used when it is produced, and solar systems produce


energy when the sun is up. Before there are large scale solutions to the issue of inter day variability and also day to day variability penetration of solar electricity will be limited. However with co-generation with other flexible sources the integration could be far greater than the current integration at a few percent.

## CSP – CONCENTRATED SOLAR POWER

### *Technology*

CSP or concentrated solar power produces electricity by concentrating or reflecting sunlight from a large area onto a focal point. In the focal point the solar radiation is heating up a medium, for instance water, used to drive a heat engine (i.e. a steam turbine). Two of the main technologies are parabolic through and towers/central receivers.

CSP is still a fairly small industry and after a long stand still new capacity have been added increasing installed capacity from below 500 MW ten years ago to over 2550 at the end of 2012. CSP is an important technology for its capacity to store heat and by that controlling when to produce the electricity.

Spain and the United States of America are the countries where the main capacity in CSP is installed, Spain reaching 623 MW and the US 509 MW (or 0.6 and 0.5 GW) in 2010. Spain however more than tripled that and had more than 2000 MW of installed capacity of CSP by the end of 2012. The US was expected to reach close to 1 GW by the end of 2013. There is more than 100 MW in Northern Africa, with some of the capacity coming found in hybrid solar-gas plants. The United Arab Emirates added its first capacity, 100 MW in 2013.

Solucar PS10 near Sevilla in Spain is the first solar thermal power plant based on tower in the world that generates electricity in a commercial way. **PHOTO: ALEJANDRO FLORES, CC**

## *Growth*

In 2013 more than one gigawatt of capacity was under construction in the US. In California's Mojave desert the 392 MW Ivanpah facility is nearing completion. It was connected to the grid for testing in September 2013. Once online it can provide power for 140 000 US homes.[18] India's Godawari thermal power plant is its first major CSP plant with 50 MW installed capacity. The plant is the first of seven plants built by public bid. The CSP technology is seen as a better chance to reach grid parity in India than the PV technology.[19]

Policy changes in 2012 and 2013 in Spain pose challenges to Spain's CSP industry. South Africa was one of the most active markets in 2012. The country has three plants at a total of 200 MW under construction in 2013. UNDP and other international funders are contributing towards realizing solar CSP in Namibia by building the first 50 MW plant by 2015. Several development banks have also committed funds for CSP projects in the Northern Africa and Middle East region. Many other countries including Argentina, Chile, Mexico, Israel and China have projects under way or announced plans to develop CSP.[20]

## *Technical potential*

CSP or concentrated solar power is technology that is constantly being improved and made more efficient. CSP plant capacities now reach 500 MW in size, and the technology is deemed to reduce prices as the facility sizes grow. Specialists have noted that competition from continuously falling solar PV prices makes the technology less feasible. The REN21 network however deems the technology still viable, partly because of its unique attributes. CSP, unlike PV, can provide cheap steam for industry and has the ability to provide thermal storage. A 50 MW project in South Africa's Northern Cape includes 9.3 hours of thermal storage, which allows the plant to meet electricity demands in the peak hours between 5 and 9 pm. The South African government has also estimated that solar water heating could meet a fifth of their need for increased renewable energy.

The roll out of these technologies is still small as variability issues (sun only during the day time) are dealt with and research continues over the most effective ways of merging solar with central grid power. The technology is reaching maturity especially regarding storage potential. CSP plants can now store and release energy for several hours after the sun has gone down. Thermal power generators such as turbines are also ideal for combination with other thermal power plants, such as bioenergy plants or fossil fuel plants. CSP can also be used in cogeneration plants that produce both electricity and useful heat.

## BIOENERGY

The use of biomass for energy is divided into 'modern' and 'traditional'. Traditional use of biomass, such as burning, represents more than half of all biomass use for energy. The lesser proportion used in modern installations are primarily used for heat for industry and for heating buildings. Although there is only a small proportion of biomass used for generating electricity it produces around 1.4% of the world's electricity (2012). This is still small compared with coals 41%, but compares well to solar energy's 0.5% or wind energy's 3%. An advantage bioenergy have over other renewable sources is its ability to be integrated into thermal plants in cogeneration with fossil fuels.

