MOBILISATION OF FINANCING RESOURCES FOR RENEWABLE INVESTMENTS IN AFRICA, INDIA AND SOUTH AMERICA TO REACH THE 1.5°C GOAL

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ABSTRACT: This paper highlights that without appropriate long-term financing schemes most investments for energy supply in countries like Africa, India and South America unfortunately will be undertaken in fossil technologies. The simple reason is the fact that the investment necessary for a given quantity of energy per year is by a factor of ~5 less for fossil compared to renewable technologies. In an "ideal" world – zero Carbon emissions and equal energy per capita globally in the 2050s – the needed investments are 1,700 bn € annually starting in 2025 with a peak of 2,500 bn € in the mid-2030s and going to zero in the 2060s. Two additional scenarios ("medium" and "pessimistic") shift the peak towards the mid-2060s and mid-2090s, respectively. While this gives a reduction for the annual investment of ~1/3 and 2/3, respectively, there is an increasing danger for an unforeseeable migration of desperate people from Africa to Europe and South America to North America. If all investments are done with fossil technologies there is a cumulated amount of up to 5,000 bn t of CO_2 released into the atmosphere. Comparing this with the residual amount of 301 and 1,050 bn t CO_2 for the 1.5 and 2.0°C goal, respectively, the urgent need for investment support from the industrialized countries is obvious. Fortunately there is enough money from private people and institutional investors available, but which can only be mobilized, if the risk is minimized by governmental institutions (KfW, EIB, world bank etc). Today these banks give only for a period of 5-6 years support, while at least 15, better 20 years are necessary for such infrastructure projects like electrifying Africa, India and South America. Based on a project in Mali we could prove that with PV mini grids the electricity infrastructure can be implemented with private money, but substantial changes have to be foreseen by governmental organizations to mobilize the huge needs of private capital in the coming years. One potential financing model is discussed.

Key words: energy supply, renewable energy, fossil energy, global energy distribution, 1.5°C climate goal, mini grids, developing countries, investment, sustainable bond issues, finance banks

1 INTRODUCTION

The Paris agreement, signed in 2015, has formulated an important goal to limit the global temperature increase to 1.5°C, at least 2°C, in order to combat global warming with all its devastating effects. Climate neutrality is planned in the EU by 2050 and in China by 2060. These are good news – however nowhere near enough to really reach the important goal of 1.5°C amidst this century on a global scale. This goal can only be reached, if all regions worldwide follow a similar path as agreed in the EU (26). Many developing countries like Africa, India and South America have to decide just today, how to satisfy their huge energy needs – with fossil or renewable technologies. These regions today represent important growth areas with the need to invest heavily in additional energy production. Unfortunately these regions are lacking financial resources. Hence for a given energy quantity they try to do this with the smallest amount of investment – which today is fossil technology. In addition, today's unfair distribution of energy consumption has to be ended: ~3/4 of the 8 billion people today has only access to ~¼ of primary energy. Unless this unfair situation will be ended shortly there is an increasing danger of huge migration from Africa to Europe and South America to North America. Fortunately we have today all necessary knowledge available to create the necessary boundary conditions necessary to install large scale energy infrastructure based on renewables.

2 DATA SET FOR TODAY'S (2019) AND FUTURE (2050+) ENERGY NEEDS

Based on today's energy consumption (primary, secondary and end user energy, see Fig. 1(left) [1]) and together with UN scenarios for the future population development (see Fig. 2 [2, 3(a)]), the potential development for the future energy consumption towards an ideal world in 2050+ is calculated (see Fig.1 (right) [3(a-c), 4]) using the following assumptions stated below:

(1) Assuming today's quality of life for the ¼ privileged global population, but in the future with the same energy/person and an efficiency increase by a factor 3, the energy needs in all global areas in 2050+ are calculated
(2) For the global population in 2050+ we have used 10 bn people (see Fig. 2)
(3) In an "ideal" world we will have no fossil primary energy but only renewables are assumed (note that the primary energy (PE) for renewables is by definition equal to secondary energy (SE))
(4) Based on the fact that almost all renewable technologies produce electricity, the secondary energy in 2050+ is more than 90% electricity
(5) Part of this electricity is also used to produce useful chemicals. For example via Power to Gas (P2G) e.g. hydrogen for the chemical industry or Power to Liquid (P2L) e.g. bio-kerosine for long range aviation

