Energy and renewables: a view from the African continent

Laura Huomo and Claire Wilby

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1. Introduction

In this paper, based on the Symposium scope of 'Europe and Beyond', we look to the African continent, with a focus on countries in North and Sub-Saharan Africa. With this fascinating geography in mind, we consider:

- the industrial sector: challenges for the transition to a low-carbon economy; and
- the renewables' penetration in the electricity mix.

At this time, where the West, and the developed world more generally, has a key focus on developing energy sources that are efficient and environmentally friendly in equal measure, North and Sub-Saharan Africa face pressure from the West (from the perspective of compliance with the United Nations Framework Convention on Climate Change and in turn the heavy funding burden that is associated) to do the same but in an energy and electrification environment that significantly differs from that of the West. As stated in the African Climate Change Strategy from 2015:

> '*Africa is the most vulnerable continent to climate variability and change, a situation that is aggravated by the interaction of 'multiple stresses', including high dependence on rain-fed agriculture, widespread poverty and weak adaptive capacity*'.[1]

[1] https://www.un.org/en/africa/osaa/pdf/au/cap_draft_auclimatestrategy_2015.pdf.

With this in mind and the industrial growth of the continent moving at an increasing pace, the integration of renewables are very much on the minds of policy makers.

We consider the role that renewables should play in the short, medium and long term. And their role in the industrialisation of these growing economies.

Both of the authors of this paper are deeply involved in the energy sector with reach into Africa. With this in mind, this paper is based on practical hands on experience in the sector as well as industry knowledge gained from involvement in the area. In addition, industry views are considered and analyzed.

Based on the subject matter at hand for the Symposium:

- the industrial sector: challenges for the transition to a low-carbon economy; and
- the renewables' penetration in the electricity mix,

we have asked a number of questions in our analysis, such as:

- At what point should renewables be brought into the energy mix?
- At what point is there sufficient baseload to justify additional expenditure on renewables?
- Should developing economies prioritise climate change policies imposed by the West over the basic electrification needs of their societies, including addressing energy poverty?
- Is leapfrogging the way forward for these developing markets and will that lead to a more or less efficient industrialisation?

We have elected to cover a broad geographical analysis in this paper. This is because there are similar issues across the jurisdictions and it enables a comparative analysis. Each country in Africa has its own individual level of development as well as power demand and development needs. Further, available funding, as well as the current ability to attract funding, differs considerably (noting that the new discoveries of gas are somewhat changing this landscape as some of these counties are now starting to monetise their energy sources, or at least have identified the potential to do so).

The country specific needs have to be considered but the other, more developed jurisdictions under consideration offer precedents for future development policies. The experience of one country in their approach to electrification can serve as a useful example for other countries to learn from. The availability of baseload power and the interconnectivity of a country through established transmission lines will be key to the timing of adding renewables to the mix, as well as the possibility of leapfrogging.

Budget restrictions will hamper ideology in the implementation of energy strategies across these emerging market countries – where the availability of funding is a key driver. With the West's reluctance to finance 'dirty' energy projects, more consideration is being given to 'clean' energy projects, but funding from the East, specifically China, who are still offering funding for coal, for example, is also shaping the direction of development.

Natural resources available are also key: Ethiopia, for example has the advantage of geothermal power, which can be developed to further electrification; Kenya, Tanzania, West Africa and Mozambique have gas finds. The sun is also abundant in most of the countries we are covering in this paper and North Africa has already successfully developed large solar facilities.

Comparing these developing markets to the West is also useful as part of the analysis, for example Germany was able to decommission its reliable nuclear baseload (post Fukushima) but only because the country already enjoyed 100% electrification. When including climate change initiatives in their electrification policies, European and other Western countries with 100% electrification have a very different starting point from Sub-Saharan Africa where the electrification rate is still low on average.

Globally there is a large push for renewables – not only for environmental reasons but also due to the off-grid connectivity they can offer in countries where there is little or no transmission network. Off-grid solutions and how they can contribute to the energy mix should be considered as part of the policies of those countries.

