Advancing SDG7 ("Affordable and Clean Energy"): Towards Ending Energy Poverty for Net Zero Emissions in the Middle East and North Africa

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Abstract

This article examines advancing the United Nations Sustainable Development Goal 7 (SDG7) pertaining to "Affordable and Clean Energy", to address energy poverty (EP) and achieve the broader objectives of upcoming global agendas for the SDGs by 2030 and the Net Zero Emissions (NZEs) target under the Paris Agreement by 2050. We begin by exploring the relationship between EP and SDG7 through a comparative analysis of the six indicators monitoring SDG7 progress in the Middle East and North Africa (MENA) region. The drivers of EP and their subsequent impacts at national and regional levels are then discussed, followed by policy recommendations advocating the "right to energy".

1. Energy Poverty and the Pursuit of SDG7

Energy lies at the heart of development and the backbone of a modern economy. In the coming decades, energy systems will undergo significant transformations triggered by current global challenges, particularly those related to climate change and socio-economic inequality, with energy poverty (EP) representing a key subset at the intersection of these issues. While various EP definitions have been recognized across multiple sources [1]–[7], no single universal or standard definition is followed. Insights to common EP definitions include the lack of an efficient supply and distribution systems for modern fuels, poor infrastructure or absence of power networks, no access to reliable and affordable supply of electricity, inability or low consumption of modern energy per capita, high reliance on traditional biomass for cooking, high share of income spent on energy needs, absence of physical opportunity to connect or acquire energy, absence of sufficient choice in accessing adequate, affordable, reliable, high-quality, safe and environmentally benign energy services, absence of adequate safeguards to ensure a country's energy demand and supply patterns are sustainable, among others. These definitions imply the issue of EP is relevant in both developed countries, where it is often linked to low income and high energy prices, and developing countries, where it is primarily associated with a lack of access to modern energy services [2]. In this article, we conceptualize EP as an interconnected and overlapping issue that touches on multiple critical and emerging aspects of sustainable energy development, including but not limited to energy "sustainability", "access", "security", "justice", "affordability", "diversification", "democracy", "equity", "resilience", "reliability", "inclusion", "vulnerability", "governance" among others. The boundaries between these dimensions are blurry and the underlying concepts are all similar, indicating they should not be viewed in isolation to be able to emphasize the complex dynamics of the energy system and its broader implications on the environment, economy, and society. As human development and climate agendas crossed paths following the adoption of the United Nations Sustainable Development Goals (SDGs) and the Paris Agreement in 2016,[1] the fundamental importance of considering the interaction of energy systems with human development became increasingly emphasized given the intertwined nature of both global agendas. Accordingly, we argue that EP is closely interlinked with the aspirations envisioned by upcoming global agendas, short-term for the SDGs by 2030 and long-term for the Net Zero Emissions (NZEs) target of the Paris Agreement mainly centering around 2050. In particular, the most direct link is seen through the **SDG7 ("Affordable and Clean Energy")** with the fundamental principles to propel sustainable poverty alleviation rooted in its definition that calls for ensuring access to affordable, reliable, sustainable and modern energy for all by 2030 through the achievement of five targets and six indicators reinforcing positive change as outlined in Table 1.

Therefore, this article explores key questions regarding EP: *Where do we stand now, and where must we go next?*

We take the Middle East and North Africa (MENA) region as a case study, motivated by the ongoing political affairs and their disruptive impacts in exacerbating EP at both national and regional levels. To address these questions, we first examine the current state and emerging trends in EP, the underlying barriers and their impacts, and the strategic policy opportunities that lie ahead within the MENA context.

2. Current Energy Landscape and Emerging Trends in MENA

The MENA region has a high degree of intraregional heterogeneity owing to differences in energy infrastructure, political status, and socio-economic development, which lead to associated large disparities in access to affordable, reliable, sustainable, and modern energy. This makes EP a highly relevant issue to the region and its implications warrant far greater discussion at environmental, economic, social, and political levels. Table 2 provides a comparative analysis of 26 MENA coun-

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Table 1: Definition of SDG7 as per the latest refinements of the United Nations global indicator framework (February/March 2024) [8] with the hierarchy labeling based on definitions by [9].

Macro-level: *Goal ("SDG") = 1*		Meso-level: *Targets ("T") = 5*		Micro-level: *Indicators ("I") = 6*		Impact of Goal-Target-Indicator (Increase or Decrease) on Energy Poverty (Decrease)	
Index	Description	Index	Description	Index	Description	Index	Description
SDG7	*"Ensure access to affordable, reliable, sustainable and modern energy for all"*	T.7.1	*"By 2030, ensure universal access to affordable, reliable and modern energy services"*	I.7.1.1	*"Proportion of population with access to electricity" (% population-electricity)*	(+, −)	*Increasing access to electricity ensures that more people have reliable and affordable power supply which enables better living standards by supporting essential needs like lighting, heating, cooking, and the use of electronic devices, and facilitating economic opportunities, education, healthcare, and overall social development.*
				I.7.1.2	*"Proportion of population with primary reliance on clean fuels and technology" (% population-clean cooking)*	(+, −)	*Increasing reliance on clean fuels and technologies offers safer, more sustainable cooking solutions that improve quality of life and support long-term well-being, particularly for vulnerable populations, by reducing health risks from indoor air pollution and easing the financial burden of using traditional, inefficient fuels.*
		T.7.2	*"By 2030, increase substantially the share of renewable energy in the global energy mix"*	I.7.2.1	*"Renewable energy share in the total final energy consumption" (% renewable consumption)*	(+, −)	*Increasing renewable energy in end-use sectors decreases greenhouse gas (GHG) emissions and provides affordable electricity to underserved populations in off-grid areas using decentralized solutions such as solar and wind energy.*
		T.7.3	*"By 2030, double the global rate of improvement in energy efficiency"*	I.7.3.1	*"Energy intensity measured in terms of primary energy and gross domestic product (GDP)" (megajoule per $2017 Purchasing Power Parity (PPP) GDP)*	(−, −)	*Decreasing energy intensity indicates improved efficiency (less energy used per unit of economic output) which reduces energy waste and associated emissions, eases strain on local resources and infrastructure, and reduces costs, making energy more affordable to a broader segment of society to meet growing demands.*
		T.7.a	*"By 2030, enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency and advanced and cleaner fossil-fuel technology, and promote investment in energy infrastructure and clean energy technology"*	I.7.a.1	*"International financial flows to developing countries in support of clean energy research and development and renewable energy production, including in hybrid systems" (billions of constant 2021 US$)*	(+, −)	*Increasing international financial support accelerates research and development (R&D) and investment projects for the development of energy infrastructure, hybrid renewable systems, clean energy technologies, advanced energy efficiency solutions, and expansion of the green jobs market.*
		T.7.b	*"By 2030, expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries, in particular least developed countries, small island developing States and landlocked developing countries, in accordance with their respective programmes of support"*	I.7.b.1	*"Installed renewable energy-generating capacity in developing and developed countries" (renewable watts per capita)*	(+, −)	*Increasing renewable power production goes in parallel with expanding electricity access, particularly in remote or rural areas, which in turn directly contributes to a larger share of renewables in the overall national energy mix and reduces the carbon footprint of the energy system.*

tries for SDG7 indicators related to access to electricity, access to clean cooking fuels, renewable energy share, energy intensity of economies, international finance for clean energy, and renewable electricity-generating capacity, respectively.

The *first part* of the analysis categorizes the MENA countries into respective geographical sub-regions and income levels. The boundaries of the MENA region, as defined by the World Bank [10][11], encompass the 22 member countries of the League of Arab States which we have grouped into four sub-regions – Gulf (A), Levant (B), North Africa (C), and Least Developed (D) – along with Iran, Israel, and Malta which have been considered under a fifth sub-region – Non-Arab (E). We have also included Türkiye in the latter due to its significant influence and close interconnections with the countries of the region. Of these 26 countries, a total of 8 are classified as high-income, 14 (9 lower- and 5 upper-) as middle-income, and the remaining 4 as low-income.

The *second part* of the analysis examines the existing and announced national plans that crosscut sustainable development and climate action objectives in the MENA region. This is given within the framework of the SDGs – monitored through Voluntary National Reviews (VNRs) – and the Paris Agreement – monitored through Nationally Determined Contributions (NDCs) and Long-Term Strategies (LTSs) for the NZEs target – to highlight policy gaps in current energy governance of the surveyed countries. For the 2030 agenda, all countries report progress toward sustainable development in a periodic cycle, except for Iran – Non-Arab (E) – which has not submitted any VNRs. Regarding the 2050 agenda, all countries have NDCs except Libya – North Africa (C) – with the most recent commitment submitted in November 2024 by the United Arab Emirates through its third NDC version. As for LTSs, only six countries (Gulf (A): United Arab Emirates and Oman, North Africa (C): Morocco and Tunisia, Non-Arab (E): Malta, and Türkiye) have made official commitments, with the most recent submission given in November 2024 by Türkiye. For the NZEs target, 11 countries (out of 26) have yet to make any form of net-zero commitment, including Gulf (A): Qatar, Levant (B): Iraq, Jordan, Syria, and Palestine, North Africa (C): Egypt, Libya, Algeria, and Morocco, Least Developed (D): Yemen, and Non-Arab (E): Iran. Meanwhile, the remaining 15 countries have made varying commitments, either through policy (Gulf (A): Saudi Arabia, United Arab Emirates and Oman, North Africa (C): Tunisia, and Non-Arab (E): Malta and Türkiye), pledges (Gulf (A): Kuwait and Bahrain), or ongoing discussions (Levant (B): Lebanon, Least Developed (D): Sudan, Djibouti, Somalia, and Mauritania), and Non-Arab (E): Israel), with Comoros – Least Developed (D) – being the only country that has declared reaching a state of NZEs. No NZEs target has been legislated across the region, meaning that no country within the MENA has formally established a legally binding commitment to achieve NZEs by a specific date. While many countries have made voluntary climate commitments, these are not backed by enforceable legal frameworks. This highlights a gap in the region's policies regime, where ambitious goals may lack the necessary legal structures to ensure long-term accountability and implementation, leaving them susceptible to future policy shifts or political changes.

The *third part* of the analysis calculates the Compound Annual Growth Rate (CAGR) for each indicator over a set period of two decades (2000-2021) to reflect the extent to which countries have progressed towards achieving SDG7. The overall trend is defined on the basis of the average CAGR across indicators, with positive values indicating growth and negative values signaling regression. Accordingly, the ranking of countries' performance is determined by a three-level scheme (sustained, neutral or declining progress) based on their attained scores, allowing for a comparative analysis of their progress relative to one another.

- ↑ A total of 13 (out of 26) countries – including Oman (58.07%), Kuwait (30.85%), Malta (29.90%), Libya (23.79%), United Arab Emirates (23.38%), Palestine (23.26%), Somalia (19.45%), Saudi Arabia (15.2↑0%), Jordan (12.08%), Israel (11.75%), Yemen (11.45%), Djibouti (8.03%), and Bahrain (7.57%) – scored the highest demonstrating *"sustained progress"* towards SDG7 with all countries showing a positive performance across the six indicators. The progress of high-income countries (Gulf states, Israel, and Malta) is primarily driven by advancements in renewable energy systems. For the remaining countries (Palestine, Jordan, Libya, Somalia, Yemen and Djibouti), progress is largely due to the expansion of renewable energy generation capacity followed by international financing to advance clean energy transitions.
- → A total of 11 (out of 26) countries – including Lebanon (4.93%), Egypt (2.46%), Tunisia (2.40%), Morocco (2.02%), Mauritania (1.88%), Türkiye (1.88%), Comoros (-0.55%), Iraq (-0.55%), Qatar (-1.83%), Algeria (-2.59%), and Sudan (-3.18%) – demonstrate *"stable progress"* towards SDG7. Rather than showing consistent advances in a particular domain, these countries experience a mix of positive and negative fluctuations across the various indicators. In many cases, minor improvements in specific indicators are offset by slower growth or weaker performance in others. This pattern suggests that while incremental progress is being made, none of these countries have achieved significant gains across all fronts, highlighting the need for more targeted interventions to enhance the overall performance of respective energy systems. In high-income countries like Qatar, decline in progress is primarily attributed to the limited integration of renewable energy into the national energy mix. For Mauritania, Comoros, Iraq, Algeria, and Sudan, the main factor driving the decline is the lack of green financing mechanisms for clean energy initiatives, followed by lack of renewables in energy mix and the persistence of high energy-intensity economies, respectively. For the remaining countries (Lebanon, Egypt, Moroc-

Table 2: Comparative analysis of MENA countries with respect to SDG7 as a measure to eradicate regional energy poverty (Source: Data referenced from [12]).

Part I – Geographical and Income Classification				*Part II – Existing & Announced National Plans*				*Part III – SDG7: "Ensure access to affordable, reliable, sustainable and modern energy for all"*															
				SDGs	Paris Agreement			T.7.1						T.7.2			T.7.3			T.7.a			T.7.b			
Code	Geographical Sub-Regions	Country	Income Level	VNRs [13]	NDCs [14]	LTSs [15][16]	NZEs (Target Year and Status) [17]	I.7.1.1 (% population-electricity)			I.7.1.2 (% population-clean cooking)			I.7.2.1 (% renewable consumption)			I.7.3.1 (megajoule per $2017 PPP GDP)			I.7.a.1 (billions of constant 2021 US$)			I.7.b.1 (renewable watts per capita)			CAGR, % (Overall Trend)
								2000	2010	2021	2000	2010	2021	2000	2010	2021	2000	2010	2021	2000	2010	2021	2000	2010	2021	
1.	Group A: Gulf	Saudi Arabia	High	☐ (2023)	☐ (2021)	☐	☐ (2060, Policy)	100.00	100.00	100.00	100.00	100.00	100.00	0.01	0.01	0.08	5.14	6.70	5.81	–	–	–	0.02	0.08	12.31	15.20% (↑)
2.		United Arab Emirates	High	☐ (2022)	☐ (2024)	☐ (2023)	☐ (2050, Policy)	100.00	100.00	100.00	100.00	100.00	100.00	0.08	0.11	1.01	4.13	5.36	5.48	–	–	–	0.00	1.28	320.70	23.38% (↑)
3.		Oman	High	☐ (2024)	☐ (2023)	☐ (2022)	☐ (2050, Policy)	100.00	100.00	100.00	100.00	100.00	100.00	0.00	0.00	0.10	3.69	6.61	7.21	–	–	–	0.00	0.00	45.37	58.07% (↑)
4.		Kuwait	High	☐ (2023)	☐ (2021)	☐	☐ (2060, Pledge)	100.00	100.00	100.00	100.00	100.00	100.00	0.00	0.00	0.07	6.91	7.42	7.75	–	–	–	0.00	0.00	22.74	30.85% (↑)
5.		Qatar	High	☐ (2021)	☐ (2021)	☐	☐	100.00	100.00	100.00	100.00	100.00	100.00	0.08	0.13	0.03	8.91	6.26	7.20	–	–	–	0.00	0.00	8.96	-1.83% (→)
6.		Bahrain	High	☐ (2023)	☐ (2021)	☐	☐ (2060, Pledge)	100.00	100.00	100.00	100.00	100.00	100.00	0.00	0.00	0.02	10.43	9.59	9.23	–	–	–	0.00	0.56	8.20	7.57% (↑)
7.	Group B: Levant	Iraq	Upper-middle	☐ (2021)	☐ (2021)	☐	☐	96.81	98.36	100.00	70.50	95.10	99.30	0.36	1.67	1.10	13.05	5.17	4.96	0.00	158,120	980	27.20	72.74	36.62	-0.55% (→)
8.		Jordan	Lower-middle	☐ (2022)	☐ (2021)	☐	☐	99.01	100.00	99.90	99.60	99.90	99.90	2.09	2.95	11.50	4.61	3.62	3.39	0.00	6,930	24,710	2.85	2.44	194.55	12.08% (↑)
9.		Syria	Low	☐ (2024)	☐ (2018)	☐	☐	93.39	92.70	88.82	98.50	98.60	96.30	2.00	1.35	1.14	13.64	11.58	10.68	0.00	5,210	0.00	94.11	38.38	71.76	-17.19% (↓)
10.		Lebanon	Lower-middle	☐ (2018)	☐ (2020)	☐	☐ (2050, Discussion)	99.30	99.50	100.00	–	–	–	4.88	5.70	6.82	3.66	2.80	3.55	0.00	1,800	2,200	65.27	56.51	86.16	4.93% (→)
11.		Palestine	Lower-middle	☐ (2018)	☐ (2021)	☐	☐	99.70	99.90	100.00	–	–	–	17.52	14.06	15.40	2.85	2.61	3.13	40	1,500	25,270	0.00	0.00	34.71	23.26% (↑)
12.	Group C: North Africa	Egypt	Lower-middle	☐ (2021)	☐ (2023)	☐	☐	97.70	99.36	100.00	82.80	99.20	99.90	8.26	5.37	6.11	3.16	3.51	3.06	11,430	1,089,830	160,440	41.01	39.39	57.27	2.46% (→)
13.		Libya	Upper-middle	☐ (2024)	☐	☐	☐	99.80	81.90	70.21	–	–	–	2.05	2.50	3.12	4.65	4.18	5.26	0.00	0.00	5,560	0.00	0.57	0.94	23.79% (↑)
14.		Algeria	Upper-middle	☐ (2019)	☐ (2015)	☐	☐	98.64	98.91	99.79	96.90	99.20	99.70	0.43	0.26	0.12	4.25	4.49	5.61	0.00	430	100	8.99	7.04	13.29	-2.59% (→)
15.		Morocco	Lower-middle	☐ (2020)	☐ (2021)	☐ (2021)	☐	69.81	95.73	100.00	90.20	96.50	98.20	15.54	13.87	10.90	3.35	3.21	3.14	290	8,720	1,290	42.98	48.09	98.12	2.02% (→)
16.		Tunisia	Lower-middle	☐ (2021)	☐ (2021)	☐ (2022)	☐ (2050, Policy)	94.80	99.50	99.90	93.60	99.30	99.90	14.24	12.61	11.58	4.05	3.77	3.81	4,830	143,240	20,520	7.43	10.78	33.10	2.40% (→)
17.	Group D: Least Developed	Sudan	Low	☐ (2022)	☐ (2021)	☐	☐ (2050, Discussion)	23.00	35.99	61.77	7.40	31.90	62.80	80.42	61.31	60.98	4.51	3.26	4.83	0.00	93,380	290	14.79	42.06	39.79	-3.18% (→)
18.		Comoros	Lower-middle	☐ (2023)	☐ (2021)	☐	☐ (2050, Achieved)	39.79	69.66	87.94	0.50	3.20	11.30	69.87	66.02	41.19	2.79	2.78	4.27	0.00	0.00	40	0.00	2.21	1.76	-0.55% (→)
19.		Djibouti	Lower-middle	☐ (2022)	☐ (2015)	☐	☐ (2050, Discussion)	55.96	57.87	65.44	3.90	6.30	9.60	31.44	32.54	26.56	3.75	3.55	2.08	0.00	13,540	370	0.00	0.00	18.42	8.03% (↑)
20.		Somalia	Low	☐ (2022)	☐ (2021)	☐	☐ (2050, Discussion)	2.11	52.27	49.32	0.40	1.10	3.80	93.28	93.57	95.37	12.23	7.51	6.57	0.00	0.00	150,010	0.00	0.00	1.59	19.45% (↑)
21.		Mauritania	Lower-middle	☐ (2024)	☐ (2021)	☐	☐ (2030, Discussion)	19.15	34.20	47.70	29.40	41.50	48.30	44.41	34.00	22.08	2.55	2.81	3.54	0.00	0.00	20	0.00	0.00	26.42	1.88% (→)
22.		Yemen	Low	☐ (2024)	☐ (2015)	☐	☐	49.24	60.78	74.88	55.50	59.70	61.30	0.95	0.78	3.67	2.88	3.12	2.07	1,650	350	8,290	0.00	0.04	7.79	11.45% (↑)
23.	Group E: Non-Arab	Iran	Upper-middle	☐	☐ (2015)	☐	☐	97.90	99.43	100.00	92.90	96.60	96.40	0.44	0.90	0.91	7.13	7.52	9.32	62,160	0.00	0.00	30.67	113.94	135.69	-15.02% (↓)
24.		Israel	High	☐ (2019)	☐ (2021)	☐	☐ (2050, Discussion)	100.00	100.00	100.00	100.00	100.00	100.00	5.96	8.55	6.20	3.97	3.70	2.39	–	–	–	1.08	13.48	410.14	11.75% (↑)
25.		Malta	High	☐ (2018)	☐ (2023)	☐ (2021)	☐ (2050, Policy)	100.00	100.00	100.00	100.00	100.00	100.00	0.00	1.22	8.62	2.6	2.54	1.21	–	–	–	0.00	1.91	399.27	29.90% (↑)
26.		Türkiye	Upper-middle	☐ (2019)	☐ (2023)	☐ (2024)	☐ (2053, Policy)	99.90	100.00	100.00	90.20	94.10	95.40	17.29	14.21	12.02	3.25	3.03	2.48	142,400	311,220	414,960	176.06	237.29	627.25	1.88% (→)

**Legend for Ranking Countries Performance:*

Overall Trend	Progress Level	Defined Range (%)	Interpretation
↑	Sustained	CAGR > 5	Values in this range indicate strong positive performance and improvement.
→	Stable	-5 ≤ CAGR ≤ 5	Values in this range indicate relatively neutral performance with minimal growth or decline.
↓	Declining	CAGR < -5	Values show a significant negative trend indicating major performance deterioration.

**Notes:*

[1] World Bank's 2023 income classifications categorize countries based on GNI per capita: low (≤ $1,145), lower-middle ($1,146–$4,515), upper-middle ($4,516–$14,005), and high (> $14,005) [18][19].

[2] Palestine is commonly referred to as West Bank and Gaza (the non-occupied territories) by international organizations such as the World Bank [10].

[3] The "–" denotes that data for this indicator is either unavailable or not reported for this country.

[4] CAGR(%) for I.7.3.1 (Energy Intensity) has been inverted, as a higher CAGR(%) for this indicator signifies worse performance (higher energy use per unit of GDP), for consistency in interpretation with other indicators where a higher CAGR(%) reflects positive progress towards sustainable development.

[5] Renewable energy in indicators I.7.2.1 and I.7.b.1 includes solar (photovoltaic and thermal energy), wind, geothermal, hydropower, bioenergy, and marine (ocean, tidal and wave) sources.

[6] The year in brackets for the VNRs, NDCs, and LTSs represents the latest available versions of the strategies, and for the NZEs represents the target year and current target status.

co, Tunisia, and Türkiye), the primary contributors of declining performance are the limited share of renewable energy in end-use consumption. Nonetheless, all these countries show positive progress in improving access to electricity and clean cooking fuels and technologies.

↓ A total of 2 (out of 26) countries – including Iran (-15.02%) and Syria (-17.19%) – exhibit "declining progress" towards SDG7, primarily due to the lack of financial support for developing renewable systems and associated infrastructure. Energy intensity, a measure of energy efficiency, also remains a challenge across both countries. In fact, Syria scored the lowest progress for SDG7 across the MENA. Securing funds is critical for these territories given the destructive impact of past wars and ongoing political conflicts which have severely damaged energy infrastructure. The destruction of power plants, grids, and supply chains has left these countries heavily reliant on outdated and inefficient energy systems making it difficult to attract international investments, further hindering the development of clean energy solutions.

It can be observed that progress is being made across all indicators but to varying degrees across countries, inferring that the current rate of ambition may be insufficient and will likely fall short of reducing EP. Furthermore, the data of this analysis is based on the latest available figures for 2021 for all countries and does not account for the impact of the October 2023 Israel-Gaza war on national and regional levels, including neighboring countries such as Lebanon, Iran, and Yemen, nor the re-escalation of the recent intense conflicts in Syria since early December 2024. These ongoing conflicts may have introduced new challenges that could delay the region's progress towards eradicating EP and ultimately the broader objectives of the 2030 and 2050 agendas. Overall, each country has distinct performance patterns, underscoring the need for tailored strategies that address specific challenges within different local contexts.

3. Causes and Implications of Energy Poverty in MENA

EP is a result of the multifaceted challenges to current energy systems across the MENA region, influenced by several prohibiting factors as discussed below [5]–[7], [20]–[22]:

(1) Income Poverty and Inequality

EP in the MENA is most prevalent in countries with high rates of income poverty. Wealth is mainly concentrated in the oil-rich Gulf countries, while in other sub-regions, a small fraction of the population controls most of the wealth. Households with limited disposable income struggle to afford modern energy services, such as electricity, and the initial investment required to access these services, including the cost of an electricity connection, a new stove, or equipment for liquid fuel supplies. Income inequality further exacerbates unequal land ownership and reliance on precarious, informal employment in rural areas leading to volatile incomes that hinder energy access for many households. In many cases, illegal connections to the national grid or a neighbor's line at a low informal fee provide an alternative for households unable to afford formal services, potentially leading to a decline in electrification rates as infrastructure fails to keep up with the pressure of continuous high demand.

(2) Political Instability and Conflict

Virtually all MENA countries possess adequate energy resources that, if utilized, produced and distributed efficiently, could meet their population energy needs. However, the escalation of regional geopolitical tensions in past and recent years, particularly in countries like Libya, Egypt, Sudan, Syria, Iraq, Lebanon, and Yemen, along with the ongoing wars happening in Palestine, Lebanon and Syria (as of this writing), have severely damaged infrastructure, disrupted energy supply chains, and displaced millions. These conflicts reduce the availability and affordability of modern energy sources, and access to basic energy services for mundane activities such as cooking, heating, cooling, food refrigeration, lighting, and others. The reoccurring political uprisings, protests, and instability have impeded coordinated regional solutions for EP, as immediate humanitarian needs are prioritized over long-term energy planning and development objectives.

(3) Rural and Remote Geographies

Rural energy markets in the MENA region are small and geographically dispersed, correlating with overall poverty levels. Large rural populations in countries like Comoros, Sudan, Yemen, and Egypt are isolated from central energy grids, making network expansion technically and financially challenging. The high cost of extending transmission and distribution infrastructure to low-density areas often renders these projects economically unfeasible due to the significant investment needed. Transport and logistics, particularly across scarcely inhabited mountainous terrain, also raise the cost of local fuel supply which must either be borne by suppliers or local communities despite national price controls. This leaves many disadvantaged and energy-poor communities reliant on traditional energy sources like biomass and diesel generators, which are costly and have negative environmental and health impacts.

(4) Energy Supply Volatility

Despite over 90% of the MENA population having access to electricity in 2021, service disruptions in the electricity sector are common, especially in conflict-affected countries and those hosting large refugee populations. Insufficient generation capacity, underinvestment in maintenance/upgrading of outdated transmission and distribution infrastructure, and illegal grid connections overload the system and exacerbate frequent outages. In rural areas, access is limited and intermittent, with mini-grids supplying electricity for only a few hours a day. Recurring shortages force households and businesses to resort to backup noisy and polluting private generators fueled by diesel or

fuel oil at substantial cost, where the additional burden to households' expenditure is more than twice that of normal grid-based electricity. Low-income households are the least able to afford backup generation and thus are left behind.

(5) Influence of Tradition and Custom

Custom and convenience significantly influence households' energy choices in the MENA region. Income gains and fuel availability do not automatically translate to a shift up the energy ladder due to factors that can dampen consumers' interest in modern fuels like personal preferences, perceived fuel supply unreliability, price volatility, and switching costs. In rural MENA areas, household time management and the distribution of household tasks are often shaped by time-honored traditions, including the ancestral division of labor that assigns women and children the responsibility of collecting biomass and firewood locally. These deeply ingrained customs contribute to the continued reliance on traditional fuels and a general perception that modern fuels like electricity necessitate changes in cooking habits and equipment. Households relying on traditional fuels, especially in areas with low education and limited media access, face severe health risks and environmental damage (such as deforestation), due to insufficient information. Cultural norms, combined with income barriers and a lack of public awareness about the long-term benefits of clean energy, prevent many households from transitioning to affordable modern fuels.

(6) Energy Demand Growth

The region has experienced an unprecedented surge in energy demand, with primary energy consumption increasing by over 112% from 2000 to 2021 [23], which is stimulated by multiple factors. The region's population has nearly doubled over the past few decades from around 341 million in 1990 to more than 658 million in 2023 [24]. The fast-growing population led to rapid urbanization which necessitates critical energy infrastructure investments in MENA countries over the next few years to meet future energy needs, but the slow pace of investment in infrastructure expansion projects poses significant long-term risks for EP. Concurrently, economic growth and industrialization, particularly in upper-middle- and high-income countries, led to rising living standards. Ineffective demand-side management, due to the lack of energy efficiency regulations and subsidized energy pricing, has also distorted energy dynamics and exacerbated EP levels across the region. Many MENA countries keep energy prices below market levels to fulfil national development objectives, without differentiating between user groups, causing high-income households to pay the same low rates as the poorest, widening the already existing social class gap. Regulated energy prices have also inhibited the adoption of efficient energy technologies where possible, causing wasteful consumption habits due to the perceived low value of energy and related products. In many countries, artificially low energy pricing schemes have led to the accumulation of fiscal burdens, which divert government spending of public funds away from pro-poor investments.

(7) Carbon-Intensive Energy Mix and Harsh Weather

The region heavily relies on fossil fuel-centered economies, primarily oil and gas, for domestic energy supply and as revenue streams, resulting in a lack of diversification in the energy mix and increasing vulnerability to persistent or even escalating levels of EP. The rising cost of hydrocarbon consumption raises concerns about the long-term affordability of the current energy mix, as depletable fossil fuels would either need to be imported in larger volumes from global markets, or hydrocarbon exports would need to be reduced which would threaten economic sustainability for many countries across the region. The high susceptibility of MENA countries to climate change risks stems from the arid conditions and extreme heat waves to which they are exposed, which impacts the structural integrity, operation, and lifespan of critical energy infrastructure. This includes a geometric rise in cooling demand which would place strain on electricity networks and lead to higher operational and maintenance costs for energy systems.

4. Policy Remedies to Eradicate Energy Poverty in MENA

The prevailing consensus is that while some progress has been made across the region, it is not enough, and we must accelerate policy efforts to advance further and faster. By rapidly accelerating progress in all components of SDG7, the MENA can eradicate EP while simultaneously moving towards NZEs for the 1.5°C pathway at the center of the Paris Agreement. This is a win-win proposition that warrants the "right to energy", asserting that every person has equitable access to affordable, reliable, sustainable, and modern energy services as a basic human right [25]. As such, the following series of policy recommendations are directed at government, business, and societal levels for the consideration of decision-makers, managers, and individuals, respectively [5]–[7], [20], [21]:

(1) Intraregional Energy Trade and Cooperation

A region-wide policy for energy system integration in MENA, aligned with international energy laws, can address growing energy demand, and enhance energy security through bilateral cross-border energy trade and cooperation. Examples include interlinking electricity grids and natural gas supply networks with neighboring countries, scaling up joint investments in clean energy technologies, and creating regional energy markets to optimize renewable potential across countries with diverse resources. These mechanisms help foster political stability and peace within the region through context-specific strategies that address security concerns by managing reliance on external energy sources and building the capacity of fragile governance structures. Establishing regional knowledge-sharing platforms and centers can also facilitate the exchange of best practices between countries. This can include benchmarks on energy efficiency, energy diversification, and advanced

technology adoption to capture opportunities in the design and implementation of energy projects and advance efforts to monitor and make decisions on EP across the region.

(2) Strengthen Public-Private Partnership (P3)

MENA countries can implement clear and comprehensive P3 laws to leverage private sector expertise for investment in clean energy by de-risking projects through financial assurances such as loan guarantees and credit enhancements, and streamlining related processes through technical assistance and feasibility studies. The law could establish a central "one-stop shop" institution to simplify procedures for obtaining regulatory licensing/permits and investment approvals, while fostering intergovernmental coordination among public institutions involved in the execution and oversight of clean energy projects. Examples include energy efficiency and infrastructure development projects aimed at strengthening transmission networks, increasing installed generation capacity, and expanding off-grid solutions, particularly in rural, underdeveloped, or conflict-affected areas. The legal framework would also mandate resilience planning as a prerequisite, requiring project planners and stakeholders to integrate climate change mitigation and adaptation considerations into the design, operation, and maintenance of clean energy projects.

(3) International and Regional Green Financing

MENA countries must prioritize strategic investment in climate-smart infrastructure across the energy system, to improve society's ability to cope with climate-related risks. Effective finance mobilization enhances the share of grant or concessional financing, attracts additional private sector investments, and implements innovative financial instruments including blended finance, green bonds, credit lines, revolving funds, along with fiscal and tax incentives dedicated to EP. Subsequent laws are imperative to mobilize international green funding by encouraging global investors to finance clean energy projects through multilateral organizations like the World Bank and Green Climate Fund. This can also be achieved through regional help from high-income countries, such as the Gulf states, whose fiscal stability endows them with financial resources to address unsustainable development patterns in their own countries as well as other peer countries. The legal framework should clarify the country's energy requirements to financing bodies and participants for project approval including proofing processes, impact assessments, efficiency standards, eligible technologies, registration and certification, and the systems for verification, validation, reporting, and monitoring.

(4) Social Welfare and Energy Pricing Reforms

Strengthening energy governance and institutions in the MENA to support the expansion and improvement of social welfare and safety programs enables households to overcome income poverty which directly improves EP. This can be achieved by effectively registering households, assessing their socio-economic needs, and providing accountable responses. To promote an equitable and clean energy future, suggested pricing policies should involve the careful re-adjustment and re-distribution of energy pricing reforms considering the specifics of vulnerable social groups. Gradually phasing out fossil fuel subsidies encourages the adoption of renewable energy alternatives and re-invests the savings into sustainable energy projects. Improving the governance of targeted subsidies through innovative tools, such as smart cards and micropayment schemes, bridges the rural-urban divide by ensuring equitable energy access for low-income households while advancing clean energy solutions.

(5) Improve Energy Efficiency Regulations

Policies across the MENA should aim at sustainable management of natural resources and the adoption of energy-efficient practices and technologies across key sectors of the energy systems. This can include programs for retrofitting energy infrastructure to improve performance and promoting clean cooking technologies to reduce dependence on harmful traditional biomass fuels such as wood and charcoal stoves. Another key priority is rural electrification programs to provide quality electricity services to poor households using decentralized renewable solutions, such as solar photovoltaic generators, small hydro turbines, wind turbines, grid extensions and stand-alone systems, and avoid the price volatility of fossil fuels. Renewable energy applications should extend beyond power generation by setting national targets for integrating renewables into end-uses such as heating, cooling, and transportation, supported by financial incentives and infrastructure development. Additional measures can focus on promoting a circular economy by establishing standards for end-of-life management, mandatory take-back, and waste recycling schemes. Also, developing national clean hydrogen strategies with clear regulations, incentives, and infrastructure investments can diversify export earnings and aid in emissions reduction for decarbonization purposes.

(6) Develop Local Capacity Building

Renewable energy is associated with several challenges, including supply chain issues for critical materials, limited availability of suitable land, insufficient grid infrastructure, renewable waste management concerns, slow permitting processes, and profitability concerns. Policies should invest in research and development (R&D) and promote transparent reporting to foster the growth of local renewable energy industries, identify innovative recycling technologies for material recovery, and reduce reliance on imported technologies. Building local capacity through targeted training and education programs is imperative to develop clean energy skill sets and innovation. MENA countries with established electrical and mechanical industries can undertake feasibility assessments to explore the manufacturing potential of renewable energy equipment based on domestic capacities, which in turn helps create new employment opportunities. A parallel shift to increasing public awareness and incentivizing energy-saving behavior is equally important to over-

come cultural preferences and scale up consumer motivation. Informational campaigns can protect vulnerable populations and mitigate the negative impacts of biomass use, such as poor indoor air quality and prolonged exposure to pollutants affecting women and infants. Expanding knowledge about inexpensive small-scale solutions, such as micro-hydro installations, biomass biodigesters, improved cook stoves, and guidance on proper house ventilation, can also significantly enhance consumption quality and improve energy access in local communities.

(7) National Databases and Monitoring Regimes

To effectively map and address rising patterns of EP across the region, national authorities should first develop clear, conceptual, and transparent national statistical databases that detect and outline specific landscapes of vulnerability through country-specific analyzes of the various environmental, economic, social, and political threats to energy security. Subsequent response programs can follow with definite objectives for energy access, coupled with monitoring regimes based on well-established metrics, expanding beyond the definitions governed by SDG7, to manage and track progress in EP levels throughout the MENA region. Some commonly used metrics to effectively measure EP include single indicators such as 10%, Twice the National Median (2M), Minimum Income Standard (MIS), Low Income High Cost (LIHC), After- Fuel-Cost Poverty (AFCP), and composite indicators such as the Multidimensional Energy Poverty Index (MEPI) and Multi-Tier Framework (MTF), among various others [2], [3], [26]–[28]. Such an operational framework effectively evaluates the practical efficiency of energy justice programs and monitors progress based on predetermined timelines. It also helps resolve conflicting or overlapping strategies and rules across the different governing sectors and institutions and allows for the development of coherent programs that eliminate inconsistencies.

To this end, the proposed policy solutions emphasize achieving SDG7, which in turn enables mitigation and adaptation action to combat climate change in favor of the Paris vision while also catalyzing progress towards the attainment of other SDGs. This is because strong interlinkages, both direct and indirect, have been proven between SDG7 and all the other goals [29]–[35], notably SDG1 (“No Poverty”), SDG3 (“Good Health and Well-being”), SDG4 (“Quality Education”), SDG5 (“Gender Equality”), SDG8 (“Decent Work and Economic Growth”), SDG9 (“Industry, Innovation and infrastructure”), SDG11 (“Sustainable Cities and Communities”), SDG12 (“Responsible Consumption and Production”), SDG13 (“Climate Action”), and SDG15 (“Life on Land”). This implies policy frameworks should be designed in an integrated fashion to maximize synergies and minimize trade-offs between and across the different SDGs for the effective and timely attainment of the objectives of approaching global agendas. The latter calls for coordinated action from all relevant stakeholders at national and regional levels to acknowledge these implications and seize opportunities for integrated energy policy planning, formulation, and management across the MENA.

Footnotes

[1] Following the Millennium Development Goals (MDGs) (2000-2015), the SDGs were adopted in September 2015, implemented on January 1, 2016, and are monitored through the Voluntary National Reviews (VNRs). Concurrently, the Paris Agreement was adopted on December 12, 2015, came into force on November 4, 2016, and is monitored through the Nationally Determined Contributions (NDCs)

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