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ABSTRACT

Trend in Energy Intensity and Carbon Performance in North Africa[1]

Decoupling economic growth from environmental degradation and climate change, increasing resource efficiency, and promoting both sustainable production and sustainable lifestyles is a challenge in North Africa, a region where even a relative decoupling of income growth and carbon (CO2) emissions has not been achieved. This chapter aims to examine recent trends in emissions and the main drivers of improvement in the region's carbon intensity (carbon emissions per unit of GDP), energy intensity (energy use per unit of GDP), and per capita emissions. It also analyzes the effect of policies such as energy taxes and energy standards on the energy efficiency of SMEs in North Africa and suggests actions and policies to encourage structural transformation and ensure better energy efficiency.

JEL Classification: D22, G21, G32

Keywords: carbon emission, carbon intensity, energy intensity, inclusive growth, SMEs

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[1] Views expressed are those of the authors and do not necessarily reflect those of the UNECA or its Member States.

I. Introduction

Achieving inclusive and sustainable economic growth is a priority for improving people's lives globally and in North Africa. At the same time, reliable access to energy is key for achieving inclusive growth and reducing poverty. However, for North African, higher economic growth and subsequent increased GDP per capita continue to be closely linked with increased energy consumption and negative environmental impacts (carbon emissions, air pollution, waste production…). The region is one of the few where even a relative decoupling of income growth and carbon (CO2) emissions has not been achieved, i.e., CO2 emission growth per capita continues to exceed GDP per capita growth (Heger and Vashold, 2022).

Energy intensity has remained almost stagnant over the last two decades, due to limited institutional capacity and the lack of markets that would attract the necessary investment. Despite this and the social and political challenges, North Africa has increased its renewable energy production by 40%, by adding 4.5 GW of wind, solar Photovoltaics (PV) and solar thermal capacity (IEA, 2020). Moreover, renewables generation capacity in North African countries grew by 80% while the governments have developed national policies for energy transitions.

Despite these efforts, renewable energy currently accounts for a small share of total energy provision (about 5% vs. the global average of 25%) as the region's energy mix is skewed towards fossil fuels. This is not commensurate with the available resources, as North Africa has some of the most favorable sites in the world for solar irradiance as well as significant wind potential in the coastal areas (Kost et al., 2011). Indeed, North Africa has tremendous potential for increased renewables deployment, which could reduce dependence on imported fuels in Morocco and Tunisia while freeing up additional resources for export in Algeria (Nathaniel et al., 2020). Algeria, Egypt, Libya, Morocco, and Tunisia have long-term targets for increasing renewable electricity capacity for the region's sustainable energy transition and strategy towards achieving energy security.

According to OECD (2018), SMEs can be one of the tools through which greening, energy efficiency and adaptation to climate change can reach all sectors of the economy, including industry and manufacturing, agriculture, tourism, energy, and others. This is particularly important for North Africa, which is one of the region's most vulnerable to climate change impacts (Schilling et al., 2020). Given the impact of energy use and management on the sustainable development goals of firms, energy efficiency of SMEs is paramount (Gahm et al., 2016).

Horbach and Rammer (2018) show that a local or regional framework conducive to the use of renewable energies, notably laws and regulation, can support the transition of firms towards sustainable energy. On the other hand, when carbon taxes are implemented, measures improving energy efficiency allow firms to mitigate the negative effects of these taxes on their performance (Dorsey-Palmateer and Niu, 2020). This helps accelerate the energy transition while reducing carbon emissions. Energy standards policies can also improve energy efficiency (Noailly, 2012). But the literature on the effect of carbon or energy taxation policies and energy standards on the energy efficiency or green transition of companies is lacking, especially in North Africa.

The objective of this chapter is therefore, firstly, to examine the trends of carbon emissions and the drivers of carbon emission, carbon intensity (carbon emissions per unit of GDP) and energy intensity (energy consumption per unit of GDP) in the region over the last period. Secondly, to analyze the effect of policies such as energy taxes and energy standards on the energy efficiency of SMEs in North Africa notably Egypt, Morocco, and Tunisia. Finally, it then provides key recommendations, strategies, and actions for better energy efficiency and performance.

II. Empirical methodology and data

To better understand the carbon trend and to get a better idea of the drivers of carbon performance in North Africa, we will decompose carbon emissions and carbon intensity to GDP according to different contributing factors based on a simplified version of the Kayak identity inspired by EBRD (2011). The two Identity are respectively as follows:

$$C = C/GDP * GDP/Pop * Pop \quad (1)$$

[2]

$$C/GDP = E/GDP * C/E \quad (2)$$

where C is the Carbon emission of the country, C/GDP is the Carbon intensity to GDP[3] (Carbon performance indicator), GDP/Pop, the PIB per capita (economic activity of the country), Pop, the population (Size of the country), E/GDP, the Energy intensity to GDP *and* C/E, the Carbon intensity to Energy. This will allow us to see the variation of the emissions according to the changes of the other factors mentioned above in the time. We will proceed with an analysis of North Africa[4] as a region and then a country-by-country analysis for more insights. To do that we will data from Global Carbon Project, Our world in Data and World Bank databases.

Secondly, we will also analyze the effects of tax and energy standards policies on the energy efficiency of SMEs. To carry out our analysis, we will use probit and PSM models. The econometric model is as follows:

$$Y_i = \alpha Z_i + \beta X_i + \varepsilon_i$$

where Y_i is a dummy variable that takes 1 if the SME implements energy efficiency measures [5] (energy management, energy monitoring and adoption of energy efficiency measures) and 0 otherwise, Z_i is a dummy variable that takes 1 if the SME is subject to the measure put in place by the government to improve the energy efficiency of enterprises and 0 otherwise (tax policies and energy standards), X_i is a set of control variables representing the characteristics of the SMEs that can influence its energy efficiency (size, turnover, loan access, sector etc...) and ε_i, the error term. We will use data from the World Bank Enterprise Survey conducted in 2019 in Morocco and in 2020 for both Egypt and Tunisia. The surveys provide a representative sample of firms that have been identified in the countries (by region, sector, and size).

2 The composition is done using logarithmic Mean Divisia Index (LMDI). See (Ang, 2005)
3 We use here the GDP PPP (constant 2017 international)
4 Algeria; Egypt, Libya, Mauritania, Morocco, and Tunisia
5 Several proxies of energy efficiency will be used in for robustness issues.