3 SECONDARY ENERGY DEVELOPMENT

In Fig. 3 the fossil fraction (~80% from primary energy) for the needed annual secondary energy for the 7 world regions is shown from 2010 until 2019 with data taken from IEA [1] and extrapolated until 2025 (these numbers are also approximately similar to the secondary energy numbers). From 2025 onwards we assume a dramatic change towards a world in 2050+ which has the same energy per person and the respective volume

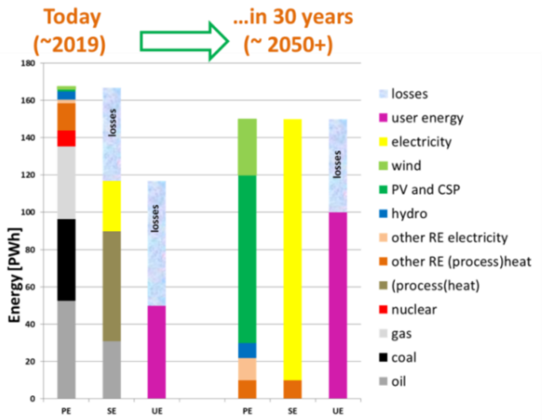

Figure 1: Primary (PE), secondary (SE) and (end) user energy (UE) as of today [1] (left) and potential development in 2050+ ((right), [2-4])

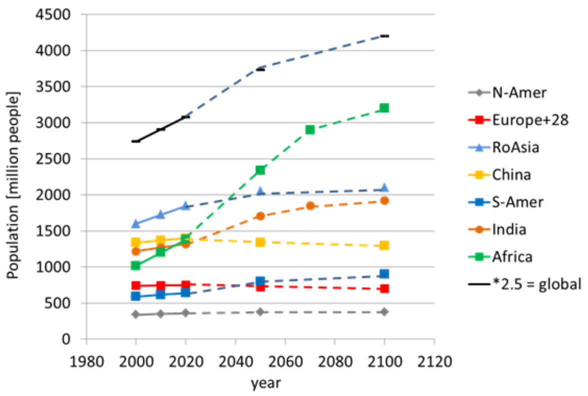

Figure 2: Development of the population in the various regions. Total numbers from UN and the split for the 7 regions based on earlier UN models [2] and own assumptions

proportional to the number of people in each region. The data between 2025 and 2100 are calculated with a logistic growth function (with initial growth of 15% for the ideal case). The asymptotic SE for the 7 regions is 140 PWh (150(total in 2050+) - 10(already present today)) with the fraction for each region according to the population in Fig. 2 for 2050. For a sensitivity analysis we have also calculated two additional growth cases: medium and pessimistic with 10 and 5 % initial growth, respectively. For clarity these curves are shown in Fig. 3 for Africa only.

Only Europe has demonstrated in the past a reduction of SE and as we already have a decent kW/person no further decrease is needed but only the energy efficiency and change to 100% renewables to be implemented. In contrast, North America with today one of the highest kW/person needs a dramatic decrease. It is only Africa, India and South America which need a huge increase of SE. This increase can be powered either with renewables (here PV assumed with 2kWh/W_{PV} and 500 MW_{PV}/TWh electricity) or with coal and gas (7.5 kWh/W_{fossil} and 133 MW_{fossil}/TWh electricity.

The necessary annual secondary energy additions for the three growth cases ideal, medium and pessimistic are shown in Fig. 4.

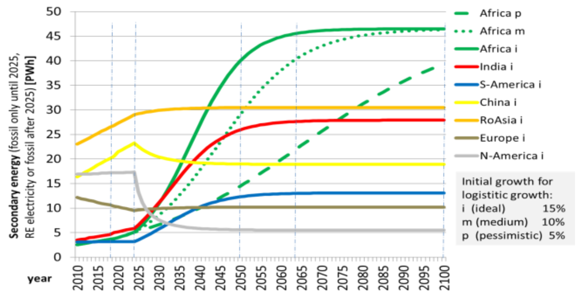

Figure 3: Secondary energy per year for the 7 regions for ideal case (IEA WEO 2020 for 2010-2019 data, own research by extrapolation until 2025, logistic growth function afterwards). For Africa two additional growth cases, medium and pessimistic, are shown

