Em-Powering Africa

The importance to face energy poverty

Rie for Fondazione dei Popoli

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INDEX

CHAPTER I
THE "CRITICAL ISSUES" OF ENERGY IN AFRICA

Energy poverty in Africa

1. Energy is essential to modern society, not only in terms of economic development but also for the very human survival. Energy and development have an interdependent relationship through which there cannot be the first without the second, and viceversa. The new challenge of modern society is that of satisfying the thirst for energy especially, but not exclusively, in low income countries. 2.4 billion of people do not have enough energy to assure themselves minimum vital needs, like food cooking and heating. 1.3 billion people do not even know what having access to electricity means.

2. Today, the world's key challenge is defeating energy poverty. This represents that ethical issue that the richest countries – dissipater of energy – cannot elude. It represents a "sine qua non" condition in order to mitigate life condition of half of world's population still living in the extreme poverty, to reduce the demographic pressure and the migratory flows which, otherwise, would affect the rich world. The unequal distribution of energy consumption, concentrated for over an half in the industrialized world, reflects the disparity of wealth distribution worldwide. Removing the first is a precondition to improve the second.

3. Almost a third of the global population relies on wood, agricultural residues, dung, or other traditional fuels to meet their primary needs (cooking, lighting, heating), detracting these resources from alternatives productive uses. The difficulty of many countries to accede to the international energy markets to acquire what they need, due to the cyclical price crisis[1], contributed to worsen both their already miserable standard of living and the environment. Indeed, the over utilization of such resources exceeds their reproductive capacity. In 2010, the global consumption of biomass was attested to about 1.1 billion tonnes of oil equivalent (toe), representing 9% of the global energy consumption.

4. Wood is the dominant biomass with an energy consumption estimated between 3-4 billion cubic meters. It represents in many contests the best energy solution due to its accessibility and cheapness; however, its gathering rises relevant environmental risks and contributes to deforestation. Tanzania, where biomass (prevalently wood) accounts for more than 90% of energy consumption, registers the highest levels of deforestation estimated to 412,000 hectares per annum. A report published by the United Nations last year shows that the Tanzania's estimated sustainable annual supply potential of wood products from natural forests in 2011 was around 18 million cubic meters while the actual amount harvested was over 50 million cubic meters. The huge exploitation of biomass as a fuel obliges women and children to walk long distances and spend many hours per day to fetch firewood. This phenomenon has caused the decline of forest cover per capita from 6.3 hectares from 1961 to around 0.7 ha in 2010. [2]

5. Energy poverty afflicts a large part of Africa, especially the Sub-Saharan area, the mountainous lands of Asia and the Andean zone of South America. These regions may register a per capita

[1] Every year, the African households and business spend upwards of $17 billion on fuel. G8 Energy Ministers Meeting (2009).
[2] Mushi (2012).

energy consumption ratio up to 1 to 20 in respect to developed countries. Biomass low availability in rural villages and growing prices in urban towns costs families excessive quantity of time and income to gather and buy anything working as a fuel. In some areas, women and children dedicate to this activity up to 300 days per annum and up to half of their income.[3]

6. In addition, negative externalities at the global level are also relevant. From one side, decay, erosion, land desertification are caused by deforestation[4] with a decline of the available agricultural production; from the other side, climate change worsens by lesser capacity of the environment to absorb the CO_2 released in the atmosphere. The global consequences of these externalities show, one more time, the strict interdependence between the energy systems of industrialized and developing countries and the fact that fighting energy poverty is a win-win strategy.

7. While energy security – meant as "a situation in which all end-users demand can be met by a supply in sufficient quantities at a reasonable and relatively stable price"[5] – represents for industrialized countries the most relevant aspect of their energy policies, for developing countries the need to assure minimum conditions of living to their population is more prominent. It is not a case that the International Energy Agency (IEA) defines access to energy modern services as "a household having reliable and affordable access to clean cooking facilities, a first connection to electricity and then an increasing level of electricity consumption over time to reach the regional average"[6]. For these countries energy access is a precondition for any economic development.

8. Electricity is the most important mean to satisfy primary needs. For instance, power generation can run desalination plants with an increase of the available drinking water. Moreover, power better rationalizes household daily activities, improving the life style and the whole community well-being; indeed, women can generate extra income, children can study during the night, men can irrigate land and improve their gathering. In brief: modern energy services shortage affects the productivity of the population impeding, in a sort of vicious circle, the emancipation from the poverty state in which they live. Similarly, the current way of consumption has negative consequences on health. According to the WHO estimates, indoor pollution is responsible for 1.5 million deaths per year, mainly children and women.

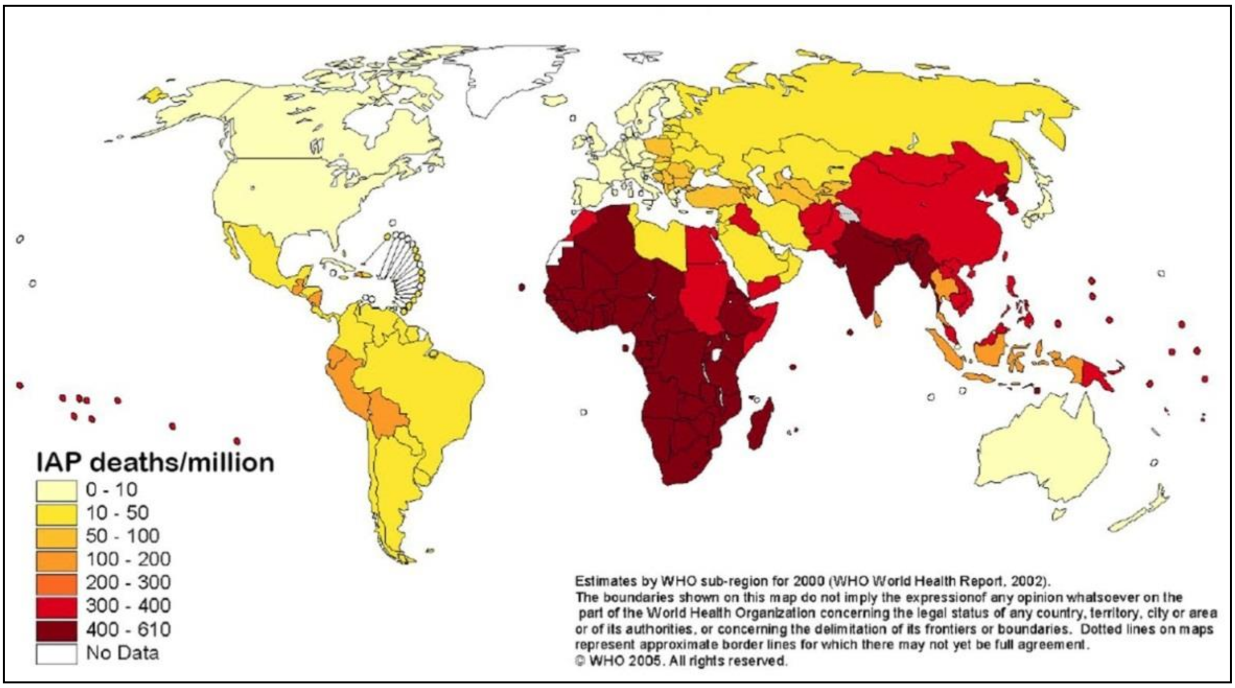
[3] World Resources Institute (1986).

[4] Annual deforestation rate (1990-2005) is estimated between 40.000 and 50.000 square km in low income countries and between 30.000 and 40.000 in medium income countries.

[5] Martin-Amouroux (2006).

[6] IEA (2011).

Fig.1 Deaths from indoor smoke from solid fuels



Source: WHO, 2005

The numbers of the African power crisis.

9. Worldwide, yet nearly 1.3 billion people lack electricity. 45% of them are located in Africa where almost 600 million people still have no access to electricity. Although accounting for only 12% of the global population, Sub-Saharan Africa represents the more problematic area of the African Continent. While only 1% of North Africa population lives without access to electricity, it reaches almost 70% in Sub-Saharan Africa. Asia has the largest number of off-grid population, mainly concentrated in India, with over 620 million people still living without electricity. Instead, Africa has the least electrification rate attested to 42% for the overall population, falling to only 25% in the case of rural household.[7] In Africa, 80% of people without electricity access lives in rural areas.

Tab.1 People without access to modern energy services by Region, 2010 (million)

	People without access to electricity	Share of population	People relying on the traditional biomass for cooking	Share of population
Africa	590	57%	698	68%
Sub-Saharan Africa	*589*	*68%*	*696*	*81%*
Developing Countries	1265	24%	2588	49%
World	1267	19%	2588	38%

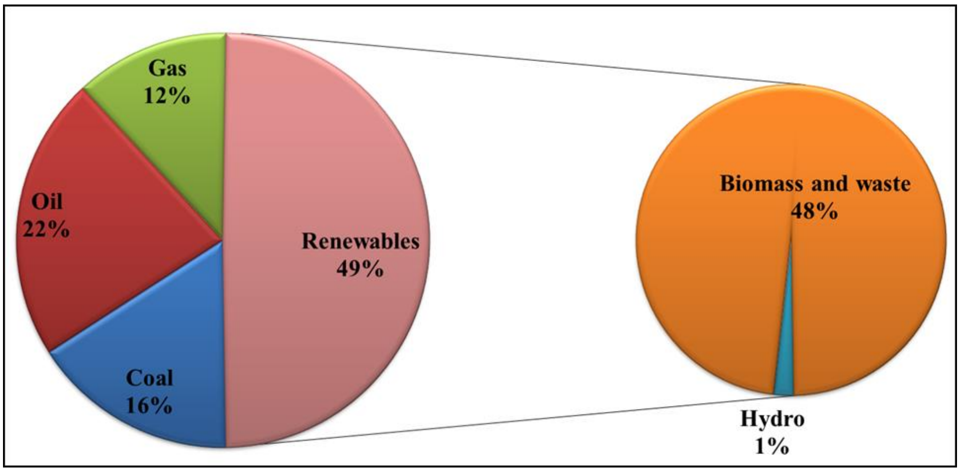
Source: WEO 2012

10. According to IEA estimates, in 2010 almost 2,6 billion people relied on the traditional use of biomass for cooking, around 40% of the global population. In Africa, biomass is a very important fuel, sometimes exceeding 90% of the total national energy use of some countries: this is the case of

[7] Bardouille (2012).

the Democratic Republic of Congo, Ethiopia and Tanzania. In Nigeria, over 100 million people use biomass for cooking.[8]

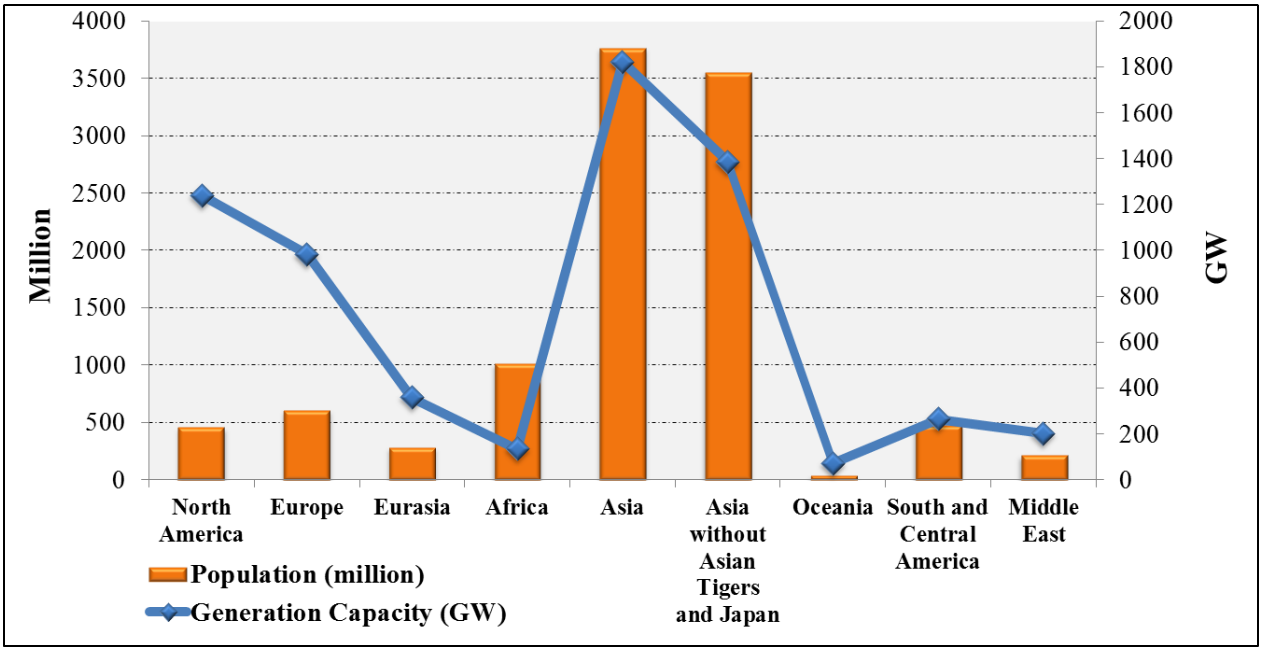
Fig.2 Total Primary Energy Demand, 2010



Source: WEO 2012

11. African total primary energy demand in 2010 is attested to 690 million tonnes of oil equivalent (Mtoe) and is supplied for almost 50% by biomass and for the remaining 50% by fossil fuel of which oil represents the largest component. African power generation is dominated by fossil fuels, accounting for more than 80% of the total. Coal represents the largest source of electricity in 2010 accounting for 45% of total generation, followed by natural-gas (31%) and oil (14%). The remaining share of power generation is attested by hydropower accounting for 6% of total power generation.[9]

Fig.3 Comparing Population with Generation Capacity by Region, 2010



Source: US EIA (Energy Information Administration)

[8] IEA (2011).

[9] It's not surprising to note the dominant role of coal in power generation as 65% of 2010 Sub-Saharan Africa (SSA) electricity has been generated in South Africa where are located 98% of coal reserves of the Continent and 3,5% of those at global level. BP (2012).

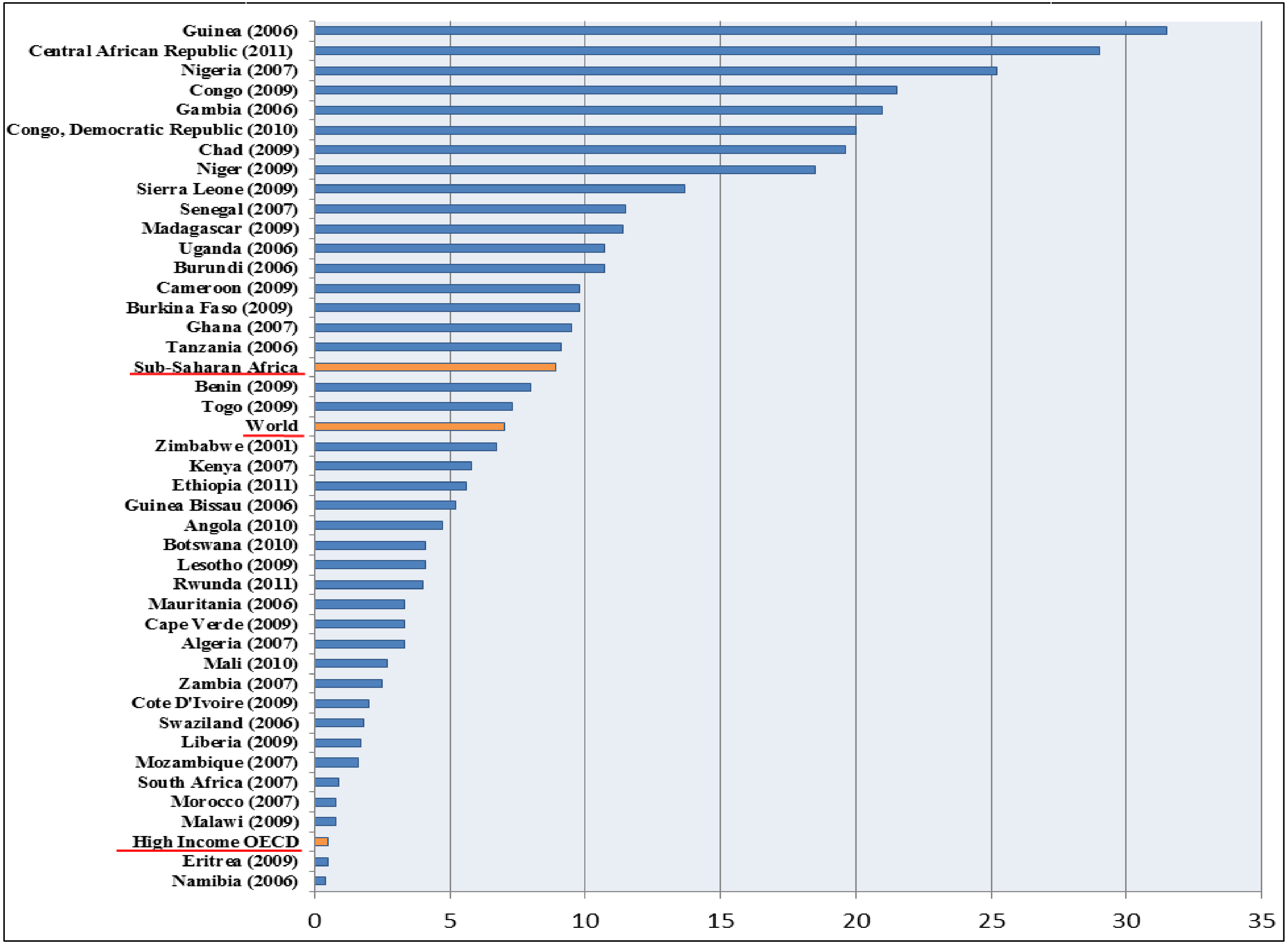
12. As noted in fig. 3, generation capacity can vary a lot by region: with North America's and Europe's power generating capacity/population ratio reflecting a high per-capita consumption while other regions, in particular Asia and Africa, suffering a power shortage for most of their population. In 2010, generation capacity in Africa was attested to about 134 gigawatts (GW), over seven times less than that found in Europe. Although African population is double in respect to Central and South America, its generation capacity is a half of the level found in this region, which is attested to 263 GW.

13. The entire generation capacity of the 49 countries of Sub-Saharan Africa (75 GW) is less than that of South Korea. Without South Africa, the total falls to a mere 31 GW, equivalent to the installed capacity of Norway. Moreover, the region's GDP doesn't grow at the same rate of generation capacity, as it should generally be in order to sustain the demand, affecting the economic growth of the Continent. Instead, while African GDP has grown in recent years at an annual rate of about 5%, generation capacity has grown at an annual rate of less than 3% since 1980.[10] The power crisis faced by most of African countries is marked not only by insufficient generating capacity and by a low rates access to the electricity grid, but also by unreliable energy services. Frequent outages in African countries constitute a significant burden for the economy and the development of the Continent.[11]

[10] AICD (2009).

[11] Although collecting data can be difficult for many African countries, the World Bank Enterprise Surveys developed a useful alternative instrument to measure the reliability of power systems. The surveys give confirmation of the difficulties faced by many African countries in providing a good and reliable power service. For example, in 2007 Nigeria experienced in a typical month about 25 power outages with an average duration of 8,2 hours each; it's not surprising, for this reason, to note that 75,9% of Nigerian firms identified electricity as a major constraint in their business. Frequent power outages, indeed, cause a loss of competitiveness for enterprises in terms of activities delay, equipment damages and major use of expensive backup generators. AICD (2009)

Fig.4 Number of electrical outages in a typical month, latest year available



Source: World Bank Enterprise Survey Database

African Energy Access Outlook

14. As we have already seen, the state of art of the access to modern energy services in Africa is highly critical. The future can be even worse. The IEA estimates in the New Policy Scenario (NPS) of its last *World Energy Outlook* that in 2030 almost half of the Sub-Saharan African population will still not have access to electricity, while 65% of it will still rely on traditional biomass for cooking. These data show a percentage improvement in respect to 2010. However, in absolute terms, people living without modern energy access are going to increase (+67 mln and +188 mln, respectively) due to the growing demographic trend[12].

Tab.2 Number of People without Access to Modern Energy Services in the New Policy Scenario (million)

Regions	People without Access to Electricity						People without Access to clean cooking facilities					
	2010			2030			2010			2030		
	Rural	Urban	%	Rural	Urban	%	Rural	Urban	%	Rural	Urban	%
Africa	475	114	57	572	83	42	518	180	68	629	257	39
Sub-Saharan Africa	*474*	*114*	*68*	*572*	*83*	*48*	*516*	*179*	*81*	*627*	*256*	*65*
Developing Countries	1.081	184	24	879	112	15	2155	433	49	2139	456	39
World	**1083**	**184**	**19**	**879**	**112**	**12**	**2155**	**433**	**38**	**2139**	**456**	**31**

Source: WEO 2012

15. Despite a quite optimistic approach, the NPS delineates an anything but idyllic scenario that gives rise to growing global concerns. In particular, the UN retains the criticalities related to energy poverty as an unavoidable barrier toward the Millennium Development Goals (MDG)[13]. For this reason, it has declared 2012 the *International Year of Sustainable Energy for All*. To achieve the universal energy access target by 2030 ("Energy for All" scenario), IEA estimates the need of $48 billion of annual investments, about which $30.5 in electrification projects. A value far more considerable than the even remarkable $14 billion annual investments foreseen in the NPS, which in turn are greater than the highest level of global energy investments ($9.1 billion) recorded in 2009[14].

[12] It is important to underline that the NPS, adopted as WEO reference scenario for the first time in 2011, is a quite optimistic scenario that takes into account that the policy commitments declared by governments will be fairly implemented, even when implementing measures are still not defined.

[13] The eight Millennium Development Goals (MDGs) are: eradicating extreme poverty and hunger; achieving universal primary education; promoting gender equality and empowering women; reducing child mortality rates; improving maternal health; combating HIV/AIDS, malaria, and other diseases; ensuring environmental sustainability; developing a global partnership for development.