III. Carbon Performance in North Africa

1. *Trends in Carbon emissions in North Africa*

North Africa has experienced a growth of more than 130% of its carbon emissions over the period 1990-2020 while the world growth has been around 50% (Table 1). Mauritania and Sudan have the highest CO2 growth rates in the region over the period 1990-2020, while Libya has even experienced a decline in emissions due to the negative impact of the socio-political crisis on its economic activity (World Bank, 2020). Although for the latter, even before the period 2000-2010[6], the variation of its emission rate was much lower than that of other countries in the region and even the world average.

Table 1. CO2 emissions from fossils fuel 1990-2020

	Annual average growth			**Total growth**
	1990-2000	**2000-2010**	**2010-2020**	**1990-2020**
Algeria	7.14%	43.28%	31.56%	101.98%
Egypt	86.59%	43.10%	6.28%	183.78%
Libya	30.12%	27.65%	-16.37%	38.90%
Mauritania	30.47%	75.98%	72.28%	295.58%
Morocco	48.88%	63.75%	18.70%	189.42%
Sudan	6.00%	184.79%	30.98%	295.46%
Tunisia	49.86%	37.76%	3.78%	114.28%
North Africa	43.40%	44.96%	11.93%	132.69%
World	10.92%	32.13%	4.39%	53%
Lower middle income	23.99%	52.98%	37.18%	160.22%
Upper middle income	1.80%	81.75%	15.94%	114.52%
Costa Rica	85.16%	38.91%	5.53%	171.45%
Ethiopia	15.95%	82.99%	131.41%	391.03%
Vietnam	146.94 %	163.5%	83.5%	1093.89 %

Source: Global Carbon Project, Our world in Data and UNECA calculations.

[6] UNECA (2022). Economic Commission for Africa. Sub regional office for North Africa. Progress towards achieving SDG 12 in North Africa. Report for the Intergovernmental Committee of Senior Officials and Experts for North Africa. Thirty-seventh meeting, Marrakech, Morocco, 1–3 November 2022. https://knowledgehub-sro-na.uneca.org/wp-content/uploads/2023/04/SDG-Report-2022-ENG.pdf

By comparing the growth rates of CO2 emissions over the period 2000-2010 and 2010-2020, we find a decrease in the growth rate of carbon emissions for all North African countries for the latter. The reduction in growth rate from one period to another is much higher for Sudan (153.81 points). After Sudan follows respectively Morocco (45.05 points), Egypt (36.82 points), Tunisia (33.98 points), Algeria (11.72 points) and Mauritania (3.7 points). However, it should be noted that even countries such as Costa Rica[7]and Ethiopia[8] which are often cited as examples in the transition to renewable energy in their region still have higher average rates than North Africa. This suggests that it is not only the carbon emissions themselves that are the problem, but also the carbon intensity relative to GDP (Jaller and Matthew, 2021).

2. ***Drivers of carbon emissions changes***

a. *Carbon decomposition in north Africa region*

The decomposition of emissions for the global region of North Africa shows very interesting features (Figure 1):

- From 1990 to 2000 the increase in emissions of 45% is mainly determined by an increase in population (25%) and economic activity (20%),
- From 2000 to 2010, carbon emissions continued to increase compared to the previous period, but this time mainly driven by economic growth. An increase in economic activity of 30% led to an increase in carbon emissions of about 50%. There was also a slight improvement in carbon intensity over the period (-4.4%).
- From 2010 to 2020, the decrease in carbon emissions compared to other periods is explained by a decrease in economic activity compared to other periods but also an improvement in carbon intensity by investing in renewable energy (Kong et al., 2022). The increase in emissions is mainly the result of an increase in population[9].

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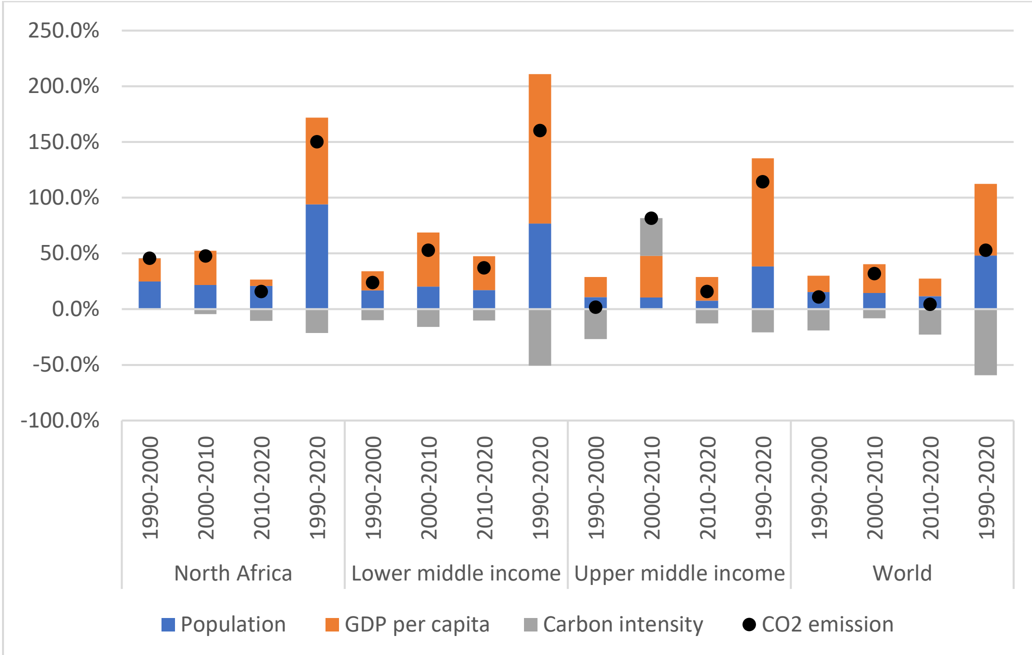
[7] https://www.worldfuturecouncil.org/100-renewable-energy-costa-rica/
[8] https://www.iea.org/countries/Ethiopia
[9] UNECA (2022). Economic Commission for Africa. Sub regional office for North Africa. Progress towards achieving SDG 12 in North Africa. Report for the Intergovernmental Committee of Senior Officials and Experts for North Africa. Thirty-seventh meeting, Marrakech, Morocco, 1–3 November 2022. https://knowledgehub-sro-na.uneca.org/wp-content/uploads/2023/04/SDG-Report-2022-ENG.pdf

Figure 1: Decomposition of Carbon emission changes 1990-2020 by groups and regions.



Source: Global Carbon Project, Our world in Data and UNECA calculations; Note: Due to the unavailability of some data for the period 1990-2000 for Libya, it has not been included in the results of the aggregate decomposition of North Africa.

