



TECHNICAL PAPER 9

ENERGY



9 ENERGY

Access to affordable, sustainable, and efficient sources of energy is a ballooning challenge for Pakistan and for Punjab, in particular. The province has to explore and develop multiple resources of energy for fueling its growing economy and population. The importance of localized solutions has increased after 18th Amendment and its consequent implications in growing energy gaps.

Despite all the efforts and investments made, after 18th Amendment, in energy infrastructure, Punjab still has serious gaps to fill in this aspect. Punjab's economy is unable to perform on its optimum level due to a mismatched energy infrastructure coupled with forced electricity load shedding, prolonged gas disruptions and dollar-linked energy pricing mechanisms. Predominately fossil fuels and now the natural gas too are import oriented thus both energy prices and efficient distribution are the major concerns for Punjab's energy requirements.

9.1 ENERGY CONSUMPTION AND CHANGING MIX

Punjab's energy consumption is augmenting very sharply with a changing mix. In just course of five years, from 2012 to 2017, the total energy consumed in Punjab has risen by 30% i.e. 6% per annum on average. The energy consumption patterns also corroborate, somehow, with the economic progression of the province in this period. During 2011-12 total energy consumption, comprising

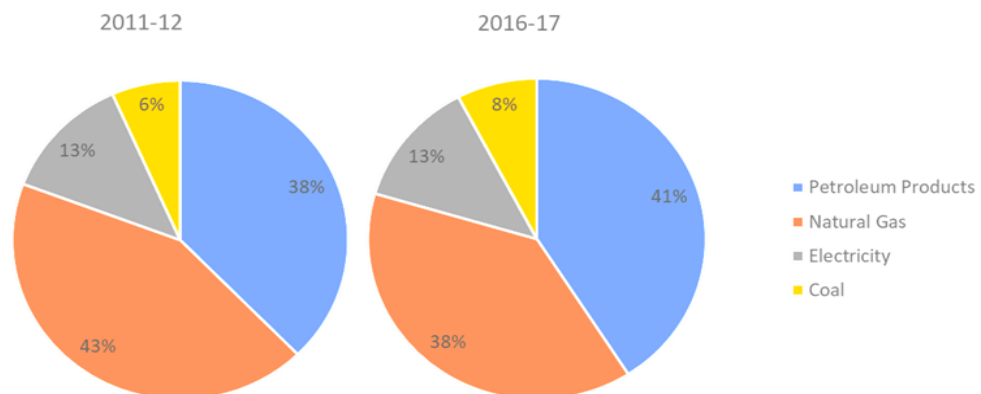
different sources, was around 30 MTOE (Million Tons Oil Equivalent), and the consumption increased to above 38 MTOE by 2016-17 despite the limited supplies and disruptions. Figure 1 depicts the changing energy mix of Punjab:

In five years span, the of Petroleum products' consumption have bumped up from 38% to 41% in overall energy consumption. Punjab energy mix is converging to fossil fuels largely due to limited and curtailed supplies of natural gas. This changing trend also being supported by the electricity load shedding which has kept the share of electricity 13% without any change. Owing to the limited supplies and continuous disruptions from the network-based energy, both natural gas and electricity, the consumers have largely shifting towards alternate fuels which driving the consumption of imported energy upward overall.

Petroleum Products

Punjab consumes above 60% of total Pakistan's oil consumption which has an increasing trend with a rate of above 8% per annum as compared to 6% of overall energy consumption. The increasing dependence on fossil fuel is further denting the provincial competitiveness dimensions and country overall economic progress as a result. Vehicles on roads are growing which is the major oil consuming sector of Punjab with 61% share in its oil consumption followed by Power sector, Industry and Domestic sectors. Punjab's agriculture has consumed above 90% of the oil being consumed by the whole Agriculture sector in Pakistan that is mainly due to Diesel consumption in Tractors and Tubewells across Punjab.

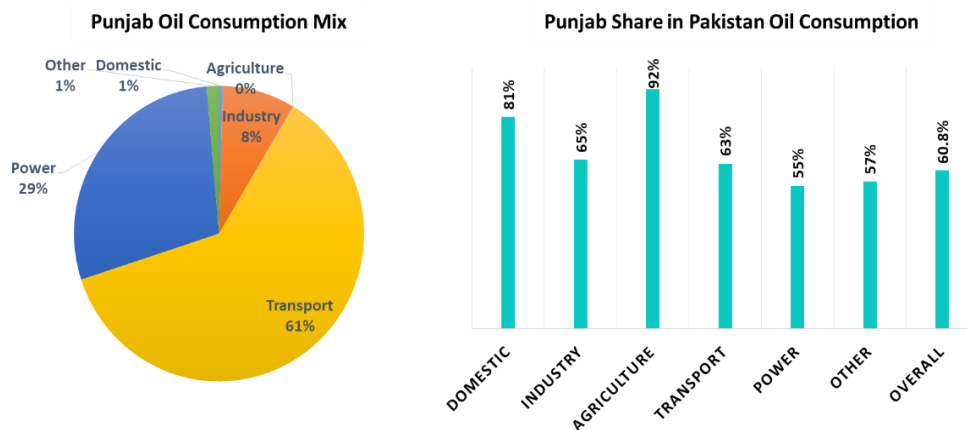
Figure 9.1 Changing energy consumption mix of Punjab



Source: Authors' calculations using Pakistan Energy Year Book, 2017 and 2012



Figure 9.2 Punjab oil consumption mix



Source: Authors' calculations using Pakistan Energy Year Book, 2017 and 2012

Natural Gas

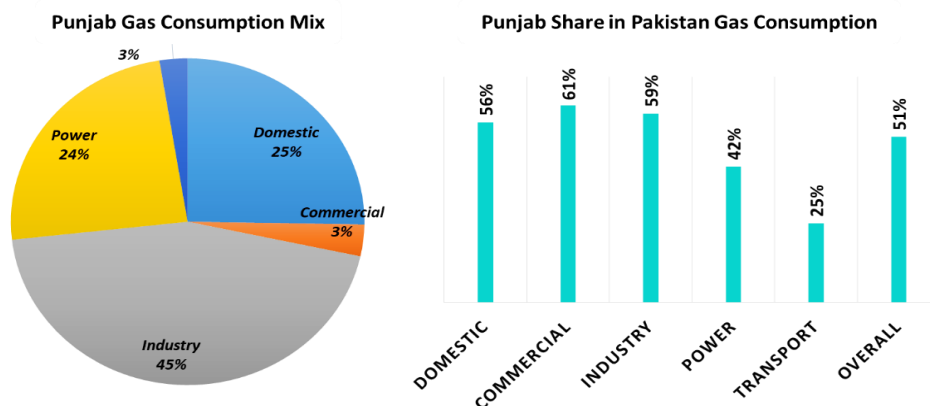
Overall, Natural Gas consumption in Punjab had been declining since 2008 until 2016 due to limited supplies. The declining trend was compensated, at somehow, by imported RLNG (Regasified Liquid Natural Gas) and its consequent delivery to the Industrial sector of Punjab starting 2016 onwards. Nevertheless, Punjab still maintains above 51% share in overall country's gas consumption. Overall, during 2012-17, the natural gas consumption has increased by 15% in Punjab averaging merely 3% compared to country's average less than 1%. As depicted in the following figure, Punjab Industry is largest gas consuming sector followed by domestic and power sectors. Transport sector share has reduced to 3% only due to non-availability of gas at CNG stations.

The increasing gap between demand and supply of natural gas being met by RLNG by Punjab. Overall, Pakistan's

indigenous gas production stands around 2 Billion Cubic Feet per Day (bcfd) against demand of 4 bcfd. There are very limited gas field in Punjab which produce gas and therefore Punjab relies either on the other provinces resources to meet demand or through imported gas. Punjab demand of natural gas is increasing whereas the supply is depleting and therefore the gap is augmenting and the curtailments get even worse in winter season.

There are limited consumers in the Punjab across different sectors, especially in industrial chains, opting for RLNG due to non-availability of indigenous gas. The price differential, however, is the major factor and keep on increasing as the RLNG rate is determined in parity with US dollar on monthly basis. The below figure depicts that how the differential between RLNG and network gas (indigenous) is soaring, and thus posing serious challenges for Punjab its deprived consumers, in particular.

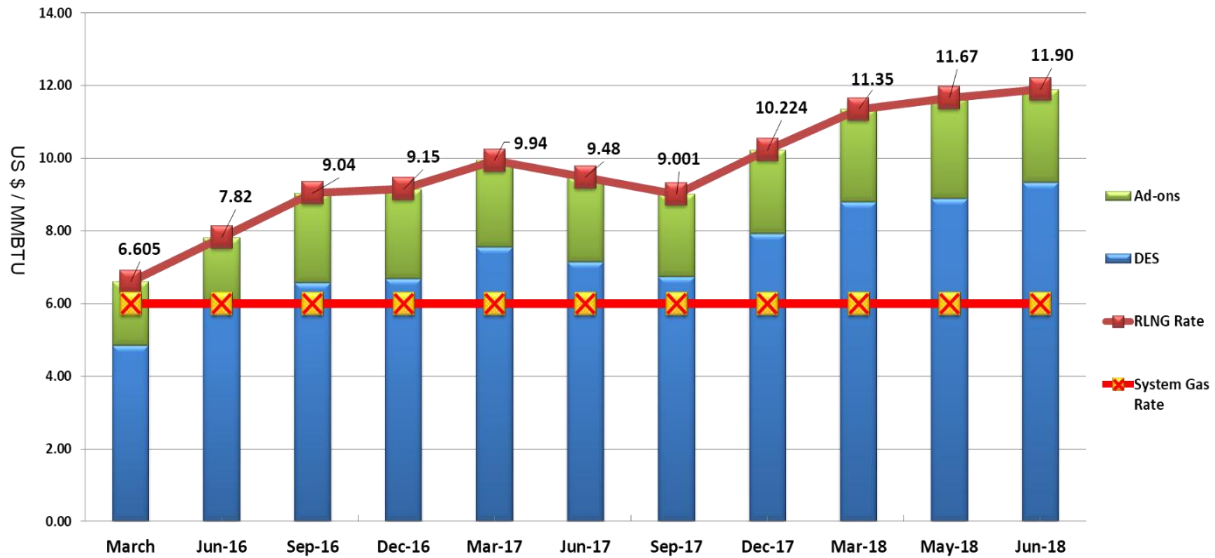
Figure 9.3 Punjab gas consumption mix



Source: Authors' calculations using Pakistan Energy Year Book, 2017 and 2012



Figure 9.4 Increasing gas price for Punjab industry

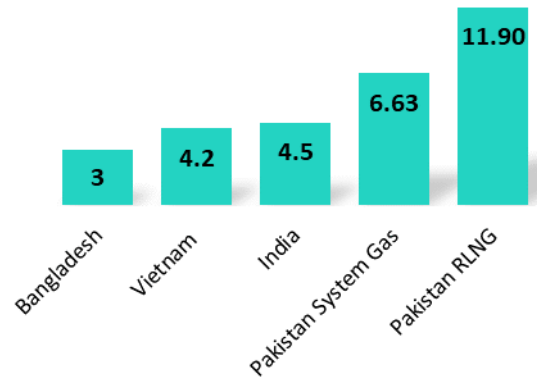


Source: Authors' calculations using OGRA and PSO monthly data

It is very important to highlight that the competitiveness of Industries' related factors should be safeguarded if Punjab wants to focus on structural transformation through industrial development. In competitiveness Gas supplies play an important role for the industrial sector. Punjab-based Industries cannot perform in international markets with high cost of doing business especially the high-priced utilities. Following figure portrays the challenges Punjab-based Industry is facing in shape of gas rates;

In addition to the challenge of high prices, the growing gas consumption is denting on the overall gas infrastructure of the province. There is a strong likelihood that the province gas demand shall be multiplied within a very short period. For instance, data reveals that Punjab domestic consumers rely majorly on gas and firewood for cooking purposes and yet less than 40% population having gas connection.

Figure 9.5 Natural Gas price for industry



Source: Various sources from respective Regulatory Authorities

Interestingly, above 15% of rural population have access to the natural gas. Most heaters are gas-based which requiring extensive gas supply if served in full. Other than cooking, gas is being used for space heating. However, 87.7% of the population still have no access to heating appliances which means that the same shall be increased gradually. Major urban districts such as Rawalpindi and Lahore have high heating appliances rates i.e. 57% and 28% respectively. Districts in the Southern and the Eastern parts have very low heating appliances mainly due to climatic conditions.

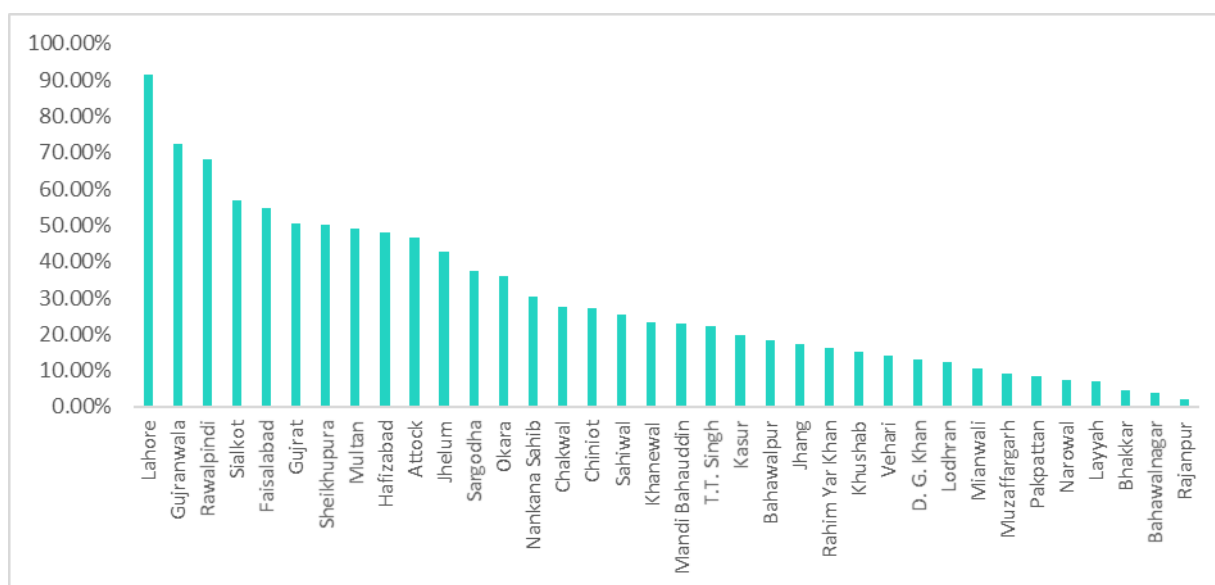


The districts of Lahore, and Faisalabad have better access to gas with 91.5%, and 55% respectively. However, the people of districts of Mianwali and Layyah rely on mostly on firewood. Pakistan has major tugs on gas consumption from different sources such as Industry and Transport. Providing gas to such districts will require planning for excess demand. The gas network will have to improve to provide gas in a sustainable matter. Following graph is depicting the gas accessibility rate of Punjab on district levels.

