**THE INFLUENCE OF FUEL SUBSIDIES AND TAXES ON THE POTENTIAL FOR DECENTRALISED PV POWER ON THE AFRICAN CONTINENT**

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ABSTRACT: Many people in African countries lack access to sufficient electricity supply mostly due to high power generation costs. In order to provide electricity access to a wider part of the population, it is necessary to exploit the vast renewable resources in African countries. Therefore, this paper scrutinises the economic advantages of photovoltaic-based hybrid systems over fossil-fuel based generation. The assessment calculates the cost advantage of hybrid systems compared to diesel-only systems for the entire continent on a long term basis and by applying two scenarios: One based on world market diesel prices and the other one based on national diesel prices. The results indicate that average power generation costs per country can be reduced by up to 0.11 €/kWh considering world market diesel prices and by up to 0.48 €/kWh considering national diesel prices. Furthermore, the effect of fuel-price subsidies on the renewable energy potential and the respective savings are examined. The findings may ameliorate the policy development and demonstrate the advantages of decentralized renewable hybrid systems especially in rural areas of Africa.
Keywords: Hybrid, Economic Analysis, Modelling, Rural Electrification, Batteries, Developing Countries

## 1 INTRODUCTION

The African energy sector faces outstandingly high power generation costs [1]. The intensive use of oil-based power generation, such as diesel generators, is one of the reasons. Apart from being one of the most expensive means to generate electricity, production costs are highly unpredictable due to rapidly fluctuating fuel prices [2]. Most African countries therefore spend significant parts of their GDP on subsidizing electricity prices in order to enable access to electricity to a wider part of the population [2]. Nevertheless, more than 590 million find themselves without electricity access; its provision consequently remains a major challenge [3] (Fig. 1).

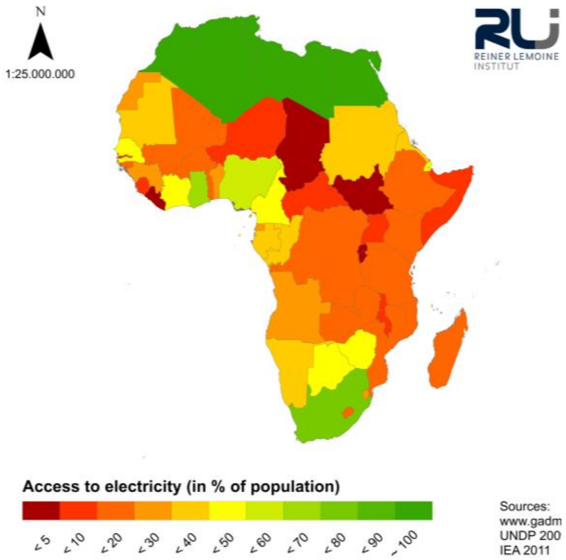


**Fig. 1:** Access to electricity in % of population. The majority of countries in sub-Saharan Africa are characterized by low parts of their population with access to electricity.

The conventional approach to solve this issue is the usage of diesel generators if an extension of the transmission grid is not feasible or planned in the near future. Yet, this reinforces the dependency on fossil fuels and forces governments to spend scarce budgets for electric power subsidies. With the rising price competitiveness of renewable energy (RE) technologies, decentralized renewable off-grid solutions present a viable alternative, especially in rural areas [4]. In particular hybrid systems consisting of photovoltaic (PV) modules, battery storage and backup diesel generators are of great interest, since they make use of the high solar power potential in Africa [5] and can be integrated into the preexisting infrastructure of small diesel grids [6].

However, for a broader integration of renewable energies fossil-fuel subsidies are obstructive. As high upfront payments are necessary for renewable technologies, hybrid systems cannot compete with conventional systems under subsidized fuel prices on a short-term basis. Until now, few studies were carried out addressing this issue [7, 8]. Generating knowledge in these areas will therefore ameliorate the policy development and demonstrate the advantages of decentralized renewable hybrid systems especially in rural areas of Africa.

## 2 METHODS

The purpose of this study is to quantify the potential for decentralized PV power for different locations by comparing the power generation costs of pure diesel systems to RE-based hybrid systems in two scenarios: The scenarios are chosen in order to study the effect fuel taxes and subsidies have on the economic feasibility of a PV-based solution. Naturally, high fuel subsidies pushing local diesel prices well below the world market level render the renewable system unprofitable for the end user. On the other hand, seen from the national economy standpoint it is very reasonable to export oil (or import fewer oil) for the world market price instead of paying for the subsidies. Consequently, scenario I is based on the world market diesel price and scenario II on national diesel prices.