In general, over the whole period, population growth is the factor that has contributed most to the increase in carbon emissions in the region. It is also worth noting the effects of measures to reduce carbon intensity in recent years, without which carbon emissions would be over 170% instead of 150%.

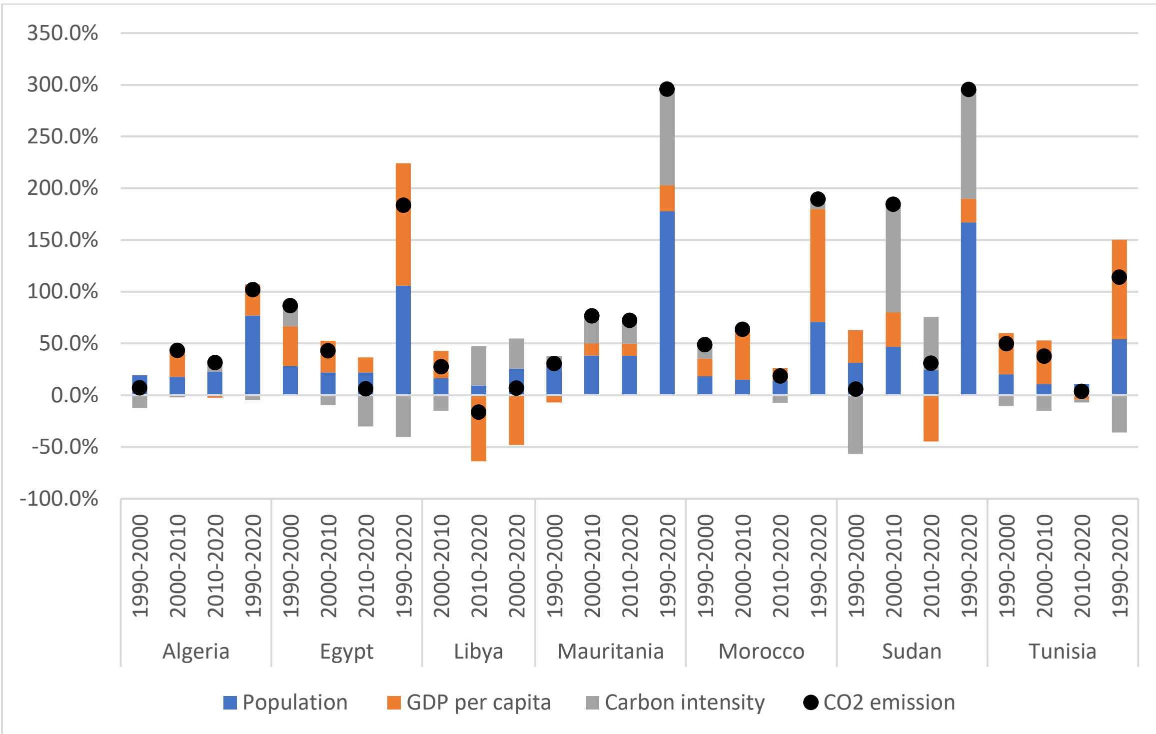
However, despite this progress, there is still a lot to do. By comparing with the results in the upper and lower middle-income countries, we notice that over the whole period, carbon intensity has been much more reduced. This has even allowed the lower income countries to avoid a growth in emissions of more than 40% over the period 1990-2020.

b. Carbon emissions decomposition by countries[10]

The analysis by country of the results of the decomposition shows contrasting realities in the region (Figure 2). For the period 1990-2000, the growth of carbon emissions in Algeria and Mauritania, is mainly explained by the growth of the population. The economic activity in these countries is decreasing over the period. There is also a slight decrease of the carbon intensity of Algeria over the period. In Egypt and Morocco, the emissions are also mainly driven by population size, economic activity but also an increase in carbon intensity for the latter. For, Sudan and Tunisia, both income and population growth explain mostly the variation of carbon emissions. There is also a decrease in carbon intensity in both countries, but it is much higher in Sudan.

[10] Ibid.

Figure 2: Decomposition of Carbon emission changes 1990-2020 in North African countries.



Source: Global Carbon Project, Our world in Data and UNECA calculations.

From 2000 to 2010, some changes occurred. Egypt, Algeria, Libya and Tunisia experienced a decrease in their carbon intensity and the increase in emissions is mainly explained by economic activity and population growth. Tunisia is the only country in the region to achieve a relative decoupling[11]. According to USAID (2015), the production of electricity from oil in Tunisia has decreased drastically between 1990 and 2011, being compensated by the one coming from natural gas. Furthermore, the country also presents a decrease of its carbon intensity. For Morocco and Sudan, the increase in carbon emissions is mainly explained by economic activity while for the latter it is also the result of a high increase in carbon intensity.

Over the period 2010-2020, in Libya, the increase in carbon emissions is mainly driven by an increase in carbon intensity and this despite a sharp decline in economic activity due to the civil war of 2011. Algeria also experiences some decline in GDP per capital growth over the period but the growth in emissions is mainly driven by an increase in population size and a slight increase in carbon intensity. For Morocco, Egypt, and Tunisia, we see an improvement in carbon intensity, the growth in emissions is mainly explained by the increase in population size. For the two countries, the carbon intensity is decreasing. Over this period, Egypt was even able to mitigate the effect of population and economic growth on carbon emissions by reducing its carbon intensity and thus achieved relative decoupling. This is in line with the country's various investments in

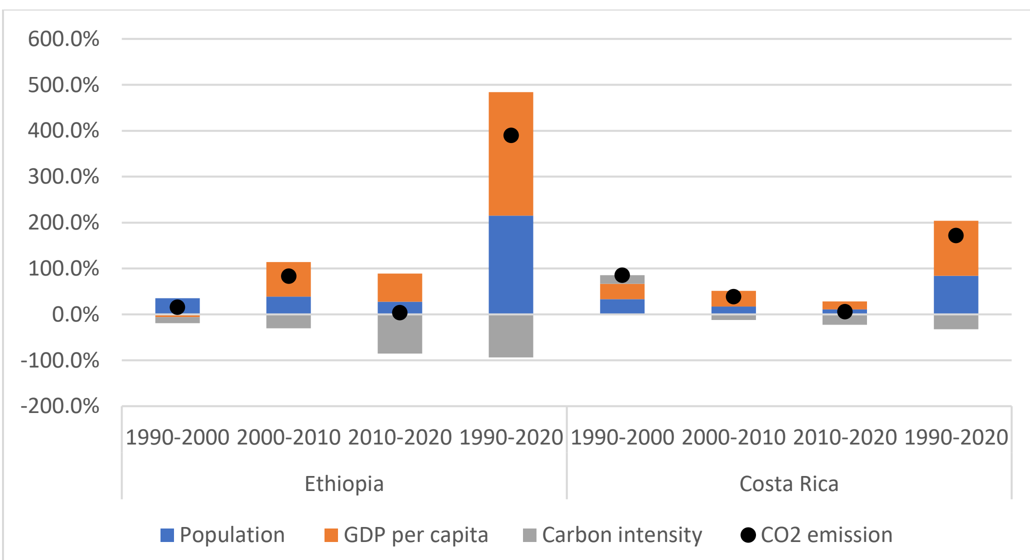
[11] Emissions have increased less than the income growth.

energy transition with the goal of having 20% of the electricity supply from renewable energy by 2022 (IRENA, 2018).