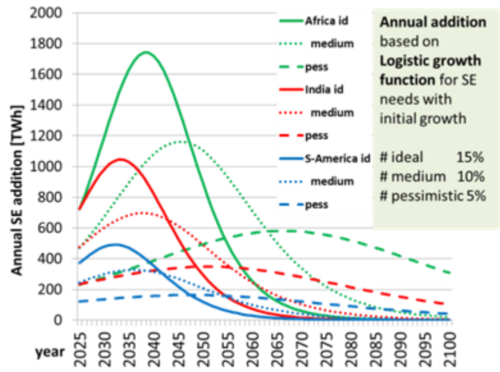

Figure 4: Annual SE addition in the 3 regions for the 3 cases i, m and p

The "ideal" growth corresponds to the SE growth curves as shown in Fig. 3. The two other scenarios "medium" and "pessimistic" are shifting the saturation in Fig. 4 from the 2050s towards the mid 2060s and late 2090s, respectively. In particular the pessimistic growth would have a very negative consequence: energy inequality would be reached much later and a massive migration from Africa towards Europe and South towards North America would most probably be the consequence.

4 RESULTING INVESTMENT NEEDS FOR THE THREE REGIONS

The investment numbers used in this study are shown in Fig. 5 for renewables and fossil. In this study we have only used PV as renewable technology. This is based on the fact that PV is now reckognized as the lowest cost technology (even more so in southern regions). Hence any reasonable portfolio with other technologies (like wind, hydro) will only add additonal cost to the later cost numbers. The blue diamonds show the investment as function of time for 1 W_{PV} plus 1 $Wh_{battery}$, while the red squares are for 1 W_{PV} only. Three battery scenarios are analyzed: storage addition from the beginning (blue curve (1)) for each W of PV power one Wh of storage ("batt_100"). Starting in 2020 with 30% (green curve (2) or only 10% (yellow curve (3)) of the respective PV power addition, with further continuous growth as shown ("batt_30" and "batt_10"). Considering storage capacity and cost we assume for each power unit of PV [W] the same storage capacity [Wh] with also the same investment number [€/Wh] as function of time. This assumption reflects for 2020 approximately the situation as of today and given the fact that the Price Experience

Curve for Li-ion batteries is very similar to the one obtained for PV modules [5], the assumed further price development for the two should be a reasonable approximation. The green triangles show the investment for the battery case 2 (batt_30).

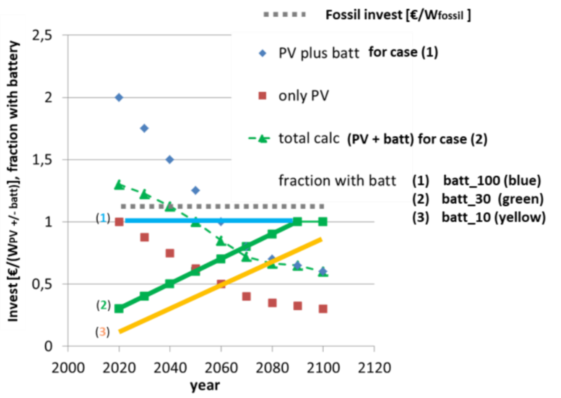

Figure 5: Investment [€/WPV] for 3 scenarios (batt_100, batt_30 and batt_10) for the addition of storage and fossil invest

Using the invest numbers from Fig. 5 and the annual secondary energy additions from Fig. 4 the annual investment numbers for the combined 3 regions are shown for the 3 growth cases (i, m, p) and two battery scenarios (batt_100 and batt_30) in Fig. 6. In comparison the needed investment numbers for fossil investments for the three growth cases are included. Also shown are the cumulated investments from 2025 to 2100 for all investments. Fossil investment is a factor ~4-5 less expensive compared to the 100% batt case renewable investment. Comparing fossil with the batt 30 case the factor decreases to ~3-4. The cumulated investment for the „best case" (ideal growth and batt 100) is 56 trillion € with the annual distribution shown (max 2.5 trillion p.a. in the mid 2030s). For the „bad case" (pessimistic growth and batt 30) the cumulated investment is ~28 trillion € (max 0.5 trillion € in the 2050s. If all investments are done with fossil technologies there is a cumulated amount of up to 5,000 bn t of CO_2 released into the atmosphere. Comparing this with the residual amount of 301 and 1,050 bn t CO_2 for the 1.5 and 2.0°C goal, respectively, the urgent need for investment support from the industrialized countries is obvious.

A sensitivity analysis is shown in Fig. 7 for Africa, using the 3 growth cases and three battery scenarios. Also included is the integrated investment between 2025 and 2100 in absolute and relative numbers. Such sensitivity analyses are important for the future optimization on how to reach the best service for the people with the invested money. For the shown graphs it is seen that the ideal growth case with retarded battery addition (batt_30 with 22.7 trillion €) is less expensive compared to the medium growth case and complete storage from the beginning (batt_100, 24.2 trillion €). Depending on the price development for renewable power stations and battery storage on the one hand and the desired requirements for the people such and even more elaborated analysis are an important tool to optimize the ongoing investments.