Reference points are defined using the open source software packages QGIS and SAGAGIS. In a preparatory work step a raster grid is created which covers the entire African continent. This raster grid is composed of more than 12,000 pixels with a pixel size of 0.45˚ x 0.45˚. Each pixel's centroid is used as reference point for deriving resource data of a certain location (hourly solar irradiation and local diesel price), necessary as input parameters for the simulation model. For each reference point and for both energy systems the power generation costs are computed using a Matlab-based simulation tool developed by the Reiner Lemoine Institut (RLI) [9].

This model simulates an energy system in hourly time steps over one reference year regarding the fossil and solar resources as well as technical, economic, and load data to define the most economical configuration of RE-based hybrid systems. It describes energy flows between system components and their resulting costs (Fig. 2). Thereby capital and operational expenditures for each component, as well as local fuel costs are considered. Diesel generator capital expenditures are set to zero, assuming that the diesel power generation infrastructure is already in place. The cost data form the baseline for calculating the system's overall levelized cost of electricity (LCOE) [10] (Eq. 1 & 2) for one reference year. The results provide the cost-optimized system configurations for a project period of 20 years.

$$LCOE = \frac{Capex * CRF(WACC, N) + Opex + Costs_{fuel} * Fuel}{El_{consumed}}$$

**Equation 1:** Levelized cost of electricity (LCOE) for power systems. Abbreviations stand for: Capital expenditures (Capex); capital recovery factor (CRF); weighted average cost of capital (WACC); project lifetime (N); operation and maintenance expenditures per year (Opex); cost of diesel per liter ($Costs_{fuel}$); consumed diesel per year (Fuel), consumed electricity per year ($El_{consumed}$).

$$CRF(WACC, N) = \frac{WACC * (1 + WACC)^N}{(1 + WACC)^N - 1}$$

**Equation 2:** Capital recovery factor (CRF). CRF is set according to weighted average cost of capital (WACC) and project lifetime (N).

Two energy systems are considered: A diesel system consisting only of diesel generators and a hybrid system consisting of crystalline-silicon PV modules, lead-acid battery storage systems, and a diesel generator (Fig. 2). The configuration of the components in the hybrid system is optimized in order to minimize the LCOE. One basic constraint is that the load has to be covered in every time step, i.e. every hour. The primary energy source to cover the load is always PV if applicable. The battery stores PV surpluses if available, or otherwise discharges energy if the load exceeds PV production. Finally, in case of insufficient power supply from both PV and battery, diesel generators fill the power supply gap. Yearly operational costs for the diesel power generation are dominated by fuel costs and thus decrease with higher renewable share and battery capacity, since less diesel fuel is consumed.

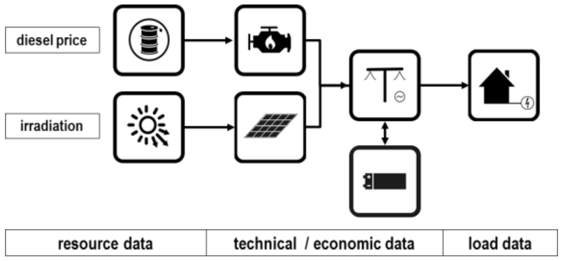


**Fig. 2:** Renewable based hybrid energy system. Diesel generator, PV module, battery storage and load are the considered parts.

The simulation model is fed with the site-specific input parameters supplemented by the general input parameters (Tab. 1). Resource data is derived by taking the geographic positions of the defined reference points: The potential PV yield is deduced from the site specific global horizontal irradiation [11] for optimally fixed, tilted mono-crystalline modules [12]. For assessing the local diesel price, transport costs are added to the average diesel world market price in 2013 of 0.58 €/l [13] in scenario I, or the national diesel price [14, 15] in scenario II (Annex 1). The national diesel costs refer to retail prices rather than to pump prices for diesel. The specific transportation costs are computed by assessing the time required to reach the off-grid locations [16] and are subsequently converted into a cost value according to an adjusted formula of Szabo et al. [8]. A typical load curve is assumed for all locations in order to estimate the energy demand (Fig. 3). The selected load curve shows a maximum load more than three times higher than the minimum load, including a significant peak load in the evening hours. This load curve is derived from a real load curve of a Tanzanian village and reflects the energy demand profile of a typical rural settlement, the focus object of the analysis [17].