Production of electricity from biomass is often labeled biopower. By the end of 2012 the world had close to 83 GW of installed capacity of biopower, an increase of 11% since 2011.

Biopower is produced by various technologies. The plants are mostly medium to large scale direct-fired, but also smaller scale systems and gasifiers. The EU and US are the main producers of bio-power with Brazil and China also being considerable producers. 2012 saw some notable growth in the BRICS countries.[21]

### *Traditional biomass*

In developing countries and parts of the world that do not have access to modern electricity grids, there is a much greater reliance on energy from traditional biomass. Large numbers of communities in Africa, Asia and Latin America have to rely on traditional biomass such as firewood or charcoal to meet their energy needs. The use of basic stoves and wood fires for indoor heating and cooking often leads to poor air quality and health risks. Traditional use of biomass also has a very much lower efficiency than modern energy generation from biomass. Many people suffer from respiratory related health problems. Around 3 billion people live in homes were heating and cooking is done by burning biomass. Nearly 50% of children's death from pneumonia before the age of five are due to indoor pollution.[22] Unfortunately electric energy cannot meet the need for heating and cooking in the near future. Electricity is too scarce and too expensive to be used for more than lighting and other low intensity uses for most of these 3 billion people.

### *Modern electricity producing biomass*

In some countries burning biomass for electricity production has had a substantial impact on meeting energy demands. Notably in countries with a large sugar industry, but it also figures high in Europe and the US. Pellets used for thermal power plants are a commodity increasingly traded internationally.

Biomass can be used to power thermal power plants quite similar to coal or gas fired plants. Biomass is also successfully integrated into thermal plants interchangeably with fossil fuels. With carbon capture and storage the burning of biomass could represent a carbon sink.

Thermal plants can use both standard boilers and turbines but are more efficient with advanced high pressure boilers and more advanced turbines, or by using gasification. Plants range from under 100 MW to the 750 MW Tilbury Bio power plant in the UK. The UK is also converting a 4 GW coal fired plant to run half of it on pellets.

Critique voiced against biofuel for generating mono culture plantations and otherwise displace necessary uses of land is also voiced towards production of solid biofuels. This is revisited in the paragraph on technical potential and challenges.

### *Current penetration and growth potential*

100 bio power projects came online in the United States during 2012, bringing total capacity to 15

GW. In Europe the capacity at the end of 2012 was 31.4 GW, up 2% from 2011. Germany, Europe's leading bio power producer is second only to the US in annual production. Close to Germany's 37 TWh per year is Brazil's 36 TWh per year.[23] Brazil also saw considerable growth in 2012 with an 8% increase reaching 9.6 GW. China also increased its capacity by remarkable 14% to 8 GW in 2012. Japan being the fifth on the list of producers has 3.3 GW of installed capacity. At the end of 2012 India had above 4 GW of bio power capacity.

Bagasse is important for the bio power plants in Brazil, generating combined electricity and heat, so called co-generation. Plants generating Ethanol from sugarcane is frequently self-sufficient with power, but also deliver power to the national grid. Grid connected co-generation plants also exist in a long range of countries, including: Mauritius, Tanzania and Zimbabwe. Kenya and other African countries are planning similar installations. Guatemala produces 21% of its electricity from biomass in the harvesting season from January to April.

The island nation of Mauritius has had a strong sugar and agricultural sector for many years and has invested in power plants that convert the agricultural residues into electricity. A favorable policy for developing renewable energy has led Mauritius to produce close to 18 of its electricity from bagasse.[24] The country is expanding its solar and wind capacities and is planned to reach a renewable capacity of 60 MW in 2015. Several countries in the global south are well positioned to take advantage of residue biomass from agricultural production. Mozambique's sugar sector could facilitate a growth of bio power, in Uganda small advancements are being made with some plantations producing their own energy.

South Korea is part of the global expanding pellets trade. The country is expanding the import of pellets for its thermal power generators in order to reach their 2% renewable goal. Producing power from burning biomass has proven to be cost competitive with fossil fuel based energy sources. Availability of biomass none the less differ, and import of biomass in the form of pellets are subject to transaction costs just like other thermal energy sources.

What is needed in developing regions is a sustained effort at creating a more sustainable agricultural production system. Bioenergy plants need a consistent supply of the combustible matter in order to avert the risk of power lapses. In some regions, commercial agriculture operations can supply this demand and electricity is produced for national grids.

## *Technical potential and challenges*

The output from bio power plants can increase significantly with implementation with more advanced burners and high pressure boilers. Gasification also increases the output from biomass. In Brazil estimations cite a nine fold increase in output from the bagasse industry given technical improvements.

The production of biofuels and bioenergy is said to have increased the global food crisis in 2010. Sustainable production of bio mass for energy needs is therefore a vital matter. Also transformation of forestlands into plantations for bioenergy production is an increasing problem. According to the European Union sustainability criteria land with high carbon stocks and high biodiversity should not be converted for biofuel production. The EU is also emphasizing the need for a minimum level of greenhouse gas savings from biofuels. REN21 is underlining that the sustainability of land use change and food stock competition are under review. However short rotation energy crops is a fairly small proportion of all bio energy consumed, only 3-4%.

## GEOTHERMAL POWER

Geothermal power plants can produce electricity or heat for direct use in space heating or industry. Geothermal energy is harnessed from the heat in the earths crest. Water is injected through bore holes, so called injection wells, and after being heated hot water returns back up through what is called production wells. The hot water is used to heat a medium driving a turbine or for heating purposes. The depth of the boreholes vary depending on the thickness on the earths crest, making geothermal power easier accessible in certain areas.

Two thirds of the geothermal energy harnessed is used directly as heat, and one third as electricity. Ground source heat pumps use electricity to extract heat multiple times that of the electricity used. The use of geothermal heat has increased significantly in the last ten years, especially due to ground source heat pumps. Ground source heat pumps reached 50 GW installed capacity in 2012. China, the US and Sweden are the largest producers of geothermal heat, in that order.

Global electricity production from geothermal power reached an installed capacity of 11.7 GW in 2012, up 300 MW from the year before. Geothermal energy has the technical potential to meet the world's electricity needs. It has generally experienced limited growth due mainly to the large investment costs. The technology is mature and leveled costs are cost competitive with conventional power sources.

### *Current penetration and expected growth*

Geothermal electricity is a consistent source of energy and currently meets base load electric generation in 24 countries and 10% of electric needs in 10 countries. In addition it contributes to heating and cooling needs in 78 countries.[25] Indonesia allegedly has 40% of the world's geothermal potential. It has 1.3 GW installed capacity and in 2007 it represented 3.7% of the country's electricity output. Both the Philippines and China have considerable capacity in geothermal energy, however numbers are elusive. The United States has the world's largest installed capacity with 3.4 GW and produced 0.41% of their total electricity from geothermal plants in 2012-2013.