The current supply of Natural gas is around 4 Bcfd. Whereas, the constrained demand is around 7Bcfd, resulting in a demand / supply gap of around 3Bcfd. The indigenous supplies of natural gas are expected to reduce drastically in the coming years. Projections w.r.t. demand

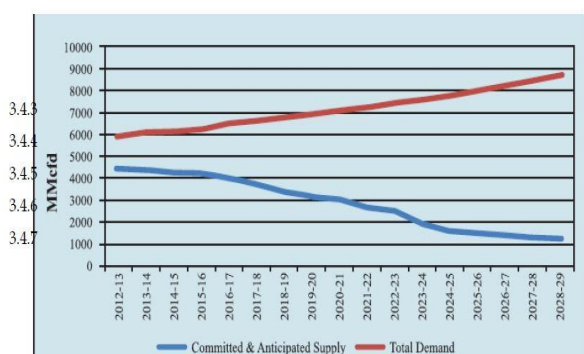
supply scenario (indigenous supplies only) are given as under. The projections of the natural gas demand and supply suggest that Pakistan is likely to face a huge gap of 6.5 Bcfd by the year 2028-29. The scenario calls for immediate measures today that should be taken to bridge this gap.

Figure 9.6 Gas Accessibility Rate



Source: PSLM 2015

Figure 9.7 Demand Supply gap of Natural Gas



Source: OGRA Report

In view of severe energy constraints, there is a dire need to increase energy supplies and conserve the existing supplies. In this regard, pricing is also one of the tool for the judicious utilization of energy source.

Electricity

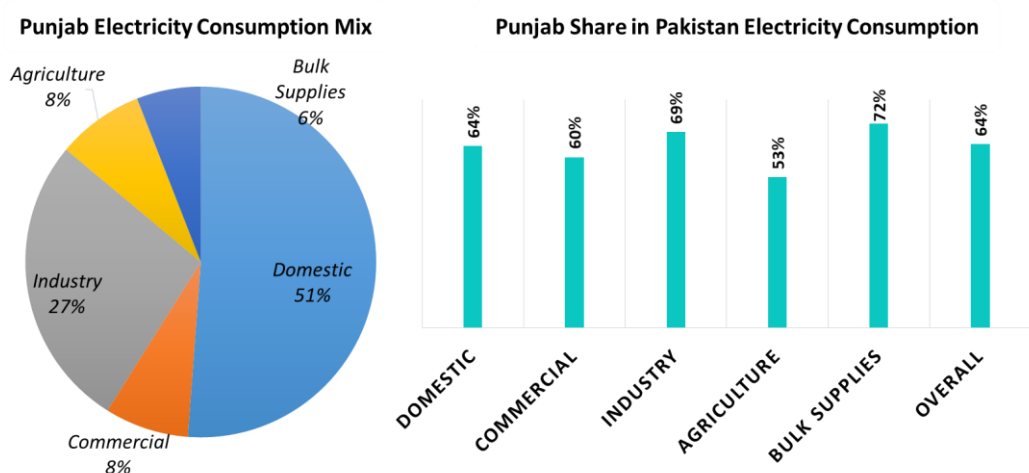
Despite several-hour-long load shedding spans, Punjab electricity consumption still posted a modest growth in last five years. Overall, Punjab electricity consumption grew by 6% from 2012 to 2017 on yearly average. The trend is almost similar to overall Pakistan. If the electricity supplies had not curtailed, Punjab consumption would have grown in double-digit. Electricity infrastructure in Punjab is best-in-class if compared with Punjab this is the reason why over 95% of population has access to electricity (PSLM, 2015). There are very few remote areas in Punjab which are not electrified yet.



Looking into detail of electricity consumption mix, Punjab is largely supplying electricity to domestic consumers which represent above 51% as shown in the below figure. When compare to Punjab population ratio with electricity consumption ratio in domestic sector, the below figure reveals that the Punjab-based inhabitants are energy intensive and consumes more electricity in per capita terms. Moreover, Punjab-based Industry is the second largest consumer with 27% share – the largest in Pakistan with 69% share in overall Pakistan Industrial consumption. Punjab is the largest power consumer in the country, its

electricity demand stands above 9,000 MW while the current supply not above 7,000 MW resulting in 4-6 hours load shedding (NEPRA).

Figure 9.8 Punjab electricity consumption mix



Source: Authors' calculations using Pakistan Energy Year Book, 2017 and 2012

Table 9.1: Electricity demand of Discos in Punjab 2017-18 (MW)

Year	LESCO	GEPCO	FESCO	IESCO	MEPCO
2011-12	4,148	2,004	2,500	2,072	3,178
2012-13	4,364	2,109	2,631	2,180	3,344
2013-14	4,621	2,233	2,786	2,308	3,540
2014-15	4,930	2,382	2,972	2,462	3,777
2015-16	5,281	2,552	3,184	2,638	4,046

Source: NEPRA Report 2016

Similar to the gas, electricity tariff also affecting economic dynamics of Punjab. With increasing share of fossil fuels and other expensive generation sources, the electricity prices are bumping up. The impact of increasing electricity tariff is very significant on all segments of the economy, especially the industrial sector with exports orientation. For instance, Pakistan's electricity tariff is the highest in the region with over US 12 cents/KWh for Industrial sector. This high-priced electricity has subjugated Punjab based industry from growth as the regional peers are enjoying very low tariffs i.e. India, Bangladesh and China where average per unit price for industry is below US 9

cents/KWh. Other than the electricity tariff, Punjab is also worst in terms of disruptions and load shedding in international standings.

Distribution and Consumption

Despite the fact that Punjab electricity distribution is better as its DISCOs are more efficient and advanced, the province is facing serious challenges when sees a significant growth in future. Punjab has to make its electricity infrastructure more progressive and state-of-the-art in meeting all challenges. Following maps are

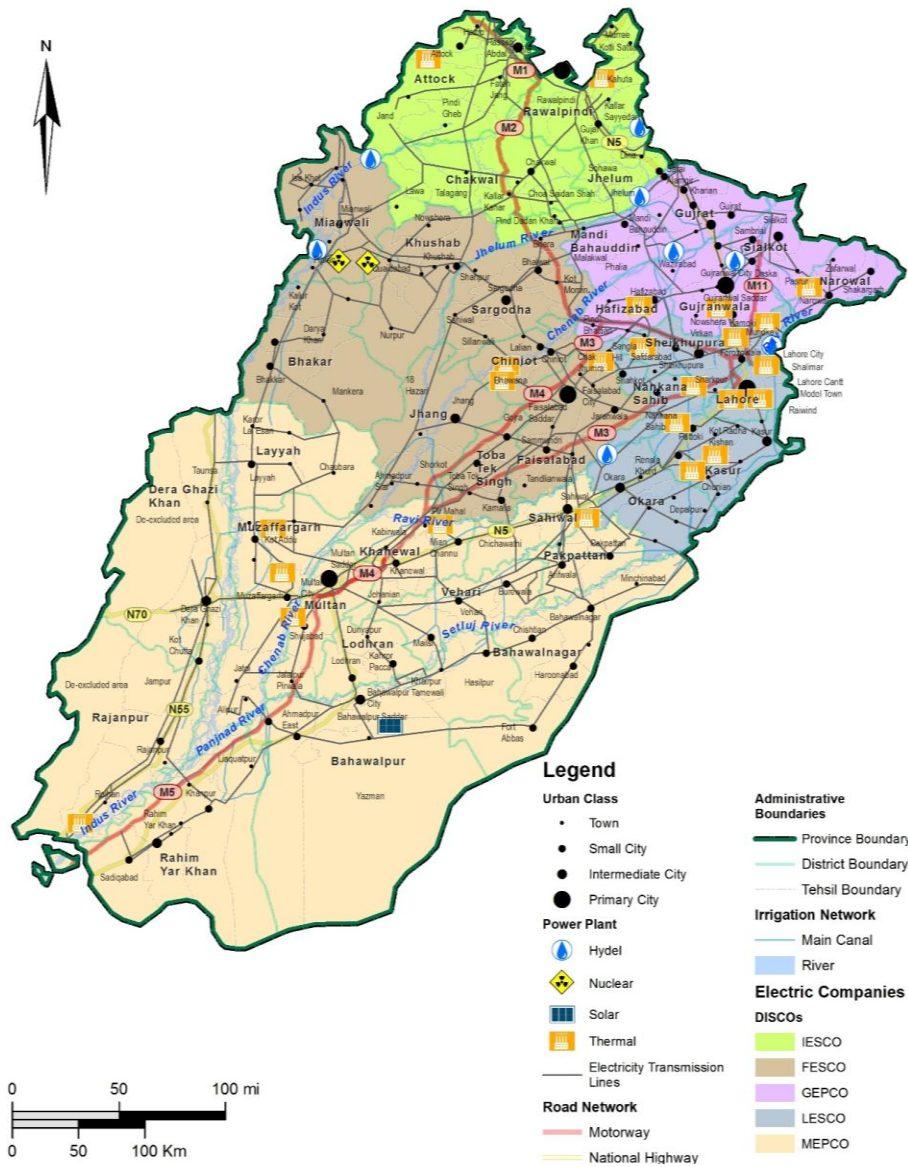


depicting Punjab's DISCOs with their consumption and consumers in different categories.

As depicted in Figure 9.8, the electricity consumption by the Industrial sector in Punjab has posted an increase of above 3% (annual average). The overall electricity consumption; however, posted a growth above 5% during the same period as depicted in Table 9.1. This trend is not very encouraging keeping industrialization in to context.

Nevertheless, the industrialized regions, GEPCO and FESCO area have witnessed the highest growth with 36% and 28% during the period of 2011-12 to 2015-16 with 7% and 6% annual average respectively. This strong growth in industrial sector is the reason of growing growth as well as the reliance on electricity instead of gas because of supply curtailments. This trend will be highly visible and further to augment in coming decades as the Industrial development is highly energy intensive and require multiple energy sources for its production

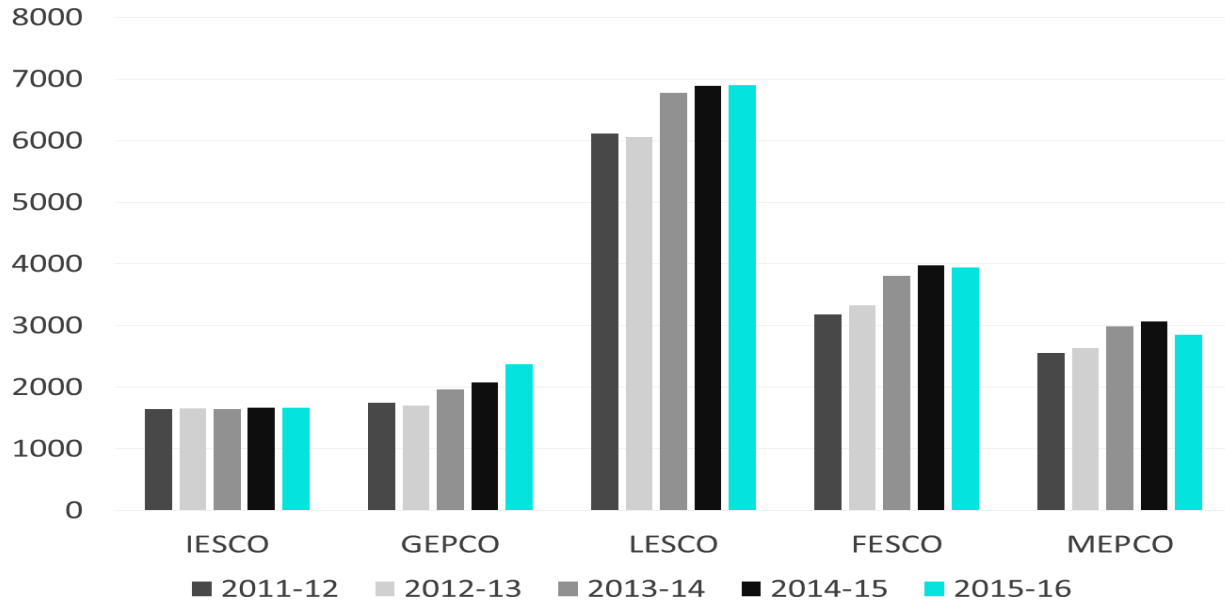
Figure 9.9 Punjab energy infrastructure and electricity distribution



Source: Urban Unit



Figure 9.10 Industrial sector electricity consumption growth



Source: NEPRA 2018

Figure 9.11 Pakistan year wise demand & shortfall



Source: NEPRA 2018

Figure 9.11 shows that continuous improvement in generation, Installed capacity, demand and shortfall. Though the data shows that the country has managed to overcome the gap; however, in order to meet the ever-growing demand of Energy we should enhance the pace of improvement and increase the share of renewable energy in our energy mix.

While keeping the accelerated growth in to context, Punjab electricity consumption growth would be much higher in coming decades. Though the electricity consumption per capita is highest in Punjab, if compared with Pakistan, the intensity would further increase as most of the population is still not complemented with energy intensive appliances i.e. Air Conditioners. Only 7% of the population has access to air conditioners (PSLM, 2015). The demand for air conditioning is expected to go up with increasing middle income group of the society. The

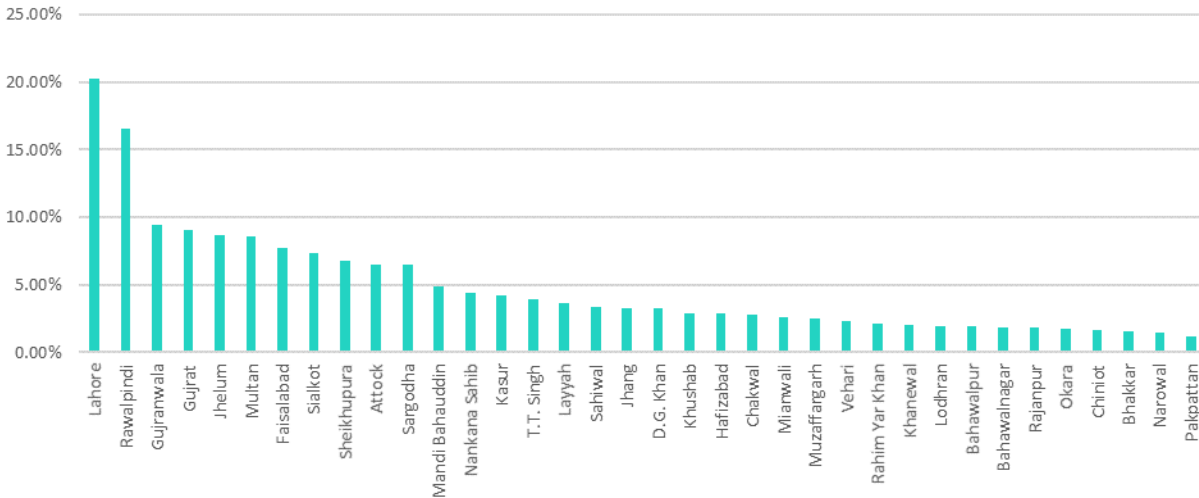


percentage of people using air conditioners is likely to reach 20-30% which would require more energy as a consequent.

The present electricity infrastructure is not adequate therefore gaps are indicating to balloon further. Therefore, it is prudent to invest in cost effective renewable energy sources and improve the existing energy infrastructure.

Following figure highlights on the electricity consumption intensity across Punjab in district level if we take Air Conditioning a proxy:

Figure 9.12 Use of air conditioners in Punjab



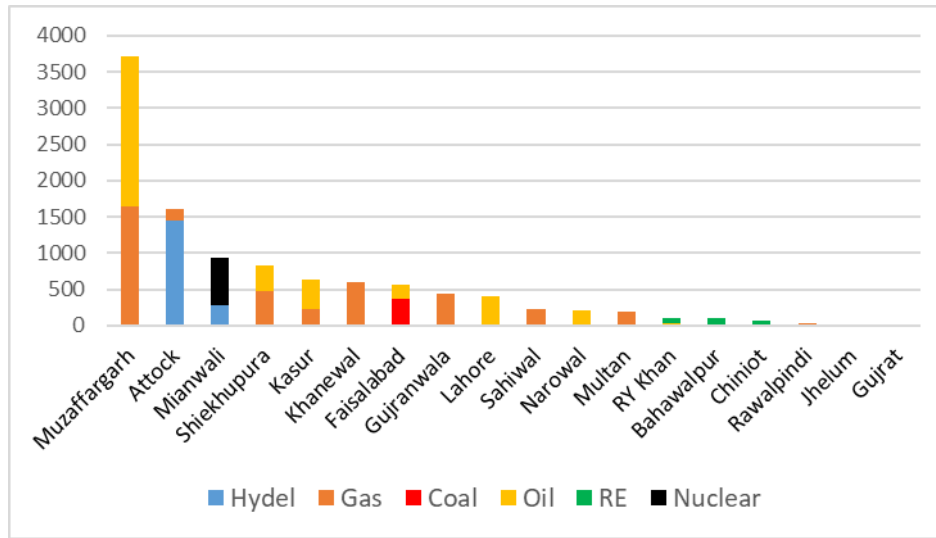
Source: PSLM 2015

Lahore electricity consumption is on the highest and its households have highest ratio of air conditioning facilities. Lahore is the highest but there is still a significant gap as it stands at only 20%. The electricity consumption in the domestic sector will increase if the buying capacity of consumer increases— a fact that will go up. Punjab has to be very active in undertaking appropriate planning for meeting future electricity demand keeping sustainability and affordability in the focus. Though, there are several federal institutions and regulatory regimes are involved in the power sector, Punjab has to play a very active role in streamlining and aligning them for a collaborative development. The advent of Pak China Economic Corridor has provided a window of opportunities. Previously important projects had not implemented due to lack financial resources; however, CPEC is now investing heavily for developing coal, wind and solar energy projects in Pakistan and several in Punjab too.

For Electricity, starting from generation to distribution and regulation all major players are federal not provincial. In parallel; however, Punjab has developed various institutions and successfully implemented number of initiatives for electricity generation in Pakistan. Overall, following figures are showing the electricity generation capacity of Punjab, with both Federal and Provincial initiated, as of 2015.



Figure 9.13 Electricity installed capacity in Punjab

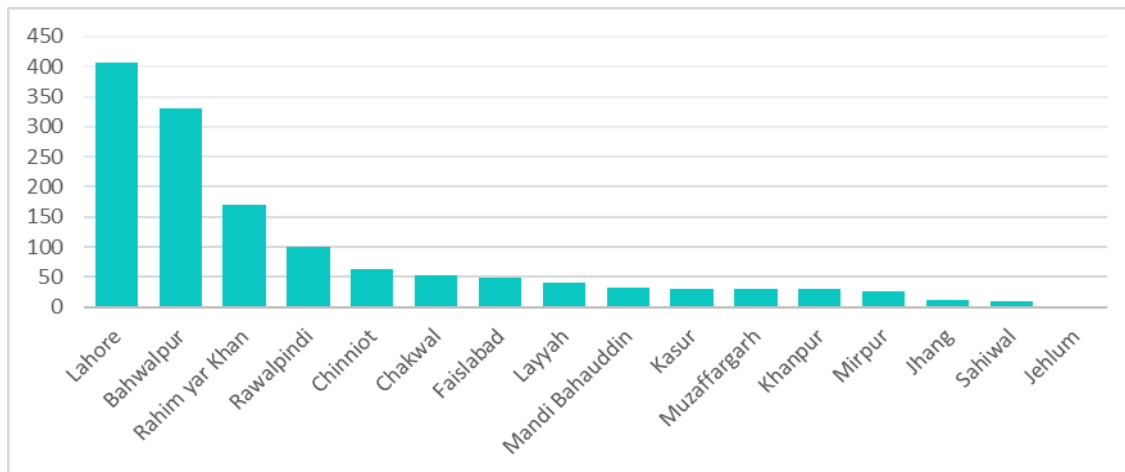


Source: NEPRA Report 2015

The Punjab’s district wise electricity generation by source breakup is indicated by the above shows that districts like Muzaffargarh, Narowal, Mandi Bhaudin, Sheikhupura, Lahore, Kasur Khanewal, Jhang and Gujranwala generate energy through gas and oil. Attock is primarily generating electricity through Hydrel resources while Sahiwal and Faisalabad are utilizing mostly coal as fuel for electricity. Renewable energy and Nuclear are scanty amongst the regions.

Thermal is the major source of energy in Punjab with most of the plants located in the northeastern side of the province. There is limited renewable energy sources such as solar and wind resources. The Hydrel potential has not been developed optimally thus leading to stagnant growth in hydrel energy generation. Nevertheless, In generation capabilities, Punjab is now on track to produce a sizeable electricity from renewable sources by 2023.

Figure 9.14 Renewable energy plants in Punjab by 2023



Source: NEPRA Report 2016



9.2 ADDRESSING GAPS WITH SUSTAINABLE AND INDIGENOUS ENERGY SOLUTIONS

Punjab is blessed with huge renewable resources, such as good solar insolation, hydropower resources in the Northern areas, a large livestock population that generate biomass; a massive irrigation network that has a huge power generation capacity, and strong winds in certain areas of the province. Many of these technologies are also suitable for off-grid electrification, and therefore have a very low impact on the existing infrastructure. Preliminary resource assessment of Punjab indicates that it has great renewable energy potential for energy access applications.

Solid Waste

Punjab being the most urbanized province has a huge potential in solid waste management based energy solutions. As per the government directive however, overall production capacity for solid waste plants has been capped at 250 megawatts for the entire country; share of each province and federal territory is capped at 50MW for a notified tariff. In Pakistan, more than 20 million tons of municipal solid waste is generated with annual 2.4% growth. All major cities – Islamabad, Lahore, Karachi, Peshawar and Quetta – are facing enormous challenges in tackling the problem of urban waste. Thousands of people die every year due to waste-related diseases.

Considering the environmental issues and acute energy challenges, Punjab has to act and utilize all its solid waste to generate clean energy. Most of the countries in the region have already set up municipal waste power plants and they are reaping dual benefits with the disposal of garbage and generation of electricity through this garbage.

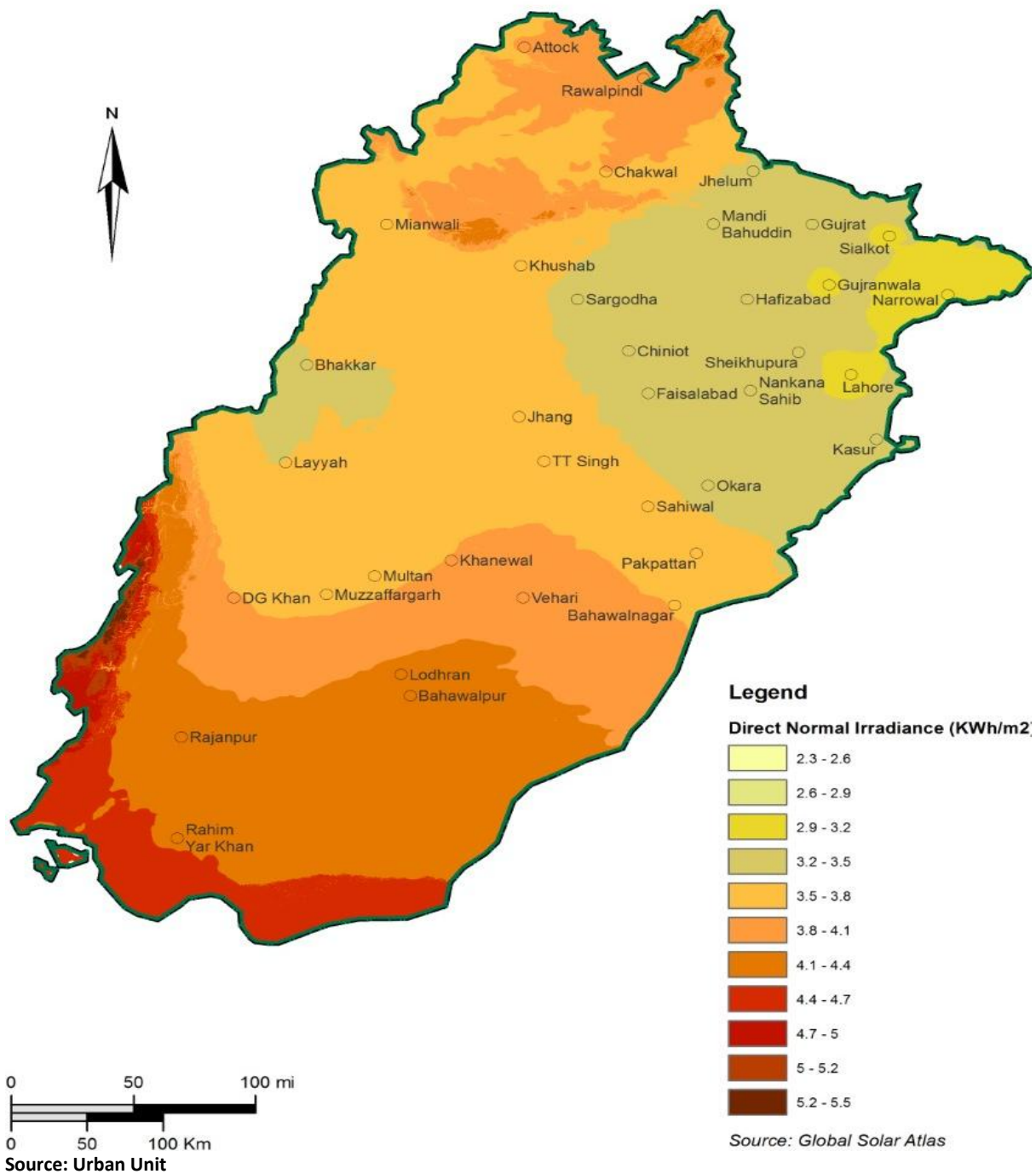
PV Solar

South Punjab's solar insolation ranges from 4.5 to 5 kWh/m²/day which is good potential for the use of PV solar generation for both individual household systems as well as micro- and mini-grids. PV solar panels are arguably the easiest generation technology to apply in off-grid areas of Punjab for rural electrification. It has been identified a growing private sector in solar technologies, including traders of solar components, such as panels, batteries, charge controllers, and the such, as well as companies with technical capacity to install larger systems, of 30-50 kW. Moreover, some companies are actually building large PV solar farms of over 10 MW that would be grid connected. Therefore, local technical capacity in Punjab is not a challenge for the development of solar-powered mini-grid systems (ADB, 2014).



Figure 9.15 Solar energy potential in Punjab

Direct Normal Irradiance





Biogas

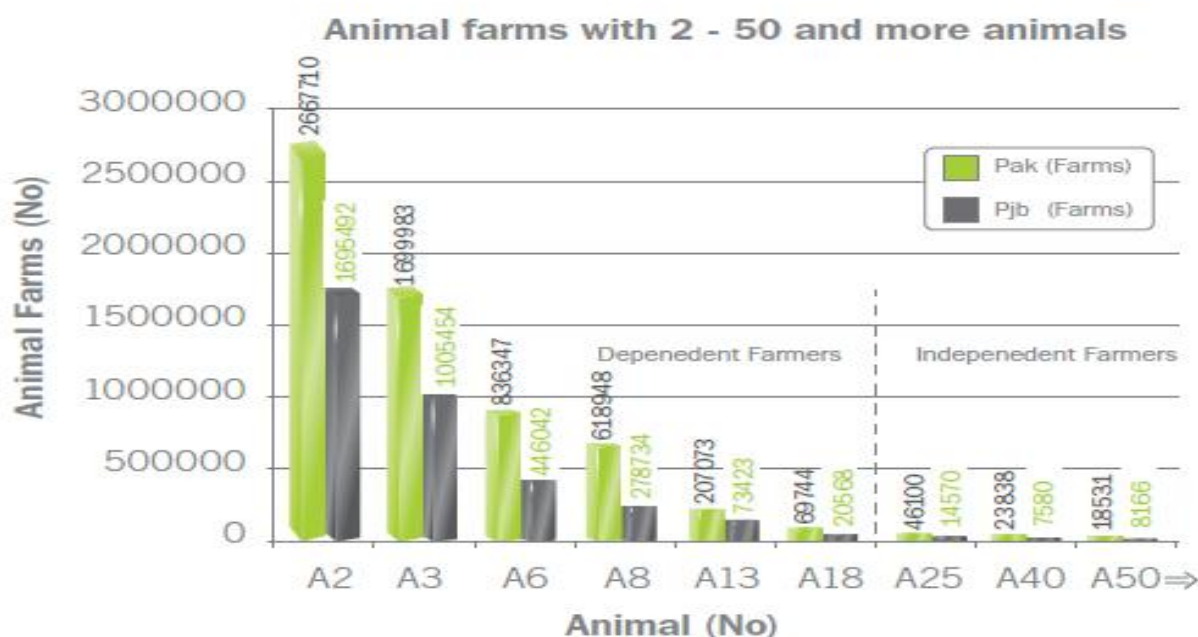
According to census done in 2010, there are more than 30 million headcounts of cattle in Punjab and the theoretical potential for biogas-fired power stations could reach up to 230 MW and or equivalent gas, if the whole cattle manure were utilized¹. In reality, the actual production would certainly be much lower, but it would still make sense in medium-scale biogas and cogeneration plants. The Punjab government has already commissioned a feasibility study of a 200 kW biogas-fired power plant in Kasur district, although the project was not pursued forward. The highest concentrations of cattle in the province are in the so-called 'dairy districts' of Kasur, Okara, Sahiwal, Sheikhupura, Chiniot, Faisalabad, and Jhang.

The waste from animals can be utilized for production of 24 million m³ biogas. The number of animal farms with 2-50 and more animals is given in Figure 9.16:

Biomass

Biomass is considered to be one of the key renewable resources of the future at both small and large scale levels. It already supplies above 15% of the world's primary energy consumption. Recently, the Economic Coordination Committee of the Cabinet (ECC) approved the 'Framework for Power Co-generation' for bagasse and biomass-based sugar industry projects. Under this framework, 1,500 to 2,000 MW is forecasted to be generated in the short term, and thus letters of intent (LOIs) have been issued to a number of projects in Punjab.

Figure 9.16 Animal Farms in Punjab



Source: Energy Department, Government of the Punjab

¹ ENERGY ACCESS ASSESSMENT PUNJAB (Pakistan) ADB 2014



Table 9.2 Biomass availability in Punjab for energy generation

	Waste Type	Area Under Crop	Gross Quantity of Waste	Net Collectable Waste	Consumed Locally	Available for Power Generation
		(M. Acres)	(M. Ton)	(M. Ton)	(M. Ton)	(M. Ton)
Cotton	Cotton Stalk	5.705	11.43	10.288	5.144	5.144
Wheat	Wheat Straw	16.154	18.63	16.764	15.088	1.676
Rice	Rice Straw	4.229	4.869	4.382	2.191	2.191
Rice	Rice Husk	1.39	1.252	0.25	1.002	-
Sugarcane	Sugarcane Waste	1.897	42.982	6.44	6.44	-
Corn	Stalk	1.492	5.163	4.646	4.646	-

Source: Punjab Energy Department

Mini-Hydro

More than 20% of electricity produced in Punjab is from hydro power stations, and there is still large untapped potential in the province. The irrigation system of Pakistan is the world's largest contiguous irrigation system and there are many potential sites that allow Punjab to capitalize and generate a sizable electricity. The Energy Department of the Government of Punjab has compiled a list of 55 potential sites on Punjab's canals for small hydro stations. These potential sites offer 1.14 to 5.63 meter high falls in canals, with electricity generation potential ranging from 11 to 11.9 MW. Meanwhile, there have been recent developments in the province worth noting. The Government of Punjab has issued LOIs to private investors for the establishment of 10 small hydro projects with a cumulative capacity of 142 MW at different locations. The micro Hydel potential of Punjab is around 7,000 MW.

Wind

There is no doubt that certain areas of Pakistan, such as the Gharo Corridor in Sindh, have great potential for wind power development. Recent wind maps developed by the Alternative Energy Development Board (AEDB) have attracted the attention of private project developers to invest in wind farms for power generation. However, the

wind farms being planned are large-scale grid connected, using large wind turbines of over 500 kW each.

Regarding small-scale wind-powered technologies, there is still a gap to be filled; but the limited wind resources in most of Punjab province, as well as inefficient wind technologies for small scale systems, make difficult the promotion and investment in wind turbines for small-scale off-grid systems.



Figure 9.17 Wind energy corridors in Punjab

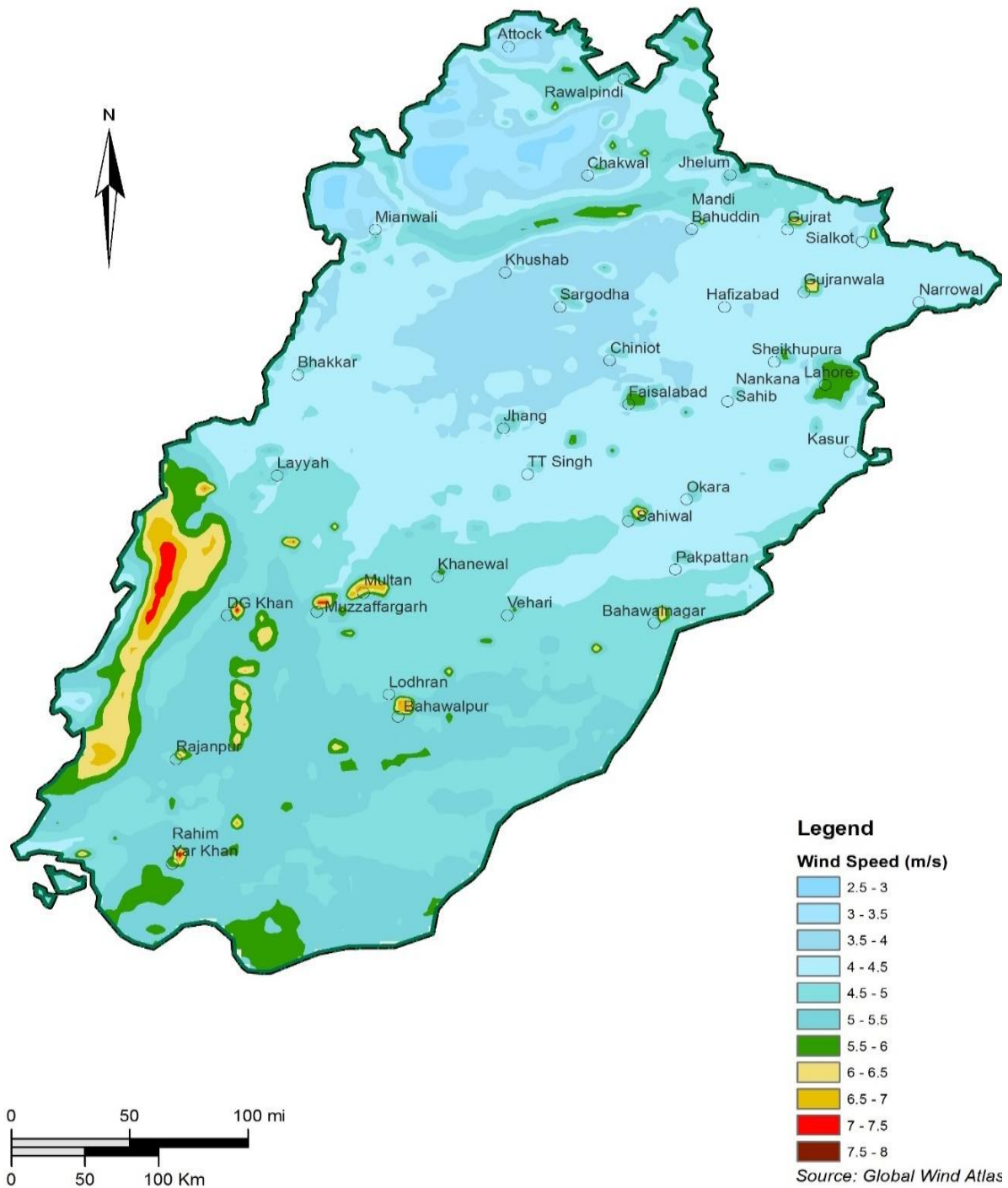
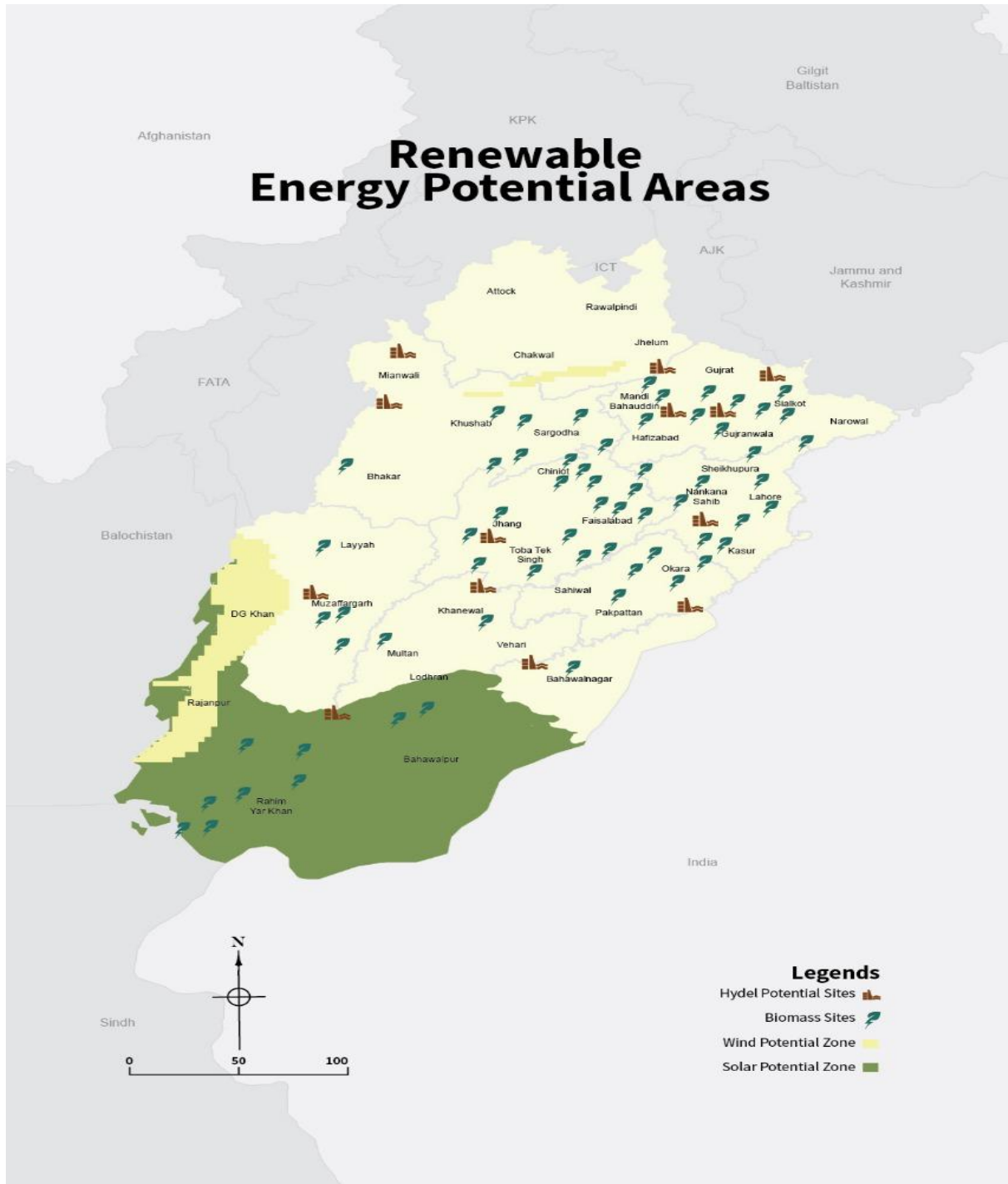




Figure 9.18 Renewable energy potential areas in Punjab



Source: Urban Unit



9.3 Targets for a green and competitive Punjab

Focus Area	2027	2037	2047
Change in overall Energy Consumption Mix	Petroleum products' Share: 30% Renewables: 5% Electricity, Coal and Natural Gas: 50%	Petroleum Share: 25% Renewables: 10% Electricity, Coal and Natural Gas: 65%	Petroleum Share: 20% Renewables: 20% Electricity, Coal and Natural Gas: 40%
Electric Vehicles on the road	5% of the total motor vehicles	10% of the total motor vehicles	30% of the total motor vehicles
Energy savings across sectors	15% network energy saved through conservation and technology shifts	10% network energy saved through conservation and technology shifts	5% network energy saved through conservation and technology shifts

9.3 KEY POLICY FOCUS AND STRATEGIC AREAS

Though the energy is mainly a federal subject, as per the present dynamics, the Province needs to advocate its issues to the respective forums and also introduce localization solutions and interventions where if possible. Following are key points Punjab to focus on:

Affordable Energy Supplies

Energy prices need to be rationalized and brought to a level which will enable our production sectors, particularly the industry, to become competitive in international markets in face of stiff competition from other regional economies. Currently the energy prices in Punjab are much higher than other regional economies such as China, Bangladesh and India which is hampering our competitiveness and hence the growth of export-oriented industry in the province. The export-oriented industry need to be supported, on emergency basis, in terms of energy prices and quality of supplies to improve the export competitiveness of Punjab.

Import oriented energy production, which is currently the main component in the energy production mix of Pakistan, needs to be discouraged and domestically available resources should be developed and utilized on a national level. Punjab will have to champion the use of domestically available resources such as coal to the Federal government as import of expensive thermal fuels for energy and electricity production not only drive up electricity costs but also is a heavy burden on the foreign exchange reserves of the country.

Distribution and transmission losses of electricity due to inefficient transmission systems further aggravate the electricity demand and supply gap leading to more hours of load shedding. These losses need to be curbed to

improve the consistency of supply to the industrial and domestic sector.

Efficient consumption of available energy sources

Use of high-efficiency domestic appliances should be promoted to minimize the demand side inefficiencies. Highly energy intensive appliances and equipment should be replaced with modern technologies through government backed incentives. Introduction of taxes should be made on inefficient usages including appliances and machineries. Similarly, the use of inefficient vehicles including diesel and conventional petrol engines needs to be discouraged. Import levies on hybrid and electric cars should be immediately reduced to promote their use and in the meanwhile Punjab should develop domestic capacity for manufacturing hybrid and electric vehicles by identifying and enabling Automobile industrial clusters in the province.

Industrial units in Punjab in all major sectors are using outdated and energy intensive technologies. Up gradation of current technologies and incorporation of high-value added technologies should be encouraged. Modern technology, high value added and low energy intensive sectors need to be supported. Punjab need to promote off grid and localized energy generation solutions for rural and remote areas through private sector and communities' participation.

Optimum utilization of indigenous and renewable energy resources

Support for Solar PV on large scale for domestic consumers through net metering and banking facilities. In order to overcome the high capital investments, Solar panels manufacturing industries should be incentivized and installed with allied infrastructure and support leveraging CPEC and Chinese technologies. Agriculture and municipal wastes need to be fully converted into energy through feasible and economic instruments. Punjab also



needs to explore power generation opportunities from its Coal resources and installing plants at mine mouths. Mini and micro hydro plants should also be installed by supporting private sector and local communities on run of the river and canals with high streams (55 potential sites already identified). Wind and other renewable sources to be supported wherever feasible and accessible.

Improved Infrastructure and Energy Quality

Along the generation and energy production efforts, Punjab also need to lobby and support the upgradation of transmission and distribution networks to aid the industrial development. With present infrastructure as it is prone to losses, jerks and disruptions, Punjab based Industry cannot sustain. All energy sources' quality has to be best-in-class for making Punjab a transformed and competitive investment destination.

Identification and development of energy corridors

Leveraging the spatial and geological advantages, Punjab has also to identify and develop its energy corridors to support high energy demands in future. For instance, as per current scenarios, Wind and Solar corridors are already identified which have to be developed at higher pace. For solar energy district Rahim Yar Khan, Bahawalpur, DG Khan, Lodhran and Rajanpur have great potential and for Wind energy Chakwal, DG Khan and Rajanpur have high potential according to Global Energy Atlas. The potential of these areas can be used at least to fulfill the demands of local domestic consumer initially and later expending the generation system and macro level.

In addition to Solar and Wind, Punjab has to speed-up the exploration of potential energy resources i.e. Natural gas, shale gas, oil and coal for sustainable and feasible energy options.