**Tab. 1:** Simulation input parameters.

| | |
|---|---|
| **Resource data** | |
| Diesel base price | Scenario I: 0.58 €/l world market base price |
| | Scenario II: according to national retail price |
| Diesel transport costs | Transportation costs according to [8,16] |
| Diesel price increase | 3% annual increase |
| PV yield | Varies according to geographic location (in kWh/kWp/a) [11,12] |
| **Technical data** | |
| Diesel generator efficiency | 30 % |
| Battery round cycle efficiency | 85 % |
| Battery max. depth of discharge | 50 % |
| Battery life time | 10 years |
| Battery C-rate | 1:6 kW/kWh |
| **Economic data** | |
| Capital expenditure diesel generator | 0 €/kW |

| | |
|---|---|
| Operational expenditure diesel generator – variable | 0.01 €/kWh |
| Capital expenditure PV | 1,600 €/kWp |
| Operational expenditure PV – fixed | 2% of Capex/year |
| Capital expenditure battery | 350 €/kWh |
| Operational expenditure battery – fixed | 10 €/kWh/year |
| Project duration | 20 years |
| WACC | 10 % |

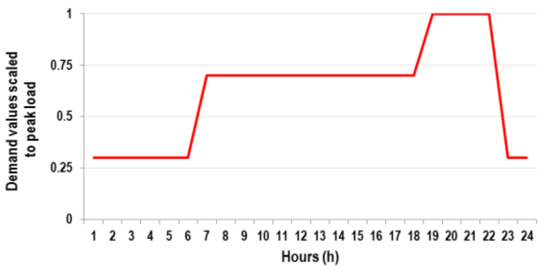


**Fig. 3**: Typical load curve of a rural village [17]. This daily load curve is converted to a yearly load curve by repeating it 365 times.

Finally, a sensitivity analysis of the diesel price for two selected locations, Tamanrasset (Algeria) and Lubango (Angola) is conducted. Both locations are chosen because the RE share in the optimal system differs severely between the two scenarios (Δ=40%), since high diesel subsidies are in place in both countries. Within the analysis the diesel fuel price is increased in 5 ct€/l steps from 0.05 €/l to 1.50 €/l and its impact on the PV share and LCOE reduction in the optimal hybrid systems is analyzed.

## 3 RESULTS

The results reveal a high potential for decentralized PV power in both scenarios. If current world market diesel prices of 0.58 €/l [13] are assumed as base prices (scenario I), the RE-based hybrid system outperforms the diesel-only system nearly all over the African continent (Fig. 4). Only locations which are easily accessible or show below average global horizontal irradiation bear little potential for LCOE reduction through the implementation of PV-battery-diesel systems. In contrast, remote areas with high global horizontal irradiation (prime example Sahara) show a very high potential. The maximum LCOE reductions stand at 0.43 €/kWh.

Scenario II, in which national diesel fuel retail prices are assumed as base prices [14,15], outlines the influence of national fuel taxes and subsidies on the potential for decentralized PV power (Fig. 5). LCOE reductions increase significantly in countries with high national diesel prices (e.g. Central African Republic, Chad, Zambia), demonstrating peak LCOE reductions of approx. 1.24 €/kWh. In contrast, countries with high subsidies (e.g. Algeria, Libya, Egypt) achieve no LCOE reductions at all. The same effect is observed less distinctively in countries such as Angola or Sudan.

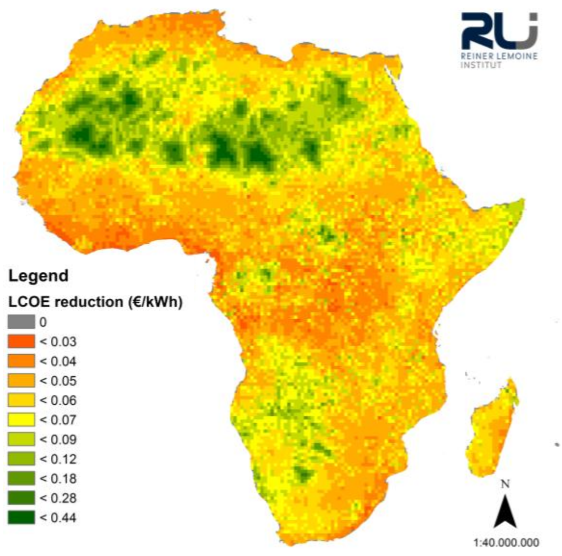


**Fig. 4:** Cost difference of a hybrid system compared to the diesel-only system in €/kWh. The figure reflects the results for scenario I assuming world market diesel prices. Regions colored in green indicate high potential cost advantages of renewable hybrid systems.

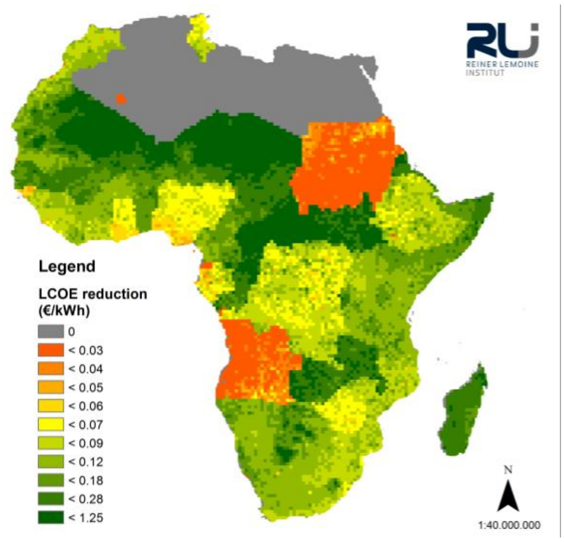


**Fig. 5:** Cost difference of a hybrid system compared to the diesel-only system in €/kWh. The figure reflects the results for scenario II assuming national diesel prices. Regions colored in green indicate very high potential cost advantages of renewable hybrid systems.

When assuming world market diesel prices, the RE share in the majority of hybrid system covers a range of 35 to 40 % (Fig. 6). Nevertheless, higher RE shares of more than 90 % are possible in very remote areas where transport costs increase fuel costs above a critical cost level. In scenario II three types of energy systems are observed (Fig. 7): systems with no RE shares in countries with subsidized diesel prices, energy systems with RE shares of 35 to 40 % in countries with diesel prices within world market diesel price range and systems with high shares of above 90 % in countries where the diesel price excels a critical price level.

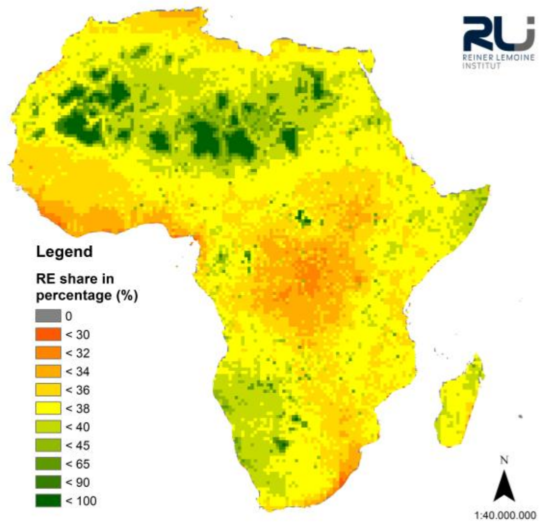


**Fig. 6:** Share of RE power in hybrid system from high proportions of RE power in green colors to low proportions of PV power in red colors. The figure shows the results for scenario I assuming world market diesel prices.

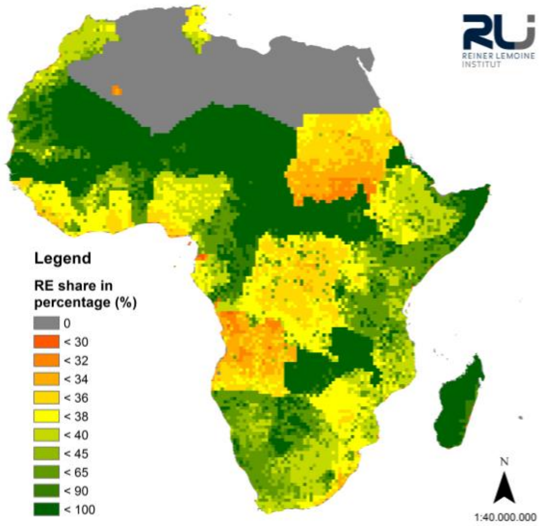


**Fig. 7:** Share of RE power in hybrid system from high proportions of RE power in green colors to low proportions of PV power in red colors for both scenarios. The figure shows the results for scenario II assuming national diesel prices.

The above stated findings are confirmed when looking at the five highest ranking countries in terms of LCOE reduction for both scenarios (Tab. 2 & 3). More country-specific results are provided in Annex 2 & 3. Average RE shares in the hybrid system for the top 5 countries in scenario I do not exceed 55 %, whereas the average RE share lays above 90 % for scenario II. A critical diesel price level exists which lies above the current world market diesel price. Nevertheless, RE based hybrid systems can significantly decrease power generation costs in the considered countries. Thus, the results demonstrate the specific regions in Africa that are most suitable for further implementation of renewable-based hybrid systems. A sensitivity analysis is conducted to investigate the critical price level for diesel fuel costs.

**Tab. 2:** Top 5 countries in world market diesel price scenario I, ranked according to highest LCOE savings. (10/90) indicate the respective percentiles.

| Country | LCOE savings (avg.) | LCOE savings (10/90) | PV power / peak load (avg.) | RE share (avg.) |
|---|---|---|---|---|
| | *(€/kWh)* | *(€/kWh)* | *(kWp/kW)* | *(%)* |
| Niger | 0.11 | 0.05/0.26 | 1.94 | 54.7 |
| Mauritania | 0.10 | 0.05/0.21 | 1.90 | 48.5 |
| Chad | 0.08 | 0.05/0.16 | 1.63 | 45.5 |
| Mali | 0.08 | 0.05/0.14 | 1.64 | 43.8 |
| Algeria | 0.07 | 0.07/0.14 | 1.51 | 41.5 |

**Tab. 3:** Top 5 countries in national diesel price scenario II, ranked according to highest LCOE savings. (10/90) indicate the respective percentiles.

| Country | LCOE savings (avg.) | LCOE savings (10/90) | PV power / peak load (avg.) | RE share (avg.) |
|---|---|---|---|---|
| | *(€/kWh)* | *(€/kWh)* | *(kWp/kW)* | *(%)* |
| CAF* | 0.48 | 0.34/0.72 | 4.34 | 93.0 |
| Chad | 0.39 | 0.21/0.56 | 3.69 | 95.1 |
| Niger | 0.38 | 0.16/0.74 | 3.52 | 94.3 |
| Mali | 0.34 | 0.17/0.55 | 3.84 | 94.0 |
| South Sudan | 0.33 | 0.26/0.45 | 4.22 | 92.3 |

*Central African Republic

The sensitivity analysis of the two selected locations shows the impact of fossil fuel price changes in steps of 5 ct€/l on the optimal hybrid system and the corresponding RE share (Fig. 8) and LCOE (Fig.9). Both locations are characterized by an average annual irradiation (1900 kWh/m²/a for Tamanrasset, 1965 kWh/m²/a for Lubango) and relative proximity to the next biggest city (91 min for Tamanrasset, 56 min for Lubango) and hence low diesel transport costs.