2. A (limited) review across the African continent

The below table sets out the countries we are considering in this paper. As noted below, the figures are only indicative, the intention being to give context to the discussion. As you will see, we have elected to discuss countries on the African continent that have substantially diverse challenges when it comes to population and rates of electrification. Not listed here, but there are also geographical and political challenges that have to be overcome, for example: Zambia is landlocked, Mozambique is politically divided with civil unrest in certain areas. Morocco and Egypt also have their own political and geographical challenges but as the statistics show, they have been able to progress significantly in the field of electrification including through renewables.

Country	**Population**	**Installed Capacity**	**Renewables**	**% of population with access to electricity (2006)**	***% of the population with access to electricity (1990)***
Egypt	**97M**	**38.86 GW (2016)**	**3.7GW (2,8 hydro/0.9 solar/wind)**	**100%[2]**	***94%***
Morocco[3]	**35M**	**8.1GW (2016**	**1,7 (hydro), 979MW (solar/wind)**	**100%[4]**	***48%***
Zambia[5]	**16M**	**2,8GW**	**2.3 (hydro)**	**27%[6]**	***14%***
Mozambique[7]	**29M**	**2.8GW**	**2 (hydro)**	**24%[8]**	***0%***

Please note that this table is illustrative only as sources per country differ and hence should also not be read as a direct comparison.

[2] https://data.worldbank.org/indicator/eg.elc.accs.zs.

[3] http://www.energynet.co.uk/webfm_send/2025.

[5] https://www.usaid.gov/powerafrica/zambia.

[6] https://data.worldbank.org/indicator/eg.elc.accs.zs.

[7] https://www.usaid.gov/powerafrica/mozambique.

[8] https://data.worldbank.org/indicator/eg.elc.accs.zs.

When addressing the question of when renewables should be brought into the energy mix, multiple factors have to be considered, including jurisdiction, legislative framework, climate, policy and geography. What are the specific needs of the country and the region? Is there a grid to support offtake from renewable sources? Is there sufficient baseload on the grid to support the fluctuation of the renewable source? Are off grid solutions perhaps an alternative? As indicated by the above table, Morocco and Egypt have established renewables as part of their energy mix, but Zambia and Mozambique, who both have the advantage of having significant hydropower sources are still very much in the renewables development phase, with regards to solar (and wind) compared to their North African friends.

The Middle East and North African region sits on top of more than one-half the world's crude oil and one-third of the world's natural gas[9] and hence is in an extremely energy rich geography. Currently, Egypt gets around 90% of its electricity from natural gas and oil even though Egypt receives some of the highest rates of solar radiation in the world.[10] In 1986, Gerhard Knies calculated that the world's deserts receive enough energy in a few hours to provide for humanity's power needs for a whole year.[11] This view is confirmed in the analyses carried out by the Desertec Project,[12] which sets out a potential plan to capture the solar power of the North African region to meet 90% of the global energy need.

Egypt

Egypt has been identified as one of the three fastest-improving countries in terms of regulatory frameworks for renewable energy (the other two being Tunisia and the UAE).[13]

[9] World Bank Report: Morocco Improves Sustainable Energy Indicators, 12 December 2018, Morocco World News.

[10] Tailored loans give Egyptian clean energy a boost, Published on 16/10/2018, 4:22pm, Sponsored content: GCF and EBRD put $1 billion toward a new renewable energy framework in Egypt, Climate home news.

[11] Morocco poised to become a solar superpower with launch of desert mega-project, the Guardian, 26 October 2015.

[12] https://www.desertec.org/

[13] World Bank's Regulatory Indicators for Sustainable Energy (RISE) 2018 report, p. 76.

Egypt has well established legislation in place that allows private-sector ownership of renewable energy and it also has a robust legal framework for renewable energy. In Egypt, there are also two nation-wide feed in tariff plans[14] to support the investments in renewable energy. Of significant importance for introducing renewables into the energy mix is a reliable legislative base for the international investors to come and participate in the substantial funding requirements for these projects. We note here that the Sub-Saharan jurisdictions we are considering are at different stages of introducing viable feed-in tariff programs and Egypt in particular is considered a helpful precedent for countries looking for a framework to apply to their own energy strategy.

Further, the establishment of a reliable grid and baseload is key, at least until energy storage becomes a more widely available and economic option or off-grid solutions can be considered as viable alternatives. As an aside here, we take the example of Elon Musk's efforts to restore power in Puerto Rico after significant damage to the grid. A significant donation was made to facilitate solar power and storage but it was reported that if a long term investment were to be made to supply 40% of the island's energy through solar and battery solutions, the cost of the project would be over $21 billion over 20 years[15]. Not a viable option for most nations let alone the developing and emerging markets we are discussing here.

Again, in Egypt, where we have seen significant investment and growth in renewables, the World Bank has been assisting in building the necessary policies to develop the energy sector. As the statistics show, the combination of a stable grid and the geographical suitability for renewables have invited significant investment. From 2015 to 2017, the World Bank granted a development policy loan totaling $3.15 billion which provided technical

[14] Enterprice – State of the Nation, 27 December 2018, Egypt among fastest-improving countries in developing renewable energy regulatory framework.
[15] https://www.teslarati.com/elon-musk-tesla-battery-installs-puerto-rico-blackout/.

assistance and financial support necessary for the energy sector and aligned with the national energy strategy. This World Bank loan assisted in the enactment of a new renewable energy law, adjusting electricity tariffs to allow recovery of operational costs, gradually phasing out fuel subsidies, revising the feed-in-tariff policy, introducing a modern renewable energy law, and establishing a regulatory framework for competitive bidding for independent power producers.[16]

CDF and EBRD's assistance in creating a regulatory support for renewable energy is also supporting the Egyptian Government's policy to transition from the country's current reliance on fossil fuels17 in the form of implementing a USD 1 billion project aimed at creating a new renewable energy financing framework in Egypt by scaling up private sector investment.[18]

Let us consider a few examples of Egypt's actual progress in putting into use its newly reformed policies and regulatory base: Benban solar plant complex will be able to produce 1.8 GW of clean energy. The project should act as a proof of concept for Egypt's solar 'resource'. Cairo-based KarmSolar is Egypt's largest private off-grid solar energy integrator. The startup has built the region's largest off-grid Hybrid Pumping & Irrigation System (147 kW). Another form of support comes from ITFC as it backs up the guarantors to facilitate due diligence in projects which facilitates insurers to act in accordance with Egypt's energy policy. Falling prices of solar components allows the competition of solar plants with oil- and gas-fired power plants. Egyptian officials predict that the nation can generate 20 percent of its power from renewable sources by 2022. An impressive target, considering the EU is targeting 20% just two years ahead in 2020.

[16] Arab Republic of Egypt: Providing Affordable Clean Energy,April 28, 2018, Worldbank brief).

[17] Tailored loans give Egyptian clean energy a boost, Published on 16/10/2018, 4:22pm, Sponsored content: GCF and EBRD put $1 billion toward a new renewable energy framework in Egypt, Climate home news.

[18] Tailored loans give Egyptian clean energy a boost, 16 October 2018, Sponsored content: GCF and EBRD put $1 billion toward a new renewable energy framework in Egypt, Climate home news.

As indicated above, Egypt has a total installed capacity of 38.86 GW (38,860 MW). In 2018, Egypt's total installed capacity of renewables amounted to 3.7 gigawatts (meaning 9.5% of the total installed capacity[19]), including 2.8 gigawatts of hydropower and around 0.9 gigawatts of solar and wind power. Conventional thermal generation accounted for approximately 90% of generation capacity in Egypt, and natural gas-fired generation accounted for approximately 75% of total generation output. Given the development of natural gas projects in the country, natural gas-fired generation is expected to remain the dominant fuel source for generation.[20] Of the installed capacity, steam accounted for 38 %, CCGT (combined cycle gas turbines) 32 %, gas 20 %, hydropower 7 % and renewables 3 % in the 2015–2016 fiscal year.[21]

Morocco

Morocco, which as seen above, has made significant progress in terms of electrification since 1990, also emerges as a prominent example of a country that has advanced policy frameworks supporting the arrival of sustainable energy.[22] As electricity demand increases with economic development, Morocco's current electricity demand grows strongly with an average rate of 6.5 % per year. The total capacity installed in Morocco in 2018 was 8,154 MW, with 34% of renewable energies with the following mix: Carbon (32%), natural gas (11%), hydropower (22%), fuel oil and diesel (24%), solar (2%) and wind power (10%).[23]

[19] IRENA Renewable Energy Outlook Egypt report, p. XIII and 4.

[20] https://www.eia.gov/beta/international/analysis.php?iso=EGY.

[21] https://www.eia.gov/beta/international/analysis.php?iso=EGY, figure 8.

[22] World Bank Report: Morocco Improves Sustainable Energy Indicators, 12 December 2018, Morocco World News.

[23] Journal of Engineering Science and Technology Review 11 (1) (2018) 189 – 198, Research Article, Renewable Energy Potential and Available Capacity for Wind and Solar Power in Morocco Towards 2030 Mohamed AZEROUAL*, Aboubakr EL MAKRINI, Hassan EL MOUSSAOUI and Hassane EL MARKHI, The Signals, Systems and Components Laboratory, Sidi Mohamed Ben Abdellah University,FST Fez, Morocco, Received 10 October 2017; Accepted 20 February 2018, p. 189-190 and Morocco World News article published on 10 Jan 2019, quoting the Moroccan Minister of Energy, Mining and Sustainable Development Aziz Rabbah.

Energy consumption in Morocco is expected to continue growing in the long term, given growth in the transportation sector, a growing population, and an improving economy.[24]

In 2018, approximately 35% of Moroccan electricity came from renewable sources.[25] So compared to Egypt, Morocco is more advanced in introducing renewables into the energy mix. Morocco aims to produce 52% of its electricity mix from renewable sources by 2030. Again, compared to the Egyptian and EU targets this is very ambitious. This development is due to several reasons. The size of the countries is one. Egypt is three times larger than Morocco and uses more electricity. Egypt is highly dependent on oil and gas and due to the increasing number of electricity need, the change in to renewables is harder to accomplish. In the industrial field, Morocco is, to some extent, turning to biomass technologies to replace oil. However, Morocco currently does not have any policies or legislation in place for the use of biomass as part of the energy mix.

Also, the regulatory base has demonstrated itself to be more stable in Morocco even though Egypt is working hard with World Bank and others to create a stable regulatory framework to work with.

Renewable energies have reduced Morocco's energy dependence from 98% in 2008 to 93% currently, mainly due to a rise in renewable energy, according to Minister Aziz Rabbah.[26] The problem is energy dependency. Part of Morocco's national energy strategy includes securing energy supply, especially by reducing the dependence on imported energy carriers through the development of renewable energy sources (from 96% in 2015 to 82% by 2030) and the increased exploration of conventional energy sources. Also, law number13-09 on renewable energy provides a legal framework for the development of

[24] https://www.eia.gov/beta/international/analysis.php?iso=EGY.

[25] World Bank Report: Morocco Improves Sustainable Energy Indicators, 12 December 2018, Morocco World News.

[26] 35% of Moroccan Electricity Came from Renewable Sources in 2018, Tarek Bazza, Morocco Word News (https://www.moroccoworldnews.com/2019/01/262953/morocco-electricity-renewable-sources/).

renewable energy projects in Morocco and sets the framework for private investments in this sector. It introduces major innovations, including the opportunity for a competition of renewable electricity production and the capacity to export electricity from renewable sources, by using the national grid.[27] Morocco seems that introducing renewables into the mix lowers the dependency but does not necessarily aid with security of supply due to possible problems in ensuring the generation of energy through receivables.

Morocco and Portugal agreed in 2015 on plans for a 1,000 MW power cable link. Feasibility studies were launched in 2016 and the feasibility studies are supposed to be finalized by spring 2019.[28] The link will be Morocco's second with Europe. The North African country has been linked to Spain's grid via a 700 MW cable since 1997. The link is bidirectional.[29] The capacity of the existing interconnection between Morocco and Spain is 1,400 MW. A new interconnection submarine with Spain of 700 MW guarantees the security and reliability of supply, contributing stability to both systems as a whole.[30]

In terms of renewables, Morocco has engaged in both wind and solar projects. Morocco is competing to be the renewable energy leader in Africa and King Mohammed VI is engaged in efforts to launch large-scale projects aiming to generate 52% of the country's electricity needs from solar, wind and other renewable sources.[31] Morocco's energy strategy targets increasing use of renewable energy to 52% by 2030, while reducing consumption of

[27] Journal of Engineering Science and Technology Review 11 (1) (2018) 189 – 198, Research Article, Renewable Energy Potential and Available Capacity for Wind and Solar Power in Morocco Towards 2030 Mohamed AZEROUAL*, Aboubakr EL MAKRINI, Hassan EL MOUSSAOUI and Hassane EL MARKHI, The Signals, Systems and Components Laboratory, Sidi Mohamed Ben Abdellah University,FST Fez, Morocco, Received 10 October 2017; Accepted 20 February 2018, p. 191.

