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Energy Transition for Pakistan

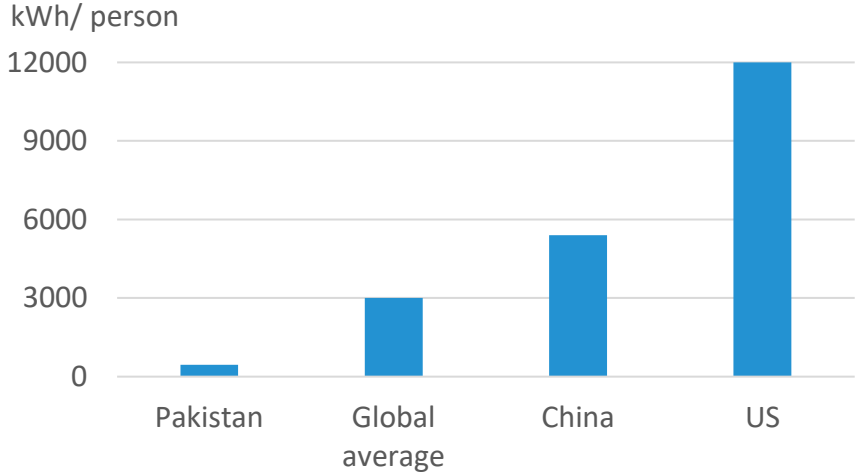
The World Bank Study

July 2022

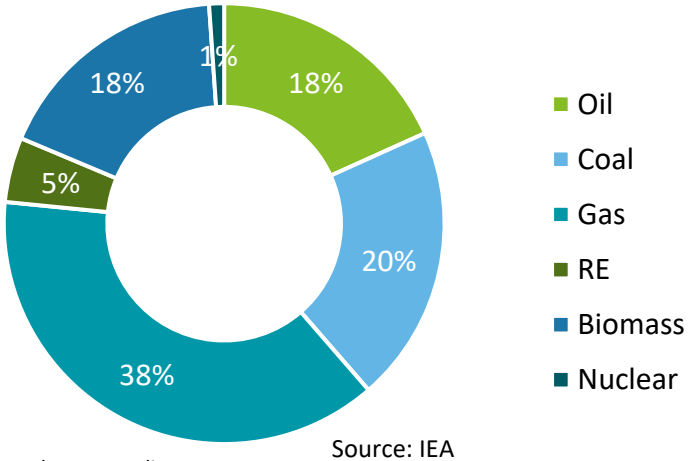
Introduction and Background

Pakistan's current low electricity consumption per capita will grow rapidly. Meeting the fast-growing energy demand in a sustainable way is a top priority and challenge

Pakistan's annual power consumption per capita is only one-sixth of the global average



Gas, coal, and oil dominate Pakistan's primary energy mix



Source: IEA

- **Pakistan's electricity consumption per capita is only one sixth of global average**, which indicates **rapid growth in energy demand in the future**
- **Energy demand is expected to be 2.65 times by 2050**, and share of electricity in energy is expected to rise from 14% to ~34% by 2050
- Industry sector contributes to the highest in energy demand with almost 35% share in 2020 & 45% share in 2050
- **Gas, coal, and oil dominate Pakistan's energy mix,** together meeting over 75% of energy demand
- Pakistan does not rank among the top-20 CO_2 emitters despite having the 5th highest population, but suffers from regional problems such as highly polluted cities
- **Meeting significant future energy demand sustainably** is a top agenda in the energy sector

The study aims to explore decarbonization pathways and estimate financing required for energy transition and WBG's role for Pakistan up to 2050

Two development scenarios are simulated to estimate emissions and investment

Methodology: Deloitte's Energy Model developed for Pakistan's energy transition

Objective of the analysis:

- Map current energy consumption and assess energy demand up to 2050
- Identification of current Energy and Transportation development and decarbonization policies and expected emission reduction impact
- Estimation of current and future emissions, and potential impacts of accelerated action
- Estimate the quantum of investment required for the energy transition

Development Scenarios

1. **Intended Policy Scenario (IPS):** Based on government policy targets, including announcements and assuming that the government's policy frameworks will be achieved*

2. **Accelerated Decarbonization Scenario (ADS):** A second scenario to be developed that targets peak CO_2 emissions around 2035-2040, and reaching net zero in 2070

Overall energy demand in terms of electricity, liquid hydrocarbons, gaseous hydrocarbons, hydrogen