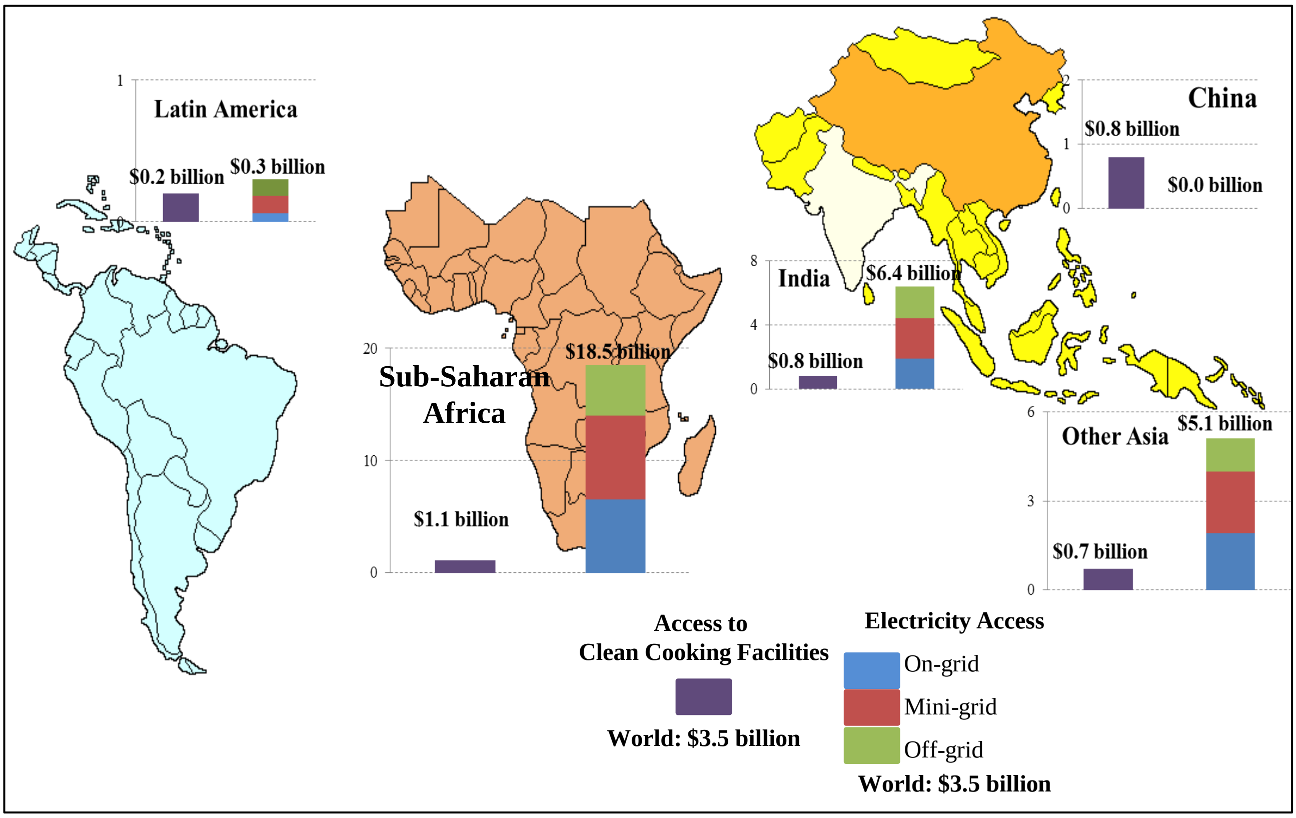
[14] Data WEO, 2011. WEO 2012 indicates in 49 bln $/a (2011 dollars) the investments need to reach an Energy for All scenario to 2030. However, such a data is not disaggregated in WEO 2012 redirecting to WEO 2011 for further information.

Fig.5 Average Annual Investment in Modern Energy Access, 2010-2030 (dollars 2010)

Source: WEO 2011

16. Hence, achieving universal energy access requires a financial commitment threefold greater than that expected in the NPS, as well as fivefold higher than the record level of investments reached in 2009. More than half (58%) of the additional $34 billion required in the Energy for All Scenario vs. the Reference Scenario would be used for Sub-Saharan energy access and, in turn, employed for the 94% of it ($18.5 billion over $19.6 billion) in electrification projects. Indeed, the African Continent electrification represents the hardest challenge to put an end to energy poverty.

Fig.6 Average annual investment required by region and technology in the IEA Energy for All Case, 2010-2030

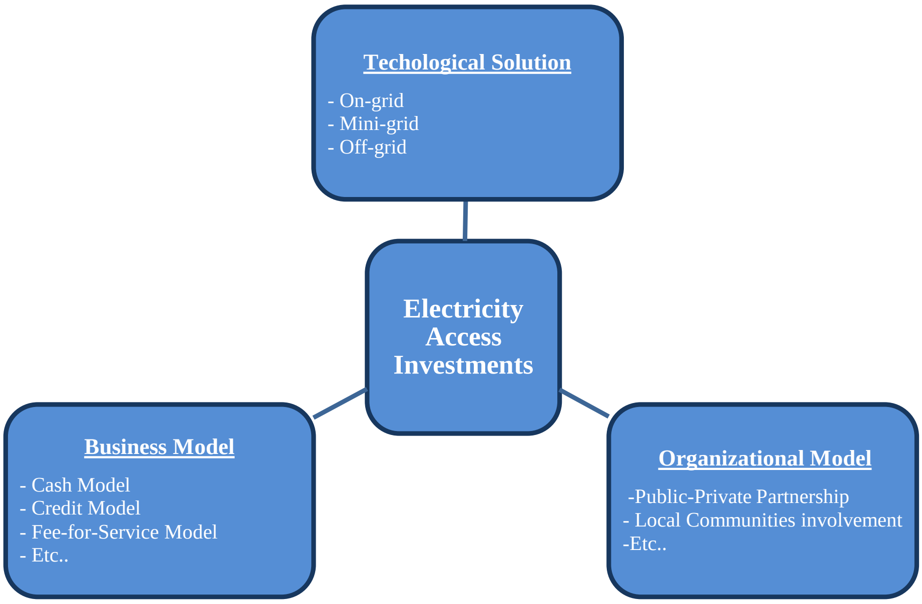


Source: WEO 2011

17. The complexity of fighting energy poverty is not circumscribed to a mere financial problem. In fact, the amount of investments estimated by the IEA is just about 3% of the global annual energy spending. Even more meaningful, just 0.7% of the oil and gas export income (by the way, $30 billion) of the first ten Sub-Saharan African exporting countries[15] would be sufficient to provide modern energy services to all their households. Furthermore, the recent successful geological discoveries in largely unexplored areas of the continent, mainly in East Africa, can convert current non-producing in producing countries. Hence, giving them access to high income that they nowadays do not have.

18. Aspects more critical than the financial disposal are how deploy it and toward which kind of investment. African specific conditions – large distances, low population density, low income level – do not allow for a traditional electrification model adopted by developed countries. For this reason various technological solutions – on-grid, mini-grid, off-grid – are required in order to achieve electricity access for the whole population. These solutions – very diversified within each group – can be more or less appropriate to electrify a particular area depending on local unitary investment costs together with the end-users density. Finally, the success or failure of the investments in these technologies is nevertheless determined by both business – cash, credit, fee-for-service, etc. – and organizational models – public-private partnership, local communities involvement – adopted.

Fig.7 Financing Modern Energy Access



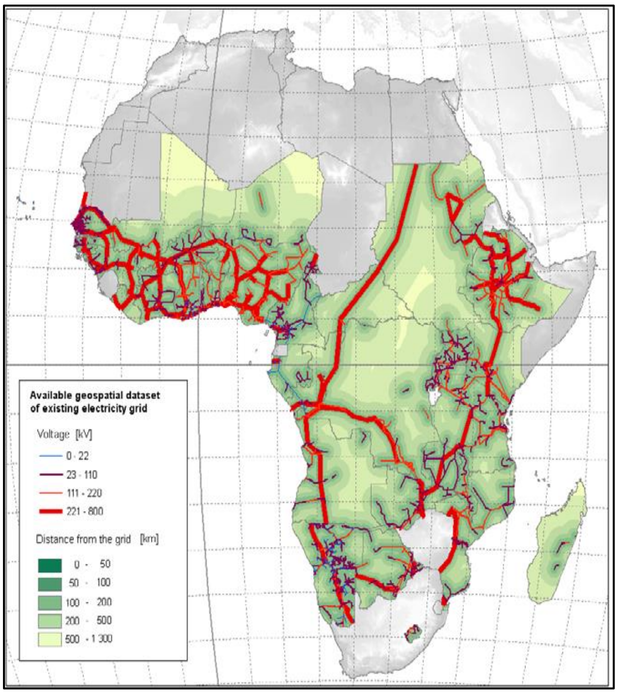
Source: Rie

Obstacles to the electrification of the African Continent

19. The electrification problem of the African Continent, despite its regional and specific differences, is mainly due to the absence of adequate distribution grids along the whole territory. Whereas many developing countries have made some progress in expanding electricity services in rural areas, in Africa reducing this gap is a tougher task for several reasons.

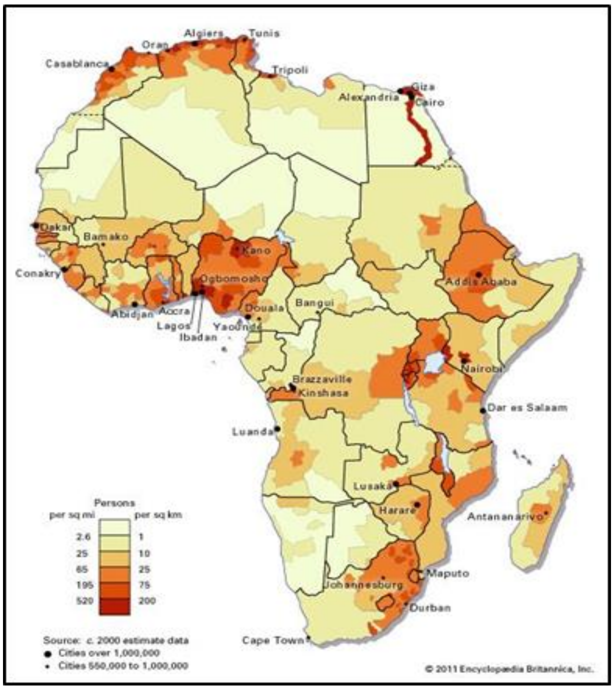
[15] Angola, Cameroon, Chad, DR of Congo, Equatorial Guinea, Gabon, Côte d'Ivoire, Mozambique, Nigeria e Sudan.

Fig.8 Sub-Saharan power grid dataset and distance from the grid



Source: Environmental Research Letters, 2011

Fig.9 African population density, 2002



Source: Encyclopedia Britannica Web Site

20. *Low population density* is one of the factors affecting the realization of efficient power distribution grids because it results in higher total and unit costs for consumers and in a disincentive for utilities to invest especially in rural areas. Indeed, building extensive central grid distribution system is very expensive and rural households cannot afford to pay these high costs. As a result, rural electricity systems need higher investment costs per consumer and per kWh of sales than urban systems.[16]

21. The high costs of supply, along with the limited capacity of household to pay for services, increase the difficulties in attracting investment in rural electrification. The absence of an appropriate incentive system is another key element which hinders the development of on-grid solution in rural areas. To do so, it would require the introduction of tariffs and subsidies in order to guarantee financial sustainability and address the problem of affordability.[17] Implementing an effective, well-planned electrification program requires technical and managerial skills not always present in the regulatory system of a low-income country.

22. To establish an entire and appropriate program for the development of a distribution system, it needs an appropriate legislation determining technical standards and regulatory procedures, planning capacity, strong institutions, significant government commitment. Despite in the 1980s many African countries started a reforming process introducing private participation and establishing regulatory bodies, the outcomes were limited. Regulators, in many cases, are far from independent and competition has not demonstrated to be as appropriate for Sub-Saharan Africa small markets.

[16] World Bank (2010).
[17] World Bank (2010).

23. The power crisis is exacerbated in some countries by specific national situation related to the presence of conflict, drought, rapid economic growth, high international oil prices. In particular, war left power infrastructure severely damaged in many countries.[18] Hydro-dependent countries, concentrated in Western and Eastern Africa, have been affected by drought, which caused a strong reduction of power availability and an increase of reliance on expensive thermal power.

24. Oil-importing countries have been affected by high international oil prices[19]. Other countries are under pressure due to a rapid economic growth not sustained by investment in the power sector.[20] Despite important proven oil and gas reserves and hydropower potential, Sub-Saharan Africa energy resources remain largely unexploited. This results in a more reliance to energy import and in higher costs of electricity production.

[18] Sierra Leone, Liberia, the Central African Republic, Somalia, Zimbabwe and the Democratic Republic of Congo. AICD (2009).
[19] Especially Benin, Burkina Faso, Cape Verde, Chad, Comoros, Eritrea, Gambia, Guinea-Bissau, Liberia, Mauritania, Senegal, Seychelles, Sierra Leone, Somalia, Sudan, and Togo.
[20] This is the case of South Africa which is facing power cuts and erosion of spare capacity due to a stagnant supply combined with a growing demand. AICD (2009)

TRADITIONAL ON-GRID ELECTRIFICATION

Introduction To The On-Grid Electrification

25. A traditional electric system is composed of four different technical phases: fuel-mix acquisition, electric power transmission (high/medium voltage), electric power distribution (low voltage), supply. The choose of the technological solution and the dimension of the power plant is function of: the domestic availability of primary energy, the market dimension, the demand profile. The greater the capital intensity of the power plant – with the prevalence of fixed costs over variable costs – the greater the importance of running the plant at its maximum capacity is. Such an arrangement is only partly suitable to the African continent because of the very different contexts it presents. Hence, a mix of technological solutions complementary to the traditional grid extension is required to bring power access to the whole Africa.

26. The use of fossil fuels is dominant in the world power generation, covering almost two third of the total production. This trend is expected to remain the same over the long term: fossil fuels should decrease to 58% of the world electric generation with coal lowering to 33% (but still the most used) and natural gas stable at 23%. In Africa, where electric generation is just 3% of world power generation, fossil fuels are even more central: they cover 81% of the continent power generation, mainly from coal (39%) and natural gas (30%). This picture should change over the long term with fossil fuels expected lowering to 59% in favour of hydroelectric and renewables.

Tab.3 World Power Generation by Fuel, 2010-2035

	World				Africa			
	Electricity Generation (TWh)		Shares (%)		Electricity generation (TWh)		Shares (%)	
	2010	2035	2010	2035	2010	2035	2010	2035
Total generation	**21408**	**36637**	**100**	**100**	**662**	**1386**	**100**	**100**
Coal	8687	11908	41	33	260	367	39	26
Oil	1000	555	5	2	80	54	12	4
Gas	4760	8466	22	23	199	409	30	29
Nuclear	2756	4366	13	12	12	61	2	4
Hydro	3431	5677	16	15	105	306	16	22
Bioenergy	331	1487	2	4	1	55	0	4
Wind	342	2681	2	7	2	37	0	3
Geothermal	68	315	0	1	1	14	0	1
Solar PV	32	846	0	2	0	41	0	3
CSP	2	278	0	1	-	42	-	3
Marine	1	57	0	0	-	-	-	-

Source: Rie on WEO 2012

27. High voltage transmission is the second phase of a traditional electric system. It is composed of electric cables, power stations and electric transformer stations that allow to bring the power generated to the consumption area. High voltage (380 kV – 250 kV – 150 kV) allows a more efficient power transfer compared with lower voltages because it has fewer losses and consequently it is adopted for high distance transmissions. The last phase imply a progressive decrease of the

voltage in order to input power into a capillary distribution grid that allows to reach each end-user with a medium (10-20 kV) or low voltage (lower than 1000 V, usually 400 V) depending on the consumption needs, if industrial or domestic.

28. Boosting and extending a traditional electric system (on-grid solution) is the most economical and relatively easy-to-enforce technical option to expand electricity access. For this reason, it is considered the optimal solution for urban and, possibly, rural electrification. On-grid electrification is the traditional solution adopted by the industrialized countries and today it is an essential option to increase energy access in developing countries. Developing countries have to face two structural trends: a growing demographic trend and the consequent intensification of the urbanization process. According to the IEA, the estimated 2.1% average annual population growth rate in Africa between 2010 and 2035 (totally 698 million people) will bring to a 13 percentage point increase in the urbanization rate to 53% of the total population[21].

29. Considering these trends, States must prioritize the access of modern energy services in urban areas in order to prevent or, at least, reduce the unavoidable social criticalities that the urbanization process cause to the city governance. The economic aspect is not less important in the choose of the on-grid solution. Investments in the electrical system development are indispensable and can attract the private sector. In fact, despite their high capital intensity, on-grid investments are economically sustainable from both supply and demand sides even in developing countries. On the demand side, the existence of a unique national grid allows to exploit the economies of scale and of density while minimizing the integrated costs of new customers, mainly low-income households. By sharing the investment cost among the community, new customers do not have to face an up-front cost too high, but just a lightened connection fee, possibly supported by public subsidies. On the supply side, the high number of new customers can attract private investments regardless of the level of the household income. The vast basin of new customers embraced by on-grid extension enables private investors to pay back the investment cost over the medium-long term despite the amount paid by a single customer. This amount can thus be quite low.

30. The strict correlation between the number of new customers embraced by a traditional grid investment and its economic sustainability opens a dilemma about the limits of this technological option to enable a wide and integrated electrification of the African continent. The combination of long distances, low population density and low income level of households hinders the adoption of the traditional grid extension as a single solution for the whole continent electrification.

Tab.4 Geographical Data by Region, 2010

	Surface (mln km^2)	Population (mln)	Density (Pop. per km^2) [22]	Urbanization rate (%)
Africa	30	1032	34	40
United States	9	314	35	82
Europe	10	560	56	74

Source: Rie on various data

[21] IEA (2012)
[22] Population density is the number of people per unit of area usually per square kilometre or mile.

31. The United States managed to solve the problem of long distances – similar to the one affecting Africa today – thanks to an electrification model that connect several urban centres bypassing vast unpopulated areas. Despite the low population density, the United States have an elevated urbanization rate that allowed to bring power to almost the whole population by connecting urban grids to the national one. However, the same model cannot be adopted in the African context to moderate the costs of the continent long distances. In fact, despite a similar population density, the urbanization rate in Africa is going to remain largely lower in respect to the United States' one. The majority of the African population lives in relatively small villages spread all over the continent. This kind of context should need a more capillary model in order to grant universal energy access through a traditional grid extension. Nonetheless, such a capillary electrification is achievable only in a long period under the right logistical, normative and economic conditions that are not present in Africa today.

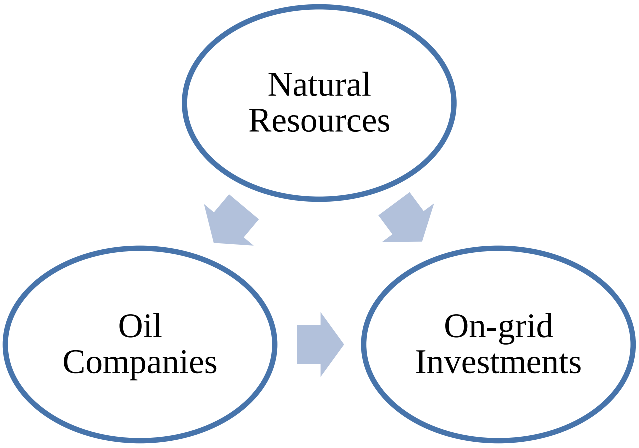
32. In conclusion, traditional on-grid electrification is the more efficient technological solution to maximize the penetration of the electric services in Africa. Nonetheless, it is not sufficient to realize an *Energy for All* scenario especially in the short term. Hence, traditional on-grid electrification must be supported by other options – off-grid and mini-grid – that, even if not without complications, are better suitable to the African remote rural context where the majority of the population lives. These kinds of technological solutions can offer just a minimum energy service. Nevertheless they seem unavoidable, at least for an undefined transitional period, as a *bridge* toward a future connection to the national grid.

Fostering on-grid investment

33. Power service penetration in the African continent is bound to the domestic disposal of natural resources, given the difficulties to acquire them in the international markets. The exploitation of domestic resources allows to: (a) have available, together with exports and royalties, the financial resources necessary to realize investments all along the electricity chain; (b) have available the natural resources necessary for the power generation, possibly exploiting otherwise-wasted resources, as for the gas flaring; (c) encourage the entry of foreign firms and investments that can bring a precious cross-disciplinary know-how in the Oil-Gas&Power sector together with important financial resources. For all these reasons we believe that the African States having primary energy resources can start an electrification planning better and before other States.

34. Nonetheless, we retain that those conditions are necessary but not at all sufficient in countries – as the African ones – that suffer from a weak governance, an insufficient business infrastructure, the lack of an internal market structure. In order to resolve this dilemma, an innovative approach to the exploitation of the natural resources is required. An approach aimed at the socio-economic development of the African resource-rich countries, first of all by avoiding the risks of political degeneration caused by the sudden disposal of a massive wealth. In order to succeed, these countries should pivot on a virtuous triangulation among *"natural resources–international oil companies–energy investments"* that allows to foster concrete electrification programmes.

Fig.10 Natural Resources–Oil Companies–On-Grid Investments Triangulation



Source: Rie

Africa: a new energy frontier

35. In recent years, the African Continent is facing a huge increase of its energy resource potential and of its production capacity due to new hydrocarbon discoveries, mainly in East Africa. Today, Africa has proved reserves of 132.4 billion barrels of oil and 14.5 trillion cubic meters of conventional gas which represent respectively 8% and 7% of global reserves. North Africa represents the richest area – in particular Algeria, Egypt, Libya – together with few big producers in Sub-Saharan Africa like Nigeria and Angola.

Tab.5 Estimated Proved Reserves in Africa (Jan. 1, 2013)

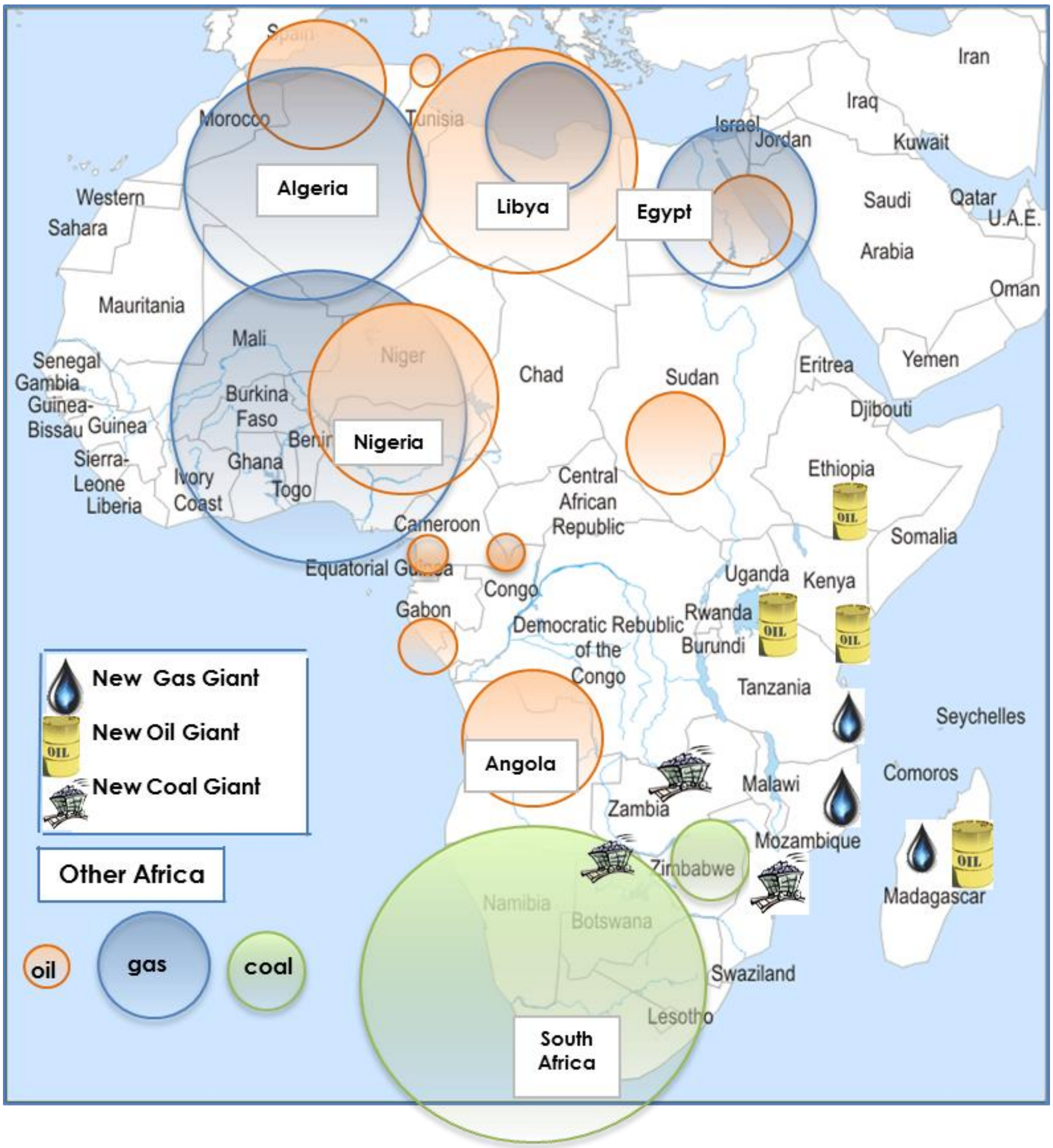
Country	Oil (1,000 bbl)	Gas (bcf)	Country	Oil (1,000 bbl)	Gas (bcf)
Algeria	12,200,000	159,054	**Libya**	48,010,000	54,630
Angola	10,470,000	12,925	**Mauritania**	20,000	1,000
Benin	8,000	40	**Morocco**	684	51
Cameroon	200,000	4,770	**Mozambique**	-	4,500
Chad	1,500,000	-	**Namibia**	-	2,200
Congo	180,000	35	**Nigeria**	37,200,000	182,008
Congo Brazzaville	1,600,000	3,200	**Rwanda**	-	2,000
Egypt	4,400,000	77,200	**Somalia**	-	200
Equatorial Guinea	1,100,000	1,300	**South Africa**	15,000	-
Ethiopia	428	880	**Sudan**	5,000,000	3,000
Gabon	2,000,000	1,000	**Tanzania**	-	230
Ghana	660,000	800	**Tunisia**	425,000	2,300
Ivory Coast	100,000	1,000	**Uganda**	2,500,000	500

Source: Oil&Gas Journal

36. Looking at coal, the most used primary energy source worldwide, there are few big basins mainly concentrated in South Africa and, to a lesser extent, in Zimbabwe. In these countries, coal is of keen importance, being responsible for, respectively, 94% and 46% of their electricity demand. It is easily presumable a coal supremacy over the other fossil sources in the next future due to the existence of a consolidated infrastructural system oriented to its production and utilization. This situation paves the way to new investment on the so called "clean" technologies which could render its use and storage less problematic in terms of environmental sustainability.