Finally, over the whole period, Egypt, Tunisia, and Algeria show the best results in terms of carbon intensity reduction in the region. However, a lot of efforts are still needed to reach and maintain a relative decoupling in the short term in order to aim at a decoupling in the long term. On the other hand, even if over the whole period, the results of the Morocco are not satisfactory, there is an improvement in its carbon intensity between 2010 and 2020. In fact, 37% of Morocco's local electricity production in 2020 came from renewable energy[12]. In contrast, Sudan, Mauritania, and Libya have the highest carbon intensity scores.

By comparing with countries such as Costa Rica and Ethiopia (Figure 3) that can be cite as example in green transition[13] (Okereke et al., 2019), we notice that some countries from North Africa such as Algeria, Egypt, Morocco, and Tunisia are on the right track, but they still need to increase their efforts to reduce carbon intensity. Indeed, the countries mentioned above do not necessarily have low carbon emissions, but they are reducing their carbon intensity and combining this with strong economic growth. In the short and medium term, this combination is essential to achieve a realistic objective of reducing carbon emissions in North Africa. It would be then interesting for North African countries to start with a transition of the most important sectors of their economies towards natural gas energy which has a smaller carbon footprint and is widely available in the region (UNECA, 2020). This will allow in the medium term to improve the carbon intensity without necessarily sacrificing economic growth.

Figure 3: Decomposition of Carbon emission changes 1990-2020 in Ethiopia and Costa Rica.



Source: Global Carbon Project, Our world in Data and UNECA calculations

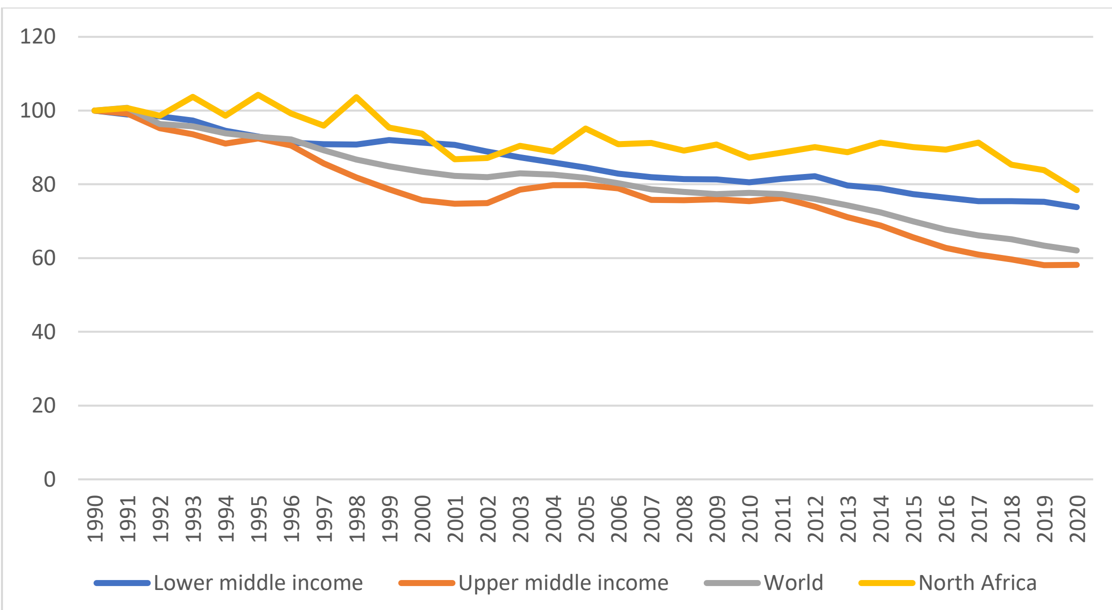
[12] https://www.trade.gov/country-commercial-guides/morocco-energy

[13] https://www.worldfuturecouncil.org/100-renewable-energy-costa-rica/

3. Carbon and energy Intensity in North Africa

Last years, most countries have generally reduced their carbon intensity (Figure 4). By comparing with the world average and even with the upper- and middle-income countries, results show that despite the efforts already made, North Africa still needs to improve its performance. While the lower middle income, the upper middle income and the world have respectively decreased their carbon intensity by 27%, 42% and 38%, for North Africa this decrease was only 22%. However, Figure 5 highlights that the best performing country over the period in terms of intensity reduction is Algeria (39%)[14]. It is followed by Egypt and Tunisia with respectively 21% and 16% reduction of their carbon intensity. Morocco over the same period has experienced a slight increase of about 5% while Mauritania and Sudan are the least successful with respectively with increases of 54% and 69%. As for Libya, using 2000 as a base, its carbon intensity in relation to its GDP has increased by about 40%. Despite this decrease in carbon intensity in North Africa on a regional scale, absolute decoupling is still far away. One of the main reasons for this is that the energy supply is still very dependent on fossil fuels. Indeed, from 1990 to 2019, the carbon intensity to energy at the global level has only slightly decreased and this is even smaller in North Africa over the same period (Figure 6).

Figure 4: Carbon intensity of GDP by region and income



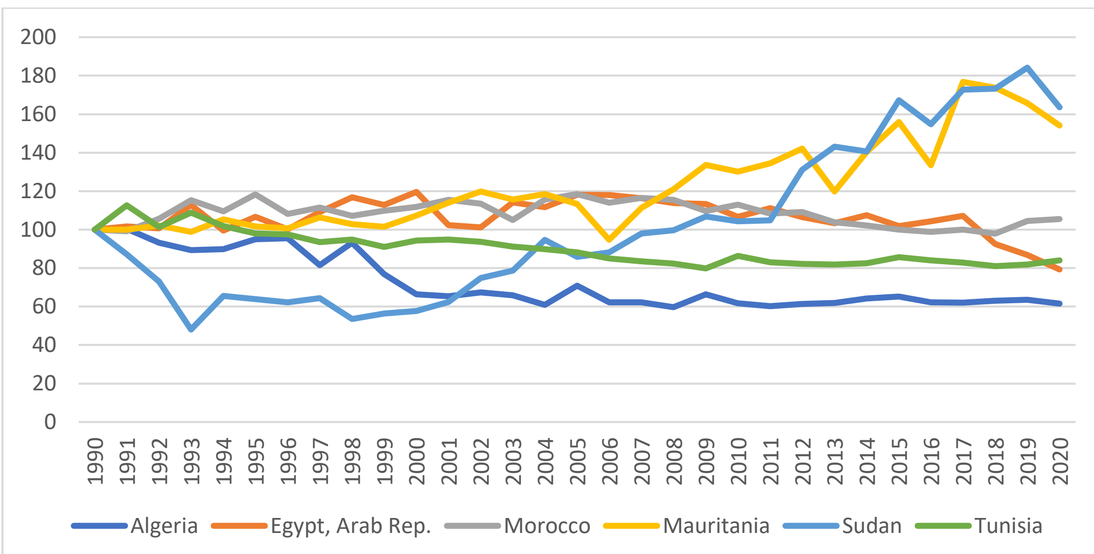
Source: Global Carbon Project, Our world in Data and UNECA calculations. Note: The carbon intensity of GDP (in Tons of CO2 per US$ GDP in constant 2017 prices at PPP exchange rates) in 1990 is the reference scenario (100).

[14] https://www.mei.edu/publications/algeria-charts-path-renewable-energy-sector-development

However, when we take the periods 2000-2010 and 2010-2019, the region shows better results than the global average in terms of carbon intensity of energy. Over the periods 2000-2010 and 2010-2019, the change in energy carbon intensity decreased by 7.3% in North Africa, while the global change increased by 3% and decreased by only -2.4% respectively. The decrease in carbon intensity in GDP in North Africa is mainly due to a decrease in carbon intensity in energy. This shows that the efforts put in place by North African countries in recent years in terms of energy transition from a global perspective are starting to bear fruit.

On the other hand, the carbon intensity would be lower if the energy intensity relative to GDP of North African countries was lower. Indeed, energy intensity of economic output (TPES/GDP), has decreased globally by 34% while in North Africa it has decreased by only 7% between 1990 and 2019. More efficient use of energy could reduce the carbon intensity and therefore the emissions.

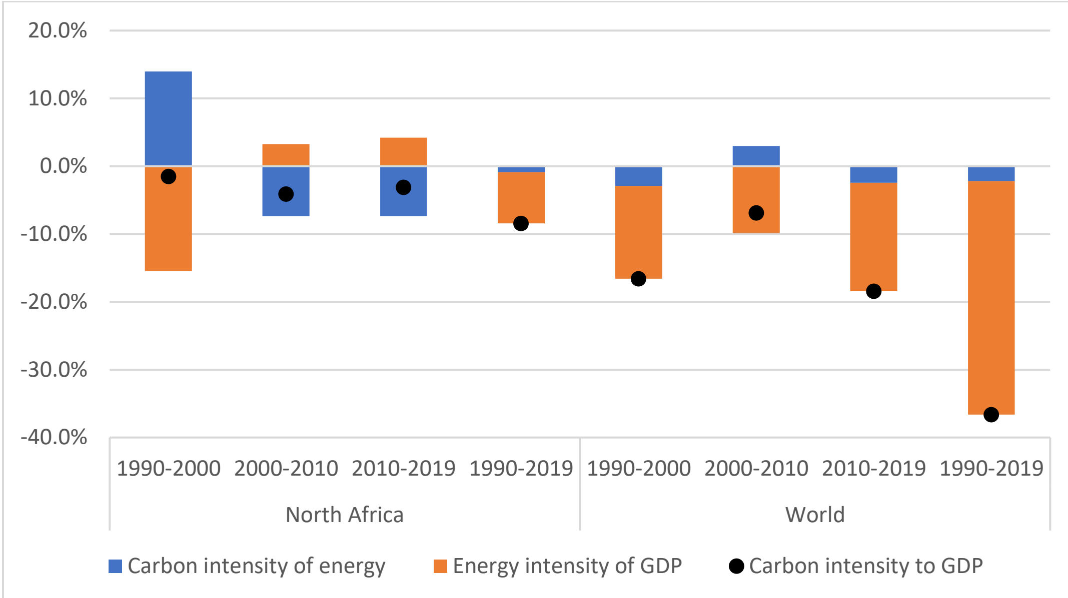
Figure 5: Carbon intensity to GDP in North Africa countries



Source: Global Carbon Project, Our world in Data and UNECA calculations. Note: The carbon intensity of GDP (in Tons of CO2 per US$ GDP in constant 2017 prices at PPP exchange rates) in 1990 is the reference scenario (100). However, due to the unavailability of data for Libya, 2000 is the reference scenario (100).

When we analyze country-by-country, we find that (Figure 7). Over the whole same period (1990-2019), all countries experienced an increase in their carbon intensity relative to energy, except for Algeria (27% decrease) and Libya (20% decrease). However, the increase is higher for Sudan around 120%. Some countries such as Tunisia, Egypt and Sudan also experiment a decrease in terms of energy intensity to GDP while Algeria, Libya and Morocco experienced an increase.

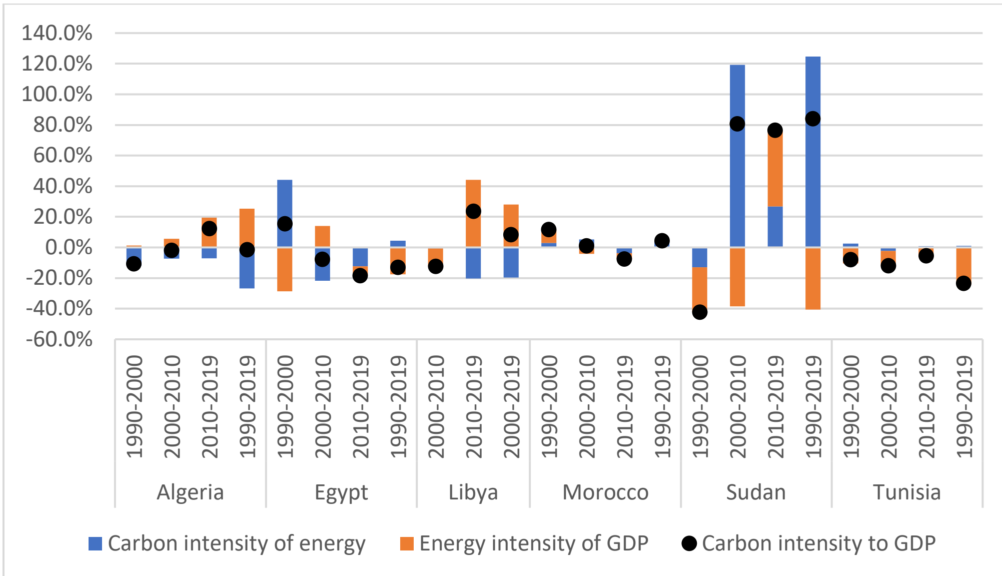
Figure 6: Decomposition of carbon intensity to GDP changes 1990–2019 in North Africa



Source: Global Carbon Project, Our world in Data, IEA, OECD and UNECA calculations. Note: due to the unavailability of data, we did not include Libya and Mauritania in the North Africa region aggregation.

On the other hand, the analysis of the last periods (2010-2019) shows some improvement both in terms of carbon intensity of energy and energy intensity to GDP for Egypt, Morocco, and Tunisia that in terms of reducing carbon to intensity (Figure 7). For Algeria, even if there is a decrease in the carbon intensity in relation to energy, the energy intensity in relation to GDP is still increasing. Measures to transition to renewable energy sources in order to reduce their dependence on fuel or coal use are needed all north African countries. Egypt, Morocco, and Tunisia also need to maintain and improve the energy efficiency efforts already in place. For Algeria and Libya, measures to improve energy intensity relative to GDP while continuing efforts to reduce carbon intensity relative to energy are needed. Finally, Sudan needs strong interventions to improve both the carbon intensity of energy and the energy intensity of GDP. Indeed, while for other countries, the increase in energy carbon intensity between 1990 and 2019 is on average 3%, Sudan's is about 125%. Moreover, between 2010 and 2019, it has the highest energy intensity relative to GDP in the region.

Figure 7: Decomposition of carbon intensity to GDP changes 1990–2019 in North African Countries



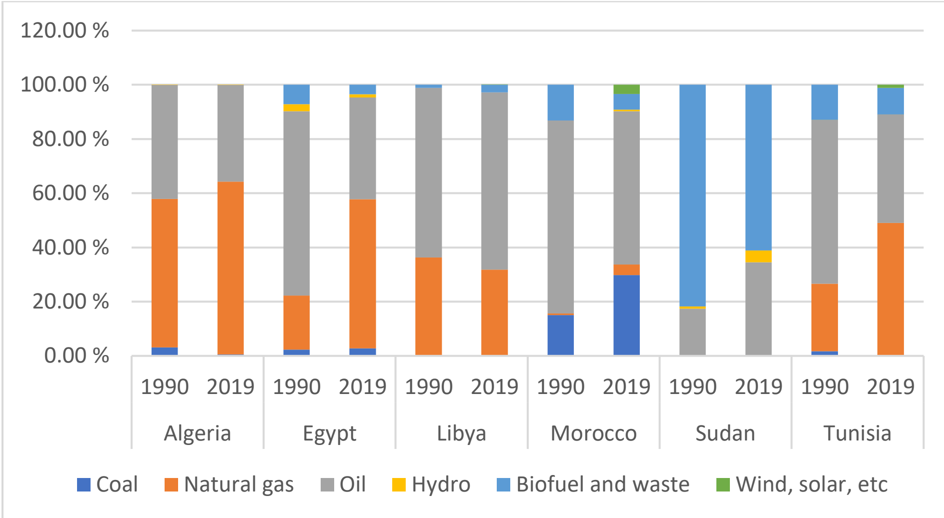
Source: Global Carbon Project, Our world in Data, IEA, OECD and UNECA calculations. Note: due to the unavailability of data, we did not include Libya and Mauritania.

Figure 8 shows that even countries like Egypt, Tunisia, and Morocco, which perform best in terms of carbon and energy intensity, still have high proportions of non-renewable energy in their energy supply. Their supply of energy from renewable energy has even decreased.

However, at the same time, the proportion of energy supply from natural gas has strongly increased from 25% to about 50% and from 20% to 55% respectively for Tunisia and Egypt while that reliance on oil has decreased. This explains the energy and carbon performance of these countries. Indeed, even if natural gas remains a fossil fuel, it is less polluting than oil or coal. In fact, in the short term and even in the long term, natural gas is a viable and pragmatic solution, especially in view of the region's natural resources (UNECA 2020).

Natural gas represents more than 60% of the energy supply of these two countries on average, the energy supply from oil has decreased to 40% and 38% respectively for Tunisia and Egypt. These figures are almost like those of Algeria, which has also reduced its energy supply from oil in favor of those from natural gas (the share of energy from oil has dropped from 42% to 36% while that of natural gas has increased from 55% to 64%).

Figure 8: Total energy supply by sources in North African Countries



Source: IEA and UNECA calculations. Note: due to the unavailability of data, we did not include Mauritania.

For Libya, the trend is rather the opposite, with trends going in the opposite direction. The energy supply from oil from 1990 to 2019 increased by 2% while that from natural gas decreased by 4%, while 3% of the energy supply in 2019 came from biofuel and waste in Libya. In view of Libya's natural gas potential[15], current figures show the negative impact of political instability and security problems on the transition to a more sustainable energy supply. Concerning Sudan, while in 1990, more than 80% of the energy supply came from biofuel and waste, this proportion has dropped to 61% in 2019 in favor of oil. This is consistent with previous results in terms of carbon and energy efficiency and is also explained by the current political instability in the country. At the same time, there is also an increase in energy sources from Hydro.

Regarding Morocco, the reliance on coal has even doubled between 1990 and 2019 (from 15% to 30%) while that of oil has decreased. However, between 1990 to 2019, Morocco has more diversified its renewable energy supply by adding hydro, wind and solar energy sources.

Finally, it can be argued that many efforts remain to be made insofar as, to speak of energy and carbon efficiency, making the transition in its energy sources remains the basis. The ideal would be a transition to renewable energies such as solar or wind or biofuels and waste but initially, a transition to natural gas could be the solution in view of the potential of the region.

[15] https://www.opec.org/opec_web/en/about_us/166.htm

IV. Energy efficiency policies and SMEs energy performance in North Africa

After analyzing the global energy efficiency of countries, we now focus on the effect of tax and energy standards policy on SMEs energy efficiency in North Africa.

Table 2: SMEs energy performance measures indicators proportion by Country (%)

	Egypt	Morocco	Tunisia	Whole sample
Energy consumption monitoring	24.47 %	22.74 %	32.96 %	25.40%
Energy management	17.57 %	34.53 %	17.97 %	19.39%
Energy efficiency measures adopted	2.57 %	13.79 %	9.18 %	4.77%

Source: UNECA calculations and World Bank Enterprises survey

In our sample, 25% of the companies monitor their energy, about 20% manage it, and only 5% implement effective measures to improve their energy efficiency. The highest proportion of SMEs monitoring their energy is found in Tunisia (32.96%), followed by Egypt (24.74%) and Morocco (22.74%) respectively. Regarding energy management, the proportion is higher among Moroccan SMEs with a proportion of about 35%. For Egypt and Tunisia, less than 18% of SMEs manage their energy consumption.

As for the adoption of effective measures to improve energy efficiency, the proportions are the lowest. In Morocco, about 14% of SMEs have implemented measures to improve their energy efficiency. These figures are even lower for Egypt and Tunisia with 2.57% and 9.18% respectively.

Table 3: Energy Tax and Standard policies application among SMEs by country (%)

	Egypt	Morocco	Tunisia	Whole sample
Energy tax	24.88 %	12.43 %	39.64 %	25.43%
Energy standard	3.87 %	11.78 %	9.95 %	5.56%

Source: UNECA calculations and World Bank Enterprises survey

On the other hand, regarding the measures implemented by the different governments, there are more SMEs subject to the energy tax than those subject to energy standards in the region. About 25% of SMEs are subject to the tax and only 5% have energy standards. This is understandable because energy standards require a lot more knowledge about companies but also more financial investment (Wiel and Mcmahon, 2003). Moreover, some authors even show that the energy tax can be more effective than standards (Levinson, 2019). The proportion of enterprises subject to energy taxes is higher in Tunisia (39.64%) compared to Egypt (24.88%) and Morocco (12.43%). However, the reverse is true for the application of energy standards to SMEs, which is higher in

Morocco (11.78%), followed closely by Tunisia (9.95%) and Egypt (3.87%).

Table 4: Effects of Energy Tax and Standards policies on energy efficiency in North Africa (Probit model)

	(1) Energy monitoring	(2) Energy manageme nt	(3) Efficiency energy measures adopted	(4) Energy monitoring	(5) Energy manageme nt	(6) Efficiency energy measures adopted
Energy Tax	**.104*** (.062)**	**-.101*** (.086)**	**. 017** (.103)**			
Energy Standards				**.079**** (.117)	**.017** (.125)	**.057***** (.13)
Loan	.028 (.088)	-.022 (.105)	-.010 (.138)	.016 (.088)	-.022 (.105)	.001 (.138)
Family business	-.081*** (.064)	-.149*** (.083)	-.035*** (.113)	-.086*** (.064)	-.142*** (.079)	-.040*** (.12)
Formalized strategy	-.009 (.064)	.023 (.075)	.005 (.108)	-.014 (.064)	.026 (.075)	.003 (.11)
Board	.024 (.063)	-.007 (.076)	.011 (.113)	.024 (.063)	-.016 (.075)	.010 (.117)
Medium enterprises	.028* (.061)	.006 (.07)	-.011 (.102)	.025 (.061)	.011 (.069)	-.009 (.104)
Women Top manager	-.030 (.119)	-.072** (.156)	.000 (.193)	-.024 (.12)	-.073** (.154)	.005 (.194)
Turnover	.023*** (.019)	.029*** (.023)	.004** (.03)	.031*** (.019)	.024*** (.021)	.004** (.03)
Firm age	-.000 (.002)	.000 (.002)	-.000 (.003)	-.000 (.002)	.000 (.002)	-.000 (.004)
Egypt	.049* (.113)	-.130*** (.125)	-.095*** (.139)	.065** (.113)	-.134*** (.121)	-.098*** (.143)
Tunisia	.144*** (.128)	-.028 (.152)	-.003 (.159)	.177*** (.128)	-.05 (.148)	-.019 (.166)

Top manager experience	.003***	.000	.000**	.003***	.002	.001***
	(.003)	(.003)	(.004)	(.003)	(.003)	(.005)
Retail	-.126***	-.050	.001	-.129***	-.053*	-.009
	(.13)	(.152)	(.176)	(.129)	(.148)	(.18)
Wholesale trade	-.126***	-.073***	-.013	-.134***	-.077***	-.014
	(.093)	(.117)	(.164)	(.095)	(.118)	(.175)
Construction	-.089***	-.020	.004	-.100***	-.010	.003
	(.117)	(.134)	(.201)	(.119)	(.132)	(.203)
Hotel, Restaurant	-.036	.027	.016	-.054*	.029	.009
	(.108)	(.126)	(.19)	(.109)	(.125)	(.199)
Services	-.027	.041*	.014	-.036	.052**	.014
	(.085)	(.097)	(.144)	(.086)	(.096)	(.144)
Environmental Manager	.198***	.127***	.053***	.195***	.126***	.044**
	(.144)	(.168)	(.193)	(.145)	(.169)	(.198)
Environmental strategy	.267***	.354***	.042***	.262***	.362***	.028**
	(.104)	(.113)	(.154)	(.105)	(.112)	(.159)
Observations	3143	2740	2981	3138	2733	2976

Coefficients are marginal effects from Probit models. Robust standard errors are in parentheses.
**** p<.01, ** p<.05, * p<.1*

The results in Table 4 show that in energy taxation policies and energy standards have a positive effect on SMEs' energy monitoring (Royal Society, 2002; Scrimgeour et al., 2005; Yuan et al.,2016). Otherwise, energy standards have no effect on the likelihood of firms managing their energy. Taxes, on the other hand, even have a negative effect. This can be explained by the fact that firms may trade off the tax they have to pay against their revenue. If they earn more by not managing their energy, they will prefer to pay the taxes, which are generally low, and not reduce their energy consumption (OECD, 2019). Finally, energy standards have a stronger positive effect on the adoption of energy efficiency measures than taxes. This is also understandable since the implementation of energy standards will force companies to consume a certain level of energy. To maintain or improve sales but also to avoid paying penalties (Price et al., 2005), companies will need to find ways to produce with the least amount of energy and reduce their carbon footprint.