[28] https://energy.economictimes.indiatimes.com/news/power/portugal-morocco-to-invite-bids-for-power-link-after-studies-in-2019/66701436

[29] Portugal, Morocco to invite bids for power link after studies in 2019, 19 November 2018, Reuters.

[30] Journal of Engineering Science and Technology Review 11 (1) (2018) 189 – 198, Research Article, Renewable Energy Potential and Available Capacity for Wind and Solar Power in Morocco Towards 2030 Mohamed AZEROUAL*, Aboubakr EL MAKRINI, Hassan EL MOUSSAOUI and Hassane EL MARKHI, The Signals, Systems and Components Laboratory, Sidi Mohamed Ben Abdellah University,FST Fez, Morocco, Received 10 October 2017; Accepted 20 February 2018, p. 194.

[31] Morocco competes to be the renewable energy leader in Africa, Yvonne Andiva, Last Updated: 5 November 2018, Construction review online.

conventional energy sources by 15%.[32] The aim of the strategy is both to enhance energy Morocco and to respond to the increasing demand for energy.[33]

Morocco built the world's largest wind farm in Africa in 2014. To date, EBRD has provided ca. EUR 200 million is for energy projects in Morocco.[34]

Morocco's plans for wind power have also seemed to have a positive effect on price. In March 2016, a consortium of Nareva Holding (Morocco), Enel Green Power (Italy), and Siemens (Germany) was chosen to develop a series of five wind farms in Tangier, Midelt, Jbel Lahdid, Tiskrad and Boujdour, with a total capacity of 850 MW. Their bid was priced at around US$0.03 US cents per kwh, one of the lowest in the world. Concessional financing from multilateral agencies seems to have played a role in reducing the cost, in addition to support from Morocco's state-owned investment holding company, Société nationale d'investissement.

Also in Morocco, (one of the MENA region's highest priced markets for electricity) average residential electricity tariffs stand at ¢11/kWh, but the price for commercial customers is more than three times as high, at ¢35/kWh, while industrial consumers pay a high ¢133/kWh. At these prices, even high-cost CSP technology could deliver a cost-effective electricity supply when this is compared with the high cost of Morocco's oil-fired power plants. This case could indeed be made for industrial users in most MENA countries, including Algeria, Egypt, Jordan, and several of the GCC economies. This data also offers an important indication of where electricity prices in the MENA region could be, if subsidies on direct electricity and on input fuels were transparently removed.[35]

[32] "Morocco to invest US $14bn in boosting renewable energy projects" Teresia Njoroge - Last Updated: 17 January 2019, Construction review online.

[33] Id.

[34] https://www.ebrd.com/where-we-are/morocco/data.html.

[35] Energy in the Middle East and North Africa, January 2014, Oxford Institute for Energy Studies, p. 10.

Mozambique

Mozambique is one of the largest producers of hydropower in Africa, the Cahora Bassa hydro plant being the most significant source. Mozambique has significant coal resources but despite plans for various coal fired power plants, coal is not currently part of the energy mix . And with coal fired power plants being more and more challenging to finance, except perhaps with Chinese investment, although these coal fired power plants are still part of the country's internal planning strategy, they are also looking towards its new found gas reserves (Mozambique has the potential to become Africa's second largest gas exporter after Nigeria) as well renewables to help meet its future energy needs.

The country has huge potential in terms of solar, wind, biomass as well as geothermic and oceanic resources. Long prior to the tragedy of Cyclone Idai, in its 2014-2023 National Energy Strategy, Mozambique has been working towards including renewables in its energy mix to address electrification but also climate change needs, including implementing a reliable legislative framework for its feed-in tariffs in the renewables sector. In the context of solar, the initiative was taken for panels to be produced in Mozambique, significantly cutting the cost of the generation.