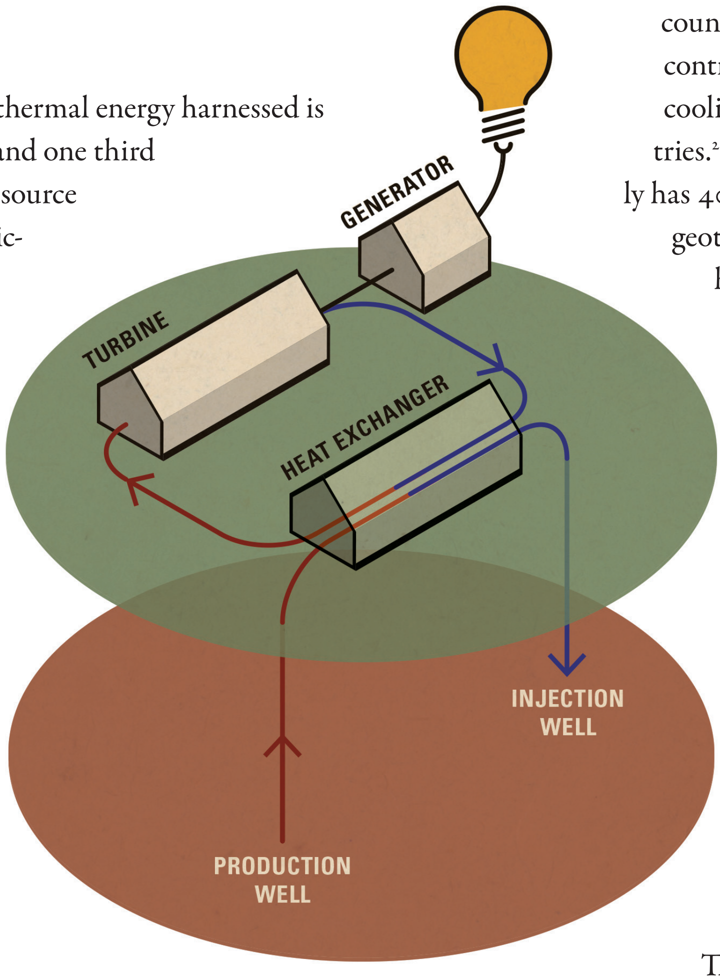



**FIGURE 7:** Geothermal power plant

Kenya is Africa's largest producer of geothermal power with an installed capacity of close to 200 MW. Due to its natural advantage from the rift valley Kenya is very well positioned to utilize geothermal energy. The country is aiming to have 5 530 MW geothermal installed capacity by 2030. The potential for geothermal power in Africa is mainly concentrated around the rift valley from Eritrea via Ethiopia, Kenya and Uganda to Zambia. Still there are several other hotspots across Africa fit for geothermal power.

Iceland has been a pioneer in geothermal power and has since the 1990s added a growing percentage to its electricity generation from geothermal power.[26] In 2010 it provide 26% of the country's electricity. 2012 saw new capacity coming on line in the United States (147 MW), Indonesia (110 MW), Nicaragua (36 MW), and Kenya (7.5 MW). The Stillwater geothermal power plant in Nevada is notable for being the first plant to combine solar PV and geothermal generation. In 2012 Nicaragua saw the completion of the second half of its 72 MW San Jacinto-Tizate project. The 72 MW project is large enough to supply 17% of Nicaragua's electricity needs.

Indonesia which has not added much capacity in recent years prior to 2012 has announced a program to push for 1000 MW new geothermal energy. The country has initiated a geothermal risk mitigation fund. One of the major thresholds for geothermal energy is the high exploratory costs and the insecurity of drilling. The drilling which is not guaranteed to give results is a great risk to investors. Risk mitigation funds is seen as an instrument to attract more private funding into geothermal power. Especially in African countries the high cost is seen as a hindrance. Several donors are now establishing risk mitigation facilities for geothermal exploration. Especially in East Africa along the Rift Valley.

