

The Punjab Clean Air Action Plan



**Environment Protection Department
Government of the Punjab**

PREFACE

This document examines options for Government of the Punjab to address the significant costs that ever-worsening air pollution and the winter fogs impose upon its economy and populace. It draws upon the available scant data on air quality in the province and on the international best practices to suggest a menu of cost-effective interventions to improve air quality management in the province, particularly in urban areas, which face the most significant deterioration in air quality.

The Punjab province experiences low visibility, especially from October to April in the form of smoke, haze, smog and fog every year. In Lahore and adjoining areas, the episodes occur from November to February with an average of 10 to 25 days. Studies link these episodes over the plains of Punjab and some states in India to higher levels of air pollutants contributed by vehicular exhaust emissions and industrialization. This document provides an overview of sources of air pollutions in the province and suggests policy measures that are expected to contribute to first arresting and eventually reducing concentrations of air pollutants in the province.

Air pollution is a regional and complex phenomenon. The air pollution and resulting smog can only be dealt with through concerted and planned efforts of various departments of the provincial and federal government spread over a medium to long term framework. In view of this limitation that no immediate measure can abate air pollution, the action plan stresses not only immediate response to smog episodes confined to measures aimed at adapting to the given conditions to reduce public exposure to its harmful effects but also delineates medium- to long-term actions.

Environment Protection Department has recently successfully negotiated about US\$ 200 million soft loan for Greening of the Punjab. In view of the rapidly deteriorating air quality in the province, the most important component of this five-year program is focused on arresting fast deteriorating air pollution in the province.

Environment Protection Department hopes that with consistent efforts in implementation this action plan, air quality of the province will significantly improve over the years to come and relieve the public of its ill effects.

1. Air Pollution

The Punjab experiences periods of low visibility due to fog, mist and smog between November and February each year for an average of 10 to 25 days. In recent years, however, the situation is exacerbating as it causes a sensation of burning of eyes and foul smell. Data shows that this is a regional phenomenon, covering large areas of South Asia from Delhi to Faisalabad and beyond. Various studies have linked the recent worsening of air quality to the burning of rice stubbles in the Indian states of Punjab, Haryana and Uttar Pradesh. During 2016 alone, around 32 million tons of rice stubble were estimated to be burnt in Indian Punjab. Local sources of pollution, however, also had their own contribution to this situation.

Data on air quality in the province is scant. Sporadic monitoring of air pollutants suggests that ambient air quality standards for particulate matter with size 2.5 micron (PM_{2.5}), oxides of Nitrogen (NO_x) and Sulphur (SO_x) are exceeded frequently. Industrial units both large and small, many of which use furnace oil high in Sulphur contents, burning of agricultural residual and municipal waste, and vehicular emissions are the main source of these pollutants. A wide range of small to medium-scale industries, including brick kilns and steel re-rolling mills make a much larger contribution as compared to the size of their economic activity due to the use of “waste” fuels such as old

Box: 1.1

The Punjab Environmental Quality Standards for Ambient Air comprise nine criteria pollutants, out of which Particulate Matter (SPM, PM₁₀, PM_{2.5}), NO_x, SO_x and Ozone are important.

- The term particulate matter (PM) is used for airborne particles. It includes dust, dirt, soot, smoke, and liquid droplets. It is the air pollutant most damaging to health. Some particles are directly emitted into the air. Particles can also be created by atmospheric conversion of sulfur dioxide (SO₂) and NO_x into sulfates and nitrates. PM₁₀ can be inhaled into the lungs and results in respiratory illness associated with premature mortality. Particulate matter of less than 2.5 microns (PM_{2.5}) is the most dangerous subset of PM₁₀.
- SO₂ is a by-product of burning fossil fuels such as crude oil, furnace oil, diesel, and coal. SO₂ can be transformed in the atmosphere into sulfates that appear as fine particles.
- NO_x derive from vehicle exhaust, combustion installations such as power plants, and industrial and agricultural activity. NO_x react with other air pollutants to form O₃ and fine particulates (nitrates) in the lower atmosphere.
- O₃ VOCs react with NO_x and other chemicals in the atmosphere to create harmful secondary pollutants, including O₃, and cause health problems ranging from eye irritation to decreased lung capacity.
- CO is a product of incomplete fuels combustion. At low exposure levels, CO causes mild effects that include headaches, dizziness, disorientation, nausea, and fatigue. However, high exposure levels of CO

tires, paper, wood, and textile waste.

At the micro level, air quality is further impaired by the widespread use of small diesel electric generators in commercial and residential areas in response to electricity outages.

Air pollution is a regional and complex phenomenon. The air pollution and resulting smog can only be dealt with through concerted and planned efforts of various departments of the provincial and federal government spread over a medium to long term framework. In view of this limitation that no immediate measure can abate air pollution, the action plan stresses not only immediate response to smog episodes confined to measures aimed at adapting to the given conditions to reduce public exposure to its harmful effects but also delineates medium- to long-term actions.

1.1 Data on Air Pollutants

Historic data on concentrations of these pollutants in ambient air is sporadic and is available for only two sites – Township and Town Hall – in Lahore. The two stations were installed by Federal EPA under a JICA assisted program in 2007. The data gathered through these monitoring stations is intermittent. The available data covers too narrow a scope for any conclusion to be based on it for the province as a whole, and it is also somewhat out of date. Air pollution control in a developing economy like that of Pakistan requires defining a set of priorities which cannot be arrived at on the basis of scant data available. Also, reduction in concentrations of these pollutants is an enormous task, which requires not only huge financial resources but also efforts consistently spanned over a time frame of years, if not decades.



Dale Evarts leads the Climate, International, and Multimedia Group in the Office of Air Quality Planning and Standards (OAQPS) at the US EPA.

He says:

- PM2.5 is a good fingerprint for vehicular, industrial, and biomass burning.
- it is most important to know the sources of pollution; this is the only way to arrive at interventions which would constitute a good policy.
- EPA Punjab need to have a dedicated program to know chemical composition of the pollutants.
- EPA Punjab could do this with 2 to 3 air quality monitoring stations.
- with quantification of sources and their apportionment, EPA Punjab can identify and prioritize the resources based upon the ease/difficulty with which they can be controlled.
- this would also provide cost effective ways

1.2 Historically High Concentrations of Air Pollutants

In the absence of reliable and time-series data on air pollution, especially particulate matter, in ambient air, a good proxy is ambient concentration of aerosols. Satellite measurements of aerosols, called aerosol optical depth (AOD), are based on the fact that the particles change the way the atmosphere reflects and absorbs visible and infrared light. An optical thickness of less than 0.1 (palest yellow) indicates a crystal clear sky with maximum visibility, whereas a value of 1 (reddish brown) indicates hazy conditions. There are two methods for measuring AOD: NASA Satellite Aeronet measures AOD from above the earth and NASA installed Aqua Terra stations measures AOD from ground. Environment Protection Department (EPD) obtained data on AOD from SUPARCO for the years 2011-16. Average AOD is graphically shown below.

The AOD data reveals that particulate matter in ambient air of Lahore remains high not only throughout the year but also it is high for the last many years.

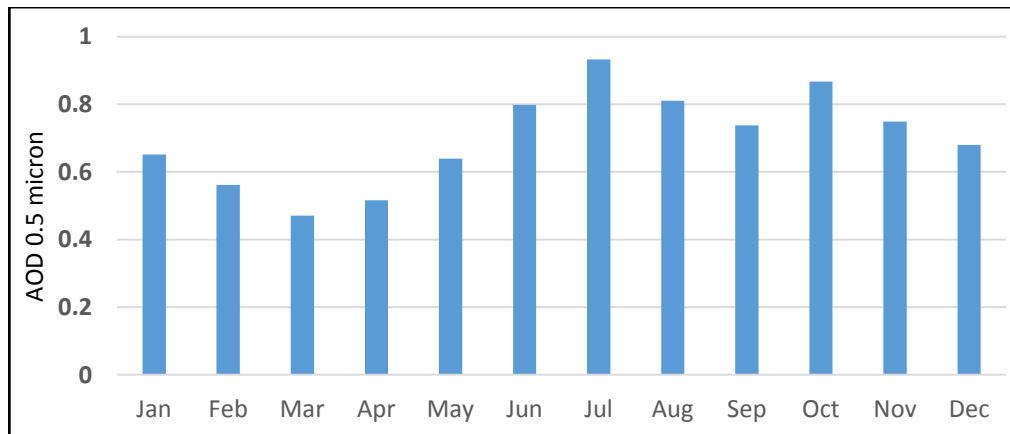


Figure: 1.1 – Average AOD AERONET 2011-2016 Lahore

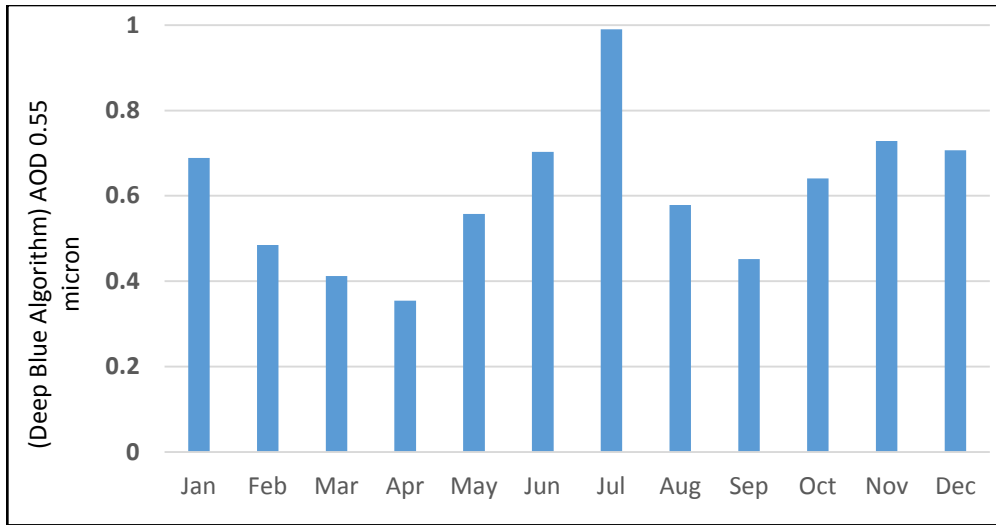


Figure 1.2 – 2011-2016 AOD Satellite (Aqua Terra) Lahore
 The data gathered by EPA Punjab from 2007 to 2015 for the month of November at Township and Town Hall stations shows that monthly average concentrations of PM_{2.5} are 280 µg/m³ and 175 µg/m³, respectively.

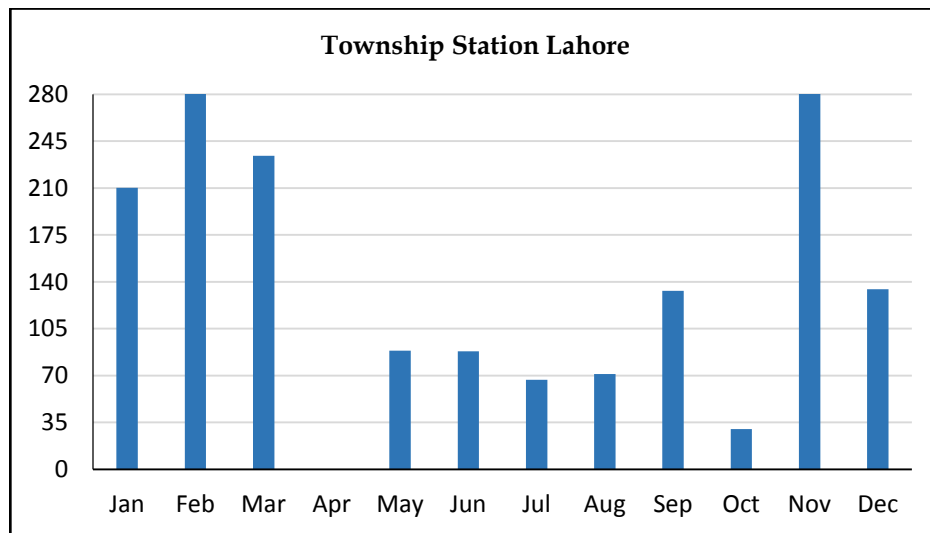


Figure 1.3 – Monthly Average Mass Concentration (ug/m³) [2007-2015]

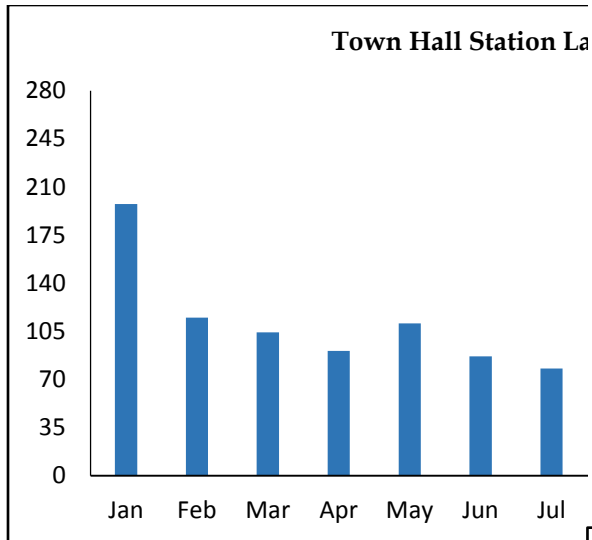


Figure 1.4 – Monthly Average Mass Concentration (ug/m³) [2007-2015]

1.3 Major Contributors to Air Pollution

A study by on source apportionment of air pollutants in Lahore from November 2005 to January 2006 finds several sources contributed to PM_{2.5} concentrations, including diesel emissions (28%), biomass burning (15%), coal combustion (13%), secondary PM (30%), exhaust from two-stroke vehicles (8%), and industrial sources (6%). Diesel and two-stroke vehicle emissions accounted for much (36%) of the measured high PM_{2.5}. Although a large component of the carbonaceous aerosols in Lahore originated from fossil fuel combustion, a significant fraction was derived from biomass

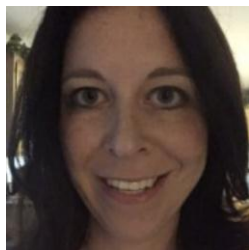


Dr Markus Amann is Program Director, Air Quality and Greenhouse Gases at International Institute for Applied Systems Analysis (IIASA), an international scientific institute that conducts research into the critical issues of global environmental, economic, technological, and social change that the world is facing in the twenty-first century, says that there is nothing surprising in the problems being faced by the Punjab province. He says:

- it does take time to address address air pollution as its description and understanding its constituents is a time taking process.
- it is commendable that EPA Punjab has set standards; the concentration level of a criteria pollutant is irrespective of how much will it costs and how long will it take to achieve the set standard.
- an alternative to this the phased approach of WHO Guidelines, which gives a set of different standards which are to be achieved in different phases.
- many traditional air pollutants and greenhouse gases had common sources. Their emissions also interact in the atmosphere, and –jointly and individually– cause a variety of harmful environmental effects at the local, regional, and global scales.
- the International Institute for Applied Systems Analysis had developed a model GAINS model that explores cost-effective emission control strategies that simultaneously tackle local air quality and greenhouse gases so as to maximize benefits

burning. Similarly, another study using a molecular marker based Chemical Mass Balance (CMB) receptor model, showed that traffic pollution, including exhaust from gasoline- and diesel-powered vehicles, was the predominant source of PM10 carbonaceous aerosols. Gasoline-powered vehicles plus diesel exhausts contribute 47.5%, 88.3%, and 15.4% of measured inhalable particulate organic carbon, elemental carbon, and mass, respectively.

More vehicles... The number of vehicles in Pakistan has jumped from approximately 2 million to 10.6 million over the last 20 years, an average annual growth rate in excess of 8.5%.⁵ From 1991 to 2012, the number of motorcycles and scooters grew more than 450%, and motor cars, close to 650%. The growth rate of mobile sources increased after 2003.



Amanda Curry Brown is Program Manager, International Air Quality and Climate at US Environmental Protection Agency (EPA), Raleigh-Durham, North Carolina Area.

She says:

- taking an action when we do not have right kind of data could be quite expensive.
- EPA Punjab needs to know both the impacts and implementation costs of its policy measures.
- taking a decision in a hurry might lead to policy measures which might subsequently prove very expensive to implement and also lose their effectiveness with time.
- Delhi, India implemented odd/even licence plate policy for vehicles but this policy was effective for one or two years only and then it lost its efficacy as people found ways to circumvent it.
- suggests the Video Conference of EPA Punjab with other countries, which had been or were facing similar high levels of air pollution would help.
- the experience and documents developed by US EPA offices in Research Triangle in North Carolina could be helpful for EPA Punjab.
- Emergency Episode Forecasting, Overview of Air Quality Management, Air Quality Public Notification Tools can be a good beginning for EPA Punjab

Industrial facilities... Industrial facilities, particularly those consuming fossil fuels, emit significant amounts of air pollutants. Emissions from large-scale facilities, such as cement, fertilizer, sugar, steel, and power plants—many of which use furnace oil that is high in sulfur content—are a major contributor to poor air quality (Ghauri, Lodhi, and Mansha 2007; Khan 2011). A wide range of small-scale to medium-scale industries, including brick kilns, steel re-rolling, steel recycling, and plastic molding, also contribute substantially to urban air pollution through their use of “waste” fuels, including old tires, paper, wood, and textile waste. Industrial emissions are further exacerbated by the widespread use of small diesel electric generators in commercial and residential areas in response to the electricity outages.

Industrial emissions are associated with poor maintenance of boilers and generators (Colbeck, Nasir, and Ali 2010a; Ghauri 2010; Ilyas 2007; Khan 2011).

Waste burning, dry weather, strong winds... Different nonpoint sources contribute to air pollution in Pakistan, including burning of solid wastes and sugarcane fields. More than 54,000 tons of solid waste are generated daily, most of which is either dumped in low-lying areas or burned. The burning of solid waste at low temperatures produces carbon monoxide (CO), PM, and volatile organic compounds (VOCs), including toxic and carcinogenic pollutants (Faiz 2011). Farmers in Pakistan burn cane fields to ease harvesting. During sugarcane harvesting, high concentrations of particulate matter of less than 10 microns (PM₁₀) are found in rural areas in Punjab and Sindh. Predominantly dry weather in arid conditions and strong winds also generate substantial dust in most parts of Sindh province and southern Punjab, elevating PM₁₀ levels in the air. Due to high summer temperatures (40–50°C), fine dust is transported into the atmosphere with the rising hot air and forms “dust clouds” and haze over many cities of southern Punjab and upper Sindh. Dust storms are also generated from deserts (Thal, Cholistan, and Thar), particularly during the summer, and adversely affect air quality in the cities of Punjab and Sindh (Hussain, Mir, and Afzal 2005).

2. Vehicular Pollution

Motor vehicle exhaust emissions are a significant source of air pollution, comprising carbon monoxide, oxides of nitrogen (NO_x) and hydrocarbons. These pollutants are harmful to human health and the environment and lead to the formation of ground level ozone (smog).

The number of vehicles in the province has jumped from approximately 6.6 million to 16.2 million from 2008 to 2016, in just 8 years, an average annual growth rate of about 12% for this period.

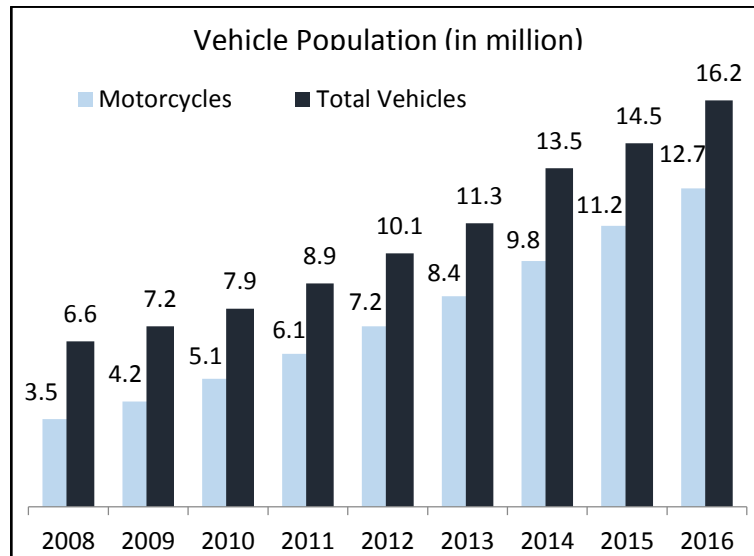


Figure 2.1 – Vehicle Population in Punjab

2.1 Managing Emissions from Mobile Sources

Possible interventions to control and reduce PM emissions from motor vehicle exhaust include (a) reducing sulfur in diesel and fuel oil, (b) retrofitting in-use diesel vehicles with PM emission-control technology, (c) converting diesel-fueled buses and vans to CNG, (d) controlling PM emissions from motorcycles, and (e) converting three-wheelers (rickshaws) to CNG.

These interventions would not only reduce PM emissions, but low-sulfur fuels would also reduce secondary particulates by reducing sulfur dioxide emissions.

2.2 Vehicle Exhaust Inspection

Transport Department, Government of the Punjab is establishing Vehicle Inspection and Certification System (VICS) in the province in PPP mode. In the first phase, these stations are being established in (Township and Kala Shah Kaku) Lahore, Multan, and Bahawalpur. These stations have presently been designed for vehicle inspection and certification from their safety and road-worthiness point of view.

Policy Measure 1: Strengthening and expanding vehicle inspection regime

Under this policy, all VICS will be enabled to also provide facilities for vehicle exhaust emission testing and certifications. Other policy actions, their approximate costs, timelines, and responsibilities are as follows:

Policy measure	Proposed action	Approx cost	Timeline	Responsibility
Strengthening and expanding vehicle inspection regime	VICS fully established, all parameters tested	PPP mode	Mar 2018	Lead: Transport Partner: Environment
	Mandatory inspection regime for all vehicles	Policy action	Jan 2018	
	Expanding VICS network	PPP mode	Dec 2018	
	On site emissions testing capacity – provisions of mobile testing facilities	Rs. TBD	Dec 2018	Lead: Environment Partner: Transport

2.3 Reducing Sulfur Content

Fuel oil in Pakistan generally has a sulfur content that averages around 3%, although some fuel oil with 1% sulfur is also being imported. The maximum allowable content of sulfur for all fuels used in the country originally was scheduled to be reduced from 10,000 to 500 ppm by 2008, but the stricter standard was postponed until 2010, and then again until July 1, 2012. The main reason for the postponements was that companies needed more time to retrofit refineries. Federal Government has extended the deadline to lower sulfur contents in fuels to December, 2017.

The country can take advantage of ultralow sulfur fuels as they become increasingly available in international markets. Pakistan currently imports about

3.5 Mt of diesel a year from Kuwait, whose content in sulfur is 2,000 ppm. Importing diesel from Oman, Qatar, Bahrain, or the United Arab Emirates could reduce sulfur contents of diesel used in urban centers to 500 ppm.

Euro Standard	Emission Limits		
	Petrol NO _x	Diesel NO _x	PM
Euro I (1993)	0.97 g/km	0.97 g/km	0.14 g/km
Euro II (1996)	0.5 g/km	0.9 g/km	0.1 g/km
Euro III (2001)	0.15 g/km	0.5 g/km	0.05 g/km
Euro IV (2006)	0.08 g/km	0.25 g/km	0.025 g/km
Euro V (2009)	0.06 g/km	0.18 g/km	0.005 g/km
Euro VI (2014)	0.06 g/km	0.08 g/km	0.004 g/km

PM emission rates from combustion of fuel oil are greatly influenced by the sulfur content. Reducing sulfur from 3% to 1% is estimated to have health benefits of US\$35–47 per ton of fuel oil. The additional cost of low-sulfur fuel oil in the international markets fluctuates and has recently been around US\$50 per ton. Thus, use of low-sulfur fuel oil need to be targeted at users within urban centers. Additional health benefits of low-sulfur fuel oil, as has already been explained, include reduced sulfur dioxide emissions and, thus, lower secondary particulates formation.

Policy Measure 2: Import and refining of low sulfur diesel and furnace oil (less than 50 ppm)

To implement cleaner fuel regime in the province, Government of the Punjab will approach Federal Government and take actions as delineated in Table 2.3.

Policy Measure 3: Checking fuel adulteration

Fuel adulteration is another contributor to air pollutant. Controlling fuel adulteration is also a mandatory part of cleaner fuel regime. Environment and

Industries Departments of the Punjab Government will coordinate with OGRA to implement a continuous program for discouraging and eliminating fuel adulteration.

Policy measure	Proposed action	Approx cost	Timeline	Responsibility
Import and refining of low sulfur diesel and furnace oil (less than 50 ppm)	Institute restrictions on import of high sulfur diesel and furnace oil	Policy action	Dec 2018	Lead: Environment Partner: Ministry of Energy, Petroleum Division; Ministry of Climate Change, Transport, Industries
	Ensure December 2016 deadline by remaining two refineries (Byco, Pakistan)	Policy action	TBD	
	Institute standards for metal levels including Manganese in gasoline	Policy action	TBD	
	Phased introduction of Euro IV compliant fuels	Policy action	Dec 2022	
Checking fuel adulteration	Continuous enforcement	Policy action	On going	Lead: Industries Partner: OGRA, Environment

2.4 Catalysts and Filters

More stringent PM emission standards and control options can be implemented for diesel vehicles once low-sulfur diesel is available. Euro standards can be mandated on new diesel vehicles (and second-hand imports), and PM control technologies can effectively be installed on in-use diesel vehicles, such as diesel oxidation catalysts (DOCs) and diesel particulate filters (DPFs).

DOCs require a maximum of 500-ppm sulfur in diesel and DPFs require a maximum of 50 ppm to function effectively. A DOC generally reduces PM emissions by 20–30%, while a DPF reduces PM by more than 85%.

All new on-road diesel vehicles in the United States and Canada are equipped with a high-efficiency DPF, while all new diesel cars and vans in the European Union are mandatorily equipped with DPF since 2009.

Potential candidates for retrofitting with a DOC, or with a DPF when 50-ppm sulfur diesel becomes available are high-usage commercial diesel vehicles that are on the roads of urban centers in the province and primarily used within

the city. The health benefits of retrofitting per vehicle per year are estimated to be in the range of about US\$95–568 for a DOC and US\$216–1,295 for a DPF, depending on the type of vehicle and annual usage. A DOC costs US\$1,000–2,000 and a DPF as much as US\$6,000–10,000. Therefore, the expected number of years that the vehicle will continue to be in use and years that the devices will be effective is an important consideration.

Given the relatively high cost of DOCs per unit of PM emission reduction, alternative options can be considered for in-use diesel-fueled minibuses and light-duty vans. One such option is conversion to CNG, which almost entirely eliminates PM emissions. The estimated health benefits of CNG conversion are in the range of about US\$455–1,288 per vehicle per year, depending on the type of vehicle and annual usage.

Policy Measure 4: Installation of catalytic converter

Under this policy measure, Government of the Punjab will make it mandatory for new vehicles, including motorcycles, registered in the Punjab to have catalytic converters.

Policy Measure 5: Fleet turn-over to low emission vehicles

Under this policy measure, capacity of EPA Punjab will be developed for strict enforcement of Euro-II (Pak-II) standards with a view to gradual shift to Euro-IV.

Policy measure	Proposed action	Approx cost	Timeline	Responsibility
Installation of catalytic converter	Mandatory for new vehicles registered in Punjab including motorcycles	Policy action	Dec 2018	Lead: Environment Partner: Ministry of Industries, E&T
Fleet turn-over to low emission vehicles	Strict enforcement of Euro-II standards (Pak-II)	Policy action	On going	Lead: Environment Partner: Ministry of Industries,
	Capacity building to test compliance levels	Rs. 600m	Dec 2018	

	Gradual shift to Euro-IV	Policy action	Dec 2022	Transport
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2.5 Restricting CNG in Autos

In view of CNG supply constraints and more energy-efficient alternative uses of CNG (for example, thermal power generation), it would be advisable to restrict CNG in automobiles and reserve its use for commercial and public service vehicles (buses, vans, utility trucks, and rickshaws).

Policy Measure 6: Reintroduction of CNG as vehicular fuel

Government of the Punjab will approach Federal Government for appropriate measures for allowing reintroduction of CNG as vehicular fuel.

Policy measure	Proposed action	Approx cost	Timeline	Responsibility
Reintroduction of CNG as vehicular fuel	Issuance of a Statutory Regulation Order (SRO)	Policy action	Jun 2018	Lead: Environment Partner: Ministry of Industries, Transport

2.6 Mass Transportation and Traffic Management

In the medium run, the Punjab Government might consider other alternatives to reduce air pollution, particularly from mobile sources, such as development of mass transportation and improved traffic management in main cities.

Experiences from countries such as Brazil, Colombia, and Mexico demonstrate benefits of relatively new public transport systems, such as Bus Rapid Transit, which can use bus-based technologies to transport increasingly larger volumes of customers at moderately high speeds even in very congested urban areas. While still substantial, the investments needed to develop and

operate these systems are significantly lower than those of traditional mass transport systems, such as underground metros. In addition, these systems have been able to demonstrate their contributions to reduce congestion and pollution, and some of them have even received international funding for their role in reducing GHG emissions from mobile sources.

Additional policies worth assessing in the medium term aiming at reduction of PM emissions include traffic control, restricted circulation of private cars during high pollution episodes, urban planning and land use, establishment of high occupancy vehicle lanes, measures to improve traffic flow such as ‘green wave’ coordination of traffic signals, and improvement of infrastructure, for example, paving of roads and regular sweeping.

Policy Measure 7: Mandatory use of bus transport for 75 percent of students in major cities

Under this policy measure, buses will be provided to public sector colleges and universities in major cities, private school and college chains will be mandated to arrange buses for student and faculty, and congestion charges will be imposed on use of cars for commuting of students.

Policy Measure 8: Road denial during high pollution period

Under this policy measure, trucks with high emission potential will be denied entry in selected zones of cities and private cars may be allowed on alternate days according to number plates (odd, even).

Policy measure	Proposed action	Approx cost	Timeline	Responsibility
Mandatory use of bus transport for 75 percent of students in major cities	Provision of buses to public sector colleges and universities in major cities	TBD	Dec 2019	Lead: Higher Education Partner: Environment,

	Mandate private school and college chains to arrange buses for student and faculty	Policy action	Dec 2018	Transport
	Impose congestion charges on use of cars for commuting of students	Policy action	Dec 2018	Lead: Transport Partner: Traffic police
Road denial during high pollution period	Progressively: <ul style="list-style-type: none"> ▪ Heavy duty trucks denied entry in selected zones ▪ Private cars allowed on alternate days according to number plates (odd, even) 	Policy action	Jun 2018	Lead: Traffic Police Partner: Environment, Safe City Authority

2.7 Retiring Excessively Old Vehicles

Very old diesel run commercial vehicles when they become unworthy for long distances they are used for short distance freight movement within cities and cause hugely to air pollution.

Policy Measure 9: Retiring excessively old vehicles

The general 80:20 principle applies classically to vehicular pollution where it is found that 20% of vehicles are usually responsible for 80% of pollution. The most polluting vehicles are usually the old vehicles. Therefore, under this policy measure, excessively old vehicles will be retired and scrapped through a buyback program.

Policy measure	Proposed action	Approx cost	Timeline	Responsibility
Retiring excessively old vehicles	Vehicles with life of 20 years denied access in major cities, selected vehicles scrapped through vehicle buyback programme	Rs. 5b	Dec 2018	Lead: Transport Partner: Traffic Police, Safe City Authority

2.8 Promotion of Non-motorized Vehicles

The use of non-motorized vehicles, such as bicycles, also needs to be promoted as a means to reduce pollution from mobile sources. However, in doing so, the government must consider development of dedicated bike paths, pedestrian zones, and other measures to reduce potential conflict between motorized and non-motorized vehicles.

3. Industrial Processes

Industrial processes, particularly those consuming fossil fuels, emit significant amounts of air pollutants. Emissions from large-scale facilities, such as cement, fertilizer, sugar, steel, and power plants – many of which use furnace oil high in sulfur content – are a major contributor to poor air quality. A wide range of small-scale to medium-scale industries, including brick kilns, steel furnaces, and steel rerolling also contribute substantially to urban air pollution through their use of “waste” fuels, including old tires, paper, wood, and textile waste.

Deterioration in air quality is further exacerbated by the widespread use of small diesel electric generators in commercial and residential areas in response to the frequent electricity outages. Poor maintenance of boilers is another contributor to air pollution in the province.

3.1 Modernizing Brick Kilns

The clay brick-manufacturing sector in Pakistan, with an estimated 1.5% contribution to the GDP, is still a highly un-regulated and un-documented area. There are about 10,000 conventional brick kilns in the Punjab. The typical processes for production of bricks consist of hand-made bricks which are baked in local made kilns. Mechanized brick making plants and different types of kilns like the tunnel kiln, Hoffman kiln, modified FCBTK and the VSBKs have also been introduced in different countries. Earlier attempts to introduce mechanized brick making and brick baking did not meet success owing to a mix of techno-operational and adaptability/ acceptability problems.

Most of the brick kilns, producing clay bricks, are located in or around the urban cities of the province. They emit thick black smoke containing several air pollutants (carbon monoxide, carbon dioxide, sulphur dioxide, nitrogen oxides)

and fine particulate matter, which present serious health hazards (human illnesses, animal and plant life destruction) to communities living around them.

Environment Department Punjab (EDP) is introducing an environment friendly and cost effective technology of brick kilns in collaboration with All Pakistan Brick Kilns Owners Association. The technology is a slight improvement on the currently prevalent Bulls Trench Kilns by modification in the flow of hot air used to progressively bake brick. This is called Induced Draught Zig Zag Brick Kiln. This technology was developed by International Centre for Integrated Mountain Development (ICIMOD) while working in Nepal.

Zig Zag Kilns are claimed to reduce 70% emissions while improving fuel efficiency by 40% as compared to the conventional brick kilns.



Figure: Traditional Bull Trench Vs. Zig-Zag Induced Draught Brick Kiln

Policy Measure 10: Technology diffusion through demonstration in most polluting sectors through matching grants

Under this policy measure, 200 brick kilns will be upgraded to more efficient Induced Draft Zig-Zag Brick Kiln technology; energy conservation,

process improvement and end of pipe treatment will be introduced for steel furnaces; process improvement and control of dust and air pollution from rice husking mills will be achieved; commercial applications of fly ash from boilers and power plants will be introduced; and dust control and process improvement in stone crushing units will be introduced.

Policy measure	Proposed action	Approx cost	Timeline	Responsibility
Technology diffusion through demonstration in most polluting sectors through matching grants	200 brick kilns upgraded to more efficient Induced Draft Zig-Zag Brick Kiln technology	Rs. 800m WB funds	TBD	Lead: Environment Partner: Industry, Chambers of Commerce and Industry, respective industrial associations
	Energy conservation, process improvement and end of pipe treatment of (TBD) furnaces	Rs. TBD WB funds		
	Process improvement and control of dust and air pollution from (TBD) rice husking mills	Rs. TBD WB funds		
	Commercial application of fly ash from boilers and power plants	Rs. TBD WB funds		
	Dust control and process improvement in xxx stone crushing units	Rs. TBD WB funds		

Policy Measure 11: Credit facility for large scale roll out

Under policy measure 10, EPD plans to introduce a number of initiatives which it may implement only at pilot scale. To further roll out the successful initiatives, EPD has negotiated with the World Bank to provide Rs. 1,200 million soft credit facility for supporting technology diffusion at large scale.

Policy measure	Proposed action	Approx cost	Timeline	Responsibility
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Credit facility for large scale roll out	Opening up a soft credit facility for supporting technology diffusion at large scale	Rs. 12000m WB funds		Lead: Environment Partner: PSIC
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Policy Measure 12: Building capacity for technology transfer

A major impediment to environmental pollution control and treatment is non-availability of relevant skills and required technology in local market. This gap can be filled by (at least secondary) research to indigenize available technologies and transfer of skills. However, to be of any value, the research needs to be demand driven. The demand arises from the industry, the end users of the outcomes of the research. Thus, under this policy initiative, EPD will function to lower the barriers to research and technology transfer by establish Technology Transfer Center to identify appropriate technologies, pilot promising technologies locally, and advise industry on adoption of successful technology

Policy measure	Proposed action	Approx cost	Timeline	Responsibility
Building capacity for technology transfer	Establish Technology Transfer Center to: <ul style="list-style-type: none"> ▪ Identify appropriate technologies ▪ Pilot promising technologies locally ▪ Advise industry on adoption of successful technology 	Rs. 300m WB funds		

Policy Measure 13: Bridging sustainability issue

To achieve the objectives of this policy, an endowment (Sustainable Development Fund) will be established to support technology diffusion on sustainable basis. This action will consolidate the outcomes and further the objectives of policy measure 12.

Policy measure	Proposed action	Approx cost	Timeline	Responsibility

Bridging sustainability issue	Establishment of an endowment (Sustainable Development Fund) to support technology diffusion on sustainable basis	Rs. 5000m WB funds		Lead: Environment Partner: Finance
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Policy Measure 14: Relocation of industry

Under the first phase of this policy measure, Sialkot Tanneries Zone will be operationalized by relocation of all intended tanneries. The utility of this action will subsequently be explored for shifting of steel furnaces, re-rolling mills in northern Lahore and Gujranwala.

Policy measure	Proposed action	Approx cost	Timeline	Responsibility
Relocation of industry	Operationalization of Sialkot Tanneries Zone and relocation of tanneries	Rs. 1500m WB funds		Lead: Environment Partner: CCI Sialkot

Policy Measure 15: Energy Efficiency

Under this policy measure, energy efficiency and conservation program in selected public sector organizations will be implemented. Public sector is one of the major consumers of energy. Energy conservation in this sector will reduce the pollution load added in the production of the saved energy.

Policy measure	Proposed action	Approx cost	Timeline	Responsibility
Energy Efficiency	Energy efficiency and conservation programme in selected public sector organizations	Rs. 1200m WB funds		

Policy Measure 16: Pollution inventories

Under this policy measure, inventories of sources of pollution in the province will be created. This will help EPD identify and prioritize its action for efficient pollution control policies.

Policy measure	Proposed action	Approx cost	Timeline	Responsibility

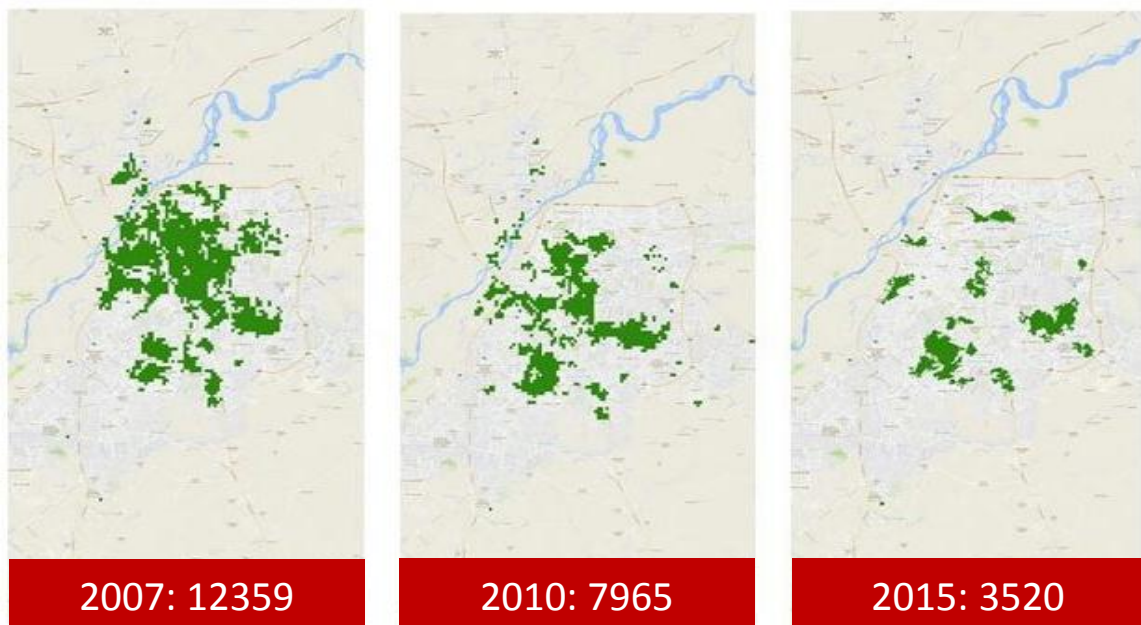
Pollution inventories	Development of pollution release and transfer registry	Policy action		
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4. Urban Pollution Control

As urban areas become more populated and new buildings constructed, urban trees are chopped down. Cities in the province are losing tree cover. And it has consequences. Trees are not just decorative. They are infrastructure. And they are important for that reason only.

Trees in general provide a large number of ecosystem services that affect us in many ways. They remove pollutants from the air, soil and water, release water vapor into the atmosphere which cools the surrounding areas, mitigate urban heat island effect, intercept rainfall and reduce storm water runoff (and thus, reducing the costs related to infrastructure required to manage it), reduce greenhouse gas emissions, sequester carbon, increase property values, to mention a few.

Satellite imagery, shown below, reveals 72% loss of tree cover in the province in just 8 years from 2007 to 2015.



Policy Measure 17: Increasing urban tree cover

Under this policy measure, transplanting rather than cutting of trees for development projects will be mandated and projects will be implemented for threefold increase in tree cover in and around six major cities (Lahore, Faisalabad, Rawalpindi, Multan, Gujranwala, Sialkot).

Policy measure	Proposed action	Approx cost	Timeline	Responsibility
Increasing urban tree cover	Transplanting rather than cutting trees for development projects	TBD		Lead: HUD & PHED, PHAs, Forest Partner: Environment, BoR, P&D
	Threefold increase in tree cover in and around six major cities (Lahore, Faisalabad, Rawalpindi, Multan, Gujranwala, Sialkot)	TBD		

Policy Measure 18: Promoting non-motorized travelling

Impromptu growth, lack of planning and enforcements in the province have resulted in worsening of situation especially related to non-motorized travelling, pedestrian walkways and cycling tracks. It is because due consideration has never been given to non-motorized movement during planning and construction phase of urban infrastructure.

Under this policy initiative, EPA Punjab shall mandate provision of pedestrian walk-ways and bicycle lanes in all new urban projects and Environmental Approval of new housing societies shall be given subject to provisions of these facilities.

Policy measure	Proposed action	Approx cost	Timeline	Responsibility
Promoting non-motorized travelling	Provision of pedestrian walkways and bicycle lanes in all new urban road projects	TBD		Lead: C&W, Local Government Partner: P&D, Environment
	Environmental Approval of new housing societies subject to provisions of these facilities	Policy action		

Policy Measure 19: Controlling fugitive dust from road shoulders

Fugitive dust from unpaved road shoulders is a major contributor of air pollution. The finer particles in this fugitive dust provide nucleation for vehicle exhaust emissions such as oxides of nitrogen (NO_x), carbon monoxide (CO), sulphur dioxide (SO₂) and contribute to toxic finer particulate matter measured as PM_{2.5}.

This policy initiative aims at initially paving of all road shoulders in six major cities of the province. Additionally, under this initiative, EPA Punjab shall be mandated to accord Environmental Approval to new housing societies subject to provisions of these facilities.

Policy measure	Proposed action	Approx cost	Timeline	Responsibility
Controlling fugitive dust from road shoulders	All road shoulders in six major cities paved	TBD		Lead: C&W, Local Government Partner: P&D
	Environmental Approval of new housing societies subject to provisions of these facilities	Policy action		

Policy Measure 20: Improved collection and disposal of municipal and industrial waste

Inadequate collection and disposal of solid waste poses a serious health risk to the population by contributing to air pollution as it disintegrates and degrades into finer particles which become airborne. For a city to be a relatively clean, solid waste collection need to be at least more than 80%.

Under this policy measure, the actions taken will be: restrictions on opening burning to continue, coverage in six major cities extended to 100%, provision of sanitary land fill sites, and setting up system for collection and disposal of industrial waste.

Policy measure	Proposed action	Approx cost	Timeline	Responsibility
Improved collection and disposal of municipal and industrial waste	Restrictions on opening burning to continue	Policy action		Lead: Local Government, Cooperatives, Industries
	Coverage in six major cities extended to 100%	TBD		

industrial waste	Provision of sanitary land fill sites	TBD		Partner: Environment
	Setting up system for collection and disposal of industrial waste	TBD		

Policy Measure 21: Reducing generator emissions

As a result of frequent rolling power black outs in the country, most of the shops, offices, and houses have restored to using power generators. Like vehicular emissions, emissions from these power generators have become a significant source of air pollutions.

To reduce their impact and contribution to air pollution, stringent emission (and noise) standards for such generators will be notified and all generators shall be required to be fitted with catalytic converters.

Policy measure	Proposed action	Approx cost	Timeline	Responsibility
Reducing generator emissions	Formulation of emission standards	Policy action		Lead: Environment
	Mandatory installation of catalytic converters on all new and sound muffles on all generators	Policy action		Partner: Industries, Local Government

Policy Measure 22: Urban planning and land zoning

Many of the issues resulting in air pollution in major urban center result from want of urban planning and land zoning. Therefore, under this policy initiative, all major and intermediate cities shall be mandated to prepare land zone and urban development plans for the next 25 years.

Policy measure	Proposed action	Approx cost	Timeline	Responsibility
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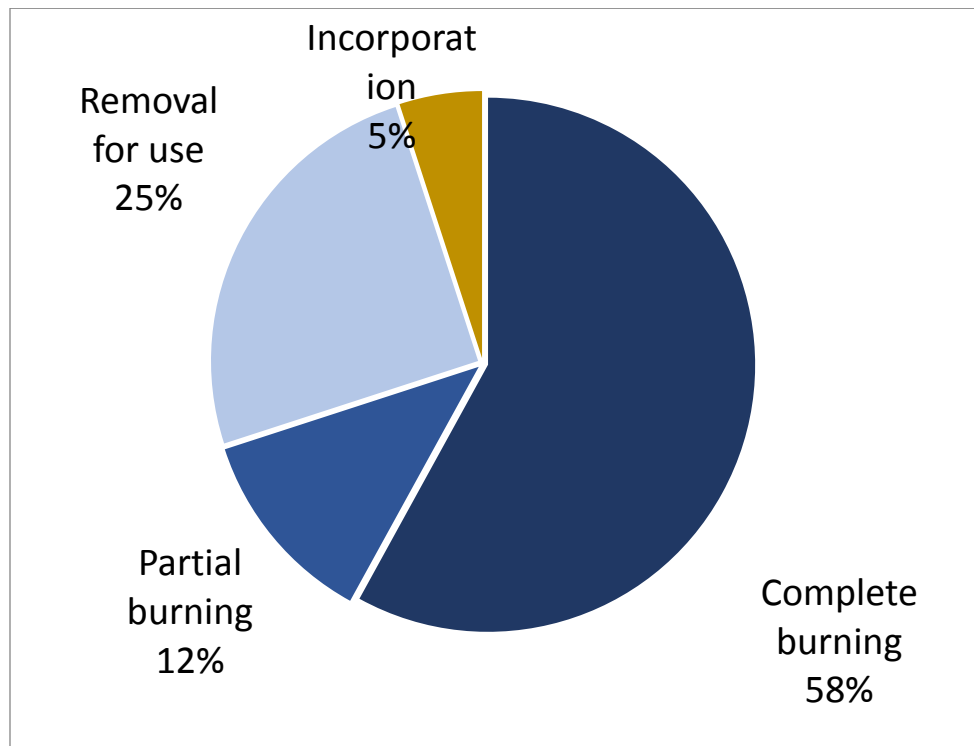
Urban planning and land zoning	Preparation of land zone and urban development plans for major and intermediate cities for next 25 years	TBD		Lead: Local Government, HUD & PHED Partner: Urban Unit
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5. Alternatives to Crop Residue Burning

According to the United Nation's Food and Agriculture Organization (FAO) study, Pakistan annually generates around 69 million tons of field-based crop residue. After harvesting paddy fields, farmers burn the crop stubbles to clear and prepare fields for wheat cultivation. Burning of crop residues emits carbon dioxide and smoke which, with lowering mercury and inversion, creates smog which lasts from the last week of October to the mid November every year.

Scale of the problem:

▪ Total area under rice:	1.7 million hectare
▪ Residue produced:	8.5 million ton
▪ Residue burning area:	1.2 million hectare
▪ Potential residue burned:	3.6-5 million ton
▪ Transboundary residue burning:	32 million ton



Disposal of Rice Stubble¹

¹ *Ahmed, 2014; **Dobermann & Witt, 2000; ***Naresh, 2017

Main consequences, besides environmental impact:

- Loss of nutrients per ton: 5-8 Kg Nitrogen; 0.7-1.2 Kg Phosphorus; 12-17 Kg Potassium**
- Green House Gases emitted per ton: 3 kg particulate matter, 60 kg CO, 1460 kg CO₂, 199 kg ash and 2 kg SO₂***

Policy Measure 23: Discouraging Crop Burning

Under this policy measure, the following actions shall be taken:

Policy measure	Proposed action	Approx cost	Timeline	Responsibility
Discouraging burning of crop residue	Restrictions on open burning of crop residue to continue	Policy action	On-going	Lead: Home Department Partner: Environment
Raising awareness among farmers	Inclusion in regular training sessions organized by Agriculture Extension Wing	TBD		Lead: Agriculture Partner: Environment
Alternate farming practices	Building on pilot projects for: <ul style="list-style-type: none"> ▪ Crop residue mulching ▪ Happy Tiller ▪ Crop residue bailing and briquetting 	TBD		Lead: Agriculture Partner: Environment, farmers associations
Using biomass for energy	Operationalization of Biomass Company	TBD		Lead: Agriculture
Regional cooperation agreements	<ul style="list-style-type: none"> ▪ Exchange of information on emission, meteorology and air quality ▪ Sharing of technology and farming practices ▪ Collective effort to control pollution sources 	Policy action		Lead: Environment Partner: Ministry of Climate Change, Foreign Affairs

6. Strengthening legal framework & organizational capacity

The state of ambient air quality in the province necessitates introduction of a specialized Punjab Clean Air Act for: defining emission reduction requirements, emission monitoring and reporting requirements for industry, installation of emission control systems by polluters, demarcating air pollution control areas, penal provisions, and revision of existing Vehicular Emission Standards for making them progressively more stringent.

Policy Measure 25: Legislative action

Under this policy measure, the following actions shall be taken:

Policy measure	Proposed action	Approx cost	Timeline	Responsibility
Legislative action	Introduction of a specialized Punjab Clean Air Act for: <ul style="list-style-type: none"> • defining emission reduction requirements • emission monitoring and reporting requirements for industry • installation of emission control systems by polluters • demarcating air pollution control areas • penal provisions 	Policy Action	June 2018	Lead: Environment Partner: Law Dept
	Revision of Vehicular Emission Standards	Policy Action	June 2018	Lead: Environment Partner: Law Dept

Policy Measure 25: Capacity Building

Under this policy initiative, capacity building under the on-going restructuring programme will be taken which comprises: strengthening human resource, policy analyses and advice, and processes reengineering.

Policy measure	Proposed action	Approx cost	Timeline	Responsibility
Enforcement capacity building	Capacity building under the on-going restructuring programme including: <ul style="list-style-type: none"> • Strengthening human 	Rs.2000 M WB Fund	June 2020	Lead: Environment

	<p>resource</p> <ul style="list-style-type: none">• Policy analyses and advice• Processes reengineering			
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CLEAN AIR ACTION PLAN

Policy measure	Proposed action	Approx cost	Timeline	Responsibility
Strengthening and expanding vehicle inspection regime	VICS fully established, all parameters tested	PPP mode	Mar 2018	Lead: Transport Partner: Environment
	Mandatory inspection regime for all vehicles	Policy action	Jan 2018	
	Expanding VICS network	PPP mode	Dec 2018	
	On site emissions testing capacity – provisions of (TBD) mobile testing facilities	Rs. TBD	Dec 2018	Lead: Environment Partner: Transport
Installation of catalytic converter	Mandatory for new vehicles registered in Punjab including motorcycles	Policy action	Dec 2018	Lead: Environment Partner: Ministry of Industries, E&T
Fleet turn-over to low emission vehicles	Strict enforcement of Euro-II standards (Pak-II)	Policy action	On going	Lead: Environment Partner: Ministry of Industries, Transport
	Capacity building to test compliance levels	Rs. 600m	Dec 2018	
	Gradual shift to Euro-IV	Policy action	Dec 2022	
Import and refining of low sulfur diesel and furnace oil (less than 50 ppm)	Institute restrictions on import of high sulfur diesel and furnace oil	Policy action	Dec 2018	Lead: Environment Partner: Ministry of Energy, Petroleum Division; Ministry of Climate Change, Transport, Industries
	Ensure December 2016 deadline by remaining two	Policy action	TBD	

	refineries (Byco, Pakistan)			
	Institute standards for metal levels including Manganese in gasoline	Policy action	TBD	
	Phased introduction of Euro IV compliant fuels	Policy action	Dec 2022	
Reintroduction of CNG as vehicular fuel	Issuance of a Statutory Regulation Order (SRO)	Policy action	Jun 2018	-do-
Checking fuel adulteration	Continuous enforcement	Policy action	On going	Lead: Industries Partner: OGRA, Environment
Mandatory use of bus transport for 75 percent of students in major cities	Provision of buses to public sector colleges and universities in major cities	TBD	Dec 2019	Lead: Higher Education Partner: Environment, Transport
	Mandate private school and college chains to arrange buses for student and faculty	Policy action	Dec 2018	
	Impose congestion charges on use of cars for commuting of students	Policy action	Dec 2018	Lead: Transport Partner: Traffic police
Road denial during high pollution period	Progressively: <ul style="list-style-type: none"> ▪ Heavy duty trucks denied entry in selected zones ▪ Private cars 	Policy action	Jun 2018	Lead: Traffic Police Partner: Environment, Safe City Authority

	allowed on alternate days according to number plates (odd, even)			
Retiring excessively old vehicles	Vehicles with life of 20 years denied access in major cities, selected vehicles scrapped through vehicle buyback programme	Rs. 5b	Dec 2018	Lead: Transport Partner: Traffic Police, Safe City Authority

Industrial Processes

Policy measure	Proposed action	Approx cost	Timeline	Responsibility
Technology diffusion through demonstration in most polluting sectors through matching grants	200 brick kilns upgraded to more efficient Induced Draft Zig-Zag Brick Kiln technology	Rs. 800m WB funds	TBD	Lead: Environment Partner: Industry, Chambers of Commerce and Industry, respective industrial associations
	Energy conservation, process improvement and end of pipe treatment of (TBD) furnaces	Rs. TBD WB funds		
	Process improvement and control of dust and air pollution from (TBD) rice husking mills	Rs. TBD WB funds		
	Commercial application of fly ash from boilers and power plants	Rs. TBD WB funds		
	Dust control and process improvement in xxx stone crushing units	Rs. TBD WB funds		
Credit facility for large scale roll out	Opening up a soft credit facility for supporting technology diffusion at large scale	Rs. 12000m WB funds		Lead: Environment Partner: PSIC
Building capacity for technology transfer	Establish Technology Transfer Center to: <ul style="list-style-type: none"> ▪ Identify appropriate technologies ▪ Pilot promising technologies locally ▪ Advise industry on adoption of successful technology 	Rs. 300m WB funds		
Bridging sustainability issue	Establishment of an endowment (Sustainable Development Fund) to	Rs. 5000m WB		Lead: Environment Partner:

	support technology diffusion on sustainable basis	funds		Finance
Relocation of industry	Operationalization of Sialkot Tanneries Zone and relocation of tanneries	Rs. 1500m WB funds		Lead: Environment Partner: CCI Sialkot
TBD	Energy efficiency and conservation programme in selected public sector organizations	Rs. 1200m WB funds		
TBD	Development of pollution release and transfer registry	Policy action		

Urban pollution Control

Policy measure	Proposed action	Approx cost	Timeline	Responsibility
Increasing urban tree cover	Transplanting rather than cutting trees for development projects	Rs. TBD		Lead: HUD&PHED, PHAs, Forest Partner: Environment, BoR, P&D
	Three-fold increase in tree cover in and around six major cities (Lahore, Faisalabad, Rawalpindi, Multan, Gujranwala, Sialkot)	TBD		
Promoting non-motorized travelling	Provision of pedestrian walk-ways and bicycle lanes in all new urban road projects	TBD		Lead: C&W, Local Government Partner: P&D, Environment
	Environmental Approval of new housing societies subject to provisions of these facilities	Policy action		
Controlling fugitive dust from road shoulders	All road shoulders in six major cities paved	TBD		Lead: C&W, Local Government Partner: P&D
	Environmental Approval of new housing societies subject to provisions of these facilities	Policy action		
	Restrictions on opening burning to continue	Policy action		
	Coverage in six major cities extended to 100%	TBD		
	Provision of sanitary land fill sites	TBD		
	Setting up system for collection and disposal of industrial waste	TBD		

	Formulation of emission standards	Policy action		
	Mandatory installation of catalytic converters on all new and sound muffles on all generators	Policy action		
	Preparation of land zone and urban development plans for major and intermediate cities for next 25 years	TBD		

Crop Residue Burning Control

Policy measure	Proposed action	Approx cost	Timeline	Responsibility
Discouraging burning of crop residue	Restrictions on open burning of crop residue to continue	Policy action	On-going	Lead: Home Department Partner: Environment
Raising awareness among farmers	Inclusion in regular training sessions organized by Agriculture Extension Wing	TBD		Lead: Agriculture Partner: Environment
Alternate farming practices	Building on pilot projects for: <ul style="list-style-type: none"> ▪ Crop residue mulching ▪ Happy Tiller ▪ Crop residue bailing and briquetting 	TBD		Lead: Agriculture Partner: Environment, farmers associations
Using biomass for energy	Operationalization of Biomass Company	TBD		Lead: Agriculture
Regional cooperation agreements	<ul style="list-style-type: none"> ▪ Exchange of information on emission, meteorology and air quality ▪ Sharing of technology and farming practices ▪ Collective effort to control pollution sources 	Policy action		Lead: Environment Partner: Ministry of Climate Change, Foreign Affairs

Monitoring, alerting and emergency response systems

Policy measure	Proposed action	Approx cost	Timeline	Responsibility
Improved emergency response system	<ul style="list-style-type: none"> • Identification of vulnerable population, farmers, and vehicle owners for targeted health and other advisories • Air quality modelling of winter smog • Pollution source attribution and prioritization for measured response to control pollution in emergency situation 	Rs 20 m	June 2018	Lead: Environment Partner: Health, Agriculture, PDMA, Met Department, Excise & Taxation, Traffic
Building environmental quality monitoring and modelling capacity	40 stationary and 6 mobile air quality monitoring stations established in seven major cities (Lahore, Rawalpindi, Faisalabad, Gujranwala, Multan, Bahawalpur, Sheikhpura)	Rs. 1,000 m	June 2018	Lead: Environment
	Establishment of a network of stations for monitoring air, groundwater, surface water, soil quality under Environmental Monitoring Center	Rs. 2,000 m WB funds	June 2020	Lead: Environment
	Air quality forecasting and source attribution			

Strengthening legal framework and organizational capacity

Policy measure	Proposed action	Approx cost	Timeline	Responsibility
Legislative action	Introduction of a specialized Punjab Clean Air Act for: <ul style="list-style-type: none"> defining emission reduction requirements emission monitoring and reporting requirements for industry installation of emission control systems by polluters demarcating air pollution control areas penal provisions 	Policy Action	June 2018	Lead: Environment Partner: Law Dept
	Revision of Vehicular Emission Standards	Policy Action	June 2018	Lead: Environment Partner: Law Dept
Enforcement capacity building	Capacity building under the on-going restructuring programme including: <ul style="list-style-type: none"> Strengthening human resource Policy analyses and advice Processes reengineering 	Rs.2000 M WB Fund	June 2020	Lead: Environment