According to the 2014-2023 National Energy Strategy, to improve the renewables development in country, there is a plan to establish a regulator, promote energy efficiency, introduce viable feed-in tariffs and extend and develop grid access. A key part of the infrastructure development is known as the 'backbone transmission line' to develop infrastructure to bring the hydro-power of the north more reliably to the South. As far as we are aware at this time the Government is pushing this project as a priority and seeking international funding.

At the time of writing, the Electricity law is under consultation for reform. We note that in the drafting seen there is the intention for the new legal framework to (a) '*promote the diversified use of new and renewable energy sources in the electric power supply*', and (b) '*develop studies and projects to evaluate and promote the use of new and renewable energy sources and energy efficiency measures*'. Further, there is the intention to relax the regulations and resulting administrative burden for renewable projects under 4MW. This change in law would offer an incentive to investors who are otherwise deterred by the cost associated with delays in administrative matters required for the projects.

Zambia

PowerAfrica has identifed the following barriers to electrification development for Mozambique's Sub-Saharan neighbour, Zambia: Continued market-based reforms: credit-worthiness of off-taker, growing government debt and transmission and distribution capacity lag. Not dissimilar to the challenges facing Mozambique – some of which are interlinked due to debt owed by each country to each other that remains outstanding. Zambia, however, has a captive market for power, being close to the Copperbelt where there is a significant power demand for the mining sector. This differs from Mozambique the industrial sector, although there is a push for development, is less developed and hence the power demand is lower.

In terms of renewable initiatives, GET FiT Zambia has been put in place to assist the Zambian Government in the implementation of its renewable energy feed-in tariff strategy (the 'REFiT Strategy'). The strategy sets out its intention to procure 200MW of renewable energy projects over a three year period with 100MW allocated to solar and 100MW allocated to hydro, with further bidding rounds for other technologies to follow. The initiative covers projects up to 20MW, so the small to medium IPPs rather than large scale initiatives.

The ReFiT Strategy has four key elements: viability gap funding, a technical assistance facility, a risk mitigation facility and a grid integration facility. The intention behind the viability gap funding is to offer a performance based tariff for new market entrants (but not for solar PV technology). This incentive is to bring new participants to the market with preferential conditions to help develop the sector. The technical assistance facility includes the introduction of a suite of harmonized documents for project implementation, an auction process and smoothing out other administrative hurdles that have previously been a barrier to new investment. The risk mitigation facility relates to the making available financial cover including insurance and short-term liquidity products to facilitate investment. The final element, the grid integration facility has been concerned with the integration of solar PV into the grid as well as facilitation funding for grid integration in relation to certain projects and technologies.

This initiative, as well as having received support internally from government stakeholders, has also attracted international investment from, amongst others, the African Development Bank and KFW.

On 5 April 2019, the initiative announced[36] the award of 120MW across six solar PV projects. As mentioned above, the intention was for 100MW but the bids that came in offered terms and the opportunity for an extra 20MW to be awarded. This concludes the award for the first phase and now the implementation can commence. The strength of the initiative will be ble to be fully evaluated only once the implementation phase is complete and the power is online.

[36] https://static1.squarespace.com/static/58c95e0c5016e18d705d710a/t/5ca7272b4e17b650f6de6cc2/1554458418539/Multiconsult-+Solar+PV_Award+Press+Release_Multiconsult_04042019-GETFIT+NEWS_+WEBSITE.pdf

Further, the Scaling Solar initiative of the World Bank has already added 76MW of capacity in Zambia since its initiation in 2015[37]. The initiative continues to drive development in Zambia to attract private investment in the sector.

Comparisons

The above mentioned factors are essential building blocks for the introduction of renewables into the energy mix. But the question is, when should renewables be introduced, meaning when is a society ready for renewables? What is the tipping point when one could say that there is enough baseload on electricity and a country could start focusing on replacing some of the conventional energy sources with renewables?