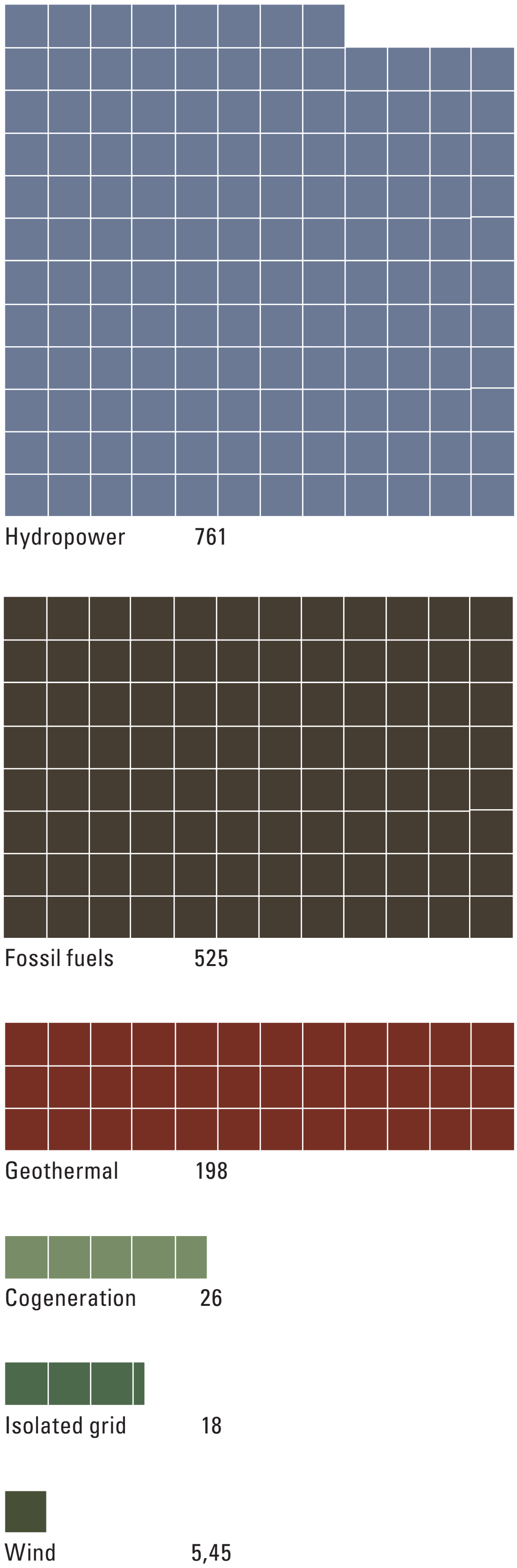



**FIGURE 8:**
The Current Power Supply in Kenya in MW

SOURCE: CC WIKIMEDIA, DATA SOURCE: HTTP://WWW.IAEA.ORG/NUCLEARENERGY/NUCLEARKNOWLEDGE/SCHOOLS/NEM-SCHOOL/2012/JAPAN/PDFS/WEEK2/CR6_KENYA.PDF

# **AFRICA:** A RENEWABLE POWERHOUSE

Many countries in Africa have traditionally been dependent on fossil fuel energy generation or large-scale hydropower. Many North and West African states have access to large reserves of oil which is used to power national electricity grids. Central and Eastern African states on the other hand have been dependent on hydropower to a large extent. South Africa has large coal reserves, which it uses to meet the demands of its large industry.

Like fossil fuel based electricity generation, large hydropower plants situated on many of Africa's largest rivers systems generate base load power for national grids.

Countries like Zimbabwe, The DRC, Angola, Zambia, Zimbabwe, Malawi and Tanzania, represent countries reliant either wholly or partly dependent on hydropower. Hydropower plants are built to supply central national grids, often centered on industry needs and supplying growing urban centers.

550 million people living in Africa have no access to electricity.[27] Another estimate from the Joint Research Centre on Renewable Energy in Africa puts the number at 600 million. Sub-Saharan African countries are the worst affected, with 99.6% of those without electricity living in this region.[28]

Rural areas are the least electrified. It is too expensive to expand central grids into smaller more remote rural communities. The lack of access to clean electricity means that rural people have to rely on more traditional sources of energy like biomass. Access to electricity has a number of social and economic benefits for the rural poor. Electricity provides lighting, improves the ability to use communication tools, allows production processes to modernize and mechanize, enables refrigeration, and improves healthcare conditions. Burning unclean biomass like wood and charcoal for domestic needs like cooking and heating has a detrimental effect on people's health. Reserves of biomass in communities may fluctuate in response to climate and other factors, leading to energy security issues. Consumption of traditional forms of biomass also places a pressure on the local environment, for example soil erosion resulting from deforestation.

The solution to these problems lies in adopting a decentralized energy strategy, which would see a greater number of people in Africa having access to clean electricity. One of the most sensible and realistic ways of achieving this scenario is by investing in smaller grids powered by alternative renewable energy. A decentralized supply would offer clean energy services to large numbers of rural communities across Africa that currently do not have access to modern energy alternatives.

## AFRICA'S NON-HYDRO RENEWABLE ENERGY POTENTIAL: A BRIEF OVERVIEW

Africa has vast renewable energy potential. In order to make the best choice of renewable resources for a particular area or region, different sustainability and environmental criteria must be taken into account.