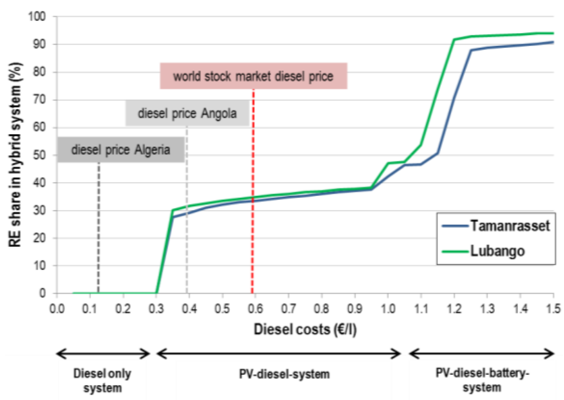


**Fig. 8:** Influence of diesel price increase on RE share (%) in the optimal hybrid system.

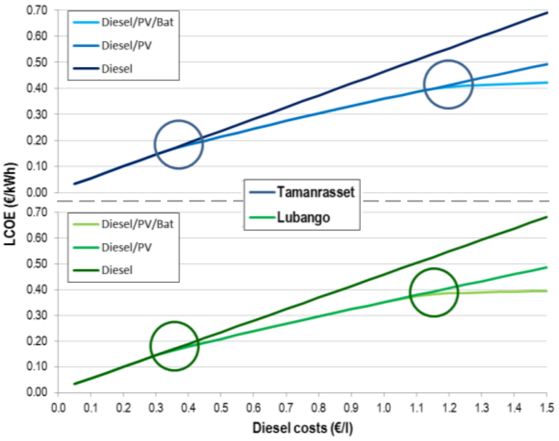


**Fig. 9:** Influence of diesel price increase on LCOE (€/kWh) and the savings potential of the optimal hybrid system (with and without batteries) with respect to the pure diesel system. Circles indicate the transition points where PV and batteries become cost-competitive.

Three distinct sectors are visible: Below about 0.30 €/l the diesel only system is the most economical way of producing electricity. Between 0.30 €/l and about 1.15 €/l the PV-diesel-system is more cost-effective than diesel alone. The maximal RE-share that can be reached in such a system is limited to below 50 %, since the load at night necessarily has to be satisfied by the diesel generator. Finally, above costs of 1.15 € for a liter of diesel batteries become cost competitive and maximal RE-shares well above 90% are possible since the battery allows to shift the energy produced by PV during daytime into the evening hours with maximum demand.The transitions from sector to sector are governed not by the diesel price alone but rather by the relative costs for diesel compared to PV and batteries. Consequently, further cost reductions that can be expected especially in the storage sector will shift the critical diesel price levels to lower values.

For the cost parameters assumed in this study we compare the results of the sensitivity analysis to the findings for the two diesel price scenarios. For Tamanrasset (Algeria) the subsidies are so high and the resulting local diesel price so low that the diesel system in fact is the favorable means of producing electricity. This is a clear example where fossil fuel subsidies are a main obstacle for the proliferation of renewable energies. For Lubango (Angola) the subsidies are not as dominant and introducing PV to the system does generate cost advantages. However, they are reduced by the subsidies lowering the attractiveness of implementing PV.

The price difference between the national diesel prices and the world market price reflects the high opportunity costs which are currently lost due to fuel subsidization. However, even a diesel price at world market levels of around 0.60 €/l does not enable high shares of RE power, since PV-diesel systems without battery are the most cost effective systems. This will change only if the costs for batteries can be significantly reduced in the future.

## 4 CONCLUSION

Several key findings can be derived from focusing on the effect of diesel costs on PV based hybrid systems. In order to enable hybrid systems with high RE shares, diesel fuel costs must surpass a threshold of 1.15 €/l under fixed PV Capex of 1,600 €/kW and battery Capex of 350 €/kWh. High diesel fuel costs allow for the implementation of batteries which shift solar power towards the evening hours and facilitate the supply of the evening demand peak with RE power. In other words, the substitution of significant amounts of diesel power generation and thus fuel savings results in a high LCOE reduction.

Under the chosen conditions hybrid systems comprised of only PV modules and diesel generator with RE shares of around 40% display the most cost effective energy system option within the wide range of diesel prices of 0.30 to 1.10 €/l. Hybrid systems cannot compete with diesel only systems below this range. However, considering current world market diesel prices of 0.58 €/l, which are most likely to increase in the future, diesel prices of 0.3 €/l are only possible with fuel subsidization. These subsidies reflect a strong economic burden for the countries, either by direct payments for diesel importing countries or by the occurring opportunity costs for diesel exporting countries.With decreasing PV and battery Capex the diesel fuel price threshold will further decrease [6].

The study shows that hybridization of diesel-based off-grid systems with PV and storage systems can lead to a significant electricity cost reduction. Especially when considering Figure 1 and Figure 7, it becomes clear that solar-based hybrid systems can contribute to the further facilitation of electricity access in countries with very low access rates to electric energy.