GHG Emissions in terms of carbon dioxide, methane and nitrogen dioxide

Overall investment requirement and potential sources of financing

Public sector climate financing needs and MDB's roles

The approach adopts an optimized energy modeling technique, focusing on 5 pillars of energy transition

Interlinkages of the energy model and the pillars of energy transition were carefully integrated in addition to estimation of in

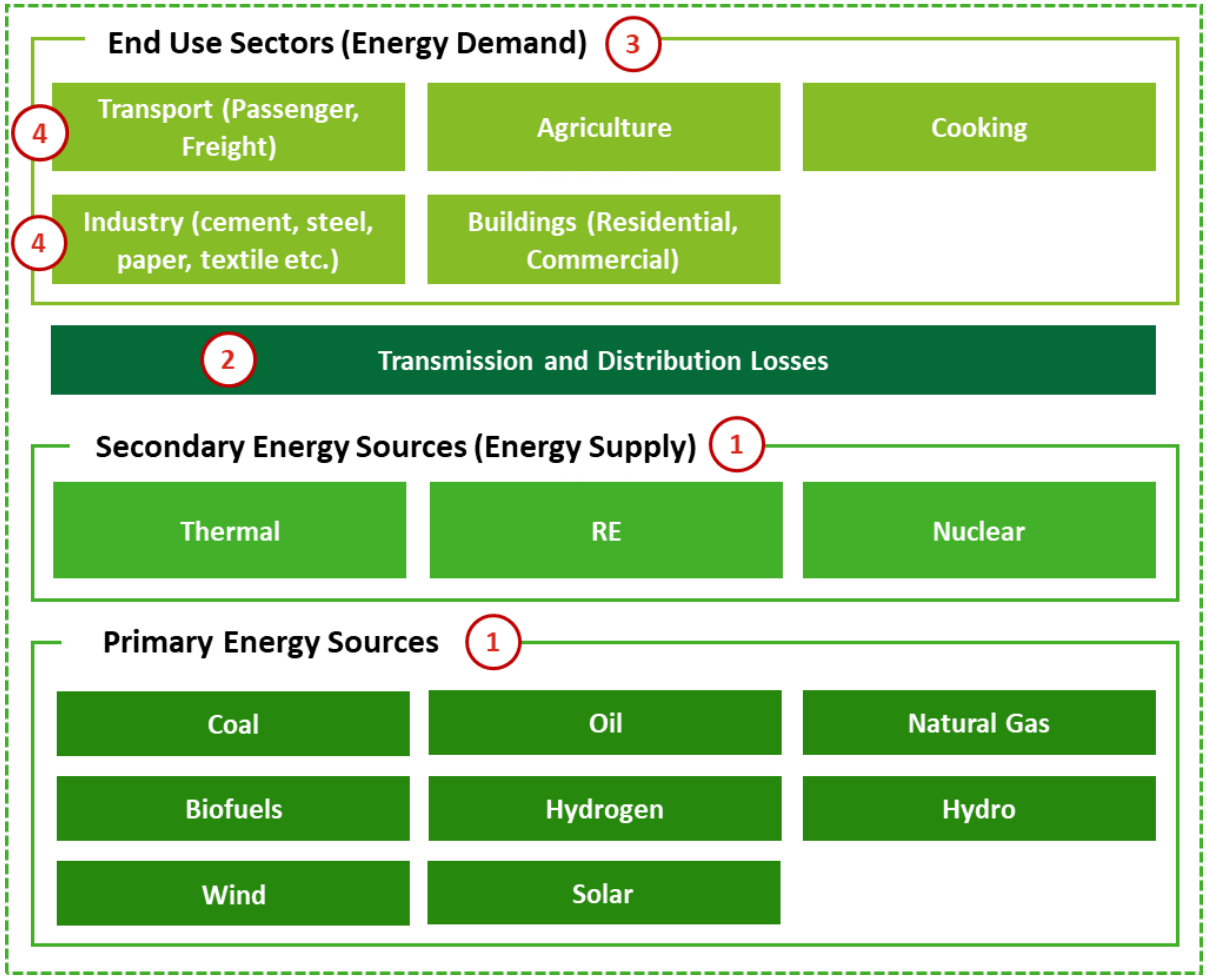
PILLARS OF ENERGY TRANSITION

1 Core energy transition	Change in supply mