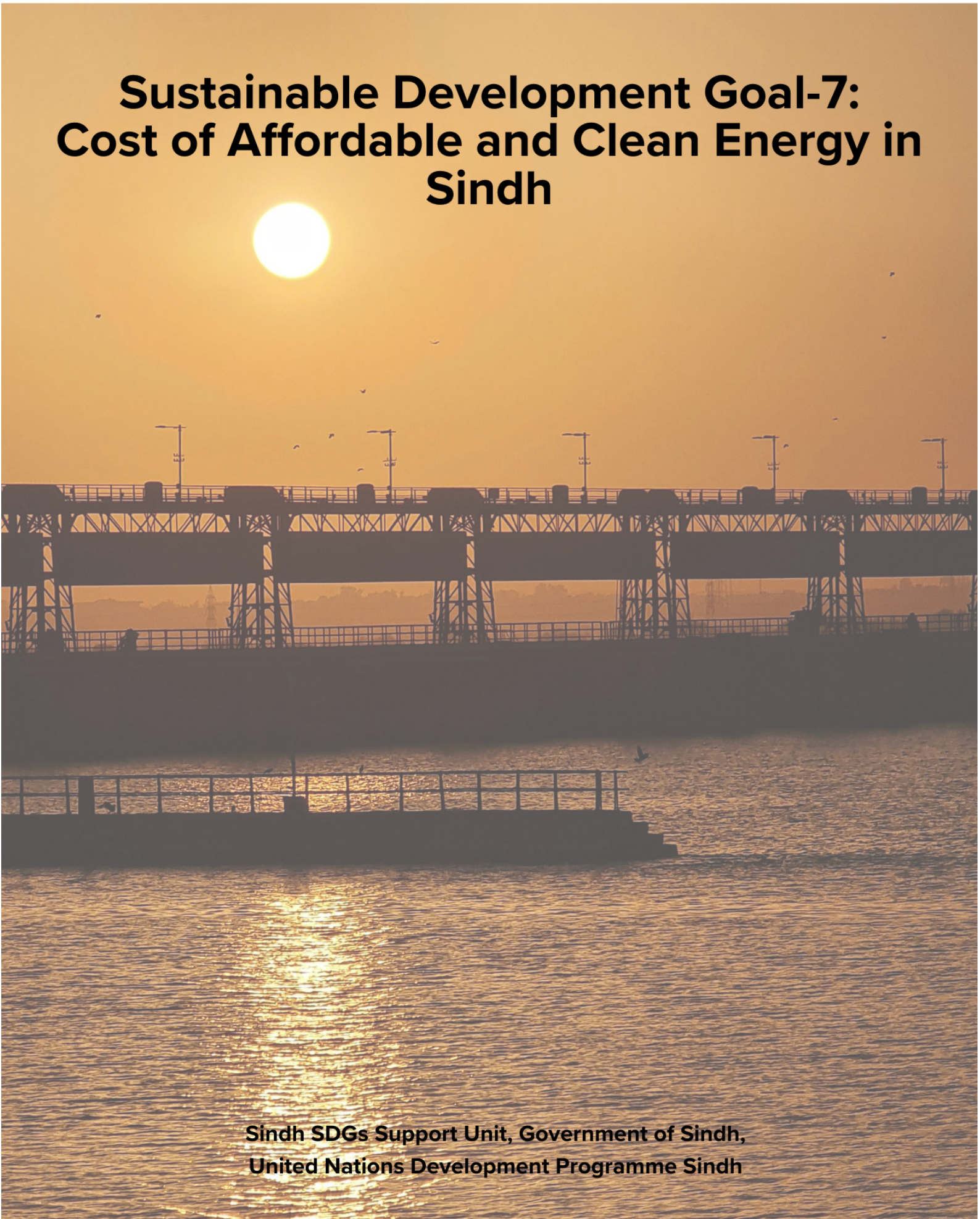
SDGs Support Unit
Planning & Development Board Government of Sindh

Sustainable Development Goal-7: Cost of Affordable and Clean Energy in Sindh



Sindh SDGs Support Unit, Government of Sindh,
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Abbreviations and Acronyms

ACEEE	American Council for an Energy-Efficient Economy
ADB	Asian Development Bank
CAGR	Compound Annual Growth Rate
CAPEX	Capital Expenditure
CPS	Current Policy Scenario
CTBCM	Competitive Trading Bilateral Contract Market
DFI	Development Financial Institutions
DISCO	Distribution Company
GCF	Green Climate Fund
GDP	Gross Domestic Product
GEF	Global Environment Facility
GFEI	Global Fuel Economy Initiative
GHG	Greenhouse Gases
GoP	Government of Pakistan
GoS	Government of Sindh
GWh	Giga-Watt hour
HESCO	Hyderabad Electric Supply Company
ICS	Improved Cook Stoves
IGCEP	Indicative Generation Capacity Expansion Plan
IPP	Independent Power Producer
IRENA	International Renewable Energy Agency
KE	K- Electric
LNG	Liquified Natural Gas
LPG	Liquified Petroleum Gas

MECS	Modern Energy Cooking Services
MICS	Multiple Indicator Cluster Survey
MJ	Megajoule
MTOE	Million Tonnes of Oil Equivalent
NDC	Nationally Determined Contributions
NEECA	National Energy Efficiency and Conservation Authority
NEPRA	National Electric Power Regulatory Authority
NTDC	National Transmission & Despatch Company
OECD	Organisation for Economic Cooperation and Development
OPEX	Operating Expenses
PSLM	Pakistan Social and Living Standards Measurement
SDG	Sustainable Development Goal
SEECA	Sindh Energy Efficiency and Conservation Authority
SEPCO	Sukkur Electric Power Company
SHS	Solar Home Systems
SSEP	Sindh Solar Energy Project
T&D	Transmission and Distribution
TPEC	Total Primary Energy Consumption
UNDP	United Nations Development Programme
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific
VEP	Village Electrification Project
VRE	Variable Renewable Energy
WHO	World Health Organisation

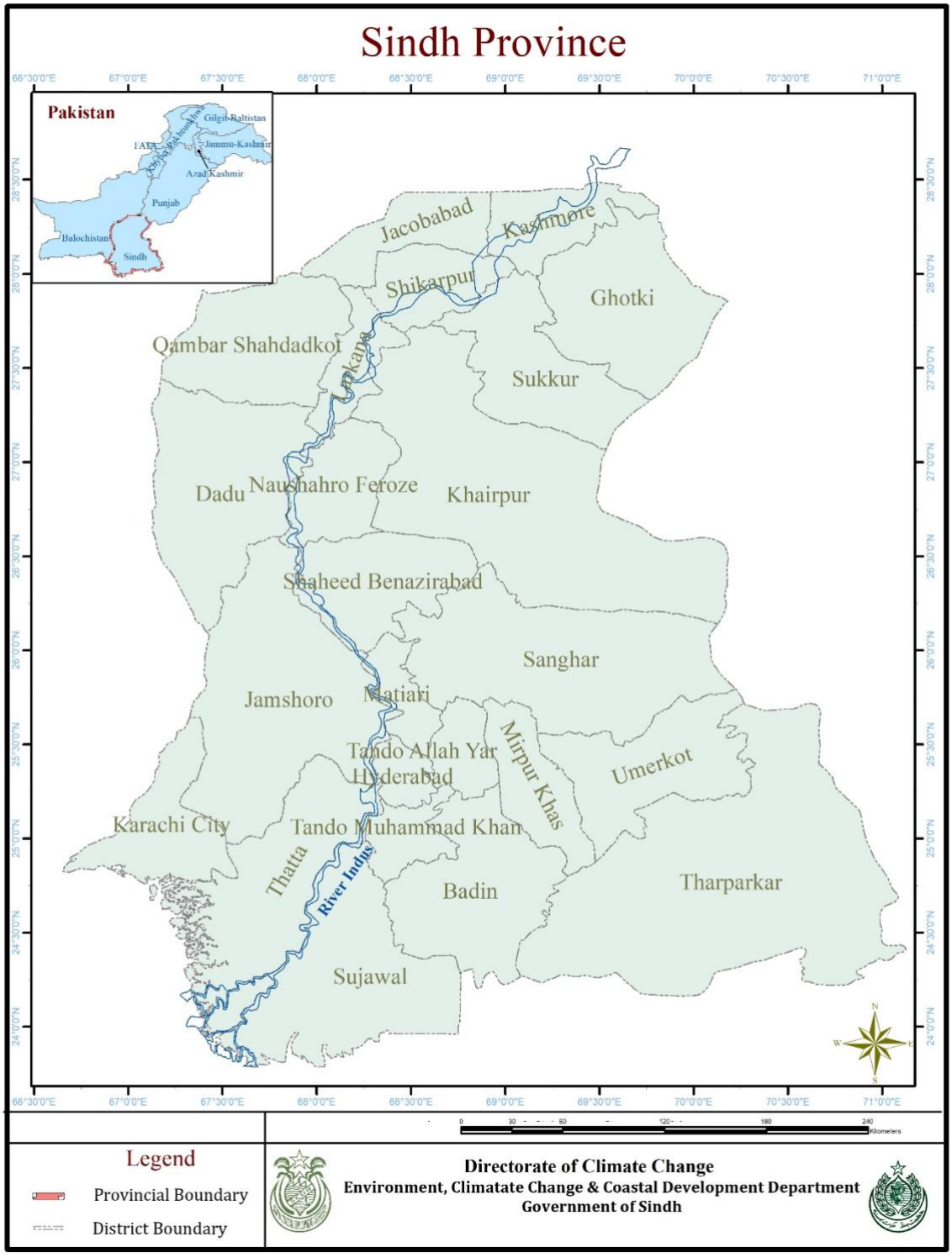

Figure 1: Sindh Provincial Map. (Source: GoS)

Executive Summary

- This report provides an estimated investment required to achieve the goals for SDG 7, "Clean and Affordable Energy," in the province of Sindh by 2030. The period for investment is considered to be 2023 to 2030 (8 years).

- Sindh's total primary energy consumption is expected to increase from 12.9 MTOE (existing demand) to 21 MTOE by 2030. Currently, 98% of energy in Sindh is dependent on fossil fuels.

- Sindh is the second largest province of Pakistan in terms of population with a geographic terrain that experiences extreme heat and cold temperatures, and a coastal belt of 330 KM.

- Sindh is naturally endowed with primary energy sources such as gas (largest contributor to Pakistan's overall gas production), coal (one of the largest deposits in the world), wind corridor and ample solar irradiation.

- Access to electricity is ~86% and the model estimates 4 million households (0.5 million per year) would need to be provided access to electricity by 2030. Expected electricity demand to be around 35,000 GWh by 2030 compared to 2021 consumption of ~21,000 GWh in DISCOs within Sindh.

- Access to clean fuels is 50%; model estimates ~6 million households (0.55 million per year) would require access to clean cooking by 2030.

- Current share of renewables would need to increase from 2,200 GWh to 10,700 GWh by 2030. This translates to an investment of 3.4GW of Wind & Solar.

- Current energy intensity needs to improve from 5.2 MJ/$ to 3.7 MJ/$

- The cost model shows that a total sum of USD 8.2 Billion is required to achieve the overall goals of SDG 7 bifurcated over the various components as follows:
    - 7.1.1 – Universal access to electricity requires USD 3.5 billion (PKR 880 billion)

    - 7.1.2 – Universal access to clean cooking requires USD 0.5 billion (PKR 125 billion)
    - 7.2 – Share of renewables in energy (20% variable renewable electricity as part of the overall electricity mix) requires USD 2.9 billion (PKR 558 billion)
    - 7.3 – Achieving 2.6% improvement in energy intensity to achieve 4MJ/US$ by 2030 requires USD 1.9 billion (PKR 494.7 billion)

- The total investment means that 1% of annual GDP would needs to be spent to achieve these goals by 2030

- Total public sector spending from 2019 to 2023 (development and non-development) in the energy sector has been PKR 164 million which requires a significant increase to achieve nearly PKR 2 trillion by 2030 to achieve the targets.

Limitations of the Study

This study aims to provide the best available information to assess the overall costing required to implement the SDG 7 goals in Sindh, the following limitations of this report should be kept in mind:

1. The report primarily relies on secondary data. The study has relied on authentic and official data sources such as the PSLM 2019-20, Pakistan Energy Year Book, Multi-Cluster Survey. Most of the surveys such as the PSLM and MICS are also based on sample sizes that project outputs on the overall population. The report was written with the latest available versions at the time of making the costing models.
2. Limited number of interviews have been conducted within the relevant departments. There are multiple stakeholders and overlapping jurisdictions for electricity, renewable energy and energy efficiency within the federal and provincial domains.
3. The study makes best estimates of overall costs per provision of such services to households when it comes to clean fuels. Average available cost of renewable electricity generation is considered when increasing the share of renewables and average cost of intensity.
4. Benchmarks for energy intensity and energy efficiency costing are scarce; the costing requires a deep dive into sectoral share pertinent to the province of Sindh along with its costing. Furthermore, there are overlapping costs & benefits from other targets achieved within SDG 7 such as renewable, clean cooking and access to electricity which runs the risk of double costing. Benchmark estimates have been provided.
5. Electricity forms a major part of the entire energy mix impacting multiple SDG indicators such as access to electricity, share of renewables and energy intensity. Pakistan's electricity market at the time of publishing this report is undertaking a shift towards CTBCM which will require Distribution Companies the authority to directly procure power from power generators rather than being bound by a single-buyer model which restricted the Sindh based DISCOs to the national energy mix. For the purpose of this study, the impact of CTBCM is not being accounted for and all historical trends and national energy mix is being accounted for in the calculations.

   Political uncertainty and turbulent economic conditions with drastic changes in fundamental variables such as PKR-USD parity at the time of this report writing has been a challenge.

1. Introduction and Background

The Government of Pakistan in line with global international commitments is committed to achieving its SDG agenda by 2030. In view of such commitment, the Government established an SDG support unit at the Ministry of Planning, Development and Reforms with the assistance of UNDP Pakistan. In order to implement these goals, the Sindh SDG support unit works in alignment with the National committee to coordinate, mainstream, implement and monitor progress at the local level. Given the priorities of the province, SDG 7 - clean and affordable energy - is one of the areas that has been approved by the Government of Sindh to be furthered as a priority in alignment within the larger development context of the province.

SDG 7 is one of the critical components in the overall sustainable development strategy. Providing affordable, reliable and clean energy is imperative to providing basic human rights, improve standard of living, ensure opportunities for equitable economic growth and reduce carbon emissions. The aim of this study is to provide an estimate of the total investment required from 2023 to 2030 to meet the targets defined as per the SDG 7 "affordable and clean energy" and identify sources of available funding.

1.1 Methodology

The study aims to build a costing model for achieving indicators within SDG 7. Publicly available data has been used to build a model that forecasts Sindh's energy consumption and mix by 2030. Official sources such as Pakistan Energy Yearbook, NEPRA state of Industry Reports and other publicly available industry sources were used to ascertain key variables. Detailed costing methodology for each section is provided later in the report.

Key personnel in the Provincial and Federal government were interviewed particularly in the Sindh Energy Department and Planning & Development, as well as the private sector were consulted to take their inputs and guidance.

1.2 SDG 7 - Introduction and Definitions

Sustainable Development Goal (SDG) 7 is one of 17 SDGs set by the United Nations under "Transforming our world: the 2030 agenda for sustainable development" which are critical towards improving standards of living, improving equity and prosperity, promoting peace and

protecting the planet. SDG 7 ensures access to affordable and clean energy which is imperative to enable human and economic development.

In 2019 it was estimated that 1/3rd of the world's population (2.6 billion) still uses dangerous and inefficient cooking systems, and 759 million people lack access to electricity. After understanding the current climate and environmental issues, it can be observed that the use of unclean energy and industrial pollution is a direct root cause of this crisis.[1]

SDG 7 breaks down the targets and agenda into the following sub-components[2]

- 7.1 'ensuring access to affordable, reliable and modern energy services' is split into 2 indicators.
    - 7.1.1 refers to the proportion of population with access to electricity- in terms of percentage of population in rural and urban areas that have access to consistent sources of electricity.

    - 7.1.2 focuses on the proportion of the population that relies on clean fuels and technology for use in cooking, heating and lighting as compared to the total population that uses energy for cooking, heating and lighting in any form (clean, traditional etc). Clean energy is defined by the WHO based on its emission rate targets and specific fuel recommendation for indoor air quality. [2]

- 7.2 was set to substantially increase the share of renewables in the global energy mix by 2030. This is indicated by the percentage of energy derived from renewable resources in the total final energy consumption. These renewable energy resources include: hydro, solar (PV and solar thermal), wind, geothermal, biogas (as well as solid and liquid biofuels i.e. biogasoline, bagasse, fuelwood, animal waste etc), marine and renewable (municipal) waste. This target focuses on the amount of renewables actually consumed instead of their capacity of production as it is not fully utilised. This helps narrow down the focus on the end consumer so as to eliminate any significant energy losses during production.

[1] Department of Economic and Social Affairs, United Nations, "Goal 7: Ensure access to affordable, reliable, sustainable and modern energy for all" (2022), https://sdgs.un.org/goals/goal7
[2] Statistics Division- United Nations, "SDG Indicators- Metadata Repository" (2022), https://unstats.un.org/sdgs/metadata/?Text=&Goal=7&Target=

- Target 7.3 specifies doubling the global rate of improvement in energy efficiency. This is indicated by measuring the energy intensity in terms of primary energy and GDP. Energy intensity is defined as the energy supplied to the economy per unit value of economic output. It can however be affected by a number of factors such as climate, nature of economic activities and the structure of economy.

- The global target, 7.a, set for SDG 7 is to 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. The indicator for this target is the international financial flows sent to developing countries to support their clean energy research and development and renewable energy production, including in hybrid systems. This includes 2 types of financial aids; the Organisation for Economic Cooperation and Development (OECD) gives out official grants, loans and equity investments to developing countries by foreign governments and multilateral agencies. The IRENA also gives out additional support in grants and loans given by foreign governments, multilateral agencies as well as development finance institutions.

- Target 7.b focuses on expanding infrastructure and upgrading 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, by 2030. This is indicated in watts per capita of installed capacity of power plants producing energy using renewable energy sources in developing countries. The capacity is defined as the net maximum electrical capacity installed at the year-end. As electricity only accounts for a fraction of the total energy use, this indicator does not take into consideration the technologies used to produce heat and provide energy for transport.

The targets and indicators for SDG7 are summarised in the table below.

Table 1: SDG 7 targets and Indicator (Source: SDGs Sindh Framework)

SDG Target (2030)	Target	SDG Indicator
7.1) Access to affordable, reliable	Universal access (100%)	7.1.1) Proportion of population

and modern energy services.		with access to electricity 7.1.2) Proportion of population with primary reliance on clean fuels and technology
7.2) Increase substantially the share of renewable energy in the global energy mix.	No global quantitative milestone; Nationally Determined Contributions can be a benchmark	7.2.1) Renewable energy share in the total final energy consumption
7.3) Double the global rate of improvement in energy efficiency.	Annual efficiency improvement of 2.6%. Progress so far has been 1.9% which requires an accelerated rate of 3.2% to reach target and 4% to reach net zero emissions from energy sector	7.3.1) Energy intensity measured in terms of primary energy and GDP
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	No quantitative target of financial flows to developing countries	7.a.1) Mobilized amount of United States dollars per year starting in 2020 accountable towards the $100 billion commitment
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 and small island developing States		7.b.1) Investments in energy efficiency as a percentage of GDP and the amount of foreign direct investment in financial transfer for infrastructure and technology to sustainable development services

According to the 2022 edition of Tracking SDG 7: The Energy Progress Report[3], the world is not on track to achieve its targets for 2030, predominantly due to COVID-19. The pandemic has impeded advancements in most regions but countries that are more vulnerable and have

[3] Tracking SDG 7, "The Energy Progress Report" (2022), https://trackingsdg7.esmap.org/data/files/download-documents/sdg7-report2022-full_report.pdf

been lagging in this department, have been adversely affected. In Asia and Africa, over 90 million people who had recently gained access to basic electricity can no longer afford to pay for it. The effects of the pandemic were not only limited to lockdowns and disorder in the global supply chain market but the decreasing GDPs of the countries had forced the governments to allocate an unprecedented amount of fiscal resources to the food and fuel divisions to retain reasonable prices.[4] Consequently, this further slowed down the progress of the SDG 7 plans globally as the appropriation of recovery funds was not significant in developing and underdeveloped countries.

1.3 Energy Mix of Pakistan

Pakistan's overall energy mix is highly dependent on fossil fuels which are imported causing a double drain on environmental and financial resources. Natural gas, considered as a bridge fuel to renewables and relatively cleaner compared to oil and coal, is now on the decline in Pakistan as dwindling gas reserves has forced Pakistan to import Liquified Natural Gas (LNG). 42% of Pakistan primary energy supply is imported. Pakistan's primary energy supply is 80.6 MTOE while its primary energy consumption is around 52 MTOE.

Table 2: Total Energy Supply in Pakistan (Source: Pakistan Energy Yearbook 2020)

	Total Primary Energy Supplies by Source (MTOE)						
	2014-15	**2015-16**	**2016-17**	**2017-18**	**2018- 9**	**2019-20**	**ACGR**
Oil	24.97	25.28	27.37	26.90	21.57	18.19	-6.10%
Gas	29.98	30.46	30.16	29.85	29.32	26.66	-2.30%
LNG Import	0.47	2.40	4.46	7.49	8.91	8.32	77.50%
LPG	0.46	0.91	1.01	1.05	0.95	1.03	17.50%
Coal	4.95	5.07	6.48	10.93	12.93	14.71	24.30%
Hydro Electricity	7.75	8.27	7.68	6.67	6.53	8.02	0.70%
Nuclear Electricity	1.39	1.10	1.67	2.36	2.37	2.58	13.30%
Renewable Electricity	0.19	0.37	0.64	0.92	1.12	0.99	38.90%
Imported Electricity	0.11	0.11	0.12	0.13	0.12	0.12	3.00%
Total	70.26	73.97	79.58	86.30	83.81	80.62	2.80%
Annual Growth Rate	5.1%	5.3%	7.6%	8.4%	-2.9%	-3.8%	

[4] The World Bank, "COVID-19 Slows Progress Toward Universal Energy Access" (2022), https://www.worldbank.org/en/news/press-release/2022/06/01/report-covid-19-slows-progress-towards-universal-energy-access

Table 3: Energy Consumption in Pakistan (Source: Pakistan Energy Yearbook 2020)

	Final Energy Consumption (MTOE)						
	2014-15	**2015-16**	**2016-17**	**2017-18**	**2018-19**	**2019-20**	**ACGR**
Oil	13.85	16.29	17.90	19.26	17.36	16.36	3.40%
Gas	15.76	15.54	17.03	16.69	17.28	15.94	0.20%
Coal	4.63	4.98	6.10	8.94	10.29	9.84	16.30%
Electricity	6.99	7.36	7.78	8.71	8.91	8.83	4.80%
LPG	0.76	1.21	1.31	1.39	1.15	1.20	9.60%
Total	41.98	45.39	50.12	54.99	55.00	52.17	4.40%
Annual Growth Rate	5.4%	8.1%	10.4%	9.7%	0.0%	-5.1%	

Around 70% of Pakistan's Total Primary Energy Consumption is based on fossil fuels.[5]

Pakistan is a signatory to international commitments made towards decreasing GHG including the Paris Climate Agreement and recently the COP 26. Pakistan's 2021 revised National Determined Contribution (NDC) commit to reduce its GHG emissions by 50% and mandate that:

1. By 2030 60 % of all energy produced in the country will be generated from renewable energy resources and that (from 2020) new coal power plants are subject to a moratorium, and no generation of power through imported coal shall be allowed, shelving plans for two new coal fired power plants (saving 1.7 MTCO2.e) in favour of hydroelectric power and focusing on coal gasification and liquefaction for indigenous coal.[6]
2. 30% of all new vehicles sold will be Electric Vehicles (EV) by 2030[7]
3. Investments will be made in nature based solutions particularly under those in the Ten Billion Tree Tsunami Project

The commitments made towards increase in renewables and mobility play their part directly towards improving the targets specified in SDG 7 particularly share of renewables, improving energy intensity and access to electricity. The commitments need to be backed by action as well as availability of finance.

[5] More than 60% of the electricity generation is based on fossil fuels which is added separately to the final energy consumption provided separately for fossil fuels.
6 Updated Nationally Determined Contributions 2021, submitted by Government of Pakistan to UNFCCC
[7] Ibid

1.4 Access to Electricity

Access to electricity as enshrined in SDG 7.1.1 is considered as the access to affordable and reliable electricity. The access to electricity rate globally has improved from 83% in 2010 to 93.6% in 2021.[8] Currently there are still 733 million people unserved with the rate of growth slowing due to the complexity of reaching populations in far-off and isolated locations. The SE4All report estimates that the world requires $41 billion annual investment till 2030 to achieve the goal for universal access to electricity (~$550-$600/beneficiary)

Pakistan's electricity access stands at 91% based on the last PSLM 2019-20. According to the NEPRA State of the Industry Report 2021, around 31,000 villages across Pakistan are still unelectrified out of which ~9,200 are within the domain of DISCOs in Sindh (SEPCO, HESCO & KE). Based on current trends, Pakistan could achieve universal access to electricity by 2027.

Access to electricity is critical to economic development, poverty alleviation and equitable social uplift. Apart from the lack of access to electricity, Pakistan's per capita annual electricity consumption of 644 kWh is one of the lowest in the world.[9]

The role of renewables is key in providing access to the pockets of population that are still unelectrified. The future strategy of bringing such households within the electrified base needs to have a consideration of affordability as well. There are primarily three ways of providing such access on a least-cost approach basis:

1. Grid extension and grid densification; stretching the existing grid infrastructure within the domain of the distribution companies to include nearby populations.
2. Mini-Grids; isolated grids which could be setup with on-site generation (generally renewables + baseload from fossil fuels and/or biomass) and a distribution network including a grid management system and billing mechanism. These mini grids can later be integrated within DISCOs based on their expansion in areas where these microgrids exist.

[8] Energy Transition Pathways for the 2030 Agenda
SDG 7 Road Map for Pakistan
http://www.indiaenvironmentportal.org.in/files/file/SDG7%20Roadmap%20for%20Pakistan.pdf
[9] According to NEPRA State of Industry Report 2022; this is 18% of the world average.

3. Stand-alone home systems; these are usually the solar home systems that provide solar based generation and basic storage along with lighting and cooling appliances that are plugged in.

In 2019 around 39 million people had access to electricity through tier-1+ decentralized renewables-based systems, out of which 21.1 million relied on 11-50 watts solar home systems (SHS) and 6.9 million through SHS > 50 watts. The rest were connected to mini-grids based on solar PV, hydro, and biogas.[10]

1.5 Access to Clean Cooking Solutions

Most of the readily available fuels in nature are solid fuels which have traditionally been used to burn and generate heat for cooking. These solid fuels include sources such as wood, charcoal, biomass or kerosene oil which are inefficient and emit fumes that cause household (mostly indoor) air pollution which are harmful for human health. The progress so far has been really modest; according to the SDG 7 Tracker report 2022 the number of people lacking such access to clean cooking solutions was 3 billion in 2010 which reduced to 2.4 billion in 2020. Most of this burden is disproportionately impacting women and children who are exposed to such activities in performing such domestic chores. The World Health Organisation (WHO) estimates 3.2 million deaths per year in 2020 (globally) including 237,000 deaths of children under 5.[11]

While "access" to clean fuels was generally considered as a binary question of whether a household uses clean fuel, the Modern Energy Cooking Services (MECS) uses a multi-tier framework for measuring access. This includes:

1. Exposure (personal exposure to pollutants depending on stove emissions and ventilation)
2. Efficiency (combustion and heat transfer)
3. Convenience (time spent collecting / purchasing fuel and preparing stove)
4. Safety (severity of injuries caused by the stove past year)
5. Affordability (share of household budget spent on fuel)

[10] IEA, IRENA et al, Tracking SDG 7, The Energy Progress Report 2022;
[11] World Health Organization, "Household air pollution and health" (2022), https://www.who.int/news-room/fact-sheets/detail/household-air-pollution-and-health

6. Availability (readiness of fuel when needed by the user)

This provides for a holistic view of access to clean cooking based on health, safety and economic outcomes intended by the use of clean fuels. Based on this definition, it was found that 4 billion people are without MECS. Only 27% in South Asia meet the criteria for access to clean cooking as defined by the multi-tier framework.[12]

Various solutions are considered when it comes to providing access to clean cooking fuels.

1. Improved cook stoves: Improved Cook Stoves (ICS) improve the thermal efficiencies which reduces the fuel required resulting in less smoke emissions and burden of collection.
2. Improved Fuels: cleaner fuel sources particularly non-solid fuels such as electricity, LPG, natural gas and biogas.

Based on global estimates, US$ 150 billion is required every year to provide access to MECS which makes the cost around $375/beneficiary. Around $39 billion will come from public sources, $11 billion by private sector and $103 billion per year from household purchases of stoves and fuels. The report also states that $10 billion per year is required to reach universal access to improved cooking services.[13] The SE4All's 2021 report on "Energizing Finance - Understanding the Landscape" report suggests that an annual investment of $4.5 billion is required for universal access to achieve this target. The tracked investment of Pakistan, Bangladesh and Myanmar is $4.9 billion, much less than the required $9.6 billion per annum.

In Pakistan, the reporting on clean fuels is generally now part of the Pakistan Social and Living Standards Measurement (PSLM). This is reported based on the type of fuel being used by the household for cooking. This SDG 7 report will continue to rely on secondary data reported within the binary domain of "access to clean cooking" rather than the expanded definition provided by the MECS multi-tier framework.

According to the PSLM 2019-20, 37% of households in Pakistan had access to clean fuels which include clean fuels for cooking, heating and lighting. The SDG 7 roadmap by UNESCAP states this number to be 49.3% in 2021 which is expected to be 59.3% by 2030, an increase of mere 10%.[14] The SDG 7 tracker report also places Pakistan as the fifth largest

[12] The World Bank, "The State of Access to Modern Energy Cooking Services" (2020),
[13] Ibid
[14] Energy Transition Pathways for the 2030 Agenda
SDG 7 Road Map for Pakistan

country in terms of population that is lacking access to clean fuels technologies. The report also states that there are no known financial commitments towards this cause as well.[15]

The PSLM reports a significant disparity existing between urban and rural areas; Sindh had a considerably higher access to clean fuels (49%)compared to Pakistan's average however this could be due to Karachi which ranks higher in access to fuels being an urban centre (Karachi Central alone is 97% access to clean fuels).

Clean fuels are generally considered as the non-solid fuels such as electricity, LPG, natural gas, biogas, solar, and alcohol fuels. However, there are categories of solid fuels that can be termed as clean such as processed biomass (wood pellets) that have low emissions when burned in a highly efficient stove and with sufficiently low pellet moisture content.[16]

1.6 Renewable Share of Total Energy Consumption

Renewable energy is critical in meeting the aims of the entire SDG 7. In a way, achieving a higher share of renewable energy improves the rest of the sub sector goals of access to electricity, clean cooking solutions and energy intensity. SDG 7.2 stresses the increase in renewable energy's share in the total final energy consumption through its deployment in electricity, heat and transport sectors. While there is no global quantitative milestone for this target, the SDG 7 tracker report 2022 specifies that the renewable shares need to reach over 30% of total final energy consumption by 2030 to be on track for reaching net zero emissions.[17] Whereas the country's current target is to achieve 20% on-grid renewable generation capacity by 2025.[10]

Table 4: Electricity Mix 2030 (Source: IGCEP)

Source	Share of Electricity Supply by 2030
Hydropower	46%
Wind	8%
Solar	8%
Bagasse	1%

Pakistan's share of renewables in the final energy consumption has been negligible so far. The major share has been hydro based electricity while the variable source of renewables such as solar and wind are still negligible. Based on the Energy Year Book 2020, renewables (other than hydro) contribute 1.2% of Pakistan's energy mix of 80 MTOE while hydro has a share of 10%. Pakistan's updated NDC

[15] Tracking SDG 7, The Energy Progress Report 2022 – IEA, IERNA et al
[16] The World Bank, "The State of Access to Modern Energy Cooking Services" (2020), https://www.worldbank.org/en/topic/energy/publication/the-state-of-access-to-modern-energy-cooking-services
[17] IEA, IRENA, World Bank, UN Statistics Division, WHO, "Tracking SDG 7: The Energy Progress Report" (2022), https://trackingsdg7.esmap.org/data/files/download-documents/sdg7-report2022-full_report.pdf

states that “Pakistan aims to shift to 60% renewable energy” by 2030 which includes the share of hydro. According to the Indicative Generation Capacity Expansion Plan (IGCEP) 2021, this has been revised to 65% with the breakdown provided in **Error! Reference source not found.**Table 4. The SDG 7 tracker by UNESCAP reports a share of around 20% in electricity consumption, and that too due to high hydropower, as shown in the figure below.

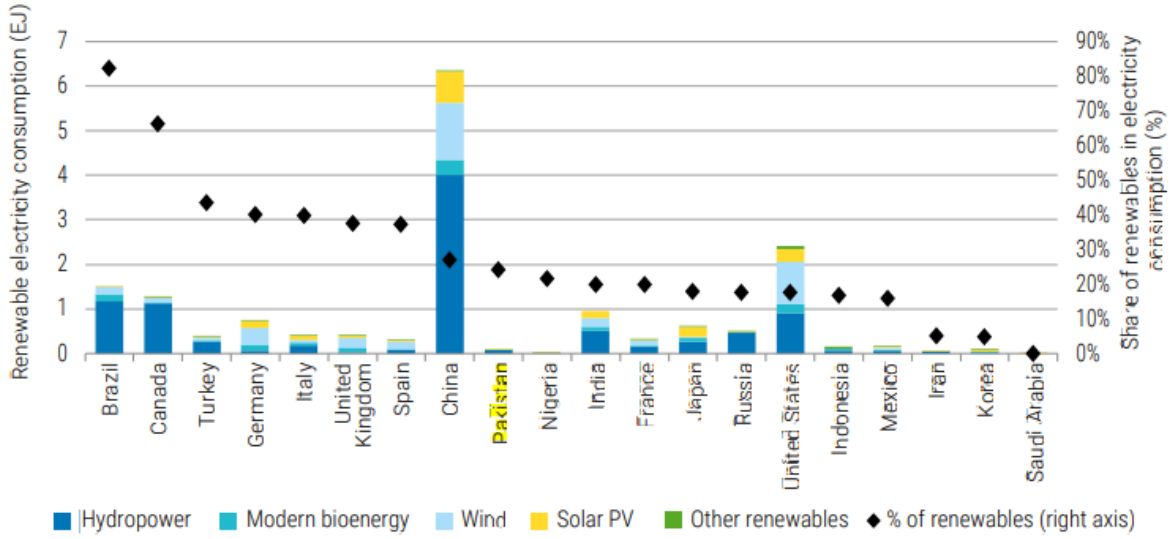

Figure 2: Share of renewables (source: SDG 7 tracker report 2022 by IEA, IRENA, UN, World Bank, WHO)

By 2030, according to the IGCEP, Hydropower will constitute as the major source of renewables while VREs are targeted to be 16% and bagasse 1%. While these numbers provide the share of electricity targets by 2030 as per NDC and the IGCEP, these are not share of the total final energy consumption (which will be lower). The IGCEP 2022-2031 states the VREs (wind and solar) to increase to ~30% of total installed capacity.

1.7 Energy Intensity

Energy intensity measures the amount of energy consumed to create $1 of GDP and is measured by the ratio of total energy supply (in MJ) to the annual GDP ($). The SDG target 7.3 aims to improve the energy intensity so as to create the same amount of wealth by consuming less energy thereby increasing efficiency of energy use. The targets recommended by United Nations was to double the rate of energy intensity (from 1.3% annual improvement to 2.6% annual improvement) between 2010 and 2030. However, based on the progress so far,

the latest SDG 7 tracker report suggests that this rate needs to be 3.2% The most recent numbers suggest that the world average energy intensity is 4.69MJ/US dollar.[18]

According to the SDG 7 Roadmap for Pakistan, the energy intensity of Pakistan is estimated to have been 4.8 MJ/USD$_{2017}$ in 2021, which as compared to 2010 is only 0.3 MJ/USD$_{2017}$ less. However, in the past the energy intensity had a much higher decline rate, between 1990 and 2010, with an average annual rate of 0.55%. As per this report, to reach the energy intensity target of 4.08 MJ/USD$_{2017}$, the annual increase rate should have been 1.11% between 2010 and 2030 to achieve the SDG 7.3 target.[19] The table below shows the country's energy efficiency target following the current (base) improvement rate, UN given target (doubling this rate), the Global Improvement Rate, as well as projected improvement rate based on the Current Policy Scenario (CPS) and SDG targets.

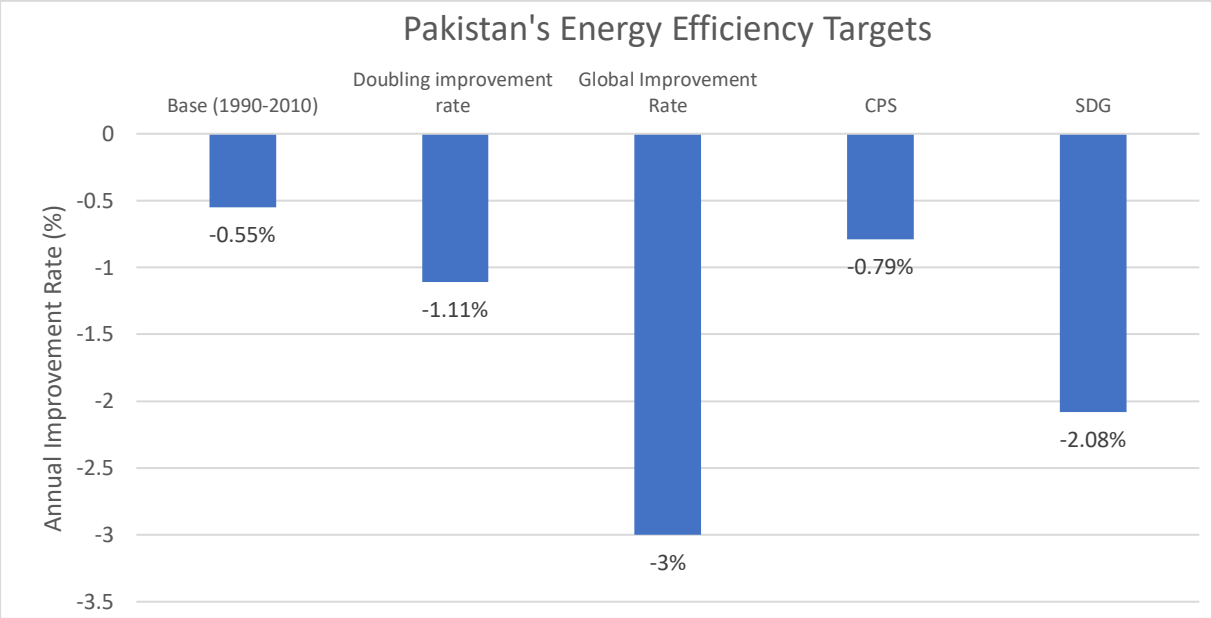

Figure 3: Energy Efficiency Targets[19]

Energy efficiency is a critical aspect in meeting the overall SDG 7 goals and particularly reducing emissions. According to IEA energy efficiency investments globally were expected to reach $300 billion in 2021 but need to triple by 2030 in order to meet the net-zero emissions scenario. The major investment in energy efficiency globally are in the buildings sector and transport, followed by industry.

[18]IEA, IRENA, World Bank, UN Statistics Division, WHO, "Tracking SDG 7: The Energy Progress Report" (2022), https://trackingsdg7.esmap.org/data/files/download-documents/sdg7-report2022-full_report.pdf
[19] Energy Transition Pathways for the 2030 Agenda:
SDG 7 Road Map for Pakistan http://www.indiaenvironmentportal.org.in/files/file/SDG7%20Roadmap%20for%20Pakistan.pdf

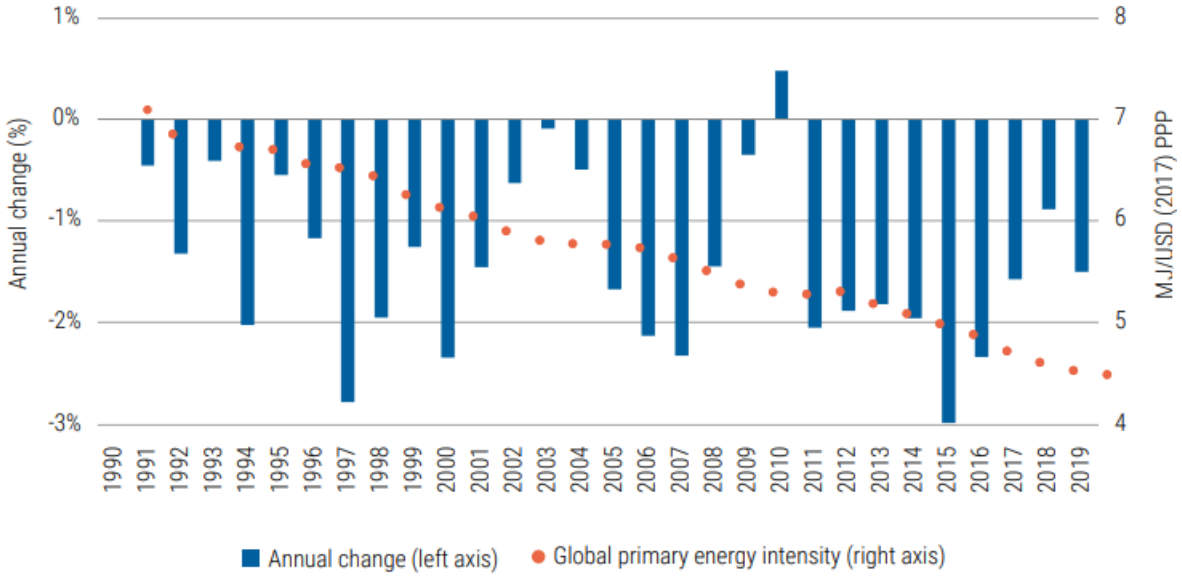

Figure 4: Global primary energy intensity & change. Source:SDG 7 tracker report 2022 by IEA, IRENA, UN, World Bank, WHO)

Pakistan's energy intensity is highest in the region (4.8MJ/$) compared to India (4.3MJ/$), Bangladesh (2.6MJ/$) and Sri Lanka (1.8MJ/$).[20] Energy efficiency is a key solution which has often been neglected due to its "invisible" nature. Pakistan's energy efficiency authority which was established in 1988 as ENERCON was renamed as NEECA through the National Energy Efficiency and Conservation Authority (NEECA) Act 2016. Energy efficiency encompasses a broad range of measures that ensures same work through less energy inputs in the entire sub-sectors of the energy system including electricity, thermal and mobility. It is particularly important in high energy consumption sub-sectors such as buildings which account for 30-40% of the overall energy consumption globally and also account for 15% of the direct Co2 emissions.[21]

According to NEECA's Strategy 2020-2030, Pakistan has the potential to reduce 10-15% (10-12 MTOE) of primary energy supply through energy efficiency and conservation. The strategy set a goal of 3 MTOE to be achieved by 2023. The most energy intensive sectors in Pakistan are industrial, transport and buildings with high energy losses, wastage in the supply chain, usage of obsolete technology and an ageing infrastructure. There is an investment potential of $18 billion by 2030 in various high potential sectors including industrial, building/residential sector, transport sector, power sector and agriculture sector.[22] Various other studies conducted

[20] Saadia Quyum, "Opinion: Pakistan needs immediate steps to improve energy efficiency" (2022), https://www.thethirdpole.net/en/energy/opinion-pakistan-needs-immediate-steps-improve-energy-efficiency/
[21] International Energy Agency, "Buildings: A source of enormous untapped energy potential (2022), https://www.iea.org/topics/buildings
[22] Ministry of Science and Technology, "NEECA Strategic Plan 2020-2023", https://neeca.gov.pk/SiteImage/Misc/files/NEECA%20Strategic%20Plan%202020-23%20Final%2028%20October%202020(1).pdf

put a conservative estimate of at least 25% in each of the sector with potential savings of around $10 billion to the national economy till 2030.[23]

Energy intensity, unfortunately, has been ignored as a target when it comes to policy making both at the federal and provincial level. A report on "Integrated Energy Sector Recovery Report & Plan" published in 2010 by ADB & Friends of Democratic Pakistan Energy Task Force estimated Pakistan's total potential saving at 11.16 MTOE and estimated that energy efficiency could reach 18% of the total energy consumed. It also estimated that annual savings of 25% are possible in all sectors which translate to $3 billion in savings annually. The report back in 2010 suggested frameworks on energy efficiency and integration of energy efficiency as part of the energy recovery plan.[24] NEPRA's State of Industry Report 2021-22 provides the following:

Table 5: Pakistan's Energy Intensity (Source: NEPRA)

Year	TOE	GDP	TOE/PKR Million
2016	45,385,026	32,725,049	1.39
2017	50,122,303	34,175,628	1.47
2018	54,992,889	36,278,011	1.52
2019	54,995,685	37,184,104	1.48
2020	52,135,439	36,710,346	1.42

The energy intensity shows that Pakistan uses 1.42 TOE energy per unit of economic output (PKR million). Providing this as TOE per PKR or MJ/$, the bottom line is that the energy intensity has worsened over the years. Improving energy intensity would require investments in energy efficiency across sectors in achieving the targets of annual efficiency increases.

NEECA provides the following energy efficiency savings through standardization and labelling:

[23] World Bank Group, "Energy Efficiency Roadmap for Pakistan" (2019), https://documents1.worldbank.org/curated/pt/280681555926394575/pdf/Energy-Efficiency-Roadmap-for-Pakistan.pdf
[24] ADB, "Integrated Energy Sector Recovery Report & Plan" (2010), https://www.adb.org/publications/integrated-energy-sector-recovery-report-and-plan

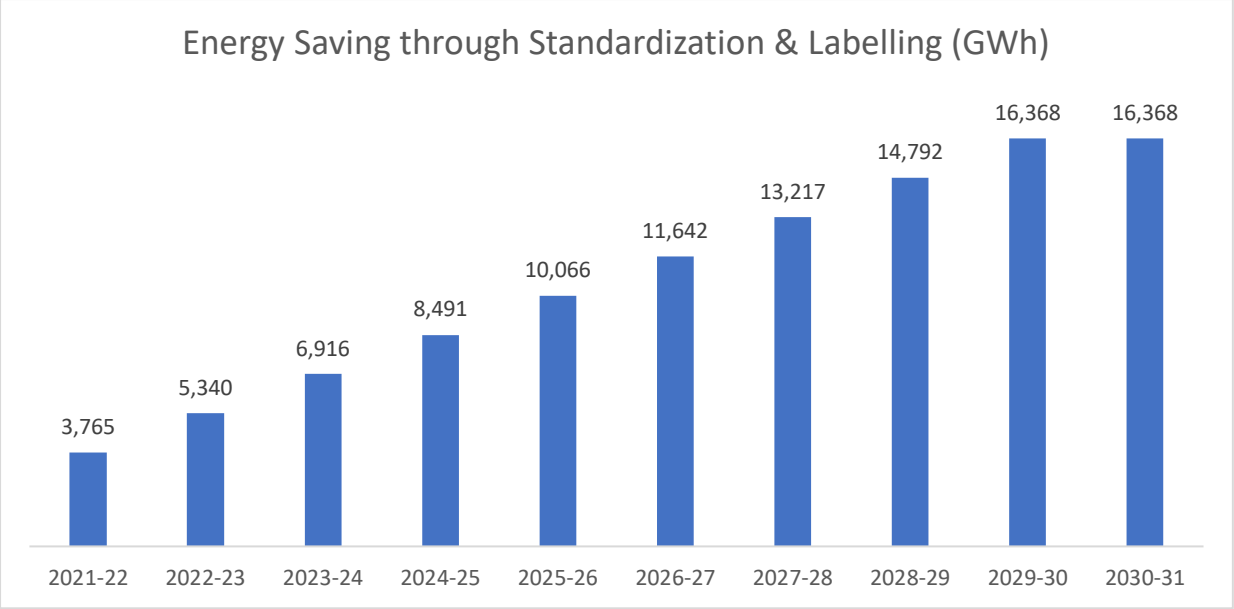

Figure 5: Energy efficiency estimates. Source: IGCEP 2022-2031

In a comprehensive study conducted by UNIDO on energy efficiency potential in Pakistan conducted through 50 energy audits in various industry, it was estimated that 427.9 GWh were saved due to energy efficiency measures at a cost of PKR 3.26 billion. The largest share of savings was from ceramic and textile industry. Province wise, the largest share of saving was in Sindh (22.5%) followed by Punjab (14.6%).[25]

2. SDG 7 in Sindh

Sindh is the second largest province of Pakistan in terms of population with a geographic terrain that experiences extreme heat and cold temperatures, and a coastal belt of 330 KM. Sindh has vast deposits of primary energy resources; 64% of the country's total gas production in 2019-20 was from Sindh, while Thar has one of the largest coal reserves in the world.[26] Sindh also has ideal wind corridors particularly in Jhimpir, Gharo and Keti Bandar[27] where most of the wind energy projects are being installed. Additionally, Sindh located in the south of the country also has ideal irradiance providing ample potential for solar as well.

[25] Energy Optimization in Industry - Sustainable Energy Initiative for Industries in Pakistan, UNIDO, GEF (2022)
[26] 16th largest according to Geological Survey of Pakistan, with 175 billion tons
[27] Wind Energy Potential in Pakistan: A Feasibility Study in Sindh Province. Asghar, R, Ullah Zahid et al.

Sindh roughly contributes 25% of Pakistan's total primary energy consumption (52MTOE) which is calculated as 12.9 MTOE (2019-20). Based on the cumulative average growth rates (last 6 years) Sindh's TPEC is expected to be 21.9 MTOE by 2030.

Table 6: Sindh's TPEC and CAGR for different energy sources

Energy Source	2019-20	CAGR
Petroleum	3,811,911	3.40%
Gas	5,725,904	0.20%
Coal	1,543,666	16.30%
LPG	119,470	9.60%
Electricity	1,700,139	4.80%
Total	**12,901,090**	

The projections based on the CAGR are provided below:

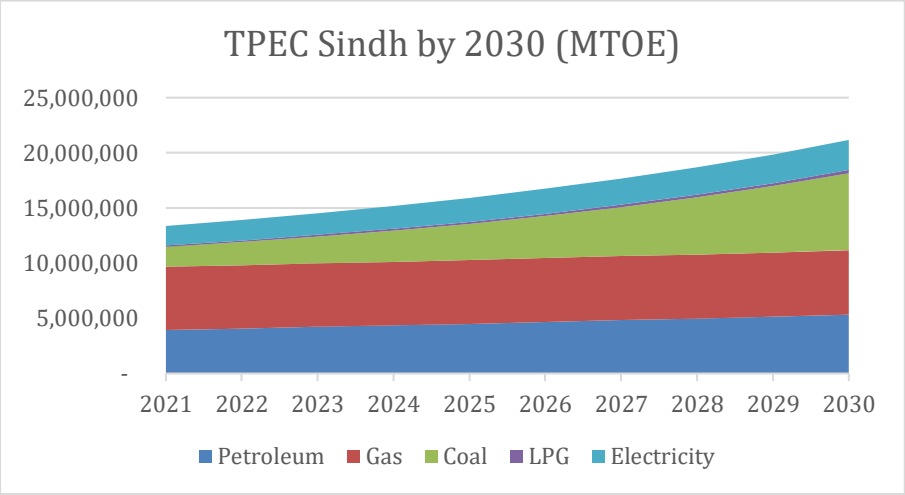

Figure 6: Estimated Total Primary Energy Consumption of Sindh in MTOE (Source: Estimated by Author)

2.1 Access to Electricity in Sindh

The total access to electricity in Sindh stands at 86% according to the MICS 2018, which has lowered compared to the previous MICS in 2014. Rural areas lack the most with access to electricity recorded at 72%, a decrease of 10% in comparison to 2014. Electrification in urban areas has been relatively stagnant over the years with a minimal drop of 1%.

The figures below show the numerous districts within Sindh and a breakdown of the different fuels they use for lighting as per the PSLM 2019-2020 in the rural and urban areas of these districts. Electricity is the most common form of fuel used, with 98% of urban Sindh having access while 1% of the population use solar panels and the other 1% uses gas and other forms

of fuels. On the other hand, in rural Sindh the access to electricity is only 73% while the rest use a mix of solar panels, gas and other fuels such as firewood, kerosene oil and candles.

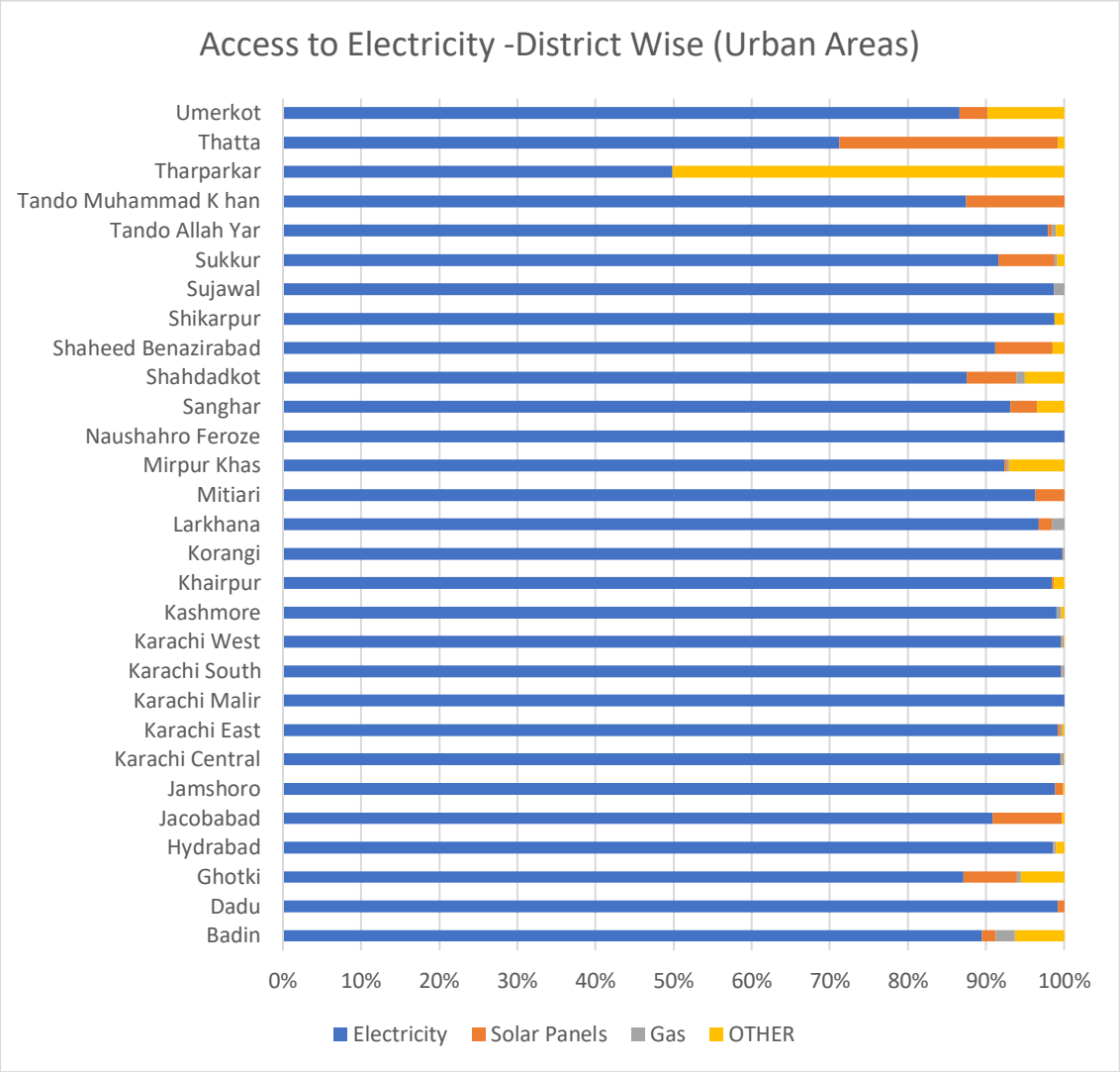

Figure 7: Sindh-Fuel used for lighting (Source: PSLM 2019-20)

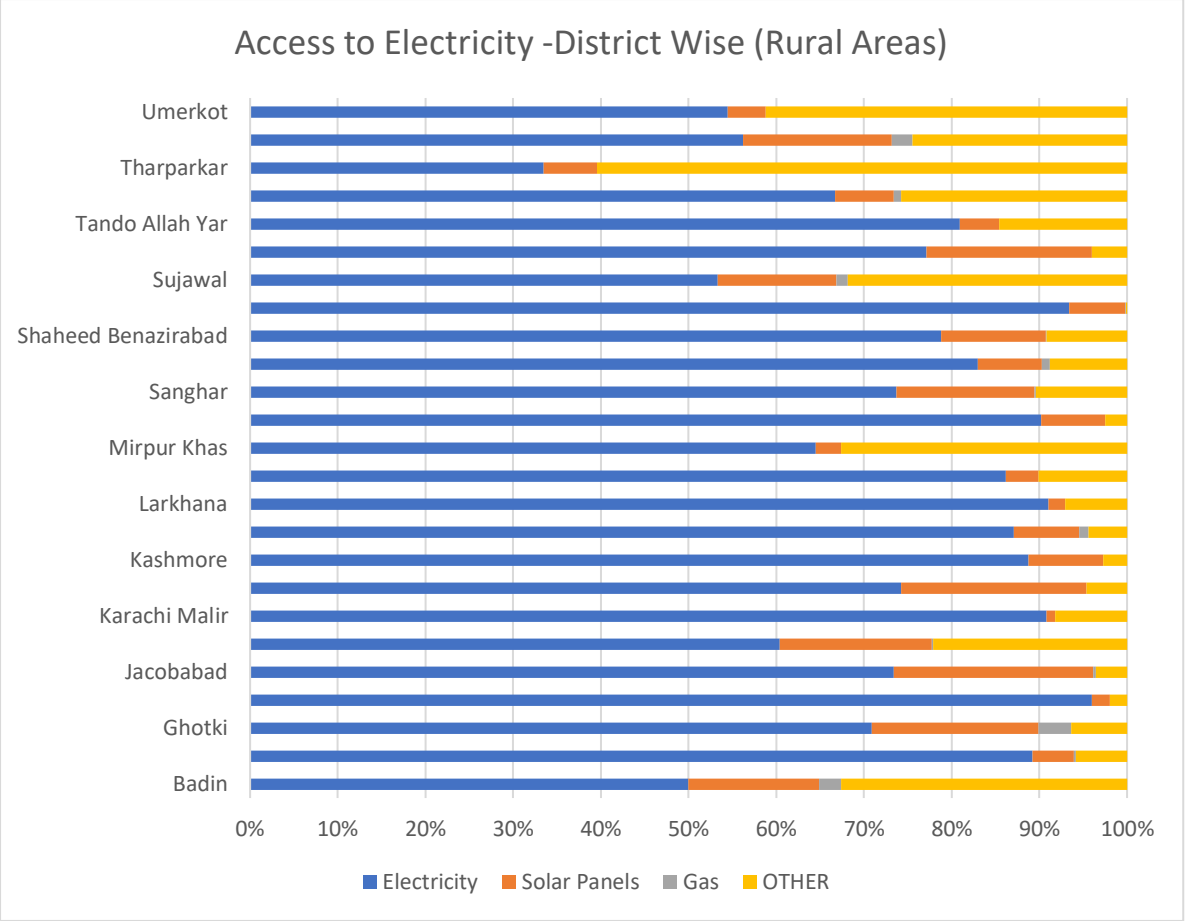

Figure 8: Rural Sindh-Fuel used for lighting (Source: PSLM 2019-20)

There are three electricity utilities operating in Sindh: K-Electric (KE), Hyderabad Electricity Supply Company (HESCO) and Sukkur Electricity Supply Company (SEPCO). KE is the only privatised and vertically integrated power utility in the country with its own generation, transmission and distribution. KE is primarily responsible for the electricity supply to Karachi and adjoining areas of Uthal, Vinder and Bela in Balochistan. HESCO and SEPCO are distribution companies that are responsible for power distribution in the rest of the province which solely rely on power purchased through NTDC. According to NEPRA's state of Industry Report 2021, a total of 20,876 Gigawatt-hours (GWh) were supplied to consumers across KE, HESCO and SEPCO. While the average growth rate of Pakistan's electricity sales has been 4.8%, NTDC projects Sindh's average annual growth rate to be 5.5%. The current domestic consumption per customer is also expected to increase

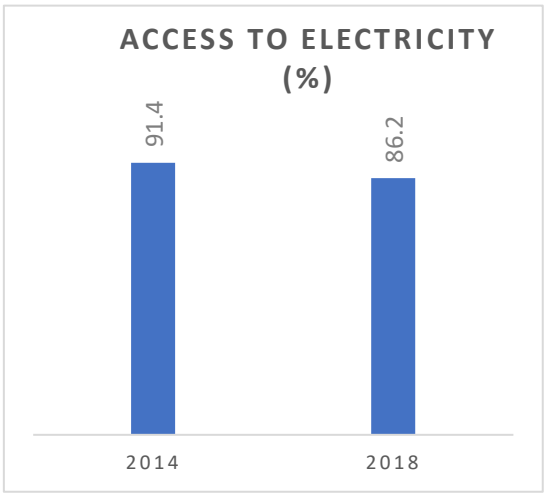

Figure 9: Access to Electricity (Source: MICS 2014-18)

from 7kWh/day to 10kWh/day.[28] Based on these projections, the total GWh electricity consumption is expected to be around 35,000.[29]

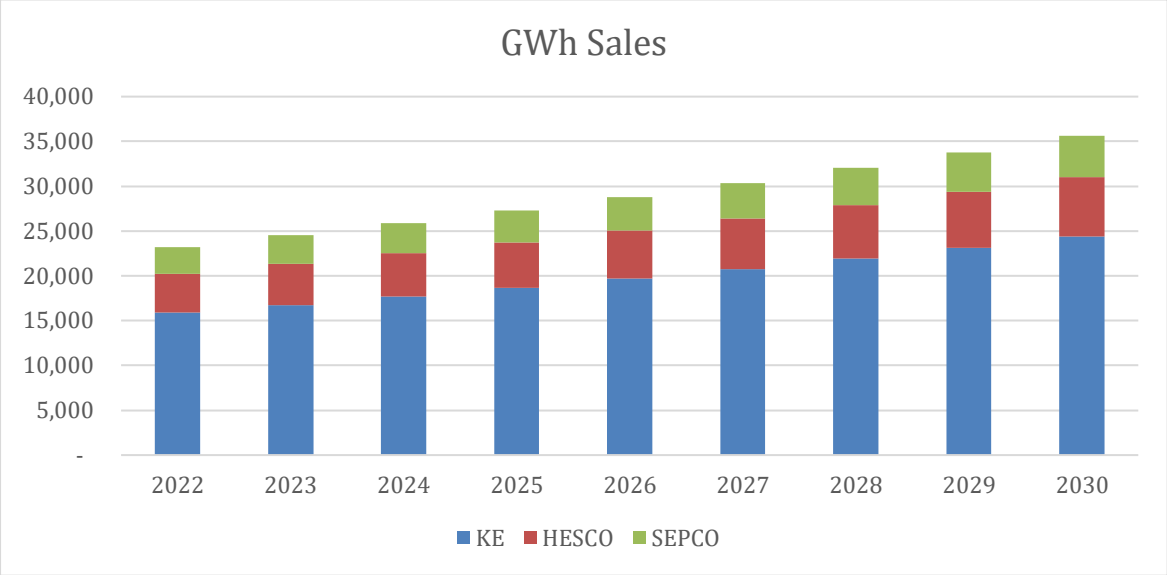

Figure 10: Electricity Sales Project (Source: Estimated by Author)

While KE is a vertically integrated utility with mandate to generate, transmit and distribute, HESCO and SEPCO are distribution companies which have to purchase electricity from CPPA-G based on the existing electricity market. The existing energy mix of HESCO and SEPCO are hence dependent on Pakistan's overall energy mix while KE has the mandate and obligation to alter its energy mix according to the targets of SDG 7 as well as the NDC. However, NEPRA is in the process of rolling out a Competitive Trading Bilateral Contract Market (CTBCM) that provides a roadmap for wholesale electricity trading whereby DISCOs will procure power through centrally organized auctions along with bulk consumers (more than 1MW) to procure power either from the DISCO or any competitive supplier.[30] CTBCM is expected to be rolled out January 2023 and is yet to be determined how this will impact supply and/or incentivize DISCOs to procure clean energy. For the current report and its assumptions, a historical trend analysis will be done to provide the estimates along with energy mix on a national level for the share of HESCO & SEPCO.

[28] The World Bank, "Pakistan Least Cost Electrification Study" (2022)
[29] Does not include the impact that electric vehicles may have on the electricity consumption
[30] NEPRA, "Competitive Trading Bilateral Contracts Market", https://nepra.org.pk/ctbcm.php

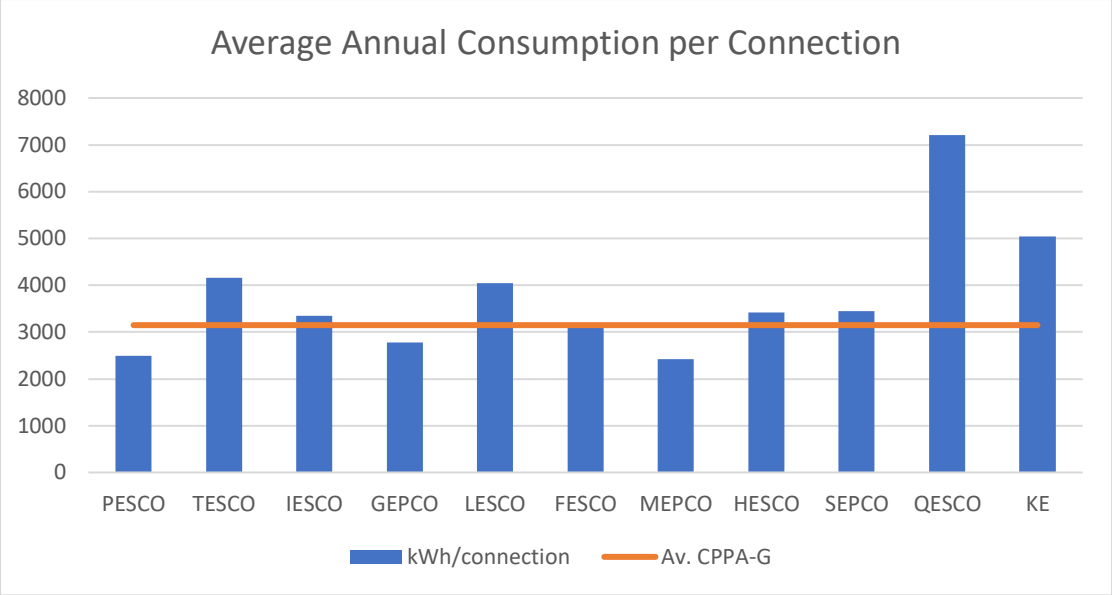

Figure 11: Average annual electricity consumption per connection. (Source: NEPRA)

2.2 Access to Clean Cooking Fuels in Sindh

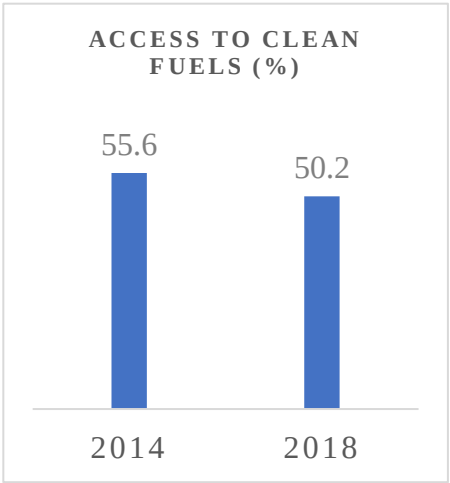

Figure 12: Access to Clean Fuels (Source: MICS 2014-2018)

According to the 2018 MICS report, the total access to clean fuels for cooking in Sindh is around 50%, which is a 5% decrease from 2014. Clean fuels refer to any means of cooking with low environmental impact, these include LPG and natural gas stoves, solar cookers, electric stoves, biogas and alcohol/ethanol burner stoves. While 85% of the urban population has access to these clean fuels, 87% of rural areas do not have access to these fuels. The figures below show the numerous districts within Sindh and a breakdown of the different fuels they have access to, as per the PSLM 2019-2020. Gas is the most common form of cooking fuel used in urban Sindh, while in rural areas wood is predominantly used. 8% of urban households use wood while the rest use gas and other forms of fuels. On the other hand, in rural Sindh gas and other fuels which include dung and crop residue are also common with around 14% of population using gas and 15% using these other fuels. The difference in access in urban and rural areas demonstrates a socio-economic disconnect between the regions as rural households predominantly use inexpensive solid fuels, mainly wood as well as animal dung and crop residue.

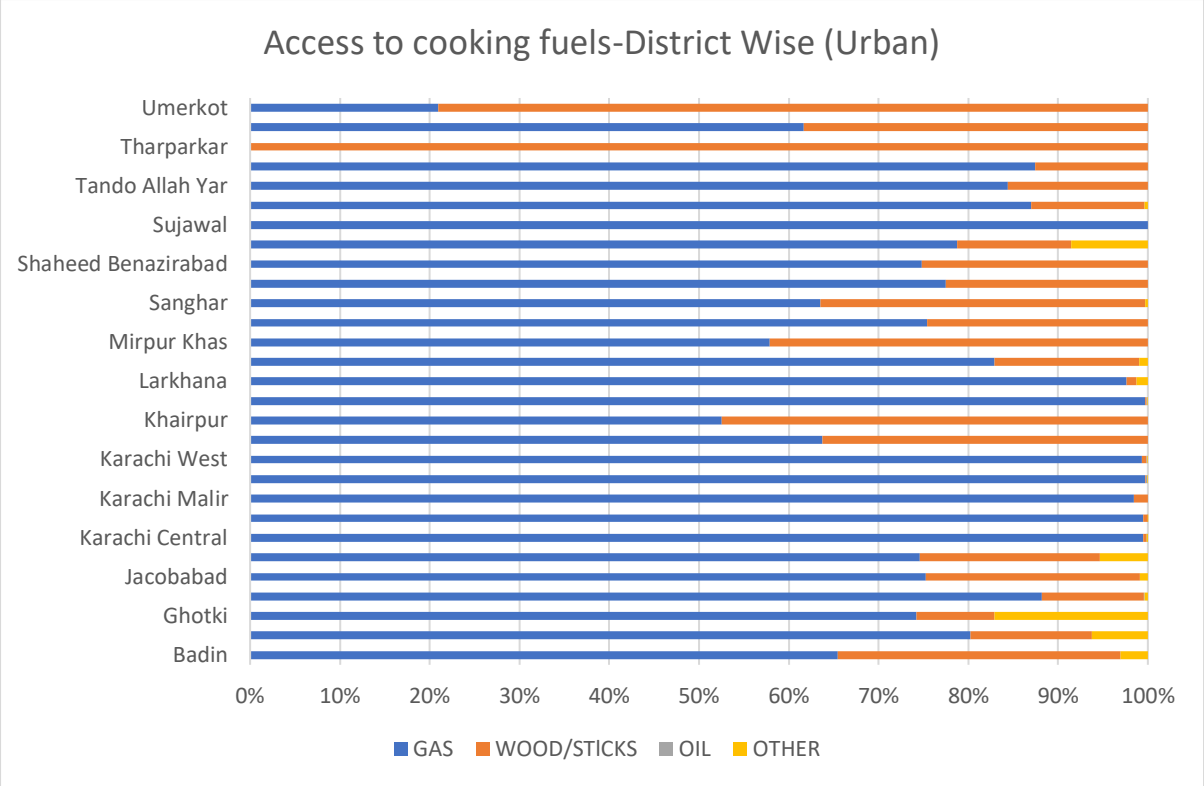

Figure 13: Urban Sindh-Fuels used for cooking (Source: PSLM 2019-20)

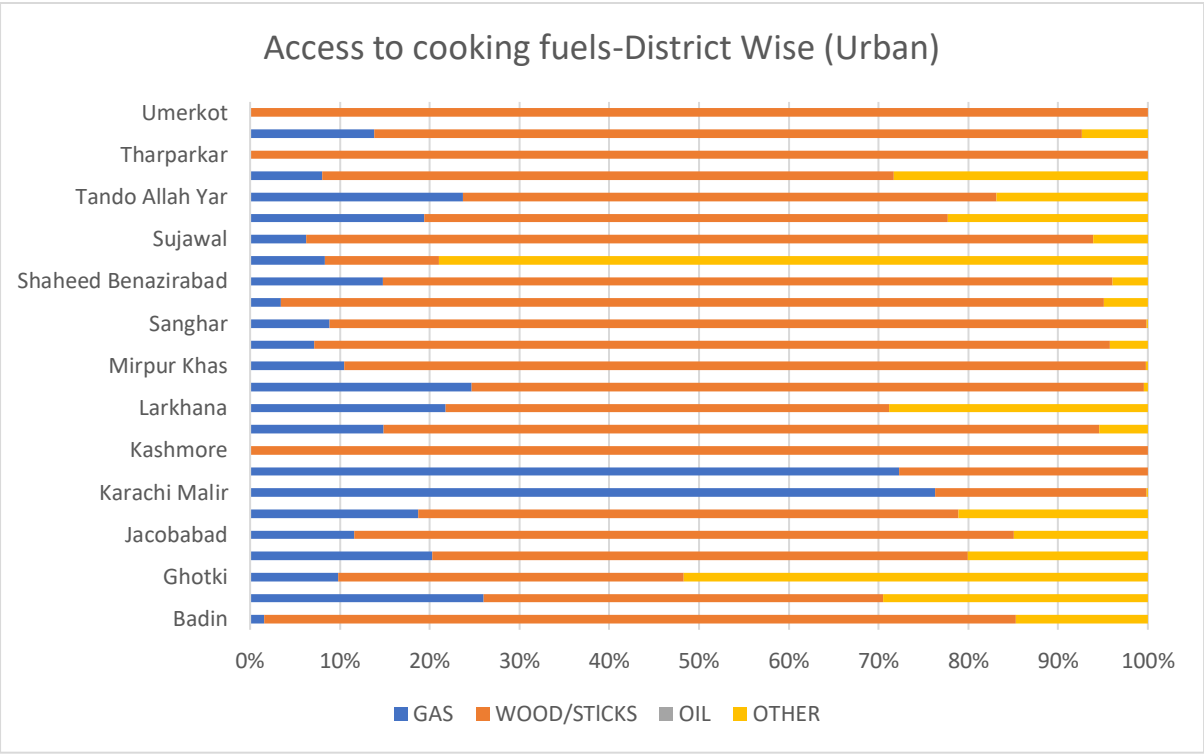

Figure 14: Rural Sindh- Fuels used for cooking (Source: PSLM 2019-20)

Table 7: Breakdown of clean fuels. (Source: MICS 2018-19)

Breakdown of Fuels used for Cooking in Sindh - 2018 (%)				
Cooking Fuels		**Total**	**Urban**	**Rural**
Clean Fuel & Tech	Electric stove	0.3	0.4	0.1
	Solar cooker	0	0	0
	LPG/ cooking gas stove	1	1.5	0.4
	Pipes natural gas stove	46.3	78.6	11.3
	Biogas stove	2.6	3.9	1.3
	Liq fuel stove (alcohol/ethanol)	0	0.1	0
Other Fuel	Liq fuel stove (not alcohol/ethanol)	0.2	0.2	0.2
	Manufactued solid fuel stove	0.3	0.1	0.5
	Traditional solid fuel stove	7.9	2.4	13.8
	Three stone stove/open fire	40.7	12.7	70.9
	Other cookstove	0.7	0.2	1.3

2.3 Share of Renewable Electricity Sindh

Renewable based electricity provides significant opportunities for Sindh to improve access to electricity and also reduce energy intensity whilst lowering its carbon footprint. However the share of renewables in the final electricity available for consumption is dismally low.

Table 8: Share of Renewables in Electricity (Source: NEPRA)

Electricity	**Energy Mix (%)**		**Consumption (GWh)**			**Sindh**
Source	National	KE	HESCO+SEPCO	KE	Total	%
Thermal	62%	97%	4,092	13,829	17,921	86%
Renewables	30%	1%	1,980	214	2,194	11%
Nuclear	8%	2%	528	234	762	4%
Total	100%	100%	6,600	14,276	20,876	100%

There are multiple important considerations for allocating share of renewable electricity for a province in Pakistan:

1) There is a huge potential for generating renewable energy specifically from solar and wind in Sindh.
2) Distribution companies such as HESCO and SEPCO purchase their entire electricity from CPPA-G which make the share of the purchased units dependent on the national average of the renewables in the entire electricity mix.
3) K-Electric is a vertically integrated power utility that has the mandate to generate and procure electricity.
4) Majority of the share of renewables as per the IGCEP will be hydro (46%) while wind and solar is expected to be 16% by 2030. Hydro based electricity sources are in the north while Sindh can focus on wind and solar.

KE has also declared as its strategic target to have a share of 20% of renewable from wind and solar by 2030. For the purpose of this report and costing methodology, a target of 20% of share of electricity units available for consumption shall be considered.

There is one important consideration that may impact the future of renewables in the province. While the province does not have any sources of hydro, the CTBCM does technically allow DISCOs to setup and / or purchase from IPPs hydro based electricity through the wheeling mechanism under the CTBCM. However, this is still under initial regulatory process and yet to be established mechanism.

2.4 Energy Intensity Sindh

One of the key limitations of measuring energy intensity in Sindh is the provincial GDP numbers. GDPs are annually reported by GoP at the national level. One study conducted by Dr. Hafiz Pasha in his book "Growth and Inequality in Pakistan" calculated Sindh's GDP to be 30% of national GDP in 2016-17. The assumption in this report takes into account this share and calculates the GDP accordingly as Energy Intensity measures the energy required to produce $1 of GDP.

As for the Energy consumption, Pakistan's Energy Yearbook provides data on energy consumption province wise. Improving the energy intensity requires improvement in efficiencies across sectors including electricity, thermal and mobility.

In order to achieve the targets for energy intensity and assuming a 2.6% annual reduction, Sindh would require a plan to save 5.5MTOE by 2030 to achieve an energy intensity of 4.0MJ/$. It is pertinent to note that investments to achieve other sub-targets such as electricity access through renewables, increasing the share of renewables and providing improved access to clean cooking all help towards the goals of improving energy intensity.

Table 9: T&D Losses (Source: NEPRA)

T&D Losses			
DISCOs	**NEPRA Target (%)**	**Reported Losses (%)**	
		2019-20	2020-21
SEPCO	25.06	36.27	35.27
HESCO	21.29	42.89	38.55
KE	16.8	19.73	17.54

Significant transmission and distribution losses exist in the electricity system. SEPCO and HESCO T&D losses are 35% and 38% respectively which translates to PKR 10 billion for SEPCO and PKR 22.8 billion for HESCO according to the NEPRA State of Industry report 2021.

According to forecast provided in this report, consumption in the HESCO and SEPCO system is expected to be around 11,200 GWh. Improving the T&D from an average of 35% to 20% is a saving of 2.7MTOE.[31]

Other sectors as identified by the NEECA Strategy identify industry, buildings, transport and agriculture. Sindh is host to a lot of industries particularly in the city of Karachi. In furtherance to improving the T&D losses, there are potential improvements in the electrical performance of end industries particularly textile sector and cement sector, most of them being hosted by the province. The NEECA strategic plan 2020-2025 estimated 2,150GWh improvement just in textile sector alone through improving efficiency of compressors, heat transfers, motors, power factors, steam optimization and variable frequency drives. While this number is for Pakistan, assuming 50% for Sindh is still around 0.8MTOE. Furthermore NEECA identifies sugar mills as a potential industry with scope for efficiency improvements; the industry has a specific

[31] Around 3,200GWh converted to MTOE (1GWh = 86TOE)

consumption of 1250MJ/ton, higher than 935MJ/ton in the region. Based on Pakistan, an overall saving of 3,730GWh is possible in Pakistan.[32]

In a study conducted by UNIDO on energy efficiency in industrial units, Sindh reported the highest share of savings (22.5%).[33]

2.5 Cost of Implementing SDG 7 in Sindh

It is estimated that Sindh would require $ 8.2 Billion to achieve the targets defined under SDG 7 by 2030. This breakdown is provided as follows:

Table 10: Breakdown of cost of implementing SDG 7 in Sindh (Source: Estimated by Author)

Indicator Number	Indicator	Estimated Financial Requirement (USD)	Estimated Financial Requirement (PKR)
7.1.1	Access to Electricity	$ 3.5 Billion	PKR 880.9 billion
7.1.2	Access to clean cooking fuels	$ 0.5 Billion	PKR 125.8 billion
7.2	Share of Renewables	$ 2.23 Billion	PKR 558.4 billion
7.3	Energy Intensity	$1.9 Billion[34]	PKR 494.7 billion
Total		**$ 8.2 Billion**	**PKR 2,059 billion**

These costs are calculated based on the available literature on gaps, solutions and unit cost metrics available.

[32] Sindh has a high concentration of industry due to Karachi being an industrial hub. A 40% of this number could mean ~1.3MTOE of savings within Sindh.
[33] Energy Optimization in Industry - Sustainable Energy Initiative for Industries in Pakistan, UNIDO, GEF (2022)
[34] Estimating the cost of energy intensity is difficult due to a very wide scope within energy efficiency, even for a back-of-the-envelope estimation. Refer to costing methodology.

3. Costing Methodology

3.1 Access to Electricity

The total electricity connections with all the DISCOs operating in Sindh are estimated to be 5.16 million. Based on the number of households and accounting for commercial / industrial connections, there is a deficit of 2.16 million households & other commercial beneficiaries that lack access to electricity. These are projected to grow to 4 million by 2030.

DISCO	No. of Electricity Connections
KE	3,185,332
HESCO	1,172,990
SEPCO	805,717
Total	**5,164,039**

Table 11: Number of Connections (Source: NEPRA)

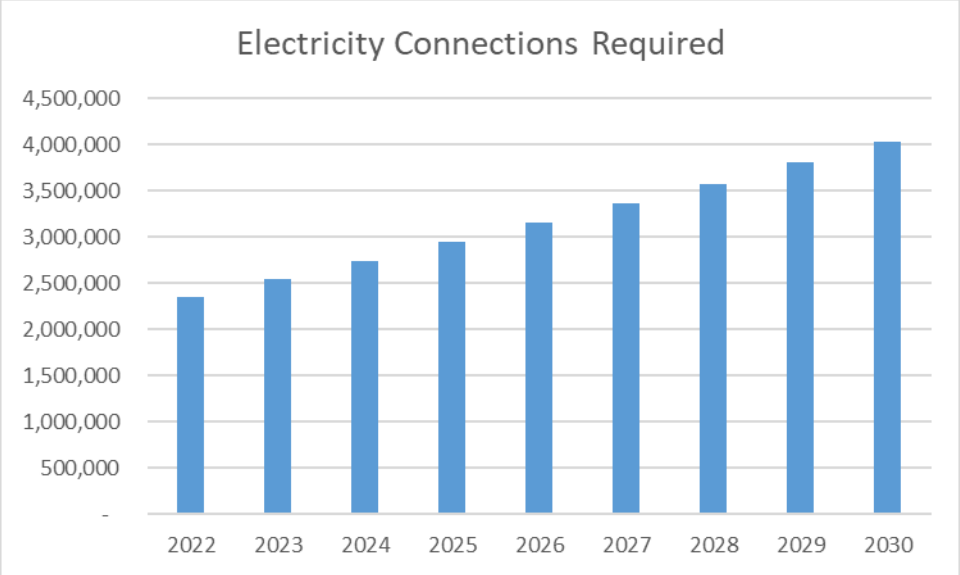

Figure 15: Number of total electricity connections required in Sindh from 2022-2030 (Source: Estimated by Author)

There are primarily three ways to provide access to electricity:

- Grid Extension & densification: According to World Bank's least cost electrification study, this method is economically the most feasible for unelectrified households within 500m of an existing grid.

- Mini Grids: advancements in distributed generation technologies and demand management systems provide this method feasible for pockets of isolated population that can be provided an off-grid solution.
- Off-grid solar systems with appropriate battery backup can provide basic electricity services for individual households as well as small businesses.

Majority of the electrified consumers (75%) are considered to be part of the grid while mini grids are assumed to cater to 20% of the population and 5% through stand-alone systems.

Table 12: Cost of electrification of a village (Source: Estimated by Author)

Method	Cost ($)[35]
Grid Extension	800
Mini Grids	1000
Off-grid solar systems	1500

The Village Electrification Program allocates annual budgets to provide electricity to villages within the HESCO, SEPCO and KE domains. An estimated PKR 2million is spent on the infrastructure to get a village electrified with 10 households (~$800).

3.2 Access to Clean Cooking Fuels

According to the MICS 2018-19, there are still around 50% of households that lack access to clean fuels for cooking, space heating and lighting. The breakdown is provided below:

Table 13: Percentage of households in Sindh with access to clean cooking fuel, space heating and lighting (Source: MICS 2014-2018)

	Access to clean cooking, space heating, lighting	Without Access	HH without Access
Total	49.50%	50.50%	3,969,738
Urban	83.40%	16.60%	636,175
Rural	12.80%	87.20%	3,333,564

Based on the population growth projections of 2.4%, the households that will require access to clean cooking would increase to around 5.9 million.

[35] Includes CAPEX an annual OPEX

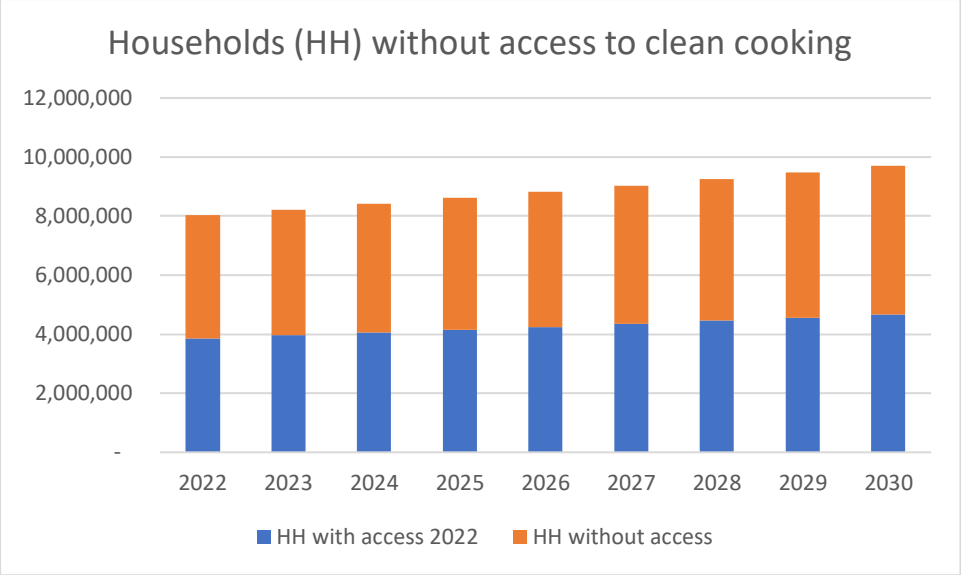

Figure 16:Projected number of households without access to clean cooking compared to status quo (source: author)

There are multiple options when it comes to providing access to clean cooking. Electricity, LPG, Gas, biogas and Improved Cook Stoves. Given that access to universal electricity can provide households with access to fuel, there would still be a need to provide appropriate cookstoves to utilize the fuel. Similar with the provision of LPG and other gas-based fuels. Improved Cook Stoves such as the Rocket cookstove also optimizes on the efficiency of currently used solid fuels. One local solution provider, Jaan Pakistan, provided estimates of low-cost models available and the useful life (generally 2 years) for such cookstoves.

Table 14: Clean cookstove prices (Source: Clean Cooking Alliance)

S.No.	Technology	Fuel	People fed per meal	Life	Price ($)
1	Solar Cookit	Solar	13-15	4	4
2	Fortune Cooker	Solar	12	21	50-150
3	Global Sun Oven	Solar	8		180-300
4	F2-m_Single stove	Biogas	50	4	40-48
5	Fogao tio Mario	Biogas	15	2	60-65
6	Adarsh Cook Stove	Dung/wood	15	3	20-30
7	BioLite HomeStove	Dung/wood	10	5	40-70

9	LPG/NG 2B SS gas stove	LPG	10	7	27-30
8	LPG/NG 4B SS	LPG	10	7	56-60
10	Induction cooktop	Electricity			40-100
11	Hadyana	Electricity	10	5	140-200
12	Coaxial Combustion System	Multiple fuels	150	35	220-560

To provide an average basked price, multiple methods were used to estimate the cost per beneficiary. Global estimates such as those provided by Clean Cooking Alliance quote an estimated $4.5 billion of annual financing required to reach around 2.6 billion households (equivalent to $20 per beneficiary). Local Improvised Cookstoves (ICS) are priced around $20 which last around 2 years would make the total cost around $40 per beneficiary. Other lifetime costs exist for procuring and collecting. SDG 7 Roadmap for Pakistan report by UNESCAP provides annualized costs of different cooking technologies. The report suggests that electric stoves will be the most appropriate option for urban areas while ICS would be suitable for rural areas..[36]

Table 15 Annualized costs of cooking technologies.[24]

Technology	Annual cost
Electric cooking stove	$162
ICS	$89
Natural gas stove	$166
LPG stove	$208

Based on the estimates provided, an average cost of $100/household is considered as annual cost as ICS is the most preferred technology in the current timeframe to achieve the SDG goals.

[36] Energy Transition Pathways for the 2030 Agenda
SDG 7 Road Map for Pakistan http://www.indiaenvironmentportal.org.in/files/file/SDG7%20Roadmap%20for%20Pakistan.pdf

3.3 Share of Renewables

Providing an estimate of renewables particularly for a province is challenging as most of the renewables and its growth is part of the entire electricity sector. The electricity in Sindh is distributed through 2 public DISCOs and 1 private utility. While the electricity is generated in various parts of the province, the share of electricity distributed by each DISCO is dependent on the national electricity mix. The estimates provided in this report, bifurcate the share of renewables in the entire electricity mix to the units of electricity available for Sindh. (**Error! Reference source not found.**).

Solar and Wind are in abundant supply in Sindh compared to the rest of Pakistan. Assuming a target of 30% from these two sources to be in Sindh's 2030 electricity mix, it is assumed that 8,500 GWh should be made available. Based on assumed capacity factors of 20% and 40% for solar and wind respectively, an estimated 3.4GW needs to be installed and invested in to achieve these goals.

Both solar and wind costs have exponentially declined over the years. The International Renewable Energy Agency (IRENA) provides the trend:

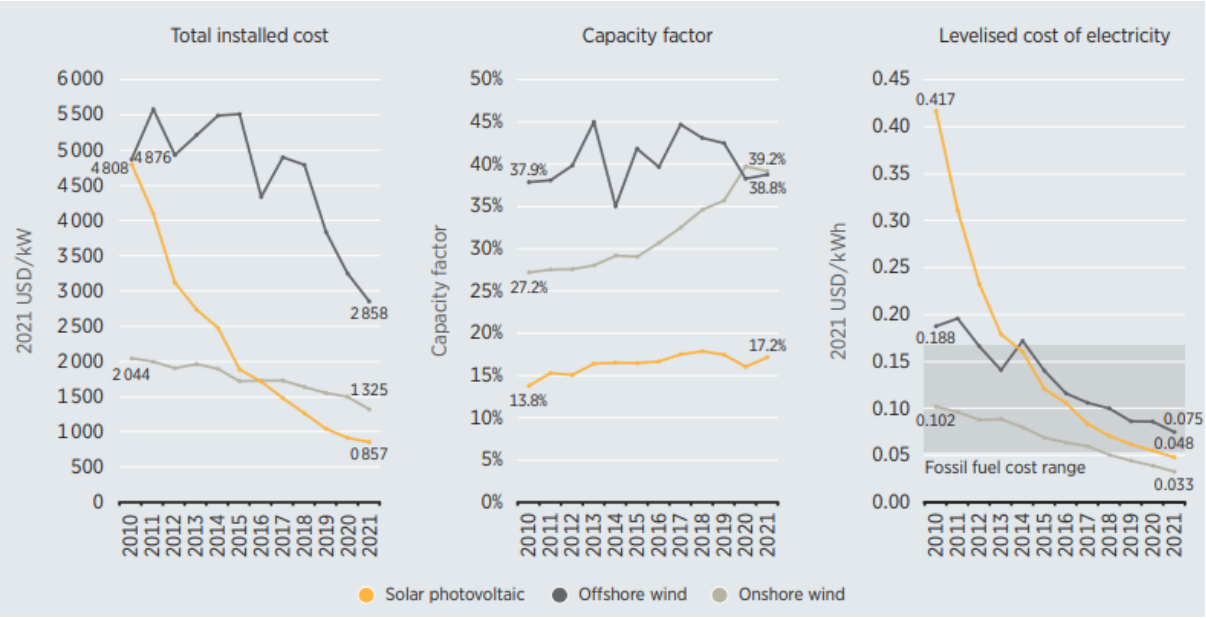

Figure 17: Global weighted average (2021). Source: IRENA

The report suggests that onshore wind was recorded at $1.3 million/MW while Solar is around $0.85 million/MW. As we expect further decline and based on latest NEPRA approved projects, we consider a cost of $0.8million/MW for solar and $1million/MW for wind-based projects in our costing analysis.

3.4 Energy Intensity

Sindh's current estimated energy intensity of around 5.2MJ/$ is above the world average. Based on estimated world targets of 3.2% annual reduction, Sindh's estimated energy intensity will be 4MJ/US$ for which 1.4 MJ/US$ needs to be reduced by 2030. This is equivalent to saving 230 Billion MJ (5.4MTOE) by 2030.

There are various ways of improving energy intensity, primarily increasing the energy efficiency in the entire energy system. This means reducing T&D losses in the electricity sector, energy efficiency in consumption sectors (particularly buildings, agriculture) and the transport sector (fuel efficiency increases, investment in electric vehicles and more public transport). The introduction of fuel efficiency standards is important in delivering the efficiency gains in the transport sector, something which is missing in the policy. The Global Fuel Economy Initiative (GFEI) aims to double the efficiency of the global vehicle fleet from an average of 8 litres per 100 km in 2005 to 4 litres per 100 km in 2050.[37] Transport efficiencies also include improved mass transit systems; particularly for Pakistan where road transport is used (>95%) rather than railroad. A key strategy is to improve the end-use appliances within the domestic, commercial and industrial sector. Measures include mandatory standards and labels for key appliances that improve awareness as well as create the foundations for the financial sector start financing energy efficiency. Following table provides figures forecasted based on the current policy levels through the NEECA strategic plan:[38]

Table 16 Potential savings in each sector by 2030, based on different metrics.

Sector	Metric	Potential saving by 2030 (ktoe)
Residential	Lighting	140
	AC & refrigerators	135
	Electric fans	146.7
	Electric Motors	142.1

[37] Sustainable Energy for All, "Energy Efficiency in Transport", https://www.seforall.org/energy-efficiency-for-sustainable-development/energy-and-transport

[38] Energy transition pathways for 2030 agenda; SDG roadmap for Pakistsan, UN ESCAP & NEXSTEP

	Building code (thermal)	128
Total Residential		**693**
Industrial	Textiles	359.3
	Food & Beverages	136
	Brick Kiln	404
	Cement	250
	Wood & paper	63.6
	Fertilizer	665.1
Total Industrial		**1,878**
Transport	ICE Vehicle	408
	Electric vehicle	622
Total Transport		1030
Commercial	Commercial (building thermal efficiency)	87
Industrial	Efficient pumps	393
Total C&I		481
Power	Transmission & Distribution	531

Most of the measures considered in access to electricity, share in renewables and clean cooking also contribute towards improvement in efficiencies and in turn the overall energy intensity. A back of the envelope calculation may have implications of double counting as these need to be removed from additional tasks required to achieve the energy intensity figures. It is also pertinent to do a sectoral analysis particularly in efficiency savings within the province of Sindh to get an idea of the magnitude of investment required within each subsector that contributes towards improving energy intensity. Achieving key goals of SDG 7 such as clean cooking, heating (High efficiency low emission stoves, improving natural gas heater by 30%), lighting (doubling adoption of LED), AC & refrigerators, fans, water pumps and televisions can save up to 14.5MTOE in the residential sector. Additionally, in the industrial sector, acceleration and implementation of zig-zag brick kilns can reduce energy demand by 359ktoe while mass transport and adopting fuel standards can add up to 3.3MTOE in energy demand savings.[39]

Costing energy efficiency is exceptionally challenging given that it is spread over various sectors and lack of standardized benchmarks exist. According to one study by American Council for an Energy Efficient Economy (ACEEE), energy efficiency programs were costing

[39] Energy transition pathways for 2030 agenda; SDG roadmap for Pakistsan, UN ESCAP & NEXSTEP

program administrators 2.4 cents per kWh. NEECA's Strategy 2020-2023 provides an estimated investment of $18 billion to save 12MTOE ($1,500 per TOE).

- Based on the figure of $1,500 per TOE, the investment comes out to be $8.2 billion. However its worth noting that most of the investments in access to electricity, renewable share and clean cooking also contribute towards energy efficiency. Excluding all the investment required in these domains would bring the investment to $1.98 billion.
- Another back-of-the-envelope calculation using a price of 2.4 cents per kWh. Given that 5.5MTOE needs to be reduced by 2030 this estimates the investment to be $1.5billion.[40]
- In a recent study conducted by UNIDO titled "Energy Optimization in Industry" in Pakistan (June 2022), it was recommended that 200.9 GWh of energy per annum can be saved at a cost of PKR 1540 million per year, which is equivalent to PKR 7.7/kWh (~3cents/kWh). The actual savings realized after implementation realized savings of 427.9 GWh at a cost of PKR 3.8 billion. This estimates the cost to be PKR 8.8/kWh. Given 5.5MTOE saving required to achieve the targets estimated in this report, the cost comes out to be $2.2billion.
- All of these estimates provide a range of the energy intensity investment from $1.5 to $2.2 billion by 2030.

[40] 1TOE = 11,630kWh

4. State of Financing

4.1 Global Funding for Climate

Global funding for financing climate projects overall are on the rise with $630 billion annual funding, equally split between public and private funding. Most of the funding has been under climate mitigation particularly solar PV, wind, and electric vehicles. The following landscape of global financing is provided by Climate Policy Initiative in the "Global Landscape of Climate Finance 2021":

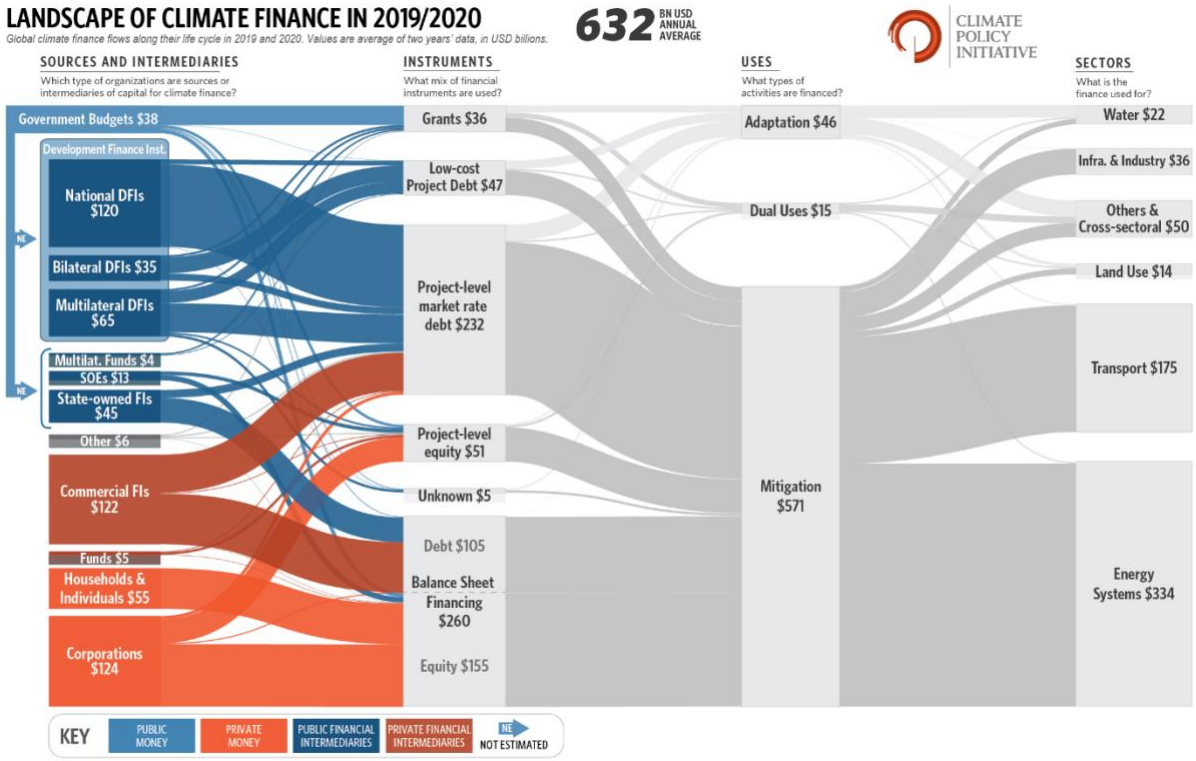

Figure 18: Climate finance landscape. Source: Climate Policy Initiative

- Development Financial Institutions (DFIs) were the major source of public sector finance (68%) and state-owned financial institutions contributed 14%.

- More than 75% of tracked climate investment flows were domestic. This underpins the importance of the need to increase the capacity of local financial institutions to provide financing for climate projects. This is currently lacking in Pakistan; most financial institutions over the past 5 years have built their capacity for Solar PV on the back of renewable energy schemes provided by the State Bank of Pakistan. However, a lot is

still to be done when it comes to the investment required for energy efficiency, clean energy and clean transport.

4.2 Global Funds Available

There is a significant need for climate mitigation and adaption in Pakistan particularly Sindh given the super floods of 2022. However global financing has been limited in Pakistan; achievement of SDG 7 is critical tool in achieving climate targets that can tap into the global funds available. The following funds exist:

- The Green Climate Fund (GCF) was created to support the efforts of developing countries towards low emission and climate resilient development. Up till October 2022, GCF has allocated $130 million for four projects in Pakistan including one BRT project in Karachi. One project within the domain of SDG 7 is the Pakistan Distributed Solar Project which is being co-financed by JS Bank to deploy financing for 43 MW solar PV for households, agribusinesses and SMEs.

- The Global Environment Facility (GEF) is another global facility available for climate resilience in developing countries that has provided $22 billion in grants and blended finance globally. GEF has supported around 40 national projects in Pakistan with $100million allocation along with ~$380million in co-financing.[41]

[41] GEF, "Pakistan: Country-At-A-Glance" (2022), https://www.thegef.org/projects-operations/country-profiles/pakistan

4.3 Public Sector Financing in Sindh

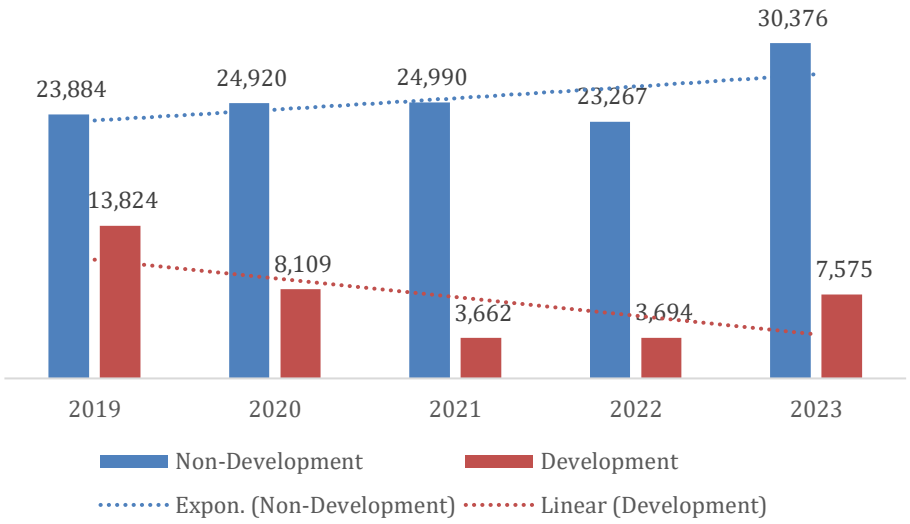

Figure 19: Budget estimates (PKR Million) (Source: GoS budget documents)

There has been a considerable decline in development funding with an increasing spend on recurring expenditure. Majority of the development expenditure has been on other than energy capital expenditure particularly on Thar coal infrastructure development.

Table 17: Development Budget (PKR Million) (Source: GoS budget documents)

	2019	2020	2021	2022	2023
Works & Services	6758	1800	916.5	-	-
Energy Department	20	665	400.5	2275	996.4
Thar coal infrastructure	6413.4	4,599	1596.4	738.7	184.5
Total Development Capital	13,191	7,064	2,913	3,014	1,181

The table shows that majority of the Development portion of capital expenditure has been on works and services and Thar coal infrastructure particularly road infrastructure. The energy development has allocated funds for the Village Electrification Program, biogas and solar PV.

Core energy development expenditure has been rising and most importantly shifting from Thar coal infrastructure development. There is a particular focus on implementing solar PV.

5. Plans and Policies related to SDG 7 in Sindh

The following major policies and projects have been on-going:

5.1 Climate Change Policy 2022

The Environment, Climate Change & Coastal Development Department was established in 2016 by the GoS that covers the various ambits within environmental protection. The Climate Change Directorate was also established under this department that spearheaded the first climate change policy that was approved by the cabinet in July 2022. This policy was in line with the Federal climate change policy.[42]

The policy provides a broad framework of climate change including mitigation and adaptation agendas relevant to the province. The policy document lays out the vulnerabilities of the province in terms of climate change and identified relevant departments that interact with each adaptation and mitigation measure.

5.2 Sindh Solar Energy Project (SSEP)

- The SSEP is a project which is financed by the World Bank (~97% financing) and the rest by the Government of Sindh. The project has three components
    - Utility Scale Solar (350MW solar park)
    - Distributed Solar – solarization of public sector buildings (20MW)
    - Solar home systems – targeting unelectrified villages (200,000) households/1.2million people)
- Estimated cost of the project according to the modified PC-1 (2019) was $105 million of which $100 million were to be provided by the World Bank.

5.3 Village Electrification Program (VEP)

Under the VEP the GoS allocates funds to HESCO, SEPCO and KE to electrify villages within their jurisdictions. The scheme has been on-going since 2008 and has been allocated around PKR 883 million in FY23.

[42] https://environment.sindh.gov.pk/

5.4 Energy Efficiency and Conservation

The GoS has recently formed the Sindh Energy Efficiency and Conservation Authority (SEECA) which is to be part of the Sindh Energy Department. FY23 budget allocates PKR 38 million for energy efficiency and conservation at public buildings.

6. Conclusion and Recommendations

Sindh is the second largest province in Pakistan. However, a major segment of population still lacks access to basic energy that is every citizen's right. There is a positive relationship between energy use per capita and GDP per capita (shown in figure 20).

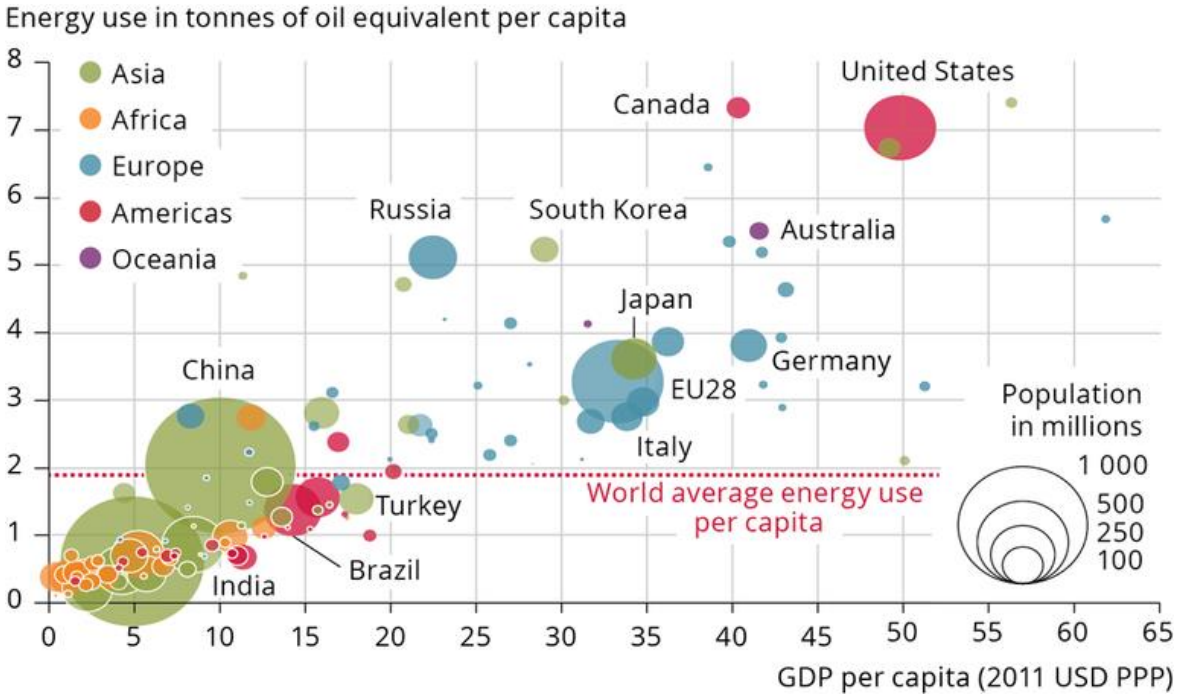

Figure 20: GDP per capita & Energy use per capita. (Source: European Environment Agency)

In order to improve the economic conditions, it is imperative to provide access to the energy required in an efficient, low-carbon and cost effective manner. Sustainable energy will require the following:

1. Access to electricity, whereby this access is not just provision of an expensive grid but also affordable. It is imperative to extend the grid in close proximity of unelectrified households, provision of reliable and sustainable grid supply while utilizing distributed generation sources for isolated areas of population such as micro-grids and solar home systems

2. Access to clean cooking: There is complete lack of ownership when it comes to clean cooking. All the national and subnational governments have failed to give the due importance to this sector which has cross sectoral implications for the energy sector, health sector and social security/poverty alleviation. Cooking fuels are an integral part of the energy sector's final consumption yet are missing from the policy focus. Most of the schemes are being implemented by grass root level NGOs. More than the cost of the cooking stoves, the sector requires a distribution network as well as mass awareness amongst the population to transition from polluting fuels. The level of intervention is only possible through public sector organization's ownership of this issue and particularly with close coordination amongst the energy department and other social welfare departments. 50% of the province still relies on traditional fuels; it needs to come within the fold of energy planning since achievement of this goal relies on the supply of clean fuel sources such as gas (LPG, natural gas, biogas) as well as through technological improvements such as solar and improved cookstoves.
3. Sindh is naturally endowed with wind and solar. The two variable renewable technologies that are spearheading the fight against climate change through decarbonizing the grid. The importance that this province has played through the supply of natural gas can now be replicated by supplying the grid with increased renewable based generation particularly with gas reserves dwindling. Solar and Wind are also now among the cheapest sources of electricity that can also reduce the average grid tariff. Solar plays an integral part through distributed solar that can conveniently be installed on rooftops, further reducing transmission and distribution losses.
4. Energy efficiency also needs to have a clear mandate. While Sindh Energy Efficiency and Conservation Authority has been established, it needs to provide a clear roadmap on broad sectors particularly buildings and transport to achieve targets by 2030. The Sindh Government needs to accelerate measures that can start with public buildings (rooftop solar, energy efficient lighting & cooling) while incentivizing industry towards energy efficient appliances.
5. Common to all the SDG 7 conclusion above, there has to be stated targets for the province for access to electricity, clean cooking, renewables and energy efficiency. Clear mandate needs to be provided by the policy with the Sindh Energy department to take the lead role. Cross departmental coordination committees also need to establish; such as mass transport/electric mobility falling within the transport department but having a major role to play within the energy efficiency.

The efforts towards achieving SDG 7 need to be addressed on war footing. Achieving the SDG 7 goals is an important path towards resilience, mitigation and adaptation in a world of evolving gloom presented by climate change. Sindh has to be at the forefront of championing the cause for its people as well as the rest of Pakistan.

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