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## 6 ANNEX

**Annex. 1:** National diesel prices (€/l) used as input values for the corresponding country in the simulation.

| Country | Diesel price (€/l) | Country | Diesel price (€/l) |
|---|---|---|---|
| Algeria | 0.12 | Malawi | 1.32 |
| Angola | 0.39 | Mali | 1.16 |
| Benin | 1.12 | Mauritania | 0.92 |
| Botswana | 0.90 | Morocco | 0.82 |
| Burkina Faso | 0.92 | Mozambique | 0.80 |
| Burundi | 1.32 | Namibia | 0.80 |
| Cameroon | 1.01 | Niger | 1.07 |
| Cent. Afr. Rep. | 1.57 | Nigeria | 0.71 |
| Chad | 1.21 | Rep. of Congo | 1.18 |
| Côte d'Ivoire | 0.93 | Rwanda | 1.10 |
| Dem. Rep. Congo | 0.78 | São Tomé and Príncipe | 0.66 |
| Djibouti | 0.99 | Senegal | 1.19 |
| Egypt | 0.12 | Sierra Leone | 0.87 |
| Eq. Guinea | 0.39 | Somalia | 0.99 |
| Eritrea | 1.25 | South Africa | 0.82 |
| Ethiopia | 0.72 | South Sudan | 1.44 |
| Gabon | 0.66 | Sudan | 0.39 |
| Gambia | 1.19 | Swaziland | 1.01 |
| Ghana | 0.73 | Tanzania | 0.92 |
| Guinea | 0.88 | Togo | 1.09 |
| Guinea-Bissau | 0.61 | Tunisia | 0.76 |
| Kenya | 0.89 | Uganda | 0.90 |
| Lesotho | 0.99 | Western Sahara | 0.82 |
| Liberia | 0.89 | Zambia | 1.19 |
| Libya | 0.07 | Zimbabwe | 0.71 |
| Madagascar | 1.18 | | |

**Annex. 2:** Results for all considered countries, scenario I world market scenario.

| Country | LCOE savings (avg.) | PV power / peak load (avg.) | RE share (avg.) |
|---|---|---|---|
| | *(€/kWh)* | *(kWp/kW)* | *(%)* |
| Algeria | 0.08 | 1.51 | 41.5 |
| Angola | 0.06 | 1.45 | 37.8 |
| Benin | 0.05 | 1.37 | 35.8 |
| Botswana | 0.07 | 1.47 | 40.5 |
| Burkina Faso | 0.05 | 1.32 | 35.9 |
| Burundi | 0.04 | 1.35 | 33.9 |
| Cameroon | 0.05 | 1.46 | 36.2 |
| Cent. Afr. Rep. | 0.06 | 1.50 | 37.6 |
| Chad | 0.09 | 1.64 | 45.5 |
| Côte d'Ivoire | 0.04 | 1.38 | 33.7 |
| Dem. Rep. Congo | 0.04 | 1.40 | 33.7 |
| Djibouti | 0.05 | 1.30 | 37.3 |
| Egypt | 0.07 | 1.42 | 41.2 |

| | | | |
|---|---|---|---|
| Equatorial Guinea | 0.04 | 1.54 | 34.5 |
| Eritrea | 0.06 | 1.29 | 36.9 |
| Ethiopia | 0.06 | 1.35 | 37.0 |
| Gabon | 0.06 | 1.76 | 37.8 |
| Gambia | 0.05 | 1.30 | 35.1 |
| Ghana | 0.04 | 1.37 | 34.3 |
| Guinea | 0.04 | 1.32 | 34.4 |
| Guinea-Bissau | 0.05 | 1.31 | 34.6 |
| Kenya | 0.06 | 1.35 | 36.9 |
| Lesotho | 0.06 | 1.33 | 36.7 |
| Liberia | 0.04 | 1.41 | 32.5 |
| Libya | 0.07 | 1.40 | 39.6 |
| Madagascar | 0.05 | 1.32 | 37.6 |
| Malawi | 0.05 | 1.30 | 36.3 |
| Mali | 0.08 | 1.65 | 43.8 |
| Mauritania | 0.10 | 1.90 | 48.5 |
| Morocco | 0.05 | 1.29 | 36.8 |
| Mozambique | 0.05 | 1.35 | 36.3 |
| Namibia | 0.07 | 1.36 | 39.2 |
| Niger | 0.12 | 1.95 | 54.7 |
| Nigeria | 0.04 | 1.36 | 36.2 |
| Republic of Congo | 0.06 | 1.72 | 38.0 |
| Rwanda | 0.03 | 1.35 | 33.6 |
| São Tomé and Príncipe | 0.04 | 1.31 | 34.4 |
| Senegal | 0.04 | 1.29 | 34.9 |
| Sierra Leone | 0.03 | 1.35 | 32.4 |
| Somalia | 0.06 | 1.39 | 38.3 |
| South Africa | 0.05 | 1.27 | 36.3 |
| South Sudan | 0.05 | 1.36 | 34.8 |
| Sudan | 0.06 | 1.28 | 37.0 |
| Swaziland | 0.04 | 1.27 | 33.3 |
| Tanzania | 0.05 | 1.34 | 36.3 |
| Togo | 0.04 | 1.39 | 35.4 |
| Tunisia | 0.04 | 1.34 | 35.3 |
| Uganda | 0.04 | 1.34 | 35.1 |
| Western Sahara | 0.07 | 1.39 | 37.9 |
| Zambia | 0.06 | 1.33 | 36.8 |
| Zimbabwe | 0.05 | 1.29 | 35.7 |