When comparing the jurisdictions we are considering here, the limitation of conventional hydrocarbon resources in Morocco and their drive for energy security is acting in their favor in terms of the energy transition to renewables. In Morocco, high energy import from other countries to satisfy its demand for energy, the Moroccan government historically resorted to fossil fuel importation and rapidly rising electricity demand have provided Morocco with the impetus to increase the RE development and appear as a stable target for power sector investment. To resolve its energy challenges, the kingdom of Morocco is turning to renewable energy development, comprising the wind, solar and hydro. Morocco has the most ambitious renewable energy targets in the MENA region, pledging to increase the energy from renewable source to 42% of the country's electricity producing by 2020 and 52% by 2030, evenly separated between the wind, solar and hydro. The introduction and success in the use of the renewable energy technology and energy efficiency measure highly depend on the existing policy framework in each country. Egypt, with its significantly larger population, has heavy reliance on its existing source of hydrocarbons, but notwithstanding this is pushing for the use of renewable for its future. Zambia and

[37] https://www.scalingsolar.org/active-engagements/zambia/.

Mozambique have a different starting point but are still considering and have now started to integrate renewables into their energy mix, both on and off grid.

Comparing Egypt with the situation in Mozambique, where factors that hinder development in the power sector are: public finances/macro-economic issues, lack of credit-worthy utility and cost-reflective tariffs, lack of a strong, transparent regulator, shows a large delta in the level of development. Although moves are being taken to address these issues including the establishment of a new regulatory body. With this background there are moves for development for off grid renewables, including those developed through PowerAfrica, a US AID funded initiative. To be taken into consideration in Mozambique are the recent gas finds, which, once online, subject to the infrastructure being in place and the political drive behind it, should change the energy landscape in the country. The wealth that should be returned to the country from this gas exploitation could indeed be reinvested into the country's infrastructure as well as providing the country with an addition energy source. Mozambique's role in the South African Power Pool (SAPP) and its supply to South Africa, again subject to improvements in the grid should also improve substantially.

What can be seen from the energy policies of the different countries we have considered are the different drivers behind the policies. The difference being geographical but also due to the size of the country and the differing stages of development. Where Egypt has a developed industrial sector, this is something that Zambia and Mozambique are working towards, both also with different starting points. Addressing poverty is also at a different stage across the jurisdictions and combatting energy poverty is a key consideration for states looking to increase their GDP and economic growth.

The balance between the size of the market, the matureness of the regulatory framework in a country and the access to the more conventional energy sources provides the basis for

transition. Transition is easier to carry out usually in a smaller country than a large one currently dependent on oil and gas.

The transition towards the utilization of renewables in industrialized countries like Denmark, the Netherlands, Italy, Japan, and the United States which have 100 percent electricity access rates is very different from the transition in sub-Saharan Africa, where more than one-half of the population do not have access to electricity.

Conclusions

As is clear from the above analysis, the question as to when is the right time to introduce renewables into the exergy mix is complex. A legal framework and incentive scheme is fundamental to the process. Core infrastructure must be available if the renewables are to be integrated to the grid, which already has sufficient, stable baseload. The stability of the grids in the countries we have considered varies considerably. Where the grid in not stable but the financing is available (and incentivized) we are seeing a trend of leapfrogging in terms of approach and a move to off grid solutions, be it for industry or at government initiative for housing, schools etc. on both a smaller and larger scale.

Where industry is established there is the drive to keep it up and running through baseload but also to address sustainability and cost. To the extent this is viable through renewables, there is a trend that this will be pursued. Where industry is at an earlier stage of development, unless funding is there to have affordable off grid solutions, there is reliance on the grid and governments are having to strive to meet those goals.

If every country had Elon Musk's charity behind it to provide not only renewables but storage, there would indeed be leapfrogging into the future. Until then, countries need to address their specific needs in their energy strategy: Morocco, as we have seen, is looking

to establish energy security, Egypt is still reliant on its abundant hydrocarbons. Mozambique is in need of developing a clear regulatory and infrastructure framework to enhance its renewables initiatives whereas Zambia is making positive moves towards establishing a viable feed-in tariff structure and implementing the results thereof. As seen in the case of Mozambique, producing the materials for renewables in country could indeed be in itself an industry to drive the development.

Time will tell but certainly Egypt and Morocco have indeed set good precedent frameworks for the inclusion of renewables into the energy mix for the continent but developments in technology may indeed allow countries such as Mozambique and Zambia to leapfrog to the future with more off grid renewable options.

When and how to bring renewables into the energy mix is complex. Governments implementing their policies need to consider national and regional factors but today it is clear that there are solid examples of regulatory frameworks and initiatives that can be used as precedents to help those nations who are at an earlier stage of development to move forward to a renewables inclusive future.