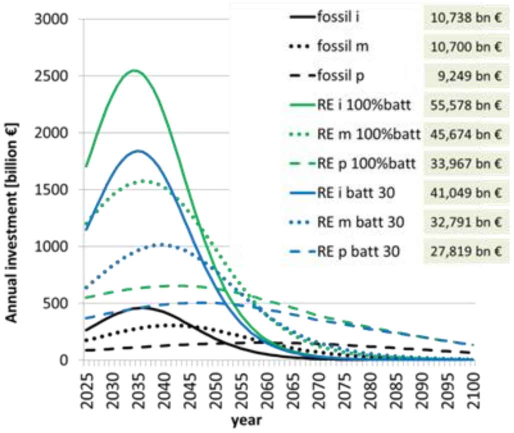

Figure 6: Comparison between fossil and renewable (2 battery scenarios) investment needs for the ideal, medium and pessimistic growth case for the three regions

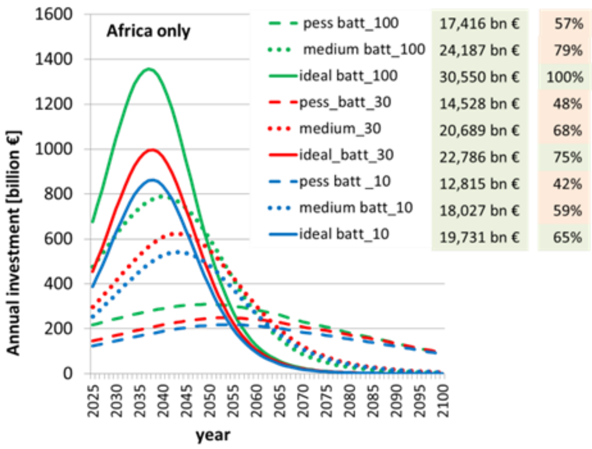

Figure 7: Investment needs in Africa for the ideal, medium and pessimistic growth case and the 3 scenarios for storage addition

5 DISCUSSION

While there is room for discussion whether the medium growth case could be enough for the people in the 3 regions compared to the ideal case there is no doubt that a strongly retarded addition of renewables similar to the pessimistic growth case is no alternative. The more an increase of renewables is retarded there will be either a cheaper addition of fossil power or an increasing danger of massive migration from Africa to Europe and Southern America to North America. Both scenarios should be avoided by all means.

A realistic pathway could be the ideal – at least medium - growth case together with the batt_30 battery scenario (see Fig. 4 and 6). Even in this case the needed investment of ~600 billion € in 2025, rising to ~ (0.6 – 1) trillion in ~2040 and then declining to less than 200 billion after 2070 cannot be financed by the 3 regions themselves. A huge "Global Renewable Investment" program must be started immediately, where private together with institutional investment money is mobilized. The investment number is not an inhibiting factor as such: the global private property increased from 125 in 2009 to 225 trillion $ in 2019 – an annual increase of ~10 trillion $ [6], where at least a part could be used as investment – if secured by state banks. Also, the globally placed issues for sustained financing increased from ~40 billion € in 2015 towards 900 billion € in 2021 with an increase of 500 billion € just in the last year [7].

So one might ask: where is the problem? This can impressively be illustrated when analyzing a real project undertaken in Africa in the last years by one of us [8]. Technically and logistically it was succesfully demonstrated that together with local personnel it is possible to install PV mini grids in Mali (Africa) in 20 villages serving ~32,000 people (see Fig. 8).

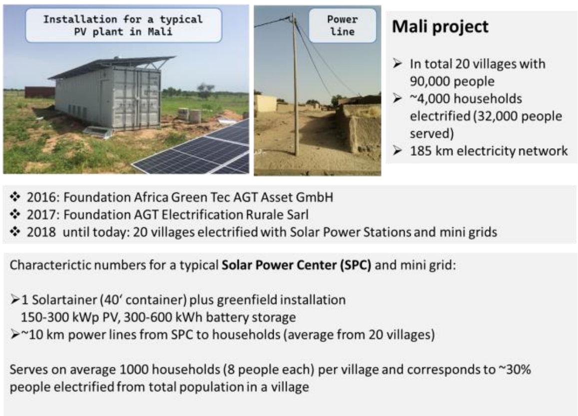

Figure 8: Installation of mini grids in Mali [8]

The customers are paying a fixed and variable tariff which is calculated to cover the total costs of depreciation, interests and OPEX (OPerational EXpenditure). Consumption and hence turnover are fluctating during the year significantly depending on the availability of financial resources. The number of customers is slightly growing, despite a high share of customer fluctuation. Major hurdles are the relative high interest payments as well as the limited economic capability of the served households.