**Annex. 3:** Results for all considered countries, scenario II national diesel price scenario.

| Country | LCOE savings (avg.) | PV power / peak load (avg.) | RE share (avg.) |
|---|---|---|---|
| | *(€/kWh)* | *(kWp/kW)* | *(%)* |
| Algeria | 0.00 | 0.01 | 0.2 |
| Angola | 0.03 | 1.19 | 33.9 |
| Benin | 0.17 | 3.36 | 77.8 |
| Botswana | 0.18 | 2.70 | 69.1 |
| Burkina Faso | 0.11 | 2.01 | 49.0 |
| Burundi | 0.22 | 4.27 | 90.7 |
| Cameroon | 0.14 | 2.69 | 58.9 |
| Cent. Afr. Rep. | 0.48 | 4.34 | 93.0 |
| Chad | 0.39 | 3.69 | 95.1 |
| Côte d'Ivoire | 0.10 | 1.91 | 41.3 |
| Dem. Rep. Congo | 0.08 | 1.69 | 37.7 |
| Djibouti | 0.14 | 2.73 | 71.0 |
| Egypt | 0.00 | 0.00 | 0.0 |
| Equatorial Guinea | 0.01 | 1.21 | 29.1 |
| Eritrea | 0.27 | 3.75 | 95.5 |
| Ethiopia | 0.09 | 1.57 | 40.7 |
| Gabon | 0.07 | 1.99 | 41.0 |
| Gambia | 0.20 | 3.94 | 92.5 |
| Ghana | 0.06 | 1.53 | 36.4 |
| Guinea | 0.09 | 1.63 | 38.6 |
| Guinea-Bissau | 0.05 | 1.34 | 35.0 |
| Kenya | 0.12 | 2.20 | 54.4 |
| Lesotho | 0.17 | 2.91 | 71.8 |
| Liberia | 0.09 | 1.83 | 38.0 |
| Libya | 0.00 | 0.00 | 0.0 |
| Madagascar | 0.22 | 3.55 | 91.5 |
| Malawi | 0.27 | 3.78 | 92.8 |
| Mali | 0.35 | 3.84 | 94.0 |
| Mauritania | 0.27 | 3.37 | 80.9 |
| Morocco | 0.09 | 1.55 | 40.7 |
| Mozambique | 0.09 | 1.62 | 40.4 |
| Namibia | 0.12 | 1.93 | 52.1 |
| Niger | 0.39 | 3.52 | 94.3 |
| Nigeria | 0.07 | 1.49 | 37.9 |
| Republic of Congo | 0.27 | 4.33 | 84.6 |
| Rwanda | 0.13 | 2.50 | 53.3 |
| São Tomé and Príncipe | 0.05 | 1.40 | 35.7 |
| Senegal | 0.19 | 3.91 | 91.9 |
| Sierra Leone | 0.08 | 1.65 | 36.3 |
| Somalia | 0.17 | 3.08 | 78.4 |

| | | | |
|---|---|---|---|
| South Africa | 0.09 | 1.59 | 41.4 |
| South Sudan | 0.34 | 4.23 | 92.3 |
| Sudan | 0.02 | 1.12 | 34.3 |
| Swaziland | 0.11 | 1.97 | 44.7 |
| Tanzania | 0.12 | 2.09 | 51.3 |
| Togo | 0.14 | 2.78 | 62.3 |
| Tunisia | 0.08 | 1.56 | 38.2 |
| Uganda | 0.10 | 1.78 | 42.5 |
| Western Sahara | 0.13 | 2.24 | 56.3 |
| Zambia | 0.26 | 3.71 | 92.7 |
| Zimbabwe | 0.07 | 1.40 | 37.2 |