Table 5: Effects of Energy Tax and Standards policies on energy efficiency in North Africa (PSM model)

		Energy monitoring	Energy management	Efficiency energy measures adopted
Energy Tax	ATT	.069**	-.152***	.029**
Energy Standards	ATT	.094*	.019	.110***

*Source: UNECA calculations and World Bank Enterprises survey. Note: ATT corresponds to the Average Treatment effect on Treated. *** p<.01, ** p<.05, * p<.1.*

The results in Table 5 also generally confirm the results obtained above regarding the effects of different government energy measures. However, there is a slight difference. The SHP model shows that the effect of energy standards on energy tracking is higher than that of tax measures while the probit model shows the opposite. Since the PSM model is much more suitable for impact analysis and its results confirm the previous results, we can state that energy standards have a higher effect on average on energy monitoring of SMEs in our sample. However, this result should be interpreted with reservations.

As for the other variables, access to credit has no effect on energy efficiency. This is understandable in the sense that given the lack of access to credit in the region, firms will tend to invest in making their operations more efficient rather than in energy efficiency. Indeed, investment in energy efficiency is not always profitable for small firms (Biscione et al., 2022). Of course, the results also show that firms with the highest turnover tend to invest more in their energy efficiency. However, in North Africa, the difference in the effect of SME size on energy efficiency measures is generally not significant.

Moreover, being a family business has a negative effect on the energy efficiency of companies. According to Koska et al, (2013), this is explained by the fact that decision-making in family firms may involve different family members with different investment perspectives. This can be a hindrance to the implementation of energy efficiency measures. Furthermore, Zhu and Lu (2020) argue that the fact that external stakeholders generally do not have an impact on the governance of family firms and therefore cannot push for a green transition.

Companies with higher turnover tend to improve their energy management. The number of years of experience of the manager also plays a determining role, especially in monitoring energy but also in implementing measures to improve energy use. However, contrary to the results of Wang et al. (2021), having a female manager decreases the chances of the SME managing its energy. This could be due to the regional context of gender stereotypes that would make it difficult for a female manager to express her views on energy efficiency or even implement it (ILO, 2016).

Furthermore, having a more formalized board of directors or management style with well-defined indicators has no effect on energy efficiency. In contrast, having an environmental strategy in place and a manager in charge of these issues greatly increases the chances of energy efficiency for SMEs (Fernando and Hor, 2017). In addition, companies in the manufacturing sector tend to implement energy efficiency measures and monitor their energy more than those in other sectors. However, SMEs in the hospitality sector manage their energy better than those in the manufacturing sector.

Regarding the differences between the countries, compared to firms in Morocco, firms in Egypt are less likely to manage their energy but also to implement mechanisms to improve their energy efficiency. However, with respect to energy monitoring, firms located in Egypt and Tunisia are more likely to implement it compared to firms in Morocco, according to Table 2.

Finally, standard energies seem to be more effective than taxes in improving the energy efficiency of SMEs in the countries in our sample. However, in both cases, a good mapping of SMEs by sector and a good knowledge of their energy consumption are crucial. Indeed, for either policy not to impinge on the activities of SMEs and to be beneficial to all, it is necessary that normative or fiscal policies be adapted to these different types of firms. Moreover, analyzing the determinants of this efficiency can also help us create a business standard on which we can build to improve the efficiency of SMEs in North Africa.

V. Conclusion and Policy recommendations

The objective of the chapter was twofold. First, to examine at the macro level the trends and key drivers of carbon emissions, carbon intensity and energy intensity in North Africa. Second, at the micro level, to examine the effect of policies such as energy taxes and energy standards on the energy efficiency of SMEs in North Africa (Egypt, Morocco, and Tunisia).

The results show that many efforts have been made in North Africa to reduce the region's carbon footprint. However, if the countries of the region have succeeded in reducing the growth of their carbon footprint to a certain extent, additional efforts are needed for a better energy performance. Egypt, Morocco, Tunisia, and Algeria to a lesser extent have made progress in terms of carbon intensity and energy intensity, while other countries in the region such as Sudan, Libya and Mauritania are still lagging.

The results show also that countries in the region are still heavily dependent on energy sources with a high carbon footprint including oil and coal. Nevertheless, some countries such as Algeria, Egypt and Tunisia use natural gas as their main energy source. For Sudan, the main sources are even renewable including biofuel and waster.

Regarding the energy efficiency of SMEs, the result show that energy standards and taxes allow for better energy monitoring of companies but also for the effective implementation of measures to improve their energy efficiency. However, while the effect of taxes on energy management is negative, energy standards have no significant effect on it.

In this context, it is advised that countries switch to less carbon intensive energy sources. In view of the natural resources of countries such as Algeria, Egypt, and Libya in natural gas, this seems the most feasible solution. However, this requires an improvement of intra-regional trade relations in North Africa which are among the weakest. The effective implementation of African Continental Free Trade Area (AfCFTA) can be a solution in this sense. In addition, investment in

renewable energy sources such as solar PV and wind, which are abundant in the region, could be increased. Specifically for Sudan which uses mostly renewable biofuel and waste energy, it would be better to diversify its renewable energy sources to be more environmentally friendly.
However, all this requires an acceleration of the energy transition of SMEs in the region to reach all sectors of the economy. Strategies to improve access to long-term investments but also to green financing of the SMEs are indispensable. Furthermore, the implementation of energy taxes or standards must be combined with measures that make the adoption of energy transition measures profitable for firms, especially information programs and financial subsidies and incentives. Finally, an effective implementation of energy standards and taxes on firms requires an increased knowledge of these companies but it is costly. Indeed, as we have seen above, standards and taxes have not had the expected effect on the energy management of SMEs, although this is one of the factors of energy inefficiency.

Firms and SMEs could play an important role in the transformation of the production process. It is important to mention that the transition from a linear to a circular economy requires a joint effort by stakeholders from all sectors. Firms particularly can contribute to the transition by developing competencies in circular design to implement product reuse, and recycling, and serving as trend-setters of innovative circular economy business models. Policy makers can support the transition by promoting the reuse of materials and higher resource productivity by rethinking incentives and providing the right set of policies and access to financing. This also needs a regulatory framework that promote the popularization of green investment including green bond, debt for climate swap and even higher energy tax for the large companies. While a strict set of regulations may also be a less costly solution (Biscione et al., 2021), the informal economic framework of SMEs in North Africa would make it unviable. An acceleration of measures for the transition of informal enterprises to the formal sector is therefore equally decisive.

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