### *Solar*

Solar potential on the African continent is huge, with an average of 325 days of sunlight per year. IRENA (2011) suggests that there is much more than 10,000 GW of potential from solar energy.[29]

The North African countries of Egypt, Algeria and Morocco utilize CSP but in conjunction with natural gas. South Africa constructed its first 150 MW CSP plant in 2012. Other Southern African countries are also beginning to take a greater interest in CSP, most notably Namibia with plans for a CSP plant by 2015.[30]

### Wind

Wind energy potential on the continent is predicted to be approximately 40,000 MW.[31] In the North African countries of Egypt, Morocco and Tunisia wind farms have been installed with Egypt producing the largest share accounting for 97% with a total capacity of 550 MW. Morocco has a capacity of around 290 MW and Tunisia is 120 MW.[28] Wind farms were predominantly built in Northern Africa along the Mediterranean, however in recent years, other countries have developed wind energy capacity. Africa's largest wind farm (120 MW) in Ethiopia reached full capacity in 2013.[32] Wind farms are being developed in Kenya (>400 MW), which aims to supply 9% of its electricity supply by 2030. It also has plans to build the largest wind farm in Africa near Lake Turkana providing 300 MW.[33] Tanzania has over 100 MW planned and these trends are likely to continue as the costs of wind power decline rapidly (Hankins, 2009).

In South Africa, the first wind energy came online in 2008 from the Darling wind farm. It is hoped that the project will provide a learning platform for future wind energy development and has been labeled a "National Demonstration Project".[34] South Africa could potentially serve as a regional first mover for wind energy stimulating developments in neighboring countries.

### Specific wind challenges in Africa

According to several studies, the wind pattern in the tropics is not favorable for wind power. Average wind speeds are generally lower in Africa than in Europe or the USA. There are exceptions however. Areas like northern Senegal, Mauritania, Morocco, Egypt, Somalia, Kenya, South Africa and Namibia show favorable conditions. However in many instances, the locations are remote, uninhabited or without infrastructure like roads and communications.

Very little effort has been made to produce accurate and reliable wind maps for much of Africa. Wind maps showing average annual wind speeds at generator height are very rare. In many areas, calculations are based on atmospheric models which have very low resolutions. This makes it very difficult to predict wind potential on the continent. There is a need to measure wind in Africa at the appropriate height above the ground before serious investment policies are to be made.[35]

### Co-generation from biomass

Electricity produced from steam by burning agricultural waste would suit a large number of African countries. According to one estimate, Africa could generate 20% of its electricity from co-gen. Mauritius is a co-gen success story, producing up to 40% of its electric supply with sugar cane waste.[27] One report estimates that, based on existing sugarcane production, cogeneration could contribute an additional 16.2% power capacity in Kenya, 23.7% in Malawi, and 144% in Swaziland.[36]

### Geothermal

Approximately 15,000 MW[37] of geothermal energy is potentially available in reserves along the rift valley. The rift valley countries include Eritrea, Ethiopia, Djibouti, Kenya, Uganda, Malawi and Zambia. One report suggests Africa has tapped less than 0.6% of its geothermal reserves. Kenya is one country that has taken serious strides towards harvesting this energy source. 10% of its electricity comes from geothermal energy. A total of 205 MW of an estimated 2000 MW of geothermal potential has been developed. A further 320 MW are planned. Uganda is known to have up to 450MW of geothermal reserves. Most of the potential lies in Ethiopia and Kenya that are said to have the best reserves.[38]

### *Small-hydro*

According to one study, 30% of Africans live in areas where mini-grid small hydro offers the cheapest source of electricity.[39] If this is true, mini hydro offers a huge potential meet rural electrification needs. Efforts are under way in regions with the appropriate hydrological features to exploit this technology. For instance, in East Africa Rwanda, Tanzania and Kenya are developing mini-hydro systems under concession agreements (Hankins, 2009). Mozambique is also developing its mini-hydro potential (See Mozambique case study).

## THE CHALLENGES

In order to analyze the most appropriate energy solution for rural electrification a number of factors must be taken into consideration. Rural electrification costs are sensitive to varying factors like geography, population density, social-economic factors, subsidized diesel (certain African countries), feed in tariffs for renewables, etc. In order to select the most favorable generation scheme for a particular area, a combination of different tools and datasets must be used. These include renewable energy datasets, resource mapping methods, satellite and terrestrial measurements, and numerical models.