37. The extraordinary growth of global energy demand, combined to the incapacity of supply to adequately correspond, represents the new structural factor which the whole world cannot miss to face. In this context, the new discoveries in Africa get a stronger value because they can change the perspectives of the African development. High crude international oil prices (a trend destined to continue in the future) and the difficulties to exploit some easy-to-develop Middle East maxi giant fields bring International Oil Companies (IOC) to take into consideration "frontier areas" earlier overlooked as unknown, inaccessible and non-economically feasible. East Africa is one of these.

Fig.11 Proved reserves and new discoveries of oil, gas and coal deposit in Africa



Source: RIE on various sources

38. East Africa is emerging as the new hot zone for oil and natural gas exploration, similar to Central Asia and Brazil, with major discoveries by some international companies like the US's Anadarko and Italy's Eni in the Indian Ocean off Mozambique and by Norway's Statoil off neighbouring Tanzania. The US Geological Survey estimates that gas reserves in East Africa could rocket to new heights and the region is set to be one of the largest gas producers in Africa as well as a major global player in oil production. By 2007, Tullow oil had discovered commercially viable oil in Uganda, stimulating other companies to decide to enter in the country, like the French Total and the Chinese CNOOC. Estimation in Uganda were recently updated upward, from 2.5 to 3.5 billion barrels, and so are those of Kenya and Ethiopia where in early 2012 were made new oil discoveries. A huge potential of oil and gas has also be found offshore in Mozambique, Tanzania, Seychelles, Madagascar estimated in a total of about 28 billion barrels of oil, 441 trillion cubic feet of natural gas and 14 billion barrels of NGL. Good perspectives are also in Congo, Eritrea and Somalia.

Tab.6 The main recent discoveries of oil, gas and coal in Africa

Country	Resource	Discovery	Company	Potential Resources
Algeria	gas	South-East Illizi	Repsol, Enel, GDF Suez	initial production rate of 105,000 cubic meters per day
Angola	oil	Kizomba Satellites (deepwater offshore)	ExxonMobil, BP, Eni Statoil	estimated 250 million barrels
Angola-Congo	oil	Lianzi (deepwater offshore)	Chevron, Total, Eni, Sonangol, SNPC, GALP	estimated 70 million barrels
Botswana	coal	Kweneng, Serowe; Sese; Moruple South; Mmamantswe	Continental Coal; AER; Hodges Resources; Aviva Corp.	estimated respectively 2.2 and 3.9 billion tonnes; estimated 2.5 billion tonnes; estimated 1.4 billion tonnes; estimated 1.3 billion tonnes
Egypt	gas	West Sama-1; Taurt North, Seth South,North El Burg; Onshore Nile Delta; North Sea; Disouq	Dana Gas; BP Egypt; Shariah Dana Gas PJSC; Saudi Aramco, RWE Dea	on-going exploration's activities
Equatorial Coast	gas	Fortuna complex	Ophir Energy	estimated 553 billion cubic feet
Kenya	oil	Anza, Lamu, Mandera, Tertiary Rift (onshore/offshore)	Tullow Oil, Africa Oil, Anadarko, Apache	on-going exploration's activities
	gas	Mbawa-1 (offshore)	Apache	on-going exploration's activities
Ghana	oil	Pecan-1 (deepwater offshore); Sankofa East-1X (offshore)	Hess; Eni, Vitol, GNPC	on-going exploration's activities
Ivory Coast	gas	Gazelle	Rialto Energy	estimated 33 million cubic feet per day
Mozambique	gas	Mamba North East 2	Eni	estimated 10 trillion cubic feet
Namibia	oil	four offshore exploration blocks	HRT	estimated 457 million barrels
Tanzania	gas	Paoa-1; Songo Songo; Lavani-2	Ophir Energy, BG PLC; Orca Exploration; Statoil, ExxonMobil	estimated 500 billion cubic feet; estimated a maximum of 40 million cubic feet per day; on-going exploration's activities
Uganda	oil	Lake Albert Rift Basin	Tullow Oil, Total, CNOOC	estimated 3.5 billion barrels
Zambia	coal	Sinazongwe prospect	AER	on-going exploration's activities

Source: RIE on various sources

39. The growing world energy demand increased the profitability of investment in the exploration and development (E&P) of coal resources, attracting a number of foreign investors interested in exploiting the vast potential of the Sub-Saharan fields. The Australian company African Energy Resources recently made relevant discoveries in Zambia, in addition to those made in Botswana in 2010 in the Sese basin, estimated to about 2.5 billion tonnes. Relevant coal discoveries have also been made in the Tete province, in Mozambique; the country is attracting in the last years several international companies like the Brazilian Vale, which already invested $1.7 billion and planned other $6 billion, and the Australian Rio Tinto, which planned a commitment of $4 billion for the development of its exploration licenses.

40. In conclusion, extremely poor African countries are discovering, even if still in an exploration phase, a huge potential of mineral resources. A very new situation for this Continent that can pave the way to significant opportunities of growth earlier unimaginable. However, the mere property of the natural resources has few meaning for the development of these countries; to reach it, they must adopt suitable development politics able to direct these resources and their related revenues toward specific targets, such as electrification.

Channelling resources toward national development

41. Natural resources – as widely observed in the developed world – can bring huge benefits in high-income countries with solid democratic institutions and diversified economies[23]. Nevertheless, they can be very harmful for low-governance countries that have in their exploitation the main, if not unique, source of revenue. These countries are known as *rentier States*. These huge profits can act in a distorted way on the economic and political structure of these countries and only hardly they are used for development promotion. A phenomenon known as *resource curse* that in reality is not a curse of the natural resource itself, but of the politics that has to manage it. Indeed, managing the resources and the revenues related appears an hard task both for "technical" – because the revenues are highly fluctuant and instable – and "power" reasons – because having available excessively high, secret and not-financed-by-taxes revenues allows governments to adopt undemocratic behaviours[24].

42. Besides exacerbating rentier States weaknesses in terms of democracy, economic freedom, civil rights, precious natural resources can even be the cause of corruption and internal and international conflicts[25]. Conflicts can be triggered at an ethnic or regional dimension for the territorial control of the fields and they are usually caused by the absence of whichever kind of local development generated by their exploitation (against several negative externalities) and by an unequal allocation of the revenues.

43. Moreover, besides the political and institutional risks related to the thirst for power, the lack of expertise and know-how in new oil-producing countries can even impede a fair use of the oil revenues for the socio-economic development. Governments without an expert domestic

[23] In some circumstances, natural resources can even be damaging for developed countries, as the "Dutch Disease" phenomenon demonstrates.
[24] Michael L. Ross clarifies four distinctive qualities of the unusual properties of petroleum revenues: their scale, their source, their stability, and their secrecy. Ross (2012).
[25] Indeed, "*oil-producing States are fifty percent more likely to be ruled by autocrats, and more than twice as likely to have civil wars, as non-oil States*". Ross (2012).

technocracy cannot succeed favourable and equal contractual conditions while dealing with the big oil majors. Hence, channelling natural resources and the related revenues toward national energy programmes requires to intervene in the modalities of their exploitation in order to make it more efficient and transparent for the whole country's well-being. This is the reason why we retain that the design of *New Contract Formula* (NCF) between producing countries and oil companies is of great political and economic relevance.

New Contract Formula

44. The definition of NCF can represent an innovative starting point for the promotion of a real economic development of the African countries. NCF can solve many problems that afflict those countries, among which the lack of electrification. For instance, in order to take part in a bid round for an exploration or development block, oil companies should be enforced to submit – along with other requisites – an electrification project proposal (power plant construction, grid upgrading or expansion, etc. according to the national requirements) to be implemented in case of win. In this way, the electrification project proposals would became one of the variables to award the block and select the oil company as partner for the country development.

45. Moreover, in order to gain a better evaluation, oil companies would be encouraged to enhance their offer by defining: the environmental and economic sustainability of the project, i.e. the reuse of flare gas; the socio-economic size, the criticalities and potentialities of the new customer basin targeted by the project; the correlated initiatives directed to improve the development potentialities of the project, i.e. the project implementation through local companies support or the development of a local expertise through training activities for TSO (transmission system operator) or utilities that will take care of the transmission, dispatch and sale management.

46. Thanks to this NCF, part of the natural and economic resources of the countries would be directly bound and channelled toward concrete development projects. Nonetheless, defining and adopting NCF represents a very hard task. It needs to involve multiple actors at multiple levels – government, international institutions, oil companies, etc. – that must perceive a tangible interest in promoting it and in acting in an agreed and coordinated way.

Producing Countries: Cooperation and "Union" Action

47. In order to obtain an impact able to modify the actual *modus operandi,* it is of primarily importance that the NCF would be adopted and agreed by the majority of the present and future oil producing countries. These countries should adopt a *common line of cooperation* so as to claim with effectiveness innovative contractual conditions. Unity of action and of intents is essential for multiple reasons. Firstly, it allows to mitigate the harmful intra-regional competition that force governments to offer increasingly favourable conditions just to attract oil companies on their country. On the contrary, the creation of a common policy action would assure producing countries a stronger bargaining power toward oil companies. Especially, in a context of great international interest towards African resources. Such a power position would persuade oil companies to negotiate new contractual conditions just not to lose the opportunity to operate in the continent. In brief: oil producing African countries should define a common contractual platform aimed at pursuing national and common interests. An action along the lines of that which brought to the

foundation in 1960 of the *Organization of the Petroleum Exporting Countries* (OPEC) and to *the harmonization of the fiscal policy* (royalties and income taxes) of its member States.

48. Moreover, a cooperative approach can generate many additional advantages. The coordination and the comparison among countries, as well as the disposal of more information (resource mapping, investment policies, export infrastructures, etc.) can facilitate the identification of solutions for several regional problems, not only on the energy front. For instance, great infrastructural projects could be promoted in a synergic way at a regional level, and their financing included – partially or *in toto* – in the contract with the oil companies. Fields development could bring to the definition of integrated electrification projects among many countries. In this way, would be possible to exploit the large economies of scale in the power generation and infrastructures. By defining integrated projects, non-oil countries could even be involved, thanks to their possibly relevance in the pipeline and transmission line transit.

49. Oil and gas should became field of cooperation. Besides promoting development projects, mitigating the harmful competition among producing countries would allow to slow down the race for natural resource exploitation and to correlate it to the effective country financial needs, while avoiding the risk of attracting more investment than those the country (and the government) can absorb and manage. Consequently, governments could focus better on primary aspects such as the outline of an internal regulatory framework stable an adapt to protect the country economic and environmental interests while creating a more secure and attractive environment for the oil companies investments.

The Role of International Institutions

50. International institution's support to the change of the oil producing countries' strategy is indispensable for its success. For instance, African Union could assume the networking role among the African countries in order to promote the cooperation policy presented above. Besides highlighting the problem of the energy access and its critical world implication on the international agenda – as the UN did by declaring 2012 the "International Year of Sustainable Energy for All" – International Institutions must go further by endorsing concrete initiatives. In the case of NCF, International Institutions should pivot on their mediation capabilities and encourage the dialogue with and among oil producing countries so as to sustain the reasons of cooperation in respect to those of an individual action. In particular, the adoption of a common policy – as presented above – implies an inevitable restriction on the governments' margin to manoeuvre that these countries could not accept. Indeed, NCF are aimed at binding natural resources and related proceeds to development projects right from the start in order to bypass public inefficiency and corruption[26].

51. International institutions should take advantage of the international interest on both the energy access matter and African natural resources in order to put pressure on governments and convince them to accept innovative and concrete solution for energy access and national development, as the NCF are. Besides supporting this kind of solutions, International Institutions should act to outline them with the greatest level of transparency achievable so as to became a bond for the governments themselves and thus limiting their possible dishonest behaviours.

[26] As introduced in Chapter I, 0.7% of the oil and gas export income of the first ten Sub-Saharan African producing countries ($30 bln) would be sufficient to provide modern energy services to each of their household.

52. Additionally, it would be of great functionality if one particular Institution would deal with the *monitoring and coordination of the cooperation*. A role that could be assumed by the African Union inasmuch it is an Institution already established and it has a continental size. This Institution would be a reference point able to: assure continuity and stability to the cooperation; contribute to the draft of the NCF; offer technical support through appropriate professional consultancies; facilitate the comparison among various countries past experiences in order to pinpoint best practices; identify common problems that could be faced through NCF.

The Role of Oil Companies

53. Last but not least, the role of oil companies is relevant as much. Oil companies are crucial in the *"natural resources–international oil companies–energy investments"* triangulation because of their huge financial capability, their know-how and their transversal business expertise. It is of keen importance that the NCF and the bond of electrification projects are not perceived as a kind of blackmail toward them. This is not about a readjustment of the balance of power. On the contrary, it means identifying a convergence of interests among the actors involved in the Oil&Gas industry: a further step along the experience drawn by Enrico Mattei since the historical establishment in 1957 of a joint-venture between the Italian *Ente Nazionale Idrocarburi* (Eni) and the Iranian *National Iranian Oil Company* (NIOC).

54. Oil companies have full interest in promoting the national development of the countries with which they maintain business relations. Not for humanitarian magnanimity, but to defend their own investments. The 2011' Arab uprising in North Africa can clearly illustrate it: the socioeconomic underdevelopment of these countries has led to national insurgencies that threatened – among others – oil industry investments. Indeed, for oil companies it is of keen relevance assuring economic security and legal certainty as well as physical integrity of their billionaire investments. On the one side, the lack of a certain and stable legal framework in a producing country can be costly for the oil companies which work there[27]. On the other side, the lack of development and the consequent risk of political instability in a producing country is a potential threat to the security and/or integrity of the oil companies investments. In case of turmoil, the expensive oil infrastructures became easy and fruitful target for armed militants looking for civil and social claims or for row material to smuggle[28]. Moreover, threats to the integrity of the infrastructures can come from piracy, as the Somali one, or from the internal or intra-regional rivalries over/for the control of the resources, as seen in the tragic Sudanese civil war and the post-independence Sudan-South Sudan antagonism.

55. Some oil companies are aware of the strict correlation between security and development. This is the reason why – apart from the will of being welcomed from the local population – they already provide development programmes aimed at, among others, increase the energy access. At the forefront we find the Italy's Eni that after half-century still keep the faith to its "Matteian" strategy according to which natural resources are of legitimate property of the country and they must be used

[27] Some recent African examples can prove this. For instance, after investing $160 million in Tanzania, PanAfrican Energy, a wholly owned subsidiary of Orca Exploration, is close to paralysis because of unpaid bills and quarrels with authorities over terms for a total amount of $33 million; or Britain's Tullow Oil in Uganda that had to pay an unexpected $300 million tax bill after its acquisition of rights. Gilblom and Obulutsa (2012).

[28] It happens in Nigeria where oil theft e local claims from MEND (Movement for the Emancipation of the Niger Delta) are one of the major causes – together with the lack of a new modern legal framework – of the national oil industry inefficiencies.

for national development. In 2005, Eni signed a Memorandum of Understanding (MoU) with the Nigerian government aimed at the implementation of an electrification project. The result was the construction of a 480 MW combined cycle power plant in Kwale Okpai able to provide energy access to more than 50 communities. Moreover, this was the second flaring down project worldwide and the first in Africa to be registered as a Kyoto Protocol's CDM (Clean Development Mechanism) activity in 2006[29].

56. Based on its experience in Nigeria, in 2007 Eni signed a cooperation agreement with the Republic of Congo. The agreement envisages the construction of two power stations that utilize the associated gas from production activities: the Centrale Electrique de Djeno with a current power output of 50 MW, and the new Centrale Electrique du Congo, with a current power output of 300 MW (planned for a future output of 450 MW). By covering the 60% of the country power generation, these plants provide power to almost 700,000 people. Besides Eni, the Australian *African Energy Resources* launched in Botswana the Sese Integrated Power Project aimed at the construction of a 300 MW power plant to be fed with local coal. Still in Botswana, Indian *Jindal Steel and Power* plans to invest $750 million in the development of the Mmamabula coal field destined to coal export and power generation.

Tab.7 Planned and Realized Electrification Project from Production Activities

Country	Resource	Company	Investment
Botswana	Coal	African Energy Resources (Australia)	AER launched the Sese Integrated Power Project designed around an initial 300MW power station with a captive 1.5 Mtpa coal mine providing cheap fuel.
		Jindal Steel and Power (India)	Jindal announced recently that it would invest up about $750 million to develop a coal mine and build a power plant at Mmamabula.
Nigeria	Associated Gas	Eni (Italy)	In 2005, Eni built a 480 MW combined cycle power plant in Kwale Okpai (Nigeria). The plant uses the associated gas from production activities, which would otherwise be flared.
Congo	Associated Gas	Eni (Italy)	In 2007, Eni built two power stations that utilize the associated gas with a generating capacity of 50 MW and 300 MW that meet 60% of the electricity production of the country.

Source: Rie on various sources

[29] Eni (2011).

CHAPTER III
OFF-GRID SOLUTION FOR RURAL ELECTRIFICATION

Why Going "Off the Grid"

58. Traditional grid extension is highly costly and not feasible in isolated rural areas while off-grid electrification is suitable in this kind of contests, characterized by low population density, long distance between the users and the existing grids, small demand. Within the medium term, grid extension projects cannot be a real option and the only way to guarantee a suitable supply in remote areas is through independent system.[30] Off-grid – in particular individual systems such as Solar Home Systems (SHS) – and mini-grids technologies may represent an appropriate solution to supply electricity to rural people in Africa. Mini-grids can also be complementary to the traditional on-grid solutions and represent a stepping stone towards electrification, opening the possibility of an integration to the grid at a later stage.[31]

59. Since now, diesel generators have been the traditional solution to decentralized electrification needs; however, kerosene is an expensive, polluting and inefficient fuel.[32] Moreover, the dramatic increase of fuel prices in recent years and its high transport costs to reach remote areas have reduced the low capital cost advantage of diesel generators and raised the competitiveness of using renewable energies.[33]

60. Rapid technological innovation and a scale-up of commercialization efforts, with corresponding falling manufacturing costs and declines in the retail product price, are becoming a substantial driver of renewable energy development.[34] Photovoltaic (PV), in particular, is considered a sustainable option for electrification in order to meet the needs of rural populations. IEA estimates that by 2030 renewables will dominate both for mini-grid and off-grid solutions, increasing access to electricity without the negative impact on health and the environment caused by diesel generators.[35]

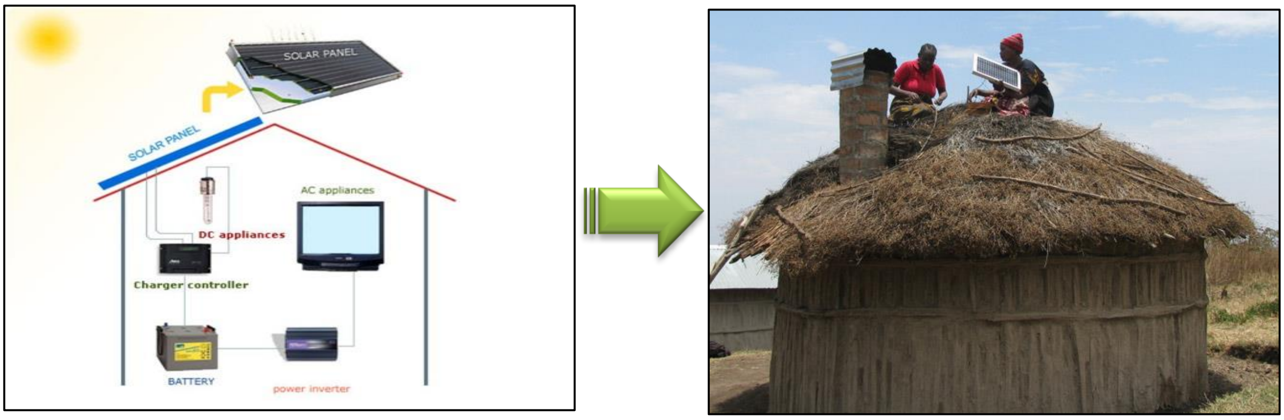
61. Small photovoltaic systems present a number of advantages for rural electrification in developing countries. [36]

- ✓ *Flexibility*: they can reach end-users directly in remote locations, where electricity can be delivered without waiting for a connection to the grid;
- ✓ *Efficiency* and *cost-effectiveness* [37]
- ✓ *Clean and Environment Friendly Energy*;
- ✓ *Employment Opportunities* in the vicinity of its operation.

[30] World Bank (2010); ARE (2011); IFC and WB (2010).
[31] IRENA (2012).
[32] Chevalier (2009).
[33] Szab´o , B´odis , Huld and Moner-Girona (2011).
[34] IFC and WB (2010)
[35] IEA (2012).
[36] Lemaire (2011).
[37] Lemaire (2011).; ESMAP (2007).

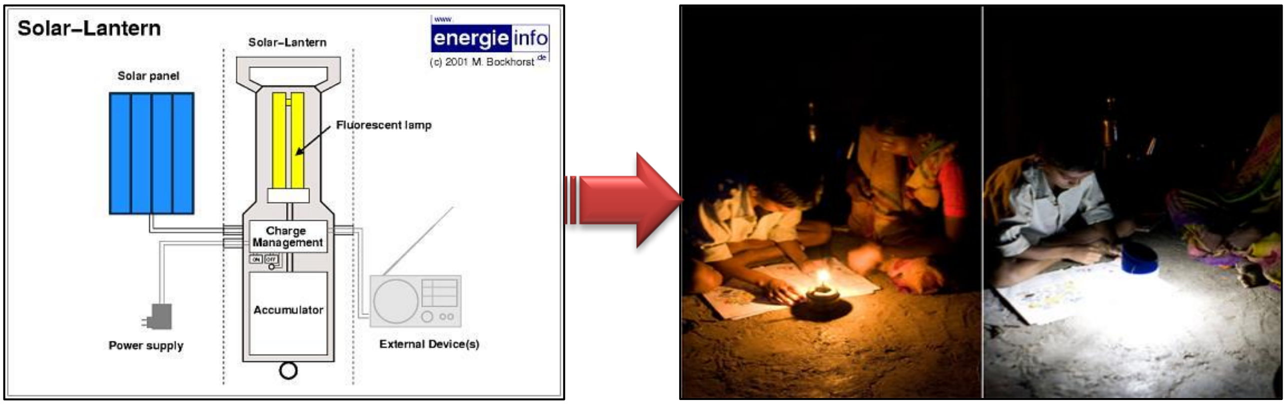
__Technology__

62. A solar home system (SHS) uses a PV module to provide the daily power for lights and small appliances. If the domestic grid is not connected to a distribution network, it is an islanded power system that needs a rechargeable battery, typically with three days storage capacity, to render power available at night and on cloudy days. The presence of batteries is also important in order to regulate and stabilize the voltage of the grid. The PV module is fixed to the home roof at the angle which collects maximum sunlight and uses semiconductor materials to generate direct current (dc) electricity. SHS is usually equipped with power electronic inverters to convert the dc electricity into alternating current (ac) compatible with household appliances. PV modules or panels are specified by their watt-peak (Wp) rating, which is the power generated under standard conditions. Usual values for PV modules are from tens of watts to few hundreds of watts. A SHS may incorporate an array of several panels. Most systems have an electronic charge-controller which indicates the state-of-charge of the battery, protecting the battery from being overcharged (when it is very sunny) or over-discharged (when people try to get too much electricity from the system). SHS can be very reliable and need little maintenance; users must be trained to check the battery, keep the PV module clean and make sure that connectors are secure. However, even with careful use, batteries deteriorate and need to be replaced every four or five years.[38]

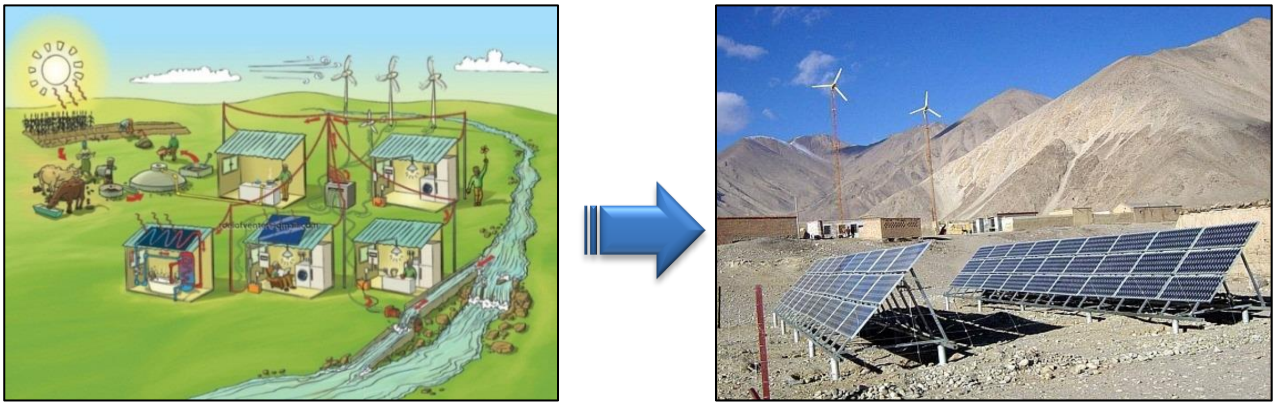


63. Some small PV systems are designed to be portable, functioning primarily as solar lanterns. Solar Portable Lights (SPL) are powered by a solar cell: some include a small built-in PV module, and others are designed to be plugged into a PV module for charging then detached for use. They have a small fluorescent or LED light with a rechargeable battery and are easy to carry and can stand on the ground or a table, or else hang from the ceiling. Given the portability factor, the solar panel size is restricted to 10 W and below.[39]

[38] Ashden Web Site; Future Power Concepts Web Site.
[39] IFC and WB (2010); Ashden Web Site.



64. A mini-grid is a small-scale independent electricity network that connects the domestic grids of neighbouring houses (e.g. those of a village) .[40] Mini-grids are a suitable solution for rural communities isolated from public distribution power networks and having a limited load demand; they can power both households and local businesses, with a higher power quality level and higher load factor compared to individual systems.[41] Moreover, providing centralized electricity generation using a village distribution network, they are often more cost effective on a US$/kWh basis.[42] In renewable-based mini-grid, small hydropower, solar PV or biomass plants are adopted, also together (hybrid systems), usually with diesel generators as a back-up source. The figure below shows 5 different renewable energy technologies and how they could be connected to the power grid. Small-hydro is the cheapest and the more mature technology, but also the most site dependent, as it requires a river with specific flow rate conditions. So it is wind power technology as it requires particular wind conditions. PV is suitable for almost any location and it is also easier to install, maintain and scale up. However, initial investment costs are higher than those of other technologies.[43] Mini-grids are an open and modular network that can easily be extended, in case of village growth, to accommodate new consumers or be integrated in the future through the national grid.[44]



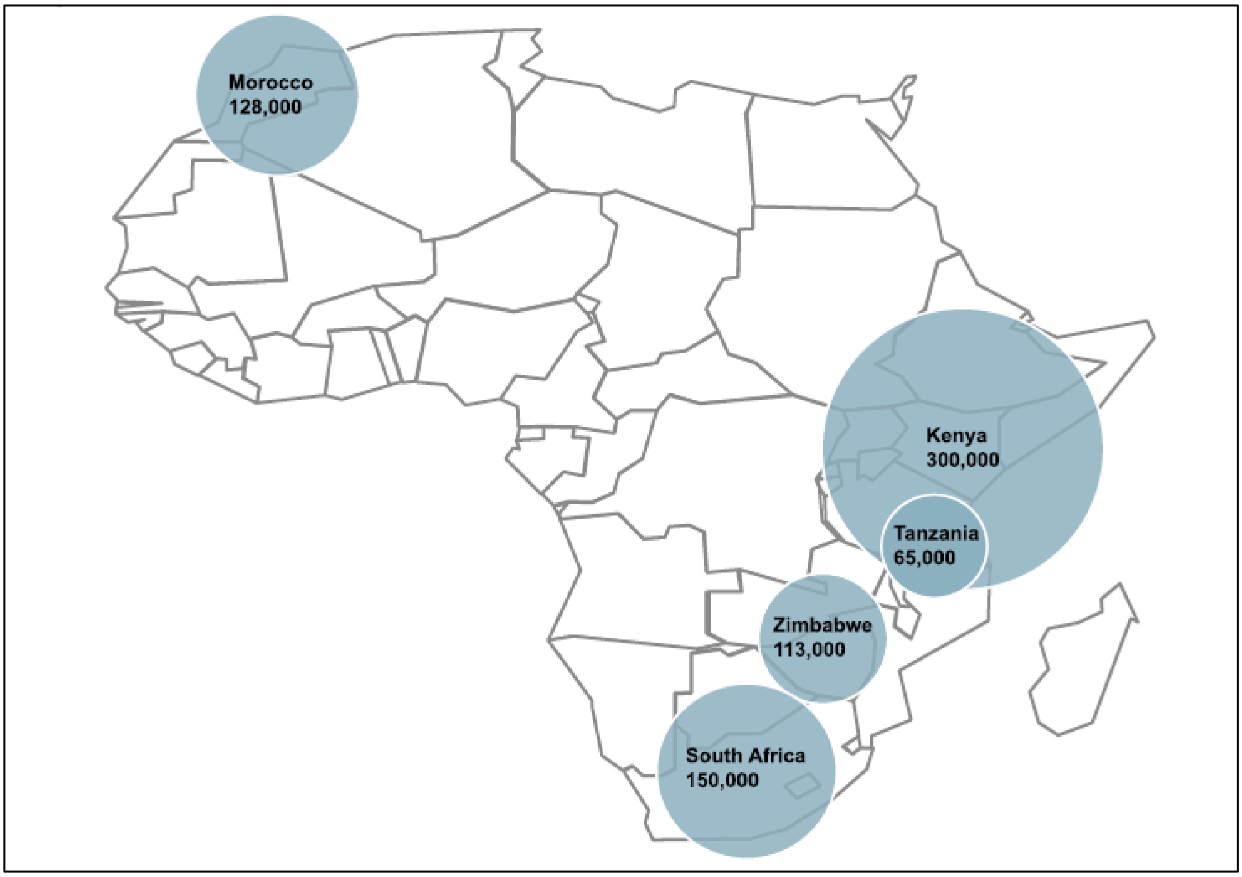
[40] FRES Web Site.
[41] ESMAP (2007); Glemarec (2012).
[42] Glemarec (2012).
[43] ARE (2011).
[44] Studer Innotec Web Site.

What Already Done

65. In the last decades, a number of different implementation approaches has been used in order to encourage the widespread affordability and acceptance of PV. A number of local initiatives for diffusion of SHS have started world-wide, implemented both in donor supported programs and projects as well as through market initiatives. In particular, since the Nineties', the World Bank (WB) and the Global Environmental Facility (GEF) have supported projects to improve commercial markets and financing for renewable energy technologies in developing countries.[45]

66. With over 2.5 million SHS installed globally and more than 850,000 installed in Africa, SHS market may be turning the corner. Previous generations achieved limited market penetration due to high costs, poor components, installation and maintenance challenges. Today, with substantially reduced prices and first signs of local assembly and/or manufacturing in Africa, SHS is increasing its market penetration, demonstrating to be a suitable solution to rural electrification.[46] It appears that there is the political will to create a positive business environment for the private sector to function as the engine of growth for job and wealth creation. However, more needs to be done.[47] Certain barriers, including awareness about the technology, capacity building and financing, still hinder the growth of a sustainable PV market. [48]

Fig.12 SHS installed in Africa, 2009



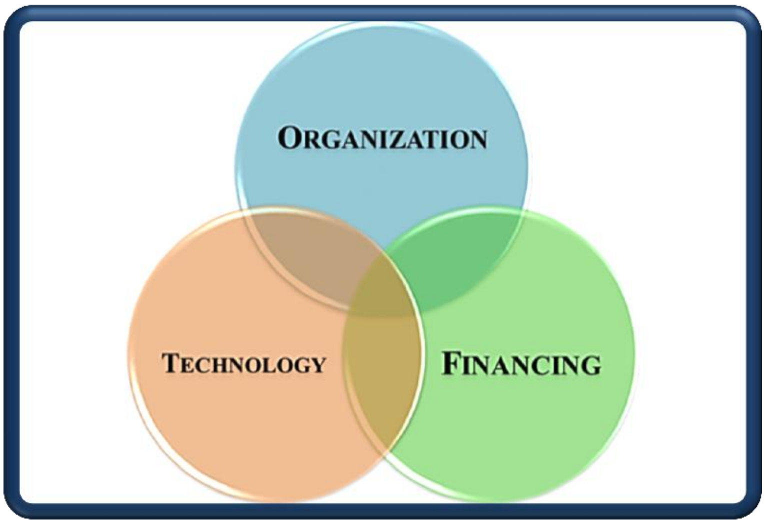
Source: IFC - WB, 2010.

[45] IEA (2010).
[46] IFC and WB (2010).
[47] OFID (2010).
[48] Anisuzzaman and Urmee (2006)

Business Model (BM)

67. In order to penetrate the market, SHS must overcome the barrier created by their high initial cost and find a way for households to continue to pay amounts equivalent to or less than those expended for conventional energy. However, lack of organizational structures, high levels of initial capital investments, and lack of ability or willingness to pay by rural customers are some of the most challenging issues hindering the development of a sustainable BM for rural electrification.

68. An ideal BM for rural electrification does not exist but its choice depends on a long range of specific local circumstances determining the effectiveness of a model: types of financial structures, organization and ownership, the choice of customers, the technology involved.[49]



69. The structure of the financing mechanism depends on the institutional, legal, socio-economic, and cultural conditions, including the amount of down payment, crediting period, target group selection, maintenance policy, service charge rate and payment collection procedure. Several financial models have been used to improve the affordability of renewable energy solutions for rural electrification, such as: [50]

- ✓ *cash model*: when customers purchase directly or via a dealer the product (PV system) paying the full cost. The end-user immediately becomes owner of the system.
- ✓ *credit model*: purchasing a product on long-term credit with payment made in installments; it's either through third-party commercial credit, dealer credit, or micro-financing.
- ✓ *mixed finance model*: when governments provide a fixed subsidy to reduce initial consumer payments;
- ✓ *fee-for-service*: when the customer pays a regular fee to the energy service company (ESCO) for using the solar panel without owning it;
- ✓ *donation model*: it refers to a technology donation to the community usually from a private entity which gives it as a gift.

[49] The ACP-EU Energy Facility
[50] Martinot and McDoom (2000); Bazilian et al. (2012); IEA (2003).

70. Another important aspect of a BM is related to the ownership, which refers to the subject(s) responsible of the project management. The institutional factors are a crucial element in determining whether a particular project is successfully implemented. They can cover different dimensions of the project: from the responsibility of the initial capitalization and development of the power system to the ownership of the generation capacity and the grid, running the operation and the responsibility of maintenance and collection of money.[51] In the following, four different types of organization and ownership are described.

- ✓ *Community-based model*: the community becomes the owner and operator of the system and provides maintenance, tariff collection and management services. This model increases self-sufficiency and self-governance of the consumers-owners but it also faces important challenges due to potential for social conflicts and the community's lack of technical and business skills and financial resources. Therefore, this model requires substantial technical assistance in management and training in operation and maintenance during the lifetime of the project which suggests the need to involve a private or a public entity.

- ✓ *Private sector-based model*: the private operator is the main designer of the system and of the technology. In the case of rural projects in developing countries, some form of public support, such as subsidies and long-term concession, is generally required to attract the private sector participation.

- ✓ *Utility-based model*: the primary responsibility lies with the utility which, due to its public or quasi-public position, has a better access to financing mechanisms and has the technical capabilities to implement and manage the project offering also extensive maintenance services. However, this model faces some important disadvantage due to the utilities' inefficiency, the scepticism they may raise on rural population and the liberalization of energy markets which is moving utilities through market-priorities (and rural electrification is not certainly considered economically attractive).

- ✓ *Hybrid business model*: it combines different ownership structures to benefit from the advantages of each model. One approach involves all three subjects with an utility company owning the system, a community-based organization managing it on a daily basis and a private company providing the technical expertise and the financial investment. Another approach involves a partnership between the national state-owned utility and local distribution entities with the former selling power at a wholesale rate to the latter that, in turn, resell it at retail price.

71. The most appropriate type of financing instrument depends also on the technological solutions implemented (on-grid, mini-grid, off-grid). In general off-grid solutions are less attractive to the private sector in respect to mini-grid projects and rising finance can represent a very challenging issue. Mini-grid projects can be run on a cost-recovery basis with a guaranteed margin and, therefore, can attract private sector finance on commercial terms. However, when projects are located in remote areas, they result less attractive and subsidies are required to support private sector activities. An important form of financing for projects destined to low energy expenditure households could be *government-initiated cooperatives* and *public-private partnerships* where loans

[51] ARE (2011)*;* The ACP-EU Energy Facility.

or grants from multilateral and bilateral sources support the initial investment and government subsidy costs.[52]

72. Moreover, the technology is also connected to the choice of the customers. The off-grid market is, in fact, stratified by a range of incomes and not the whole rural population can afford to pay the costs of the alternatives available. A price decrease of solar components, such as LEDs and batteries, could spread solar portable light (SPL) among very low income customers, not targeted by SHS technology.[53]

Fee-For-Service Vs Credit Model

73. The *credit model* refers to a subject selling the PV system to an end-user through a credit arrangement. There are three different subject that can stipulate the credit deal with the customer: the PV dealer, a credit provider, a leasing company. According to the *dealer* model, the PV company supplies hardware to the rural clients via a dealer network or directly; if the PV supplier does not have the working capital required to offer credit to the end-user, it may approach a funding source to access credit (dealer re-finance). In the case of a *third party credit* model, the dealer is not directly involved in the credit scheme but it remains responsible for the sales, distribution and installation of the PV system. The client is responsible for maintenance and repair and becomes the owner of the system either when the down payment is paid or when the credit is repaid.[54]

<u>Main stakeholders</u>

End-user: purchase of PV products on an installment or credit basis. The end-user is owner of the system and responsible for maintenance and repair, although some companies state in their terms that they remain owner until the final payment is made.

PV suppliers/dealers: sales, distribution, installation, and servicing of PV products.

Credit institutions/funding sources: Dealer re-finance; implementation of a credit line for PV systems, sometimes also sales (on a commission basis); promotion/extension work.

Government: creating the right boundary conditions for the sale of PV systems but also regulation for credit systems. This could include warranty funds for financial service providers, end-user protection through standards, certification and quality issues, information campaigns and demonstrations, taxes and subsidies, and clear policy on rural electrification.

74. In the case of a *leasing/hire-purchase* model, either the PV company or an intermediate financial institution offers the PV system to a client that pays a regular fee for a limited period (typically 2 or 3 years) during the rental or lease term after which he becomes owner of the system. The installation and after-sales service is carried out by the lessor which, however, is usually not financially and technically equipped to run a hire-purchase program. Therefore, there is very few experience of this model in developing countries because it would only apply for PV companies that have the necessary financial resources and the administrative and technical infrastructure required.

75. The *dealer* model is generally characterized by relatively short terms (mostly between 6 – 12 months), high down payments (up to 50 %) and high interest rates (20 % to 25 % are not

[52] IEA (2011).
[53] IFC and WB (2010).
[54] IEA (2003).

uncommon) but with an extra amount spent on the credit facility relatively low.[55] The payment of the hardware can be based on a monthly instalment or adapted to income cycles, providing a more flexible system of payment that better fit with the agricultural reality and allow end-users to comply with their obligations, as occurred in Bolivia. When a *third party* is involved, the end-user pays a down-payment and the remaining payments are collected by the credit institution, which usually takes responsibility for the loan and pays the complete price to the PV company. Successful examples of revolving loan fund or microcredit already exist in many developing countries.[56]

76. When a *credit provider* is involved, the PV company does not need to allocate budget to run the credit scheme, thereby avoiding financial risks and allowing it to concentrate on sales and after-sales services. However, as the credit institutions take the long-term financial risk, the PV companies may be tempted to neglect after-sales service provision. Organization aspects need also to be addressed, above all in the case of the end-user model; indeed, when two separate structures occur to manage the financial and the technical works, additional costs may be required and coordination problems may occur. The *dealer* model and the *fee-for service* model tend to reduce this risk because, in most cases, only one institution handles both the financial and the technical aspects.

77. This consumer *credit* model is widely applicable due to the reduction of the high initial investment barrier for the end-user (the main disadvantage of the cash model); however, it tends to exclude the poorest household due to high down payments and instalments rising the risk of non-payment. In order to mitigate this risk, the company must evaluate the creditworthiness of its clients and the market if often restricted generally to customers with salaried incomes, those with a guarantor or well known to the local dealer or those who have the required collateral (the PV module is usually used as collateral because it is easy to remove and reuse). In Gambia, credit sales were restricted to well-known organizations or through local dealers that know their customers because of too high financial costs and risk of non-payment. In Namibia, credit access was linked to eligibility conditions which included a minimum regular income and a positive record with previous loans. Identifying the potential SHS customers was central for reaching a high credit recovery rate with only 6% of arrears to be pay out.[57]

78. The principal role of the government is putting in place the right policy environment for PV diffusion. Policy-makers can plan least-cost energy strategies and enact or revise policies that “level the playing field” for renewable energy relative to conventional energy sources, by means of government investments, energy price reforms, institutional and regulatory reforms, tax incentives, privatization and competition.[58]

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[55] IEA (2003).

[56] In some cases, the credit institution involved has been supported by donors or government programs to keep interest rates low, as in the case of Zimbabwe. The credit scheme for the project was established and managed through the Agricultural Finance Corporation (AFC) which decided to participate despite the relatively low 15% interest rate, compared to the market rate of 40%. However, the AFC was in the first stages helped with initial seeding of $250,000 by the UNDP whose role was to facilitate funds and give the necessary technical support not readily available within Zimbabwe. Mulugetta, Nhete, Jackson (2000).

[57] IEA (2003).

[58] In the case of Zimbabwe, the government, under the support of GEF, imposed lower import duties on PV components which proved to be central in sustaining the PV market development. Martinot and McDoom (2000).

Case Study: Zimbabwe

In 1991, the United National Development Programme sponsored the Global Environmental Facility (GEF) PV project for household and community use in rural Zimbabwe in order to support the widespread use of solar electric installations as an alternative to grid extension and diesel generators. The project was implemented in collaboration with the private sector, NGOs, community-based organizations (CBOs) and the Zimbabwe Electricity Supply Authority (ZESA). The project was launched in 1992 and was almost totally financed by GEF with an investment of $7 million plus a government input of $382,650. It was designed to enhance local solar manufacturing and delivery infrastructure and to develop an expanded commercial market in rural areas by providing direct subsidies, lower import duties, and a revolving fund mechanism. In particular, this initiative was the first PV project to pilot third-party commercial credit through the Agricultural Finance Corporation's revolving loan fund that successfully provided below-market rate credit to households to purchase SHS. The five years project resulted in an expansion of the rural use of PV with the direct installation of 10,000 solar home system (SHS) by 1997, increasing the base of 3,000 PV systems already installed prior to the project. Technical knowledge of local companies was improved through training activities, a number of education courses were organized and the University of Zimbabwe began to offer a M.Sc degree in Renewable Energy Systems in 1996. It also strengthened the local business and the technical capabilities of the PV industry: before the project started, there was one PV module and systems manufacturer, and three smaller firms performing installation and system integration, while at its completion 60 firms were registered with the Solar Energy Industries Association. However, a year later only 30 firms have renewed and only six accounted for 80% of the market share for the project; it indicates that many of the small new companies came to exist because of the strong financial and material support they received from the GEF Solar project, and failed to survive once the funding stopped.[59]

79. In the *fee-for-service model*, an energy service company (ESCO) invests in PV hardware - usually decentralised individual systems on individual houses - and starts selling an energy service for a fee. The end-user pays a connection fee and a regular fee, usually monthly, as long as the energy service is delivered and never becomes the owner of the system. However, the end-user usually owns the wiring, lamps, and appliances, which are covered by the connection fee, and in some cases also the battery and charge controller.

80. The *fee-for-service* model is characterized by long-term investments. Hence, it is only applicable if the ESCO and its partners are able and willing to stay involved in the business for at least a decade. This requires long-term planning, a relatively stable economic and political situation, a clear and coherent long-term energy policy, sufficient long-term financing in addition to the general boundary conditions necessary to create the required rural infrastructure. To induce the ESCO to take such a risk, the power sector must be clearly organized, with a transparent regulatory framework[60]. By selling energy for a reasonable price, it takes between 5 years and 10 years before the initial investment is recovered by the ESCO. This means that it must be creditworthy and willing to take such investment risks. Moreover, in order to be financially sustainable, ESCO should need public concession and/or subsidies. A financial institution (bank, credit provider) can also be involved to share the risk.

[59] GEF (1992); Martinot and McDoom (2000).
[60] IEA (2003)

81. The *fee-for-service* model facilitates the implementation on a large scale of SHS by solving the issue of high up-front cost and of long-term maintenance. End-user does not have to pay the entire cost of the PV hardware, but just a connection fee (possibly subsidized), thereby enabling low-income end-users the access to the SHS technology. Maintenance is provided by the ESCO through the monthly fee paid by the end-user.

> **Main stakeholders**
>
> **End-user:** buys an energy service for a regular fee.
>
> **ESCO:** invests in energy service infrastructure and sells energy. A **utility** can assume the role of ESCO. The ESCO is the owner of the PV system. ESCO or a subcontracted **PV company** provide installation and maintenance of PV systems.
>
> **Credit institutions/funding sources:** supply of long-term capital to the ESCO.
>
> **Government:** can issue licenses and subsidies to sell energy or to electrify an area (through a combination of PV with other energy sources).

82. The ESCO remains the owner of the hardware and is responsible for installation, maintenance, repair, and replacement of the PV system and, in some cases, its components (controllers, batteries) at the end of their lifetime. Being the owner incentivizes the ESCO to provide high-quality systems, components and installation because of the inevitable long-term agreements and the will to sustain low maintenance and repair costs. ESCO also provides aftersales services (end-user formation, maintenance, repair, collecting fee) which are crucial for the success of the fee-for-service model. They must be efficient and well suited to the end-user needs. High expectations of the service can lead to disappointment and non-payment by end-users, in particular when people are required to pay while the system is not functioning because of a fault or a delay that is the responsibility of the provider.

83. Maintenance and repair service are better performed by the ESCO or a subcontracted company technicians rather than by the end-user himself. A central organization of the aftersales services can also lower the costs for maintenance and repair[61]. This is even truer for large concessions that can exploit greater economies of scale, as the South African experience shows.[62]

84. However, to make the aftersales services really efficient, the ESCO must be close to customer, as we learn from the Zambia small concession experience. End-user distance from the headquarter can be quite long (sometimes as far as 150 km) implying serious logistic difficulties for the technicians that most of the time have to use only light means of transport (bicycles and small motorcycles). Resolving a failure can indeed take several weeks thus frustrating the client. Proximity to the customers can be achieved both through small concessions, that nonetheless may have to face bigger financial problems, or through large concession with a strong logistic organization that rely on a widespread network of energy stores or local shopkeepers that keep regular contacts with the costumers.

85. Local presence enables sales information to be given, contracts to be signed with new customers, monthly fees to be collected and any repair requests to be logged. Regular visits of technicians are desirable particularly during the first months of the installation to facilitate the learning process that allows customers to understand the limits of the system which, otherwise, would bring to overuse

[61] IEA (2003)

[62] For instance, in 2006 the cost of installing a 50 Watt peak system in rural fee-for-service concession in Zambia was around $900 compared to less than $550 in South Africa. This disparity can be partly explained by the different context of the Zambian and South Africa economies, but also because of the small-size of the concessions in Zambia with 100-150 customers each which does not allow for economies of scale. Lemaire (2011).

and the discharge of the batteries. Energy stores, or subcontracted local shopkeepers, have to play a proactive role by being base for technicians and by maintaining an informative marketing and sales presence in order to strengthen its contacts with existing and potential customers[63].

86. Another key factor of the ESCO services is the possibility to choose among a variety of systems sized to the users consumption requirement. A basic photovoltaic system can include a 50Wpeak panel with a 90-105 ampere-hour (Ah) battery to enable the connection of four high efficiency compact fluorescent lamps and an outlet for a small black and white TV or a radio, operated on direct current. End-users may be disappointed by the limited capacity of this kind of solar systems, due to repeated promises of universal access made by local politicians, and they must can choose to upgrade to more sophisticated systems to have more lighting or even an inverter by paying an higher fee. The control of the level of expectations from end-users is considered a fundamental part of the success of solar home systems dissemination.

87. A clear government commitment to rural electrification with PV is needed to make the fee-for-service model successful. Subsidies and concessions are not a fee-for-service pre-condition, however they make the operation of an ESCO more attractive and can be crucial for the success of the SHS diffusion. In fact, subsidies allow the ESCO to offer a more affordable connection and monthly fee to low-income end-users, while concessions reduce the investment risk by granting it a period to recover the initial costs. The government should issue general boundary conditions to the sale of PV like clear quality regulations, information campaigns, clear tax and subsidy rules, etc. Institutional uncertainties can represent a major problem for the ESCO activities. For instance, in the South African case, the concessions were supposed to be guaranteed by a contract for 20 years; however, the government did not want to take budgetary commitment in providing subsidies for selected concessionaires initially for more than 2 years. A series of long administrative delays between each phases of the program and the uncertainty associated with government's capital grants have thus hampered the growth of the concessions.

88. Institutional inefficiencies represented an obstacle also in the Moroccan electrification scheme where the ESCO was obliged to advance the money for the equipment before being reimbursed through the subsidy from the state-run operator ONE. Notable delays in payment for the installation of the equipment have led to major cash-flow problems that the ESCO had managed to face being backed by creditworthy French oil and French electricity companies which allowed it to survive the short-term cash-flow crisis. Under different circumstances, a medium-sized enterprise facing serious payment delays would have found itself out of the business. Ensuring regular, timely payments of external subsidies by funding partners (as well as of monthly fees by end-users) remains a major challenge to be resolved.

89. Last but not least, the national electrification programme must be coherent, integrated and coordinated in each of its parts. For instance, plans for on-grid extension must not overlap off-grid concessions or ESCO investment would be directly affected in a negative way. Indeed, between grid electricity and PV service, end users always prefer the first option, even if they have to wait some years. A clear definition by the government of the technological solution required to electrify an area is thus needed. In the Moroccan case there is a clear economic threshold (3,250$) that indicates if power must be brought through grid extension or a PV kit.

[63] Lemaire (2009); Lemaire (2011).

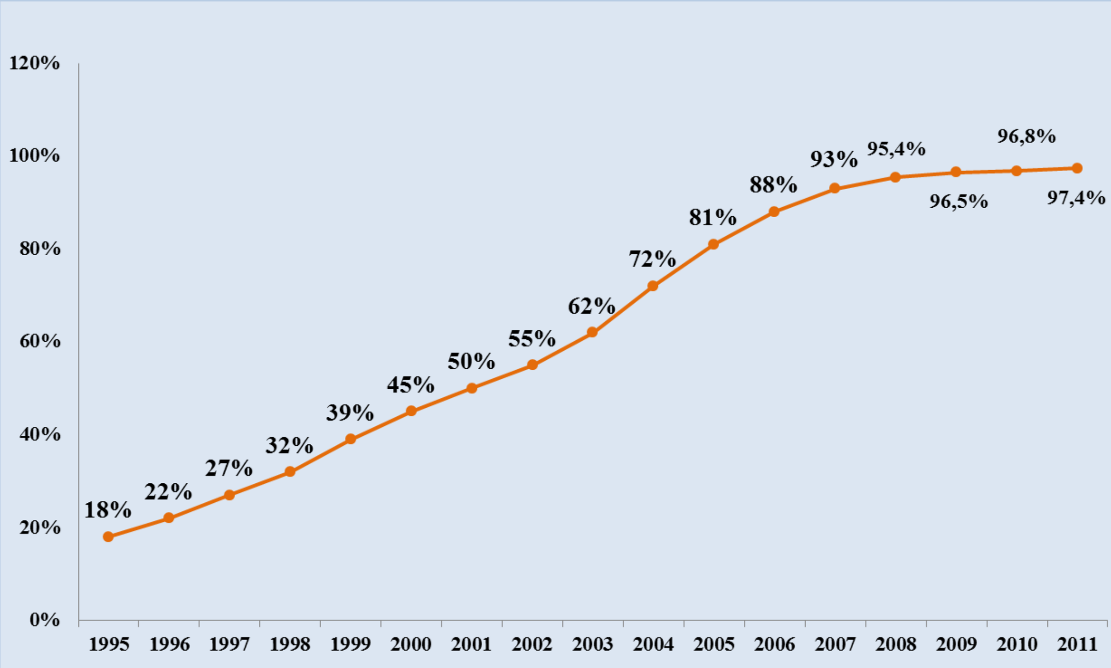
90. In the *fee-for-service model*, ESCO also provide the collection of the fees. By assuming in one entity the financial, commercial and technical activities, this model presents a more efficient organizational scheme compared to the micro-credit model where collecting fees is task of the micro-finance institutions while energy companies focusing on installation and maintenance of the SHS. However, the monthly collection of the fees remains a time consuming and expensive task. the adoption of *a prepayment system* or sub-contracting fee collection to local communities or local shopkeepers can be an alternative. A crucial point in the payment system of the *fee-for-service* model is that the client is usually not allowed to miss a monthly payment. This fact can create serious problems for low-income end-user who could indeed prefer alternatives like kerosene and batteries. A more flexible system of payment better suited to the villagers' income must be adopted to facilitate the diffusion of SHS.

91. The *fee-for-service* scheme seems a quite appropriate model to promote widespread adoption of off-grid solutions in Africa. It allows users to spread the up-front costs of PV systems over a long period and provides a solution to the problem of their long-term maintenance. A clear government commitment is nevertheless needed. The experience of Morocco, Zambia and South Africa shows that well-articulated public-private partnerships can improve rural electrification by delivering cost-effective energy services in areas where individual load is – and will remain in the medium term – very low. However, institutional uncertainties and incoherence can hinder ESCO activities undermining the success of the electrification programme. An aspect of the model that need to be ameliorated concerns the payment system. A more flexible system of payment better suited to the villagers' income can facilitate the diffusion of SHS and avoid payments complications (like delays or non-payment). Some lessons can be learned from the telecommunication industry that managed to spread the mobile revolution worldwide, including Africa.

Case Study: Morocco

In 1996, the Moroccan government launched the Global Rural Electrification Program (PERG) aimed at achieving 80% rural electrification target by 2010, from 18% starting point. The programme exceed the best expectations reaching 97.4% in 2011. At the base of such a success there is the adoption of various technological solutions: national grid extension for almost 91% of households; distributed generation (mainly photovoltaic, but also wind and hydro mini-grids and engine-generators) for the remaining 9%. According to the programme, if the on-grid connection cost would exceed a defined threshold ($3,250), electricity access would have been provided through a photovoltaic kit. Since today, almost 150,000 photovoltaic systems have been installed. Another factor that contributed to the success of the programme is the improvement of the BM adopted: from an original direct approach, where tasks were entirely fulfilled by the State-run operator Office National de l'Electricitè (ONE), the programme passed to a semi-direct approach, where maintenance and fee recovery were carried out by a private firm, to the final fee-for-service model, adopted in 2002 and based on a public-private partnership between ONE and a private operator under a ten-year concession. ONE guarantees coherence to the entire rural electrification programme and provides an equipment subsidy that enables the partnership to offer electrical service at affordable rates (by offsetting the high installation and maintenance costs associated with the SHSs). The private operator – TEMASOL, a Renewable Energy Service Company (RESCO) created by a joint-venture between the French oil and electricity companies TOTAL and Electricite de France (EDF) through their joint affiliate TENESOL – contributes to the operating costs, provides the electricity services (supply, installation and maintenance of the PV kits), and collects monthly fees that enable it to cover the amortization of its initial investment, replace equipment and cover running costs. The customers pay an initial connection fee (10% of the total cost that can be further reduced through government grants) and a monthly service fee determined by the type of service that they receive. In the case of PV, customers can choose among four kind of service – 50 Watt Peak, 75 Wp, 100 Wp, 200 Wp – depending on their consumption and budgetary needs. Furthermore, PV monthly fee is 40% subsidised to reach grid parity.[64]

Fig.13 Morocco Rural Electrification Rate



Source: ONE Web Site

A Step Forward: Lessons From The Mobile Phone Revolution

92. The "mobile phone revolution" has demonstrated how quickly decentralized services can be developed on a commercial basis in developing countries under the right conditions. The rapid diffusion of mobile phones worldwide shows how innovative commercial models can provide universal access for basic services to low-income consumers.

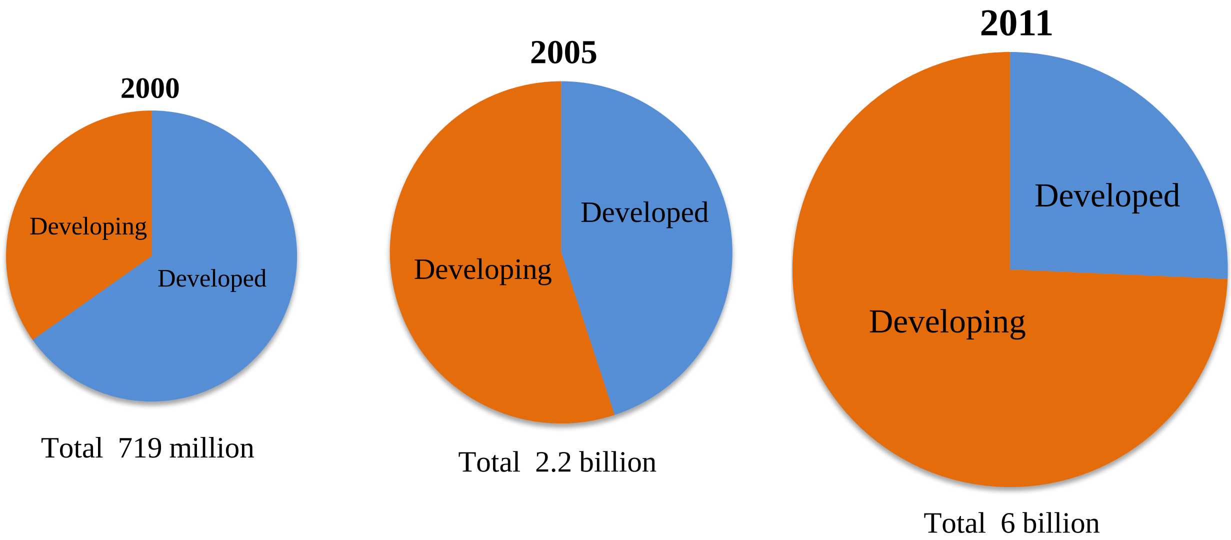
93. During the Nineteenth century, telephone landlines grew so slowly in sub-Saharan Africa that coverage was limited to 1.4 lines per 100 inhabitants in 2000. Industry watchers believed that the coming of mobile technology would have not changed the situation in markets where the majority of people live at or below subsistence-level income. The upfront cost of the cell phone was indeed considered an insurmountable barrier for the billions of individuals living on just a few dollars per day. Contrary to those forecasts, emerging markets have become the primary growth opportunity for the telecommunications industry and, thanks to the right BM, many low-income end-users today have access to mobile phones[65].

94. In 2011, total mobile-cellular subscriptions reached almost 6 billion worldwide, corresponding to a global penetration of 86%. Growth was driven by developing countries, which accounted for more

[64] UNDP (2008); UNDP (2011); ONE Web Site.
[65] Glemarec (2012).

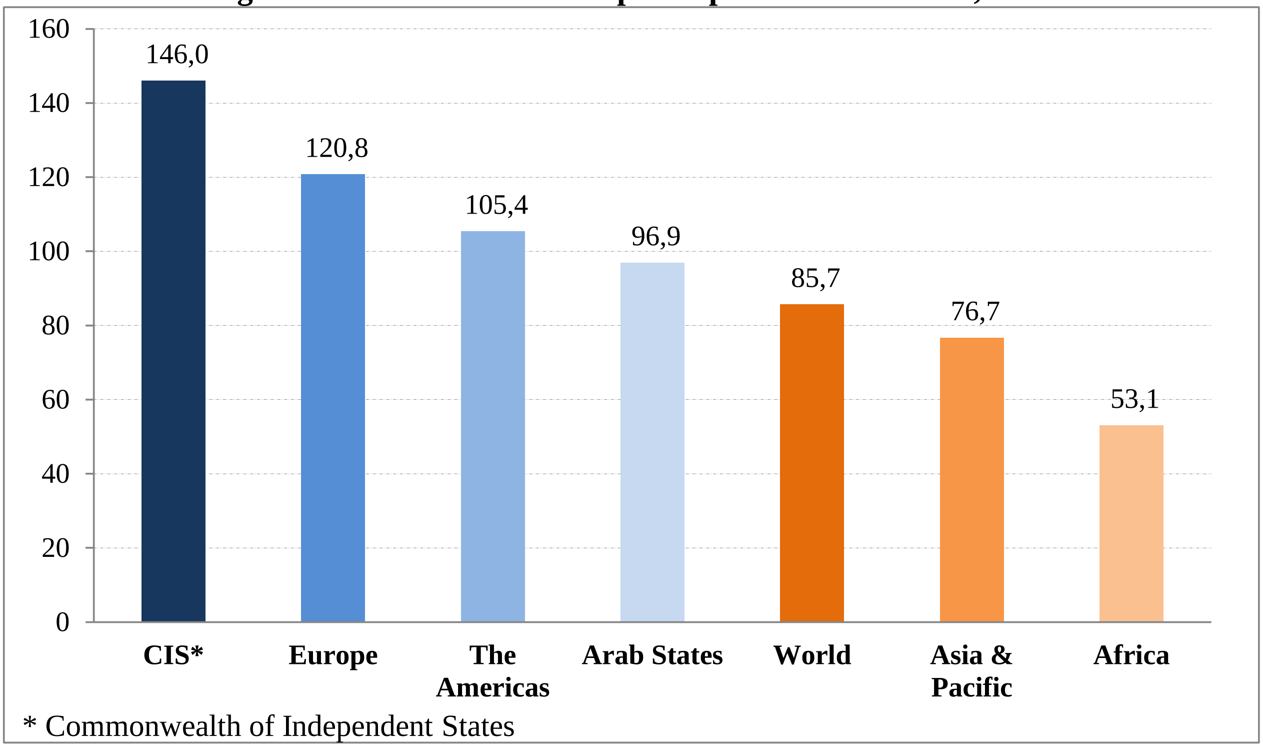
than 80% of the 660 million new mobile-cellular subscriptions added in 2011[66]. These statistics show that the majority of mobile subscribers in developing countries use a mobile phone even if they have no access to the electrical grid. Although Africa presents the world lowest mobile-cellular subscriptions per 100 inhabitants, the subscription rate is nonetheless considerable high. Moreover, in the African context the effective mobile phone usage can even be higher considering that the phenomenon of ''sharing'' is of particular importance. Furthermore, some African countries such as Botswana, Gabon, Namibia, Seychelles and South Africa have more mobile-cellular subscriptions than inhabitants.

Fig.14 Mobile-cellular subscriptions, by level of development



Source: ITU World Telecommunication /ICT Indicators database

Fig.15 Mobile-cellular subscriptions per 100 inhabitants, 2011



Source: ITU World Telecommunication /ICT Indicators database

66 ITU (2012).

95. The real break-through of mobile telephony in Africa has been the introduction of prepaid services that do not require monthly payment, but make payment dependent on usage. In sub-Saharan Africa, more than 90% of the mobile subscribers have a pre-paid subscription; it is appealing to people with low or irregular incomes, since their use does not require a bank account, a physical or a postal address, or a minimum fixed monthly subscription fee[67]. Pre-paid platforms allowed customers to purchase air-time at a price as low as $0.25 per minute, share airtime and even buy airtime on credit.

96. The growth of the mobile phone industry offers several lessons for the rapid commercialization and diffusion of other new technologies. Indeed, distributed generation markets display some characteristics similar to mobile telephony markets. With the right technology, regulatory environment and BM, low-income customers have the capacity and the willingness to fully or partially pay for services that provide clear, immediate and substantial benefits. On the other side, the private sector has the capacity and appetite to invest in new service delivery mechanisms provided that there is commercially viable unmet demand. As for the phone industry, pre-paid platforms can be adopted for providing off-grid energy services, while market evolution and technologic progress bring down SHS prices.

97. While mobile communications markets and distributed generation technologies may share some characteristics, they also have some fundamental differences. Mobile telephony has relatively low physical infrastructure requirements and can reach remote areas in a more cost-effective way than decentralized clean energy technologies. Mobile phone’s simplicity of use has also been a major factor of its success, while clean energy development and access need to face a large number of inter-connected information, institutional, behavioural, technical and financial barriers[68].

Prepayment: a more flexible system of payment…

98. Telecommunication innovations can bring many advantages for mini- and off-grid technologies diffusion in a rural context. The adoption of a pre-paid service ameliorate the fee-for-service model by providing a more flexible system of payment better suited to low-income end-users. As highlighted previously, low and volatile income is a crucial obstacle that poor customers have to face to keep up with electricity consumption bills. On the contrary, prepayment matches the needs and spending patterns of the poor by giving customers the possibility to pay when they can afford to and when they need the service, thus avoiding the barrier of a flat monthly fee.

99. Prepayment can be made in two ways: through scratch cards or through mobile payments. Scratch cards are the prepayment system that allowed spreading the “mobile phone revolution” worldwide. Mobile payment (or mobile money) is a payment service that can be performed from or via a mobile device. Instead of paying with cash, check, or credit cards, a consumer can use a mobile phone to pay for a wide range of services and goods. It is considered an appropriate payment system for developing countries inasmuch it allows to extend financial services to "unbanked" communities. In Africa, mobile payment is widely diffuse in Kenya where Safaricom, affiliated to Vodafone, launched M-PESA: a small-value electronic payment (maximum cap at $500) and store

[67] James and Versteeg (2007).
[68] Glemarec (2012).

of value system accessible from ordinary mobile phones that has 9 million registered users which transfer on average $320million per month[69].

100. Mobile payments are the way to go in the following years because they do not involve the physical distribution of scratch cards. However, they are still nascent around the developing world and many countries do not yet support them, so scratch card payments are still required. Moreover, mobile payments currently charge too much for small transactions. For instance a $1 transaction on M-Pesa can cost 20-30 cents. Indeed, partnerships between energy companies and telecommunication companies could be the right way to reduce transaction costs and increase the convenience of mobile payments (but also scratch card payments).

…with economic and organizational advantages…

101. The adoption of prepayment systems can improve the organizational efficiency and reliability of the aftersales services while lowering operating costs. The telecommunications networks that have been established in many rural areas of the African continent permit to operate mini- and off-grid systems with remote supervision and administration. With customer billing and monitoring of the system done remotely using wireless communications protocols such as SMS, the travel costs to the site can be reduced by eliminating routine visits and restricting travel to necessary maintenance visits[70].

102. As we have seen before, monthly collection of the fees is a time consuming and expensive activity. Automating payment eliminates the need for billing and collections, and managing usage in real time ensures cost recovery. Moreover, using standard SMS text messaging bypasses the need for communications infrastructure. By cutting administrative costs and bad debts, prepayment meters facilitate energy access and enhance profitability for the utility. Furthermore, by making payment easier and more flexible for customers, reducing the risk and cost of disconnection, they have an additional benefit of encouraging demand[71].

…and further opportunities

103. As utilities adopt prepayment meters, new innovative opportunities are likely to arise. As already pointed out, electricity companies could create partnership with phone companies increasing the convenience and the attractiveness of prepayment systems. Moreover, the meters could be enabled for mobile phone communications, allowing families and friends to pay an electricity bill by sending an SMS message transferring credit, as is commonly done between mobile phone accounts in developing countries. This could increase sales for the utility and improve energy access. Indeed, better-off relatives would be able to cheaply and remotely pay the electricity bill of relatives in rural areas.

104. Another opportunity could be the sale of electricity as part of a “quintuple play” along with mobile, fixed wireless, broadband Internet, and pay TV by companies that are already bundling the other four services, like Dialog in Sri Lanka. Electricity companies could even start selling “microcredits,” for as little as $0.25 worth of power at a time, like Idea Cellular has done with

[69] Mas and Radcliffe, (2010).
[70] Soto et al. (2012).
[71] IFC (2012).

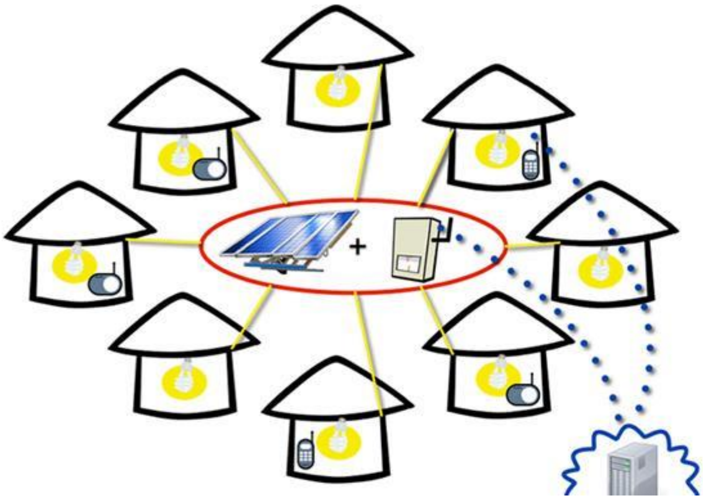
mobile talk time to expand its penetration in the rural telephony market in India. Finally, smart metering in micro-grid systems could even be used to offer special “low-price power deals” to poor users when there is excess capacity, or giving low-income customers additional credit for reducing their demand during peak times when power cuts might otherwise be a risk. (IFC, 2012)

Pilot project: Shared Solar

105. As part of the Millennium Villages project[72], in 2009 the Earth Institute’s Modi Research Group[73] took up the challenge of how to bring electricity to rural villages in Africa. After analyzing the data and sociological constraints, the team arrived at an innovative solution to the problem: solar-powered micro-grids with prepaid metering and semi-automated, remote management. They called it SharedSolar: pay-as-you-go electricity via mobile telephony.

106. In the SharedSolar system, a central small-scale (1.4 kW generating capacity with 16.8 kWh battery storage) solar system is connected to up to 20 customers (homes, businesses, or small institutions such as schools) within a 100 meter radius via underground cables. End users buy prepaid scratch cards from local vendors according to their needs and budget. Each card contains a code which, when sent by text message to a payment server, credits a smart power meter located inside the premises. Electrical current is now available. The meter monitors usage until the customer’s credit is exhausted, at which point the circuit is switched off until more funds are added. SharedSolar systems can be scaled up, adding additional generating capacity or even serve as a distribution network later when grid power arrives. In the interim, a company owned solar source with battery backup is the basis for power generation. The beauty of the system is that it pays for itself: after the initial investment, the fees paid by consumers cover both service delivery and maintenance.

Fig.16 Shared Solar System



Source: Millennium Villages Web Site

[72] The Millennium Villages Project is a project of the Earth Institute at Columbia University, the United Nations Development Programme, and Millennium Promise. The Millennium Villages aim to meet the Millennium Development Goals by promoting an integrated approach to rural development. Millennium Villages Web Site

[73] The Modi Research Group at the Earth Institute at Columbia University has developed an electricity planning and investment costing model to support national efforts to expand electricity access. This Python-based tool performs spatial processing and analysis, using simple geospatial and population data, and algorithmically generates a comprehensive and cost-optimized electricity plan, including a map of the projected grid extension grid, sites to be served by off-grid technologies, and all related costs. The model has been applied in Senegal and Kenya, and has generated interest among energy planners in ministries, utility companies, and international organizations. The project has been supported by the Bill & Melinda Gates Foundation and the World Bank’s Africa Energy Group.

107. With SharedSolar, rural electricity consumers make payments based on usage by using a scratch card and adding credit via SMS. The micro-grid provides power on a pre-paid basis similar to the way cellular phone air-time is sold. This system uses Short Message Service (SMS) messages sent over the Global System for Mobile Communications (GSM) networks for communication allowing installation in any place within reach of a GSM tower. Several of these individual microutilities are monitored and administered via a central server. Consumers in these systems are using modest amounts of power consistent with lighting usage. Some customers are unable to maintain positive account credit suggesting a benefit to the prepaid approach[74]. The SharedSolar team is testing and developing its BM to show that a case exists for micro-grids and mobile energy payment.

108. After coming up with the blueprint, the SharedSolar team went to work creating the software to operate their system, using readily available components. In late 2010 a pilot system was assembled in Pelangala, Mali, to test the technology. The community's reaction was overwhelmingly positive, and the Modi group was quickly called upon to build more installations. There are now nine SharedSolar sytems in Mali, which provide electricity to 172 households – over 2,400 people in all. Another 160 households were set to be connected to SharedSolar systems in Mali over the first half of 2012, and new programs are currently being developed in Uganda, Kenya, Tanzania and Haiti.

109. In the future the SharedSolar team hopes to join with governments and other stakeholders to expand the technology and create a more robust BM. For instance, forming relationships with suppliers and manufacturers could help reduce the total cost of deploying a system (currently about $1,570). Partnering with a telecommunications provider could lower messaging costs and allow for toll-free numbers customers could call to credit their accounts. Instead of charging a fee per message, the telecom might receive a small percentage of all transaction fees.

110. Talking about SharedSolar, Professor Vijai Modi said: "We have leapfrogged conventional technology in these settings and come up with a solution that the developed world is still trying to achieve".

Pilot project: Indigo

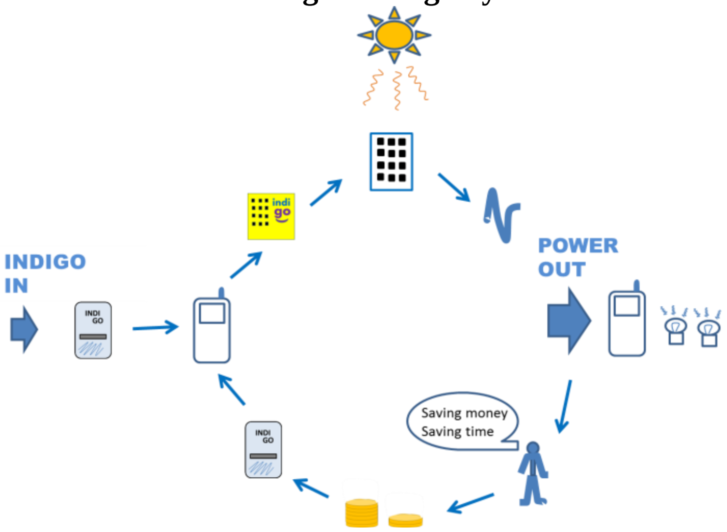
111. In 2011, Eight19, a British company spun out of Cambridge University, launched Indigo, a new way to deliver solar power in emerging economies that brings off-grid solar power to a new generation of users, transforming lives and accelerating economic development. Indigo was spun-out into Azuri Technologies in 2012, and provides a key route to market for Eight19 into high volume off-grid applications.

112. Indigo is a personal solar system provided to off-grid communities (mostly in Africa) through a "pay-as-you-go solar model". In return for a deposit of around $10 it is supplying poor families in Kenya with a solar cell able to generate 2.5 watts of electricity, a battery that can deliver a 3-amp current to store this electricity, and a lamp whose bulb is an energy-efficient light-emitting diode (LED). The firm calculates that once the battery is fully charged, this system is sufficient to light two small rooms and to power a mobile-phone charger for seven hours. Then, the next day, it can be put outside and charged back up again[75]. Local people buy scratch cards for around $1-$1.50 a week which are validated over SMS using their mobile phone and add credit to the Indigo unit. By

[74] Soto et al. (2012).
[75] The Economist (2012).

combining solar and mobile phone technology, the Indigo solar electricity system is inexpensive to buy and allows users to light their homes and charge mobile phones as a service.

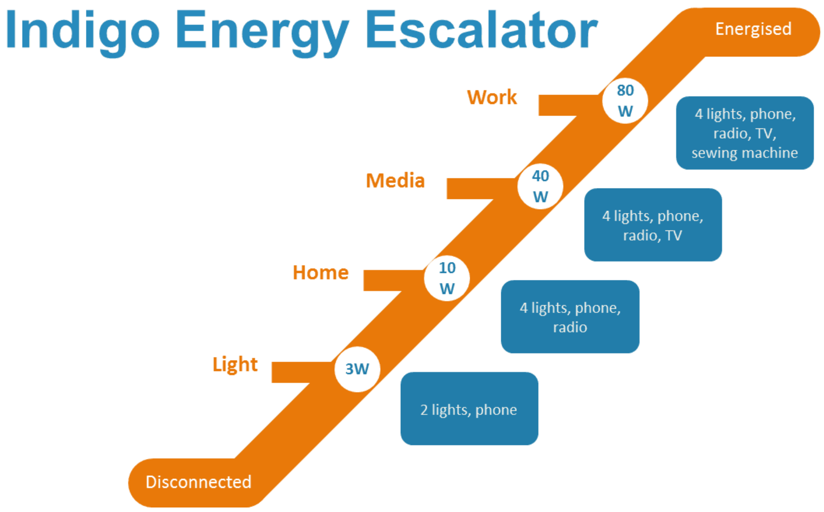
Fig.17 Indigo System



Source: Azuri Technologies Web Site

113. Indigo innovation is not limited to combining a Solar Home System with scratch card payment. Indigo offers a progressive purchase option that enables households to own the system, but customer has also the option to upgrade its device. After buying around $80-worth of scratch cards (which is expected to be reached by 18 months) the user will own the Indigo. He will then have the option of continuing to use it for free, or trading it in for a bigger model, perhaps driven by a 10-watt solar cell or higher[76]. This upgrade system is called the “Indigo Energy Escalator”.

Fig.18 Indigo Energy Escalator



Source: Azuri Technologies Web Site

114. This "energy escalator" business model supports a bottom up approach to electrification and allows users to pay less than half their normal spend on kerosene. Indeed, the initial capital of the Indigo system is recovered through the weekly purchase of scratch cards over 18 months and the user is supposed to reduce its spend by up to 50% compared to the cost of the kerosene and mobile phone charging fees it replaces.

[76] The Economist (2012)

115. Energy poverty is the new challenge of modern society. An ethical issue that richest countries cannot elude. Energy poverty is one of the main causes of economic poverty in most part of the world and it has several negative externalities at the global level: land desertification, caused by deforestation, and climate change due to the environment lesser capacity to absorb CO_2. The global consequences of these externalities show the strict interdependence between the energy systems of industrialized and developing countries. *Fighting energy poverty is a win-win strategy.* Energy poverty is mostly related to electric power, which could affect water availability (via desalination plants), community well-being, and economic productivity. Worldwide, yet nearly 1.3 billion people lack electricity. 45% of them are located in Africa where almost 600 million people have no access to electricity.

116. The United Nations consider energy poverty as an unavoidable barrier toward the Millennium Development Goals. For this reason, it declared 2012 the *International Year of Sustainable Energy for All* aimed at making the international community aware of the problem and, hence, facilitating the achievement of the universal energy access by 2030. A coalition of partners, including private sector, international finance and sovereign funds, is keenly focused to develop power infrastructures in Africa. Such investments should be promoted along with investments in roads, ports, water, pipelines, institutions, as well as in agriculture. In the same way, other key factors are required, such as effective ownership and business models for the new power infrastructures.

117. Traditional on-grid electrification system is the more efficient technological solution to maximize the penetration of the electric services in Africa. Nonetheless, this solution is not sufficient to realize an *Energy for All* scenario in the short term; indeed, it must be supported by other options – off-grid and mini-grid – that are better suitable to the African remote rural context where the majority of the population lives. These kinds of technological solutions can offer only a minimum energy service, but they seem unavoidable, at least for an undefined transitional period, as a *bridge* toward a future connection to the national grid.

118. Extremely poor countries in the African Continent are discovering a huge potential of hydrocarbons. This new situation can pave the way to significant development opportunities previously unimaginable. However, the mere property of this resources is not a sufficient condition for the national development. To reach it, producing countries must adopt suitable development politics able to direct resources and related revenues toward specific targets, such as electrification. In order to succeed, we believe that these countries should pivot on a virtuous *"natural resources–international oil companies–energy investments"* triangulation that would allow to foster electrification programmes. Hence, channelling natural resources and the related revenues toward these programmes can be done/realized through a change in the contractual schemes between producing countries and international oil companies. A *New Contract Formula* (NCF) is thus required.

119. The definition of NCF can represent an innovative instrument to promote a real economic development of the African countries as well as for solving common problems that afflict them, as the lack of electrification. For instance, in order to take part in a bid round for an E&P block, oil companies should be enforced to submit – along with other requisites – an electrification project proposal (power plant construction, grid upgrading or expansion, etc.) according to the national

requirements, to be implemented in case of win. In this way, the electrification project proposals would became one of the variables to award the block and select the oil company as partner for the country development.

120. Moreover, in order to gain a better evaluation, oil companies would be encouraged to enhance their offer by defining: the environmental and economic sustainability of the project (i.e. the use of gas flaring); the socio-economic size, criticalities, potentialities of the new customer basin; the correlated initiatives directed to improve the development potentialities of the project. Thanks to this new formula, part of the natural and economic resources of producing countries would be directly channelled toward real development projects. Nonetheless, it is of keen importance for the various stakeholders involved – government, international institutions, oil companies – to perceive a tangible interest in promoting it as well as in acting in a concerted and coordinated way.

121. In order to maximize the impact of NCF, all the African producing countries should cooperate to adopt *common policies*. *Unity of action and of intents is essential* for multiple reasons: (a) it allows to mitigate the harmful intra-regional competition that force governments to offer increasingly favourable conditions to attract oil companies; (b) would assure a stronger bargaining power of the producing countries towards oil companies. In brief: African oil producing countries should define a *common contractual formula* aimed at pursuing national and common interests, similar to the action that in 1960 brought to the foundation of the *Organization of the Petroleum Exporting Countries* (OPEC) aimed at the harmonization of the contractual policies (mainly fiscal) of its member States.

122. International institution's support to this strategy is indispensable for its success. For instance, the African Union could assume the networking role in order to promote cooperation policies among the African countries. In the case of NCF, international institutions should pivot on their mediation capabilities to encourage the dialogue with and among oil producing countries. International institutions should take advantage of the current international interest on energy access matter in order to put pressure on governments and convince producing countries to accept innovative and concrete solutions. At the same time, they should operate to define these solutions with the greatest level of transparency achievable so as to became a bond for the governments themselves and thus limiting their possible incorrect behaviours.

123. Additionally, one particular institution should deal with the *monitoring and coordination of the cooperation*. A reference point role that could be assumed by the African Union and that would help to: assure continuity and stability to the cooperation; define the NCF draft, given technical support through appropriate professional consultancies; facilitate the comparison among various countries past experiences in order to pinpoint best practices; identify common problems that can be faced through NCF.

124. Traditional grid extension is highly costly and unfeasible in isolated rural areas characterized by low population density, long distance, small demand. Mini- and off-grid solutions are more suitable in this kind of contests. Within the medium term, the only way to supply remote areas is through distributed energy systems. Off-grid – in particular individual systems such as Solar Home Systems (SHS) – and mini-grids technologies may represent an appropriate solution. Moreover, mini-grids can also be complementary to traditional on-grid solutions and represent a stepping stone towards electrification, given the possibility to integrate them to the national grid at a later stage.

125. Rapid technological innovation and a scale-up of commercialization efforts, with the corresponding decline of manufacturing costs and the retail product price, are becoming a substantial driver of renewable energy development. In particular, PV is considered a sustainable option for electrification in order to satisfy rural population power needs. IEA estimates that renewables will be dominant both for mini-grid and off-grid solutions by 2030, increasing access to electricity without the negative impact on health and the environment caused by diesel generators.

126. Small PV systems present a number of advantages in terms of flexibility, efficiency and cost-effectiveness, environment, and job opportunities. In the last decades, a number of different implementation approaches has been used in order to encourage the widespread affordability and effectiveness of PV. A number of local initiatives for SHS diffusion have been launched world-wide, implemented both through donation programs as well as through market initiatives. With over 2.5 million SHS installed globally and more than 850,000 installed in Africa, SHS market may be turn the corner.

127. Previous generation technologies achieved limited penetration due to high costs, poor components, installation and maintenance challenges. Today, with prices substantially reduced and first signs of local assembly and/or manufacturing industry, SHS is increasing its market penetration, demonstrating to be a suitable solution to rural electrification. However, more needs to be done. Certain barriers, including concerns about the technology and difficulties in capacity building and financing, still hinder the growth of a sustainable PV market. An ideal business model for rural electrification does not exist and its choice depends on local circumstances: types of financial structure, organization and ownership, choice of customers, the technology involved.

128. The main role of the government is to put in place the right policy environment for PV diffusion. Policy-makers can plan least-cost energy strategies and enact or revise policies that "level the playing field" for renewable energy relative to conventional energy sources, by means of government investments, prices, institutional and regulatory reforms, incentives.

129. The growth of the mobile phone industry offers several lessons for the rapid commercialization and diffusion of new technologies. Indeed, distributed generation markets display some characteristics similar to mobile phones ones. On the one side, with the right technology, regulatory environment and business models, low-income customers have the capacity and the willingness to fully or partially pay for services that provide clear, immediate and substantial benefits. On the other side, the private sector has the capacity and appetite to invest in new service delivery mechanisms in the case of a commercially viable unmet demand. As for the phone industry, pre-paid platforms can be adopted for providing off-grid energy services, while market evolution and technologic progress bring down SHS prices.

130. Telecommunication innovations can bring many advantages for mini- and off-grid technologies diffusion in a rural context. The adoption of a pre-paid service ameliorate the fee-for-service model by providing a more flexible system of payment better suited to low-income end-users. Low and volatile income is a crucial obstacle that poor customers have to face to keep up with electricity consumption bills. On the contrary, prepayment matches the needs and spending patterns of the poor by giving customers the possibility to pay when they can afford to and when they need the service, thus avoiding the barrier of a flat monthly fee.

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APPENDIX I
COMPANIES INVOLVED IN SHS DIFFUSION THROUGH A PRE-PAYMENT SYSTEM

a) *Indigo 'Pay-As-You-Go' Solar*

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Company overview
Eight19 is a developer and manufacturer of third generation solar cells based on printed plastic. Originating from technology initially developed at Cambridge University in the UK, these flexible, robust, lightweight solar modules benefit from high-speed manufacturing and low fabrication costs. With a fraction of the embedded energy of conventional solar modules, printed plastic solar modules are particularly well suited to consumer and off-grid applications.

In 2011, Eight19 launched Indigo, a new way to deliver solar power in emerging economies that brings off-grid solar power to a new generation of users, transforming lives and accelerating economic development. Indigo was spun-out into Azuri_Technologies in 2012, and provides a key route to market for Eight19 into high volume off-grid applications.

Indigo 'pay-as-you-go' solar
There is a common problem with most renewable sources of energy – customers are used to paying for energy as they use it but for renewables, the cost is all up front in the purchase price. This puts technologies such as wind turbines or traditional solar beyond the reach of many users.

Eight19 continues a close working relationship with Azuri Technologies which provides a key route to market for Eight19 into high volume off-grid applications through its Indigo pay-as-you-go solar solution. Indigo combines mobile phone technology with solar technology allowing customers to buy scratchcards to pay for their energy, just as they would for their mobile phones. Customers are able to charge their mobile phone and have 8 hours of clean lighting for two rooms, whilst saving money – some of which can pay for the next Indigo scratchcard. Indigo has a transformational impact from day one. In Kenya, Indigo deployments are so cost-effective that users spend half as much on their Indigo solutions that they previously did on kerosene.

But this is only half the story. Today a user may purchase an entry-level Indigo system capable of lighting 2 rooms and charging one mobile phone. But over time, that person's requirements will grow. They may want more lights, to power a radio or TV or even power a sewing machine to enable them to make more money. Indigo grows with these needs allowing customers to ride the

Indigo Energy Escalator by which products are progressively upgraded over time to grow from simple systems to full home electrification.

Eight19's new generation of low cost, lightweight and flexible solar technology is ideally suited to the hardships of off-grid markets. Earlier this year, Eight19 began organic solar trials in Africa and it is envisaged that real-world data will accelerate product deployment.

Indigo in, power out

The idea of pay-as-you-go and scratch cards is universally understood from mobile phones, which have deep penetration even in the most remote emerging markets. Indigo allows users to buy scratchcards to pay for their energy, just as they would for their mobile phones.

The Indigo scratchcard is validated using SMS from a mobile phone and the resulting one-off passcode entered into the Indigo unit which causes it to operate for a period of time (typically a week). Customers are able to charge their mobile phone and have 8 hours of clean lighting for two rooms, whilst saving money – some of which can pay for the next Indigo scratchcard. After a period of time, our customers have paid off the cost of their unit and have the unique option to upgrade to a larger system and access more energy through the Indigo Energy Escalator**.**

Azuri has pioneered the Indigo Energy Escalator which encourages users to up-grade to larger systems over time, to access more electricity and ultimately reach full home electrification. Users move over time from a starting point as a disconnected rural farmer to an informed, connected one with the benefits of electricity. Like an escalator, users can get off at any point and so are not committed to a long-term debt. This pay-as- you-*grow* business model is unique in assisting users to earn their way out of poverty without hand-outs or charity.

b) ***Shared Solar***

SharedSolar is a collaborative research effort between the below institutions and individuals. The technology is currently being piloted throughout the Millennium Villages in Africa.

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Overview

Research throughout the Millennium Villages has shown that the rural poor are paying as much as 5 USD ($) per month for kerosene, batteries, and other energy inputs that could be more efficiently and cheaply supplied by electricity from a centralized source. This 5 $/month of energy use is equivalent to about 1.5 kWh. The rural poor are paying in excess of 3 $/kWh, yet grid electricity prices in many of these countries can be an order of magnitude lower (< 0.30 $/kWh). Detailed analysis of grid connection costs have shown that extending the grid to reach these rural poor typically requires more than 1000 $/household in many cases, and still only connects the few who are nearby the existing infrastructure (roads) along which the grid would be extended. Furthermore, traditional post-pay metering is too expensive given the low energy use levels that theses populations can afford, and the variability of their use. Even individual home solar units, which might supply the right scale of energy (a few kWh per month) are expensive (>2 $/kWh when amortized over the life of the system).

The unfortunate irony is that the poorest are paying the most for the worst quality energy, and the cost to connect them to better, more traditional services does not present an appealing, profitable business model.

The Innovation

Prepaid metering (via manually keyed codes or RFID cards on the meter) is existing technology that has been utilized in traditional macro-utility managed grid based systems in India, China, South Africa, and other areas. Similarly, aggregated sub-metering or Meter circuit metering has been utilized in a wide variety of applications from apartment complexes to server database centers throughout the world. Additionally, mobile telephony providers have developed a profitable prepaid business model throughout the developing world that supplies an analogous service (low amount of highly variable use). Furthermore, small (1 kW), distributed power technologies such a solar PV or even diesel-solar hybrids are well understood and are highly flexible, due to their modular characteristics, and may offer higher reliability than even local grid services.

The marriage and modification of these four mature technologies provides a compelling solution: small scale (1 kW) micro-grids with prepaid, aggregated metering and semi-automated management.

c) ***Solarnow***

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Overview

SolarNow, Uganda's largest installer of domestic solar systems, passed an important milestone this week - 1000 systems installed since its launch in 2011. By combining quality components, installation and service with a 12 month payment plan, SolarNow seems to be winning the battle for the trust of rural Ugandan consumers.

For many years, customers have been caught between dealers offering poor quality systems that quickly failed and banks that were reluctant to lend for the purchase of higher quality, more expensive systems.

Photo: Happy 1000th customer David Ntalo (Nakabale, Busede, Jinja) with his family receiving a portable DVD player powered by his SolarNow system

The SolarNow approach is to do the installation and the credit in-house, so that customers get a system with a guarantee, and can get credit from SolarNow that allows them to pay over 12 months. After that, customers own their system which continues to provide them with power for system years to come.

It is a particularly good time for off grid customers to invest in solar with a reliable partner. The Rural Electrification Agency is currently offering an attractive subsidy of up to $250 for systems bought through approved partners such as SolarNow.

Speaking earlier today, Kevin Kennedy, General Manager Uganda said, "We are proud to have earned the trust of so many customers and to have helped them become owners of top quality solar systems. The future is bright and we look forward to many more satisfied clients".