Investments in these grids as well as the PV power production and storage are totalling up to now to more than 8 million €, financed by the private sector supplemented by grants for the grid and house installations. In order to electrify more villages and to reach overall profitability with larger systems additional 15 million € are required. To acquire this amount of money we need governmental assistance.

6 ROLE OF GOVERNMENTAL ORGANIZATIONS IN MOBILIZING PRIVATE MONEY

Given the fact that we have

- cost effective renewable technologies (PV, wind) including battery storage which deliver less expensive electricity compared to fossil technologies when calculated over the lifetime of each respective technology (15-20 years)
- enough money available from private and institutional investors to be used to finance the investments over the lifetime of the technologies (15-20 years)
- demonstrated in a challenging country like Mali that a small PV based energy infrastructure with private financing is capable to pay back the invested money including interest
- and the huge annual investment needs in the coming years of ~ 1,000 billion € can only be provided by private money

we are now in a position based on the learnings from the Mali project to initiate large scale renewable energy infrastructure investments. The challenge is to secure the necessary private investment money by intelligent backing from governmental institutions to realize the huge projects described before.

Learnings from the Mali project:

- Financing duration of 5-7 years is by far too short. For infrastructure projects 15-20 years are required.
- Minimum financing volumes of >20 million € are too big, if not paid out in installments over some years.
- Only well developed technology should be used
- Financial resource from governmental institutions should be offered as subordinated loans and with decent interest rates.

A **preferred financing model** for large scale implementation of renewable infrastructure is shown in Fig. 9 and could be as follows:

- In order to mobilize significant private money (loans, bonds, etc.) governmental institutions should offer risk money in form of e. g. a subordinated loan for 20 to 30% of the total investment volume at reasonable interest rates. The annual 100 billion $ from industrialized to developing countries often discussed in the international climate talks could be a start.
- During construction time no interests should be paid.
- Furthermore, governmental institutions should take over or at least participate in various risks like exchange rate, political and credit risks. One example is the insurance provided by the German government for taking over the credit risks associated with PPA (Power Purchase Agreements) payments. Governmental Collaterals could also be a means to mitigate those risks.
- In any case all financing instruments should have a repayment period of at least 15, better 20 years (refinancing of expiring loans should be allowed as an absolute minimum).
- Requirements towards the balance sheet and historical financial performance of the applicant should be adequate.
- Governments should prefer financing of well established technologies to build up reliable renewable energy investments fast and to build up local technical competences.

In summary the award conditions of governmental institutions have to be strongly modified in order to increase the investments with private money in renewable energy mini grids as well as central PV plants.

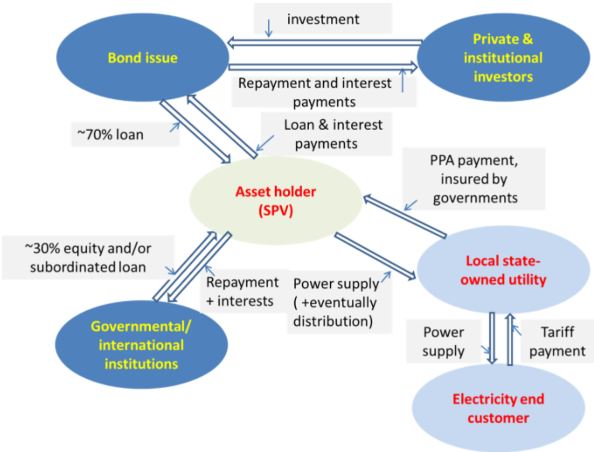

Figure 9: Financing model for large scale implementation of renewable infrastructure

If we want to reduce future CO_2 emissions at lowest cost it has to be recognized, that one EURO invested in renewable energy systems in Africa reduces CO_2 emissions by a factor of up to three compared to such an investment in Europe. It is for the global climate of minor importance if small industrialized countries use their valuable financing resources to accelerate climate neutrality before 2050. Instead this money should be used to contribute to the financing of the three regions discussed. If we are unable to find a quick solution for the regions discussed we are all suffering from a dramatic global warming and migration – if we do the job intelligently, we all have a great future ahead of us.

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