### *Renewable policies for rural electrification*

The cost of installing renewables in Africa is higher than conventional fossil or hydropower. In order to reduce the cost and increase the chance of success, a number of measures should be adopted. For instance, effective use of meters to measure electricity use in households would encourage efficient usage and make collecting revenues easier for local utilities. Offering African banks guarantees if they offer loans for clean energy projects. Africa has some of the highest import duties in the world, and reducing or removing these altogether for renewable energy systems would increase competition and reduce eventual energy costs. African governments must work to decentralize their overly monopolistic energy markets, allowing new players to enter. This will increase competition and stimulate innovation in the sector. They must create an easy route for renewable energy producers to enter the market and improve financing options for them. Producers of solar panels and other products must be encouraged to do business in Africa. Governments should adopt feed-in tariffs for renewables. Multilateral aid institutions like the Africa development bank and World Bank should establish funds for clean energy projects that go directly to reducing energy poverty in Africa. Energy subsidies need to address and account for the entire population demographic as opposed to just the better off in African society.38

If the right policies are put in place promoting alternative renewable energy sources, there is the potential to reduce the need for large hydro developments and other unsustainable energy developments. The political willingness and financial support for renewables will be important. Recently the World Bank with its latest World Development Report, called for a major hydropower rollout for the African continent. (Pottinger, 2011) These types of mega-projects continue to favor the rich and middle classes living in cities at the expense of the poor majority often living in rural areas.

### *South Africa: Pro-renewable policies and demand side management*

South Africa has made recent efforts to restructure the energy market allowing smaller producers to compete or bid for electricity supply concessions. In 2009, the National Energy Regulator approved the Renewable Energy Feed-in Tariff, which opened the doors for the renewable energy sector. This will help South Africa develop its renewable sector despite the slow start. By diversifying its energy portfolio South Africa will build a more robust energy future. Investments in solar and wind are small but with further efforts experts predict a bright future for these renewables.

In response to the energy crisis in 2008 where it faced widespread rolling blackouts, the government of South Africa announced plans for a more comprehensive energy efficiency policy. This included procedures to tighten energy efficiency standards in buildings, introduce financial incentive schemes for project developers and rollout a solar water heater program over the coming years whereby 1 million solar heaters will be installed in homes across the country.[40] It has been estimated that if only moderate energy efficiency measures are taken in South Africa, peak loads can be removed by a margin equivalent to three times the total electricity needs of Mozambique.[41] This is a staggering statistic and shows the potential that efficiency measures and demand side management can have on electricity demands in the region.

# CASE STUDY: **MOZAMBIQUE**

During the colonial period and the long civil war that ensued in Mozambique, little was done to develop rural economies or supply electricity to rural populations (Hankins, 2009). There was and still is a fixation on large energy projects that are developed in order to meet large industry needs in the capital Maputo and in neighboring South Africa. One project that highlights this, was the building of the Cahora Bassa hydropower dam. It was built on the Zambezi river in the western province, hundreds of miles away from the capital Maputo which is situated in the south of the country. The dam was built by a consortium of Portuguese, German, British and South African developers between 1969 and 1974. In order to deliver the power south, a large transmission line was built connecting the plant to the electricity grid in the south. The line has bypassed large swathes of the country`s population which 40 years later, are still without access to electricity. An additional consequence of long power lines is energy loss.

### *Response: Current efforts*

After independence in 1995, the Mozambique National Power Company (EDM) began an expansive electrification scheme, which has connected thousands of households to the grid. A separate organization, the Mozambique National Rural Energy Fund (FUNAE) was established to address rural energy needs in the country. Its role is to improve rural livelihoods by implementing rural energy initiatives. They have carried out a number of small scale energy projects in rural areas in the field of solar PV, micro hydro, wind pumps and fuel efficient cooking technology.