SolarNow Uganda imports, installs and finances top quality solar systems throughout Uganda. For further information please contact us on 0788916600 or uganda@solarnow.eu

d) *Angaza*

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Products and Technology

Customers purchase solar energy from Angaza just like they purchase cell phone minutes from their telecom.

A customer first buys a compatible solar energy product, such as the Angaza SoLite3, for an up-front fee. Its integrated Angaza hardware tracks how much energy they consume. The customer buys their energy in advance. After that energy is used, output shuts off until they purchase additional energy.

The customer can use their cell phone to buy energy at any time, in any amount. They send a payment to Angaza using phone-based mobile money, such as M-PESA, and they receive an automatic call from the Angaza Energy Hub in response. They answer that call and hold their phone near their Angaza-compatible product. Angaza then uses the open audio channel to securely communicate the customer's payment to their product. By using audio communication to leverage the customer's existing phone hardware, Angaza can embed its technology in solar products at minimal additional cost.

The flagship members of the Angaza energy platform are the SoLite3 home system, which gives customers an unmatched high-quality energy source for lighting and cell phone charging, and the Angaza Energy Hub, which gives distribution partners an unprecedented tool for growing their businesses and engaging with their customers.

The SoLite3 Solar Home System is designed specifically for the off-grid world. It outputs bright, disperse LED light, effectively illuminating an entire room, and charges customer's cell phones. Households can now purchase high-quality, reliable, and safe energy from their SoLite3, instead of low-quality lighting from kerosene, candles, and disposable batteries.

- **Contents**: LED light unit and detached PV panel
- **Runtime**: 8 hours on "normal"; 4 hours on "high"
- **Power**: 2 Watts
- **Package Dimensions**: 6.5" x 6.5" x 3"
- **Shipping Weight**: 1.5 pounds

Internal custom hardware for energy metering and secure communication link it to the Angaza Energy Hub.

The Angaza Energy Hub is the center of the Angaza technology ecosystem:

- it receives customer payments through different mobile money systems across multiple countries;
- it securely and automatically communicates with customers' Angaza solar systems; and
- it provides a management, marketing, and analytics portal that empowers distribution partners both large and small.

Through the Energy Hub, Angaza brings the tools of large-scale, real-time data analysis to the global business of off-grid energy production.

Management Team

Lesley Silverthorn Marincola, CEO Lesley's background blends human-centered design with a mechanical engineering skillset. She received her B.S. in product design and her M.S. in mechanical engineering from Stanford University, and has extensive product experience, including work on the first three generations of the Amazon Kindle. She thrives in the challenge of integrating engineering solutions with first-hand field experience. Contact Lesleyat lesleys@angazadesign.com.

Bryan Silverthorn, CTO Bryan's interests broadly encompass the application of intelligent technology to unconventional problems. He earned his B.S. in computer science from Cornell University and his Ph.D. in computer science at the University of Texas at Austin. His academic research has bridged statistics, natural language processing, and combinatorial optimization, and his industry work has spanned the spectrum from pure software engineering to robotics. In both academia and industry, his focus has been on the difficult problems that lie at the intersections of disciplines. Contact Bryan at bcs@angazadesign.com.

Victoria Arch, Director of Strategy Victoria is a life science and sustainability specialist with multidisciplinary expertise ranging from systems ecology to biomedicine. She learned the intricacies of environmental science and policy while pursuing a B.S. in earth systems at Stanford University. Following her undergraduate degree, she received a Ph.D. in biology from UCLA and undertook extensive field work in rural Southeast Asia. She now applies her systems science background toward projects with global impact. Contact Victoria at victoriaa@angazadesign.com.

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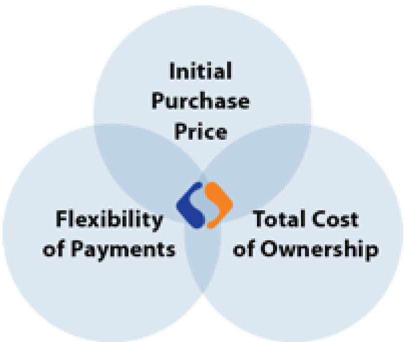
Overview
Get the Pricing Model Right Simpa has initially introduced its "**pay-as-you-go**" pricing to household energy systems. Users pre-pay based on actual usage and each payment adds up towards the total purchase price of the solar home system. Consumers can send payments using a mobile phone. Once fully paid, the solar home system unlocks and delivers free electricity for the expected 10-year life of the product. We transform an energy expenditure into an asset purchase. We offer consumers the opportunity for ownership of their energy resource and break their dependence on expensive, unhealthy, and inefficient sources of light and electricity.

To do this we have invented, built and field-tested the core technology that regulates usage of an electronic device based upon the receipt of payments. Specifically, we are introducing our patent pending Progressive Purchase™ technology – a combination of product-embedded hardware plus cloud-based software that enables a consumer to purchase a solar home system at minimal upfront cost and then to make a series of small payments over time – using a mobile phone – to complete the purchase of their system.



Our novel Progressive Purchase™ model delivers on our vision of "**radical affordability**" – defined as affordability across three axes: the initial purchase price; the total cost of ownership; and the flexibility of expenditures over time.

"Progressive Purchase" is a new pricing model that shares some characteristics of the familiar "prepaid", "pay as you go", and "installment plan" pricing models. Under Progressive Purchase™, the consumer makes a series of payments, each of which unlocks the solar home system for a paid amount of energy consumption (Kwh). Once the prepaid consumption is exhausted, the solar home system is temporarily disabled until another payment is made. Once the consumer has fully paid the total purchase price of the product, full functionality is restored and the product is permanently unlocked.

The Progressive Purchase™ pricing model is enabled by the **Simpa Regulator**, a tamper-proof, system-integrated microcontroller and user interface that regulates the function of our solar home systems based on proof of payments, and the **Simpa Revenue Management System**, a centralized software solution in the "cloud", accessible via SMS gateway and over the internet, for payment processing and accounts settlement.

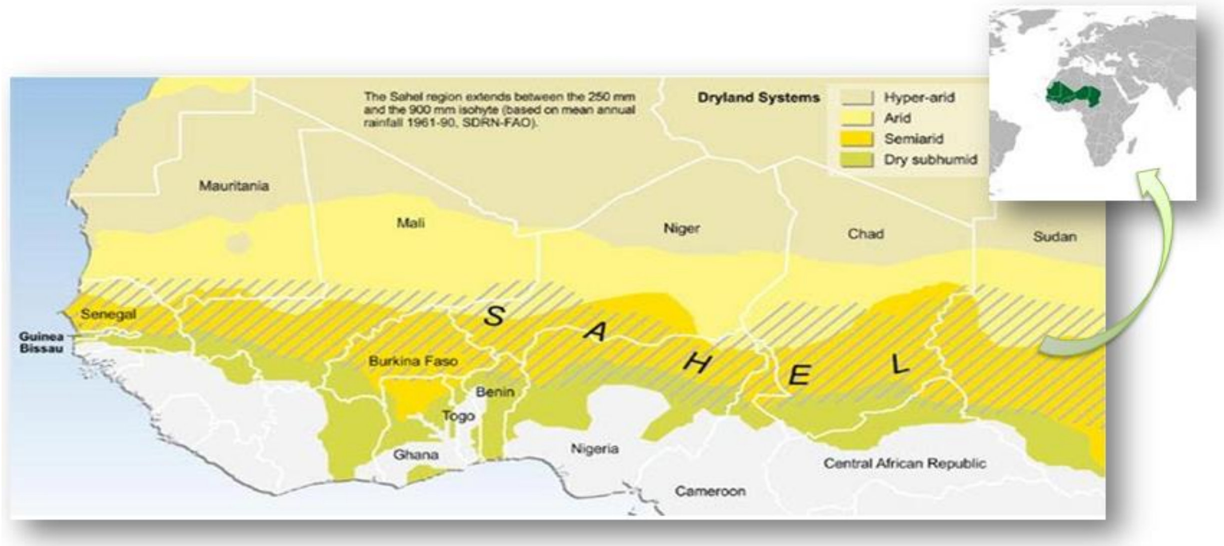
Investors

Partners and Sponsors

APPENDIX II
ENERGY POVERTY IN THE SAHEL REGION

1. The "Sahel region" commonly refers to the geographic area occupying the southern belt of the Sahara Desert. Although there is not a clear and shared definition of the borders within which the Sahel is inserted, the countries which are commonly included are: Senegal, Mauritania, Mali, Burkina Faso, Niger, Chad, the Gambia, Cape Verde, Guinea-Bissau. The Sahelian countries are part of West Africa and form a regional market named ECOWAS which includes all the Western African countries. However, the Sahel is also a distinct geopolitical entity established in 1973 by the constitution of the Permanent Interstates Committee for Drought Control in the Sahel (CILSS).

The Sahel Countries



Source: Millennium Ecosystem Assessment

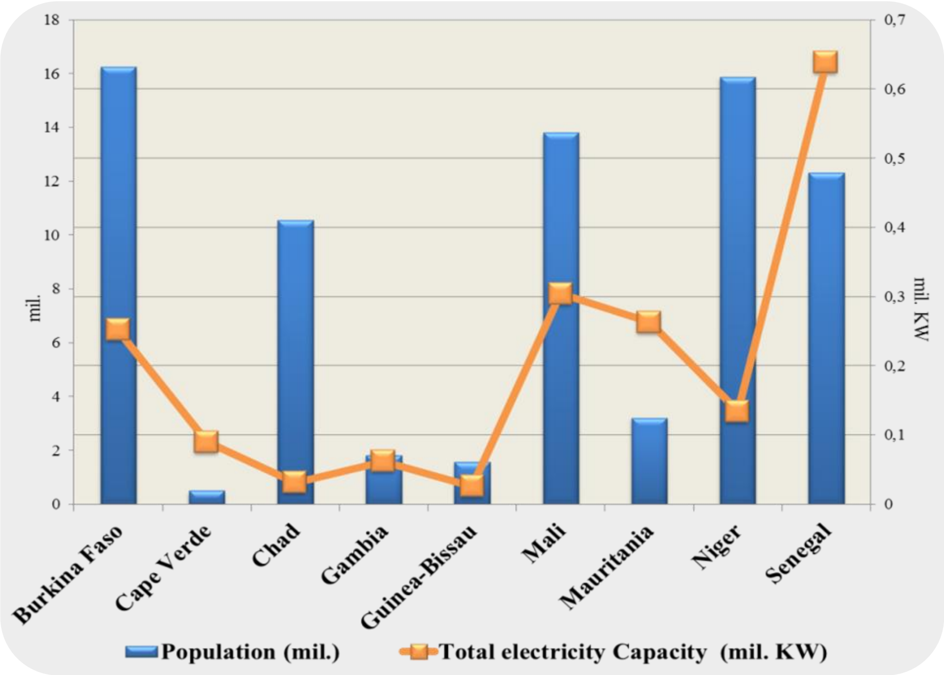
2. The Sahel has a population of almost 76 million, representing about 13% of African people. Like for many other countries of the Continent, the energy situation is characterized by serious energy challenges due to unreliable power infrastructures, over exploitation of the forestry resources, dependence on imported petroleum products, high cost of developing its abundant renewable energy potential. Energy poverty is acutized by: (a) a growing demand for modern energy services, stimulated by a rapid demographic growth; (b) the fragility of the ecosystem due to harsh climatic conditions with a progressive desertification which is reducing wood availability for energy use[77]; (c) the lack of an active private sector affected by the war, such as in Chad and Guinea Bissau, and by the absence of a strong regulatory framework, like in Mauritania[78]; (d) the lack of political support and of institutional capacity which undermine the development of national energy initiatives. However, in recent years, more concerted efforts have been put in place in order to build

[77] Wood availability is also affected by deforestation due to the intensive use of biomass in order to encounter energy needs. For example, in Mali, 6.5 million tonnes of wood was consumed in 2000 alone, an equivalent of 1.5kg/person/day. Amie Gaye, *Access to Energy and Human Development*, Human Development Report 2007/2008. Available at: http://hdr.undp.org/es/informes/mundial/idh2007-2008/trabajos/Gaye_Amie.pdf

[78] Intelligent Energy - Europe, *Energy for Poverty Alleviation in Sahel*, Handbook with appropriate framework for the development of sustainable energy systems in each Sahelian country. April 2006.

capacity at national and local level to make progress in reforming the energy sector and in promoting the country's renewable energy potential.[79]

Comparing Population with Generation Capacity by Country, 2010



Source: Rie on U.S. EIA data

3. In order to satisfy the national energy requirements, these countries rely on old, inefficient and unreliable oil-based power plants and on the use of traditional biomass, mainly wood, primarily used for cooking, with a reliance ranging from 54% in Senegal to almost 80% in Mali and 90% in Burkina Faso.[80] Moreover, the lack of exploitable hydrocarbon resources in most of these countries determined a strong dependence on petroleum products imports, making them very vulnerable to oil price volatility.[81] As indicated in the figure, comparing population with generation capacity shows a low per-capita consumption in most of the Sahelian countries, with the two most populated countries, Burkina Faso and Niger, affected by a sharp power shortage, along with Chad and Mali. Instead, Senegal and Mauritania, with a developed mining industry, are major consumers of energy.[82] Notwithstanding the problems of colletting actual and precise data, the Sahelian countries show a very low households electrification rate, which tends to worsen in the case of rural households. The best performers are Cape Verde, Guinea-Bissau and Senegal, with more than 50% of their households having access to electricity; on the contrary, Chad, Niger and Burkina Faso show the worst performance with less than 15% of households having access to electricity.

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[79] Intelligent Energy - Europe, *Energy for Poverty Alleviation in Sahel*, Handbook with appropriate framework for the development of sustainable energy systems in each Sahelian country. April 2006. p. 14

[80] Fall Mamadou, *Traditional Household Energy Sector in Sahelian Countries of West Africa*, 2nd World Conference and Technology Exhibition on Biomass for Energy, Industry and Climate Protection, 10-14 may 2004; Intelligent Energy - Europe, *Energy for Poverty Alleviation in Sahel*, Handbook with Appropriate Framework for the Development of Sustainable Energy Systems in Each Sahelian Country. April 2006.

[81] Togola Ibrahim and Dembele Pierre, *Brief Presentation of the Situation & Energy Policy of Mali*, October 2005; Irena, *Senegal: Renewables Readiness Assessment 2012*, 2012. Available at: http://www.irena.org/DocumentDownloads/Publications/IRENA%20Senegal%20RRA.pdf

[82] Fall Mamadou, *Traditional Household Energy Sector in Sahelian Countries of West Africa*, 2nd World Conference and Technology Exhibition on Biomass for Energy, Industry and Climate Protection, 10-14 may 2004.

Sahelian Households Electrification Rate, last year available.

Country	Households Electrification Rate (%)	Last year available
Burkina Faso	11,4	2003
Cape Verde	67	2005
Chad	3,5	2004
Gambia	34,3	2000
Guinea-Bissau	53,5	2002
Mali	16,6	2006
Mauritania	18,2	2005
Niger	9,3	2006
Senegal	53,5	2008

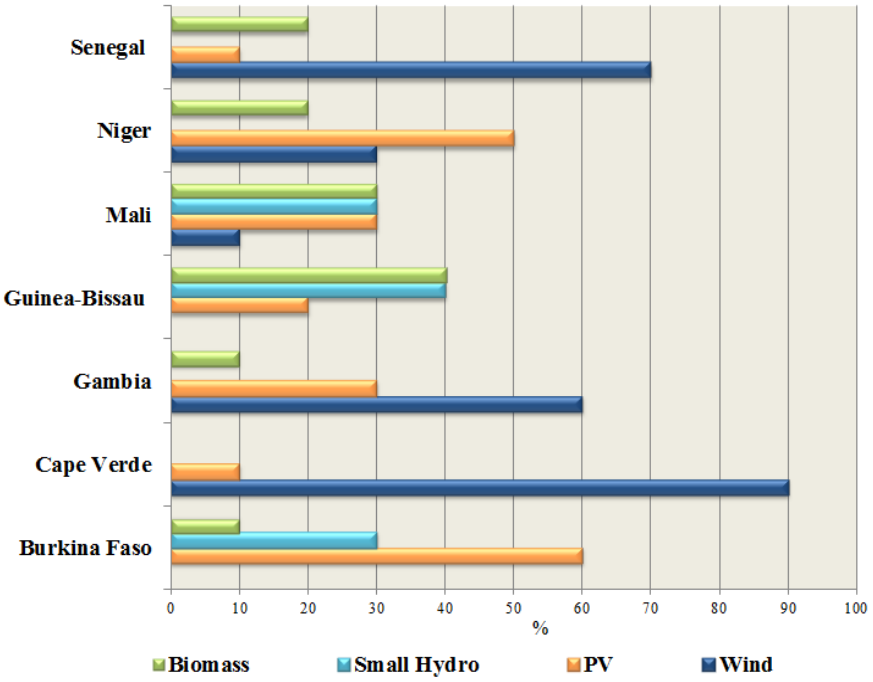
Source: Datamarket on World Bank Surveys

4. These countries are recongnized to have a significant renewable energy potential, above all for their hydropower, solar and wind resources. West Africa has been identified as a major potential area for small hydropower and, among the Sahelian countrieas, Burkina Faso, Guinea-Bissau, Mali, Niger and Senegal take the lead. Wind potential is concentrated in the costal zones, in particular Cape Verde, Senegal and, possibly, Mali. Solar energy is abundant in the whole region, with the largest potential attested in Niger and Burkina Faso.[83] We already highlighted the great advantage of renewable energy technologies as decentralised solutions; however, due to the remote areas and the limited financial resources of the interested communities, political support for an initial investment is needed to create a favourable environment to attract private sector.[84] Since today, several countries have started the process of developing a renewable energy policy and favourable institutional structure, but only few of them have taken concrete steps to implement such policies.[85] Cape Verde is considered the pioneering country making renewable energy a priority for the development of the country, aiming at 50% penetration of renewable energy in the electricity mix by 2020. Recently, the insland installed 25.5 MW of grid-connected wind farms and 7.5 MW of grid-connected solar PV plants. The solar projects were implemented through a concessional credit from Portugal to the Cape Verde government, while the wind farms investment was boosted mainly by the African Development Bank and the European Investment Bank financing, with an equity share of the Africa Finance Corporation, Finnfund, Infraco, Electra and the national government.[86] Senegal and Mali have developed a detailed renewable energy policy, with ambitious targets of 15% and 25% of installed capacity respectively by 2021.[87] In 2011, Senegal launched its first PV

[83] ECREEE, *Ecowas Renewable energy Policy (EREP)*, September 2012. p.22
[84] IRENA, *Prospect for the African Power Sector*, 2012.
[85] ECREEE, *Ecowas Renewable energy Policy (EREP)*, September 2012.
[86] ECREEE, *Ecowas Renewable energy Policy (EREP)*, September 2012; ARE, *Promoting Renewable Energy in Cape Verde*, Presentation of the ARE Administrator, Rito Evora, to the Gambia national Forum on Renewable Energy Regulatio, 2012. Available at: http://www.naruc.org/international/Documents/EVORA-%20Cape%20Verde-%20Promotion%20of%20Renewable%20Energy%20in%20Cape%20Verde.pdf
[87] ECREEE, *Ecowas Renewable energy Policy (EREP)*, September 2012.

module assembly unit (25 MW) in Dakar. In Gambia, a 10,000 SHS programme was established, with an estimated budget of nearly USD 7.4 million, mainly donor funded.[88]

Indicative Ranking of RE Potential by Country



Source: ECREEE, *Ecowas Renewable energy Policy (EREP)*, September 2012. p. 74

5. As part of ECOWAS, these countries participate in the regional initiatives promoted to address the energy access gap. One key regional initiative was the establishment in 2006 of the West African Power Pool (WAPP), as a specialized ECOWAS institution, with the aim to harmonize the electricity regulatory national frameworks and to address the grid infrastructure gap among interconnected countries. Other key ECOWAS initiatives include the Regional Electricity Regulatory Authority and the Regional Centre for Renewable Energy and Energy Efficiency (ECREEE).[89] The ECREEE target is the promotion of renewable energy through the development of regional policy guidelines for the member states to apply in order to improve energy security, increase access to modern energy services and support the region's economic and social development. Moreover, in order to provide electricity access to the Sahelian households, the CILSS launched in the late 1990s the Regional Solar Program (RSP), funded by the European Development Fund (EDF) for the promotion of PV solar energy, which installed during its first phase nearly 650 community systems using photovoltaic solar energy.[90] CILSS initiated also a Regional Program for the promotion of Household and Alternative Energy sources in the Sahel (PREDAS), with the support of the European Union and the German cooperation, with the aim to limit the effects of desertification exacerbated by the massive use of firewood. Based on common and similar concerns - in terms of energy resources and markets - affecting the ECOWAS countries, we are facing the emergence of a regional dimension of access to modern energy services in rural

[88] REN21, *Renewables 2012, Global Status Report,* 2012. Available at: http://www.map.ren21.net/GSR/GSR2012_low.pdf

[89] Irena, *Senegal: Renewables Readiness Assessment 2012*, 2012. Available at: http://www.irena.org/DocumentDownloads/Publications/IRENA%20Senegal%20RRA.pdf

[90] CILSS, *Renewables for the Sahelian Populations: the CILSS Solutions*, available at: http://www.cilss.bf/predas/publications/Renewables%20for%20the%20Sahel_The%20CILSS%20Solutions.pdf

and peri-urban areas. However, a series of barriers need to be addressed in order to develop the renewable energy potential: (a) the shortage of local actors with the capacity to run projects financially, technically, and in terms of management; (b) weak equipment production capacity at the regional level and (c) a non-incentive institutional and regulatory framework.[91]

Focus Mali

The State of Art[92]

Mali is a landlocked country in the Sahel region of West Africa. It covers an area of 1,241,248 km^2, 51% of which is desert. Its population is estimated at 14.5 million inhabitants and its average annual growth rate is 3.4%. Nearly 73% of the population resides in rural areas. The urbanization rate stands at 26.8%. Over the last decade, Mali has made significant progress in economic, political and social spheres. In less than 10 years, the Gross Domestic Product (GDP) tripled from $2.43 billion in 2000 to $9.70 billion in 2010. Notwithstanding this progress, Mali remains one of the poorest countries in the world, ranking 160th out of 169 countries.In 2007, the energy balance reported that biomass (firewood and charcoal) accounted for about 80% of national energy consumption, fossil fuel 16%[93], electricity 3% (mainly hydropower), and renewable energy (other than hydropower) 1%. Two energy sub-sectors are particularly vulnerable to climatic variability: wood fuel (firewood and charcoal) and hydroelectricity. The rate of access to electricity in Mali is low, however it has been regularly improving for almost a decade. It grew from 9 percent in 2001 to 27.1 percent in 2010. This increase is much more marked in urban areas (28% in 2001 vs 55% in 2010) than in rural areas (2% in 2001 vs 15% in 2010).[94] According to the World Bank, basic energy services have been improved and as of December 2011, about 55,900 off-grid connections in households and for public lighting have been made to provide electricity to about 838,000 persons and more than 8,598 households were connected to solar home systems and solar photovoltaic systems were installed countrywide.The *Politique Énergétique Nationale* (PEN) projects a rise in the electrification rate from 1% in 2005 to 12% in 2010 and 55% in 2015. So far, results are consistent with goals. The average electricity generation costs are estimated at USD 0.24/kWh for the electricity supplier *Énergie du Mali SA* (EDM SA), while off-grid generation costs for private energy service companies (SSD *Koray Kurumba* and SSD *Yeleen Kura*) are estimated at about USD 0.47/kWh.

Government commitment

The general energy strategy of Mali focuses on the development of local resources such as hydropower and solar energy in order to reduce petroleum imports. In 1999, the Government of Mali (GoM) issued a policy letter with the following goals[95]:

- sector liberalisation, allowing initiatives from communities and the private sector;

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[91] ECOWAS and UEMOA, *White Paper for a Regional Policy*, Available at: http://www.gm.undp.org/Reports/ECOWAS%20energy%20white%20paper.pdf

[92] The following section is largely extracted from ADB (2012), *Renewable Energy in Mali: Achievements, Challenges and Opportunities*

[93] The oil and gas sub-sector is characterized by total dependence on petroleum imports.

[94] IMF (2011), *Mali: Poverty Reduction and Strategy Paper—2010 Progress Report*, IMF Country Report No. 11/372, December 2011

[95] Energypedia

- institutional reforms to orient the State's responsibility to activities of strategic and regulatory nature;
- valorisation of national energy resources (renewable energy, hydroelectricity);
- protection of forestry resources through sustainable exploitation benefiting rural populations;
- pursuing petroleum research.

The GoM has restructured the sector by adopting a new Electricity Law and its implementation texts, which ends EDM's monopoly and has opened the sector to competition, under a regime of transparent regulation by an independent agency. Reform processes and institutions need to be strengthened to foster a lasting competitive business environment attractive to private investors and operators. The imperative to provide energy services to the poor calls for an innovative service delivery mechanisms, with participation by communities, NGOs and the private sector. The key steps of the GoM's energy policy:

a) "*Politique Énergétique Nationale*" (PEN): adopted in 2006, is a tool for balancing energy availability and national socio-economic development needs, fostering synergy between the major energy sector stakeholders, and guiding their interventions. The goals of the PEN refer to using renewable energy technologies for energy production and are fully reflected in the "*Stratégie Nationale pour le Développement des Energies Renouvelables*".

b) "*Stratégie Nationale pour le Développement des Energies Renouvelables*": adopted in 2006, aims at: (i) promoting the widespread use of renewable energy technologies and equipment to increase the share of renewable energy in national electricity generation up to 10% by 2015, (ii) developing the biofuel sub-sector for various uses (i.e., electricity generation, transportation and agricultural motorization), (iii) creating better conditions to sustain renewable energy services and (iv) searching for sustainable and suitable financing mechanisms for renewable energy.

c) "*Lettre de Politique Sectorielle de l'Énergie*" for 2009-2012 is a reference and guidance framework for the GoM's vision concerning the energy sector. The main goal is to carry out the necessary adjustments and reforms in the electricity sub-sector, such as completing the restructuring of EDM and tariff reforms, and taking steps to ensure its sustainable development. Its main objectives are: (i) to provide wide access to rural energy services at an affordable cost, (ii) to develop all available renewable energy sources and (iii) to promote access to finance.

d) "*Stratégie nationale pour le Développement des Biocarburants*": adopted in June 2008, it aims at boosting local energy generation by developing biofuels to meet the country's socio-economic needs at a lower cost while reducing Mali's high dependence on oil imports.

e) "*Programme d'Action National d'Adaptation aux Changements Climatiques*": adopted in 2007, it aims at mitigating the adverse effects of climate variability and change on the most vulnerable segments of the population for a more sustainable development. The program includes renewable energy development projects, some of which have been partially implemented.

Obstacles for Grid Based Rural Electrification	Obstacles for Off Grid Energy Technologies and Services
• The incoherence and imprecision of the EDM´s electricity concession´s contract	• The absence of a coherence strategy for rural electrification
• The non-execution of investment programmes by EDM	• The absence of appropriate finance mechanisms and institutions
• The low efficiency and high losses in EDM´s electric system	• The lack of qualified technicians for customer service
• The high tariffs for rural consumers	• The lack of local production/assembly capacity

Rural Electrification: EDF experience[96]

EDF began its exploration of creating Rural Energy Services Companies (RESCO) in Mali in the mid-1990s with a comprehensive study of the socio-economic, technical and environmental feasibility of rural electrification in the country. The study brought to the creation of two RESCO, Koraye Kurumba (1999) and Yeelen Kura (2001), in partnership with the Dutch energy company NUON, the French oil company TOTAL and with the support of the French Environmental Agency ADEME (Agency for the Environment and Energy Efficiency). An experience in line with that EDF has carried out in Morocco with the creation in 2002 of TEMASOL, a joint-venture with TOTAL[97]. Backed by a new institutional framework and international donors, the RESCOs adopted a fee-for-service business model aimed at providing low-cost electricity based on solar home systems or small low-voltage village micro-networks supplied by diesel generators. This resulted in undeniable development impacts, such as enhancing standards of living, favoring the development of income-generating activities, and improving quality of healthcare and education. In 2007, the RESCOs served 24 villages and 40,000 people.

EDF initiated the cooperation in Mali according to three key criteria which orient its strategy in this matter: *profitability*, *sustainability*, *replicability* of the project, including the fact that the companies it contributes to and creates with local partners should be ultimately owned and run by local actors. In the EDF's RESCO model, the companies install and manage local electricity generating systems to help stimulate local economic activity and reduce poverty. They are operated on a commercial basis and run by local managers and employees. The RESCOs are independent Malian companies and make all the decisions autonomously. They have a link with the shareholders through the Board of Directors. Therefore, EDF brings strong support to its subsidiaries through training programmes, development of appropriate equipment (i.e. customer interfaces) and support to management.

[96] The following section is largely extracted from Gaye M. (2008), *Rural Electrification in Mali: Improving Energy Accessibility to the Rural Poor* GIM Case Study No. A017, United Nations Development Programme, New York
[97] See "*Case Study: Morocco*" page 34 of the main study.

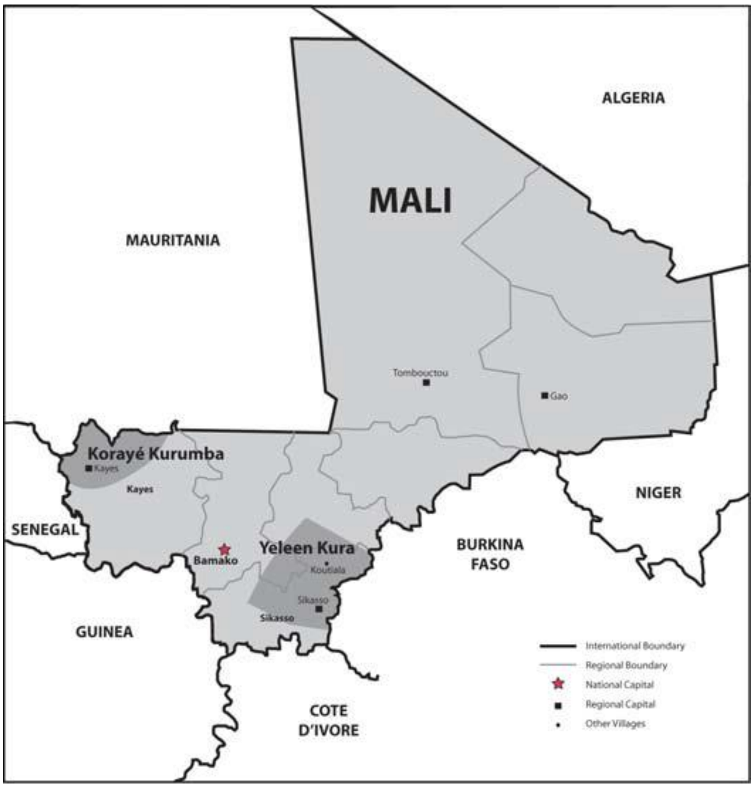
The authorization to set up RESCOs had been given originally by the *Malian Ministry of Mining and Energy*. Then, the main public interlocutor became the *Malian Agency for the Development of Household Energy and Rural Electrification* (AMADER) that promotes the development of electrification in Mali through the use of subsidies and is financially supported by the World Bank and other international donors (e.g. KfW, ADB, etc). Amader is also responsible for setting up an adequate legal, regulatory and fiscal environment for rural electrification by private operators, and helps to arbitrate any disputes between the operators and communities.

The RESCOs

Koraye Kurumba (meaning "New Light" in the Soninké language) was created in 1999 by EDF (shareholder at 70%) and French oil company Total (30%). It operates in the Kayes region, in the west of the country along the border with Senegal and Mauritania. In 2007, it provided energy to 510 clients in four villages selected by request of the Malian immigrants in Paris. In addition to providing electricity for domestic uses, Koraye Kurumba also provides public street lighting, water pumping, schools, health centres, and productive uses. In 2007, Koraye Kurumba employed 15 people, distributed between the villages and the headquarters. All the employees are Malian, including the director, Mr. Abdoulaye Keita.

Yeelen Kura ("New Light" in the Bambara language) was created in 2001 by EDF (50%) and the Dutch energy company NUON (50%) with the intent of contributing to eradicate poverty through the supply of modern energy services to rural population. However, the two partners had slight differences: NUON wanted develop renewable energies, while relying on such sources was not an end in itself for EDF. Renewable sources are used by EDF if they are appropriate to the needs of the community and economically viable in order not to charge local farmer with extra costs. The idea beyond the creation of Yeelen Kura was to commit electricity services to a local company. The French Agency ADEME joined the partnership to train and support local operators in the operation of electricity infrastructure. Yeelen Kura operates in the southeastern cotton area, on the border with Burkina Faso. This area was chosen because it is the most economically active, which would attenuate somehow the numerous barriers and risks faced by the RESCOs in addressing low-income markets in rural areas. In 2007, Yeelen Kura provided modern energy to 1,700 clients in a dozens of villages. As for Koraye Kurumba, its client base represents about 60-70% of the population living in those villages. In 2007, Yeelen Kura counted over 15 decentralized offices and 33 employees, 25 of whom live in the villages. For the first three years of the company's operation, a Dutch director managed Yeelen Kura, but management was soon passed to a Malian director, Amadou Diallo. Two vice-directors support Diallo: one director is responsible for the technical aspects of the business, and one is responsible for the financial and commercial aspects.

Map of Mali with Yeelen Kura and Koraye Kurumba Service Areas



Source: Rebecca Langstaff, 2007

Because the RESCOs were created before the implication of the World Bank, they did not benefit from its financial support at the beginning. In terms of financing, Koraye Kurumba originally relied on Malian immigrants in Paris to support the costs of the operation. On the contrary, most of the financing for Yeelen Kura came from EDF and NUON. The Dutch government provided over $1 million, which covered around 30% of the cost of installing 1,500 SHS. The initial feasibility studies had identified that this donor subsidy was essential in making the overall project feasible and allowing tariff rates to remain affordable for many customers.

Clients

A client is a household, which in rural Mali comprises an average of 15 to 20 people (up to 80), with an average monthly income of $40 to $68. Thus, with 510 clients in 2007, Koraye Kurumba benefited 10,200 people, while Yeelen Kura benefited more than 30,000 (1,700 clients).

Services

Koraye Kurumba offers a wide range of domestic services, from small (two lamps) to large (18 lamps and two electrical sockets), and provides public street lighting (about 75 lamps in total) in the four villages it serves. 90% of the electricity provided is based on small low-voltage village micro-networks supplied by diesel generators, and 10% is based on solar kits.

At the beginning of the programme, 100% of the electricity provided by Yeelen Kura was based on PV kits with panels ranging from 43 Wp to 120 Wp. Yeelen Kura has set up approximately 15 local energy stores in the villages within a 300 km radius from Yeelen Kura's head office in the town of Koutiala. In each store, one or two employees are responsible for installing, maintaining and repairing the systems in their area, as well as collecting fees and keeping track of the accounts.

Fee Structure

Under their contract with the Malian government, the RESCOs are free to set their own electricity tariff rates. The tariffs are computed in a way that tries to make the service as affordable as possible, while ensuring that the company will be able to cover its operating costs and remain economically viable. In many cases, family expenditures on electricity are the same or less than they would previously spend for traditional sources of light and energy. At the beginning, the fee structure is composed of a *fixed fee* plus a *guarantee deposit* and a *connection fee*, charged once.

The fees are collected periodically (at a payment frequency chosen by the customer), generally on a monthly basis, by clients coming to the offices. The RESCOs allow some *flexibility*, such as annual payments, for customers whose resources are received once a year (e.g. farmers). It is verified that there are no bad payers but rather people asking to be disconnected due to their inability to pay.

Financial Viability

Originally, the RESCOs did not have the necessary conditions to be profitable, but EDF involved itself knowing that a new institutional framework was being prepared that would enable them to profit. So far, the low tariffs that the companies charge and their fee-for-service business models only raised enough revenue to cover ongoing operations and maintenance costs. The expansion of Yeelen Kura's and Koraye Kurumba's coverage was dependent on donor grants to cover the costs of additional generating systems.

According to the expansion plan, the RESCOs should start being profitable since 2008. Although the RESCOs did not receive subsidies at their beginning, their expansion will be financially supported by Amader up to 70% of the investment.

Expansion Plans

After the success of both companies, EDF has been seeking additional funds to allow them to expand and, in July 2006, EDF started signing financing conventions with Amader. Under the expansion plan, Koraye Kurumba's and Yeelen Kura's customer bases will be multiplied by ten and four respectively. As both RESCOs will benefit from international donors' subsidies (through Amader), their tariffs will be divided by two, which should increase the access to 80-90% of the population living in those villages.

The first beneficiary of the new Amader financing conventions will be Yeelen Kura, with the goal to expand its coverage to cover 5,000 customers in 24 villages by 2008. Following a pragmatic approach based on local needs, 60% of these expanded services will depend on the use of low-voltage micro-networks powered by small diesel generators, and the other 40% will depend on solar home systems.

RESCOs' Challenges Faced	
The limited donor funding required a tariff structure, which meant that not all poor people could access electricity services.	Need for authorizations at various levels from the government and the Ministry of Mining and Energy, which necessitated bureaucratic processes
Grants from donors are not enough to generalize the installation of solar kits.	The low population density and the remoteness of villages in rural areas translated into relatively high transaction costs and costs of installing electrical systems.
Need of adapting and normalizing technological equipments used	Low levels of literacy and business management capacity in the rural areas
Involving all actors and implementing genuine community-based management structures	Potential international competition as the energy sector in Mali becomes more liberalized

The World Bank support[98]

The World Bank is supporting Mali in addressing its economic challenges with a focus on education, health, agriculture, and energy through its International Development Association (IDA). On the energy side, IDA is financing the Energy Support Project and the Household Energy and Universal Access Project (HEURA). IDA also supports the Félou Regional Hydropower Project, which is expected to bring additional clean generation to Mali in 2013 at a much lower cost than thermal generation. This project also promotes regional integration and energy diversification.

The Energy Support Project[99]

In urban and peri-urban areas, the Energy Support Project ($120 million) supports increased access to electricity through the interconnected network, as well as improved reliability and efficiency of supply, and by strengthening and extending the transmission and distribution networks, in and around Bamako, as well as in regional cities. There are three components to the project. The first component is the *transmission and distribution reinforcement and extension*, mainly intended to finance: (i) upgrade the electricity transmission line between Segou and Bamako; (ii) upgrade and reinforce 30 kv facilities in the peripheral area of Bamako, including the 150 kv loop; (iii) upgrade and reinforce low and medium voltage distribution networks in Bamako; (iv) upgrade and reinforce medium and low voltage distribution networks in areas of, among other, Kati, Segou, Kayes, Mopti, Sikasso, and Koutiala. The second component is the *energy efficiency and demand-side management*, mainly intended to finance: (a) a residential lighting program to replace incandescent or neon light bulbs with compact fluorescent lamps (CFLs), in urban and rural households; (b) a street lighting program to replace incandescent or neon light bulbs by CFLs and/or high pressure sodium vapor lamps, in key urban and rural centers; and (c) a public facilities' lighting program to

[98] The following section is largely extracted from WB, Mali: Country Results Profile, May 2012 http://web.worldbank.org/WBSITE/EXTERNAL/NEWS/0,,contentMDK:22898018~menuPK:141310~pagePK:34370~piPK:34424~theSitePK:4607,00.html

[99] http://www.worldbank.org/projects/P108440/mali-energy-support-project?lang=en

replace incandescent light bulbs by CFLs. Finally, the third component is the *capacity and institutional strengthening of key sector institutions*.

The Household Energy And Universal Access Project[100]

The Household Energy and Universal Access Project (HEURA) comprises an IDA Credit of $35.7 million and a Global Environment Facility (GEF) trust fund of $3.5 million. It was presented to the Board in November 2004. Based on satisfactory performance of the project, an additional IDA credit US$35 million was presented to the Board in September 2008.

The objective of the HEURA is to support the GoM's efforts to increase access of isolated low income populations to basic energy services to help achieve economic growth and poverty reduction targets, including those linked with the Millennium Development Goals. These low access rates are not allowing Mali to fully harness its economic potential to compete fairly on international markets. A spectrum of innovative service delivery mechanisms is needed with the active participation of communities, NGOs, and the private sector.

The HEURA project followed a two-pronged design. First, it helped Mali to develop a multi-layered approach to rural energy, combining bottom-up spontaneous small concessions with top down planned large concessions for electrification. Second, it built and strengthened a community-based woodland management to ensure sustainable wood fuel supply and inter-fuel substitution initiatives with a gradual introduction of improved stoves. The HEURA project supported the GoM in creating AMADER, a specialized agency for household energy and rural electrification in the country. The HEURA helped the government to set up a Rural Electrification Fund (REF) aimed at supporting partially start-up capital costs of rural electrification sub-projects. An operational rural agency and the availability of funding from the REF have enabled local private operators to become the driving force of this project. They have provided an average matching co-financing of 25% of rural electrification sub-projects.

The project address three main challenges: (i) introducing further *low-cost technologies* to reduce electricity tariff in rural areas; (ii) *ensuring sustainability* of the initiatives; (iii) *securing long term financing* to sustain the interest of local private operators in the energy services delivery business. The project is obtaining positive results:

Encouraging local private sector participation: about 80 sub-projects managed by 46 operators are financed by the project. As of May 15, 2010 about 43,311 off-grid connections in households and for public lighting have been made to provide electricity to about 650,000 persons. In addition, through the project, about 803 public institutions including 172 schools and 139 health centres have also been provided off-grid electricity access.

Empowering women: women's associations are playing an important role in remote communities as providers of energy services. After receiving training in basic accounting in local languages provided by NGOs financed through the project, they manage multifunctional platform electrification initiatives, which are village diesel motors that combine electricity production with

[100] Mali: Household Energy and Universal Access
http://web.worldbank.org/WBSITE/EXTERNAL/NEWS/0,,contentMDK:22707414~menuPK:141310~pagePK:34370~piPK:34424~theSitePK:4607,00.html

other services such as milling, husking, pumping water, charging batteries, running lights and powering tools. To date, multifunctional platforms have been installed in 64 communities resulting in 7,200 connections.

Introducing new renewable energy technologies into Mali's rural energy mix: over a period of six years, more than 7,926 households were connected to solar home systems and solar photovoltaic systems were installed in more than 500 institutions countrywide.

Promoting sustainable wood fuel management and inter-fuel substitution: in order to contribute to a sustainable supply of wood fuel, predominantly used for cooking and heating, the project in partnership with the National Directorate of Nature Conservation, has placed about 874,000 hectares under community management. NGOs and local private operators have disseminated about 748,500 improved wood and charcoal stoves and about 51,385 Liquefied Petroleum Gas stoves. The growing use of improved stoves is expected to help reduce indoor air pollution which is one of the main environmental health risk factors that women and children are exposed to. Indoor air pollution is associated with acute respiratory diseases, conjunctivitis, and low birth weight.

Shared Solar innovation[101]

The Millennium Village Project (MVP) was launched in 2005 in order to accelerate progress towards the Millennium Development Goals in the poorest regions of rural Africa. A dozen clusters of villages in 10 African countries have adopted bold and novel strategies to overcome poverty, hunger, and disease. Now halfway through the ten-year project, the results are very exciting: agriculture production is up significantly, free basic health care is in place, malaria is coming under control, many more children are in school, and farmers are organizing cooperatives to diversify their crops and increase incomes.

As part of the MVP, in 2009 the Earth Institute's Modi Research Group took up the challenge of how to bring electricity to rural villages in Africa. After analyzing the data and sociological constraints, the team arrived at an innovative solution to the problem: solar-powered micro-grids with prepaid metering and semi-automated, remote management. They called it SharedSolar: *pay-as-you-go electricity via mobile telephony*.

In Mali, the Tiby Millennium Village cluster – 11 Millennium Villages with 55,000 residents located in the southern region of Segou, one of the poorest areas in all of the country – is enjoying the SharedSolar programme

Other Projects

Iowa State University began working in Mali in 2006 with the NGO Medicine for Mali. ISU has established lighting as a primary concern, and an appropriate technology design course in the mechanical engineering department has worked to design lighting solutions using photovoltaic cells and thermoelectric devices. Sixteen prototypes designed in the course were tested in Nana Kenieba, and ISU students partnered with students from the University of Bamako in Mali to survey the costs of different light sources and battery costs. The team will now develop a battery charging station to be run by a local entrepreneur collecting the excess power from a solar-powered water system. The

[101] See page 39 "*Pilot project: Shared Solar*"

water system's electrical pump demands less power than the output of the solar panels, leaving approximately 300 watts of available power to be used for electricity in the village. Financing will be done through a micro-loan program, and the team will train local entrepreneurs and continue to monitor and support the businesses they launch.

In October 2010, *Lighting Africa* expanded into Mali and Senegal through the World Bank Energy Access Project, marking the programme’s entry into francophone countries. In Mali, Lighting Africa will develop a quality seal for solar portable lamps and pilot lamp sales in selected concession areas, building on the successful electricity expansion project that AMADER has implemented in the country, with the support of the WB. In Senegal, the program will introduce quality lanterns in off-grid rural and peri-urban areas. In both Senegal and Mali, Lighting Africa will work through rural electrification agencies. It signed an agreement with both AMADER and the *Senegalese Agency for Rural Electrification* (ASER) outlining the details of the cooperation.

Asantys Systems GmbH[102] has successfully implemented two off-grid solar installations in Mali. Commissioned at the beginning of July 2011, the two solar power plants - 50kWp and 150kWp - were installed by order of *Foundation Rural Energy Services* (FERS)[103], an NGO from the Netherlands whose aim is to provide electrification in rural areas of developing countries. The Mali plants are two of the largest off-grid solar systems on the African continent. Both systems were ordered at the end of 2010, with the turnkey installation completed within six months. The German solar system integrator and EPC provider Asantys Systems was responsible for the system design, choice and delivery of components, logistics and installation in Mali. Both solar plants are operating in combination with diesel generators in hybrid systems. They provide clean energy to approximately 1500 households in the villages of Kolondieba and Ourikela in south Mali. The yearly energy yield is predicted to be 70kWh and 212kwH. The two projects utilized components and support from Centrosolar, Hoppecke, and SMA, specifically: (i) 867 solar modules from Centrosolar, producing 203kWp; (ii) 825 batteries from Hoppecke; (iii) 55 inverters from SMA. The two solar plants are operated by the local company Yeelen Kura, which is one of six African subsidiary companies of FRES.

[102] Asantys Systems is providing the solar system maintenance for a period of five years. Asantys Systems is system integrator for grid-connected and off-grid solar systems. As an EPC provider it designs solar systems, delivers turnkey projects, and maintains solar systems in Germany and worldwide, with a special focus on Africa. The company's product-portfolio consists of solar micro grids, solar-diesel hybrid systems, solar backup systems, solar pumping systems, solar streetlights, solar home systems, and grid-injecting systems. Asantys Systems is currently exporting products and services to more than 30 countries in Africa, leveraging many years of project implementation experience across the region.

[103] FRES (Foundation Rural Energy Services) is a foundation that fosters rural electrification in developing countries by setting up small-scale commercial electricity companies in areas without a connection to the national electricity grid. It offers households and small companies access to electricity derived from solar energy.