### *Challenges*

Although EDM has one of the largest electrification schemes in Africa, hailed as a success by many in the sector, expansion has focused on homes and businesses that lie within close proximity to the national grid. The majority of communities in Mozambique that do not lie close to the grid remain without electricity. The vast size of the country has made it mostly impossible to dispatch power from the central grid system to the entire population.

Funding is also an issue. EDM is awarded an electrification budget 5 times the size of FUNAEs. This despite the fact that FUNAE is responsible for the energy needs of 80% of the population. In addition, FUNAE is reliant on external support from various international donors like the World Bank, the EU and Norad. This highlights how rural energy plays a small role as part of the national energy agenda.

In addition to funding and structural challenges, there remains a continued fixation on large centralized energy projects. Mozambique is part of the Southern Africa Power Pool (SAPP) an electricity network established in 1995 to share power between approximately 12 countries. The annual increase in demand from this network is estimated to be 1500 MW. These demands, which mostly emerge from industry in South Africa have a strong impact on Mozambique's energy portfolio. A major source of revenue for Mozambique has been the sale of electricity to its neighbors. This has led to a continued focus on centralized large-scale power projects. To highlight this, plans are being made to build a second large hydropower dam, the 2500 MW Mphanda Nkuwa downstream of Cahora Bassa. An additional two smaller dams have been proposed even further downstream, Boroma (400 MW) and Lupata (650 MW). Traditional coal and gas generation projects are also projected to supply the central grid in the future.[42] Mozambique had an estimate installed capacity of 2.4 GW at the end of 2012.

## *Solution: Renewable energy alternatives for Mozambique*

Mozambique's bioresources are by far the best option in the short term for reaching a more diversified and energy secure future. Seeing this opportunity, the government has made plans and is in the process of developing its bioenergy sector to take advantage of the large volumes of biomass produced by its commercial agricultural activities. The sugar industry in Mozambique is exceptionally well established with 5 large plantations capable of producing large volumes of bagasse waste from the sugar production process. There is the potential to generate hundreds of megawatts of electricity by burning this bagasse. Mozambique expects to add 60 MW of power to the grid soon from two sugar factories. FUNAE is also collaborating with other research institutions on a pilot rural electrification project from bagasse. In addition, an extensive biofuels program is planned for the country.

Mozambique has a huge potential to generate electricity from both solar PV and CSP as well. Solar resources are almost completely unexploited thus far. The solar energy available is estimated to be thousands of times greater than the countries annual energy needs. Small scale PV systems for rural electrification have been developed but growth is small. The technology is considered too expensive still and government duties and taxes remain on imported solar equipment.

There is very little wind energy development in Mozambique. However preliminary tests show encouraging wind resources along the coast and in the highlands. Unfortunately sufficient wind resource maps are not available making accurate estimations of potential difficult. Efforts are underway to develop these tools by the government.

Mozambique has 39 rivers with an estimated mini-hydro potential of over 1000 MW. The department of energy has estimated an additional 60 micro-hydro sites. Pre-feasibility studies for projects in several provinces were being carried out as recently as 2009. The government and FUNAE is in the process of establishing a more positive policy for micro-hydro by which interested parties can develop concessions less than 15MW.

Geothermal is also highly underdeveloped, although preliminary efforts suggest 25 MW is exploitable. The best areas are in the northern and central provinces where the resource is considered to be the most abundant.

## *Policy*

According to Mark Hankins, author of the report "A renewable energy plan for Mozambique" renewable energy policies need to be developed that prioritize renewable energy technologies. Equal attention should be made for both on and off grid alternatives. Serious strides must be made to expand subsidy funds for off grid renewable energy infrastructure. Duties and tariffs should be removed for renewable energy equipment, which would help open the sector up for private investment and manufacturers. Organizations like FUNAE should be made into active governmental facilitators of renewable energy projects and take a more central role in the overall planning of rural on and off grid electrification.41 It would be useful for Mozambique to learn from the experiences in other countries where renewable policies have had positive impacts on meeting rural energy needs. Feed in tariffs need to be promoted for mini hydro, PV and CSP, like what is being done neighboring South Africa. Designing similar policies that are supporting geothermal in Kenya, wind in Ethiopia, solar farms in North Africa and bioenergy in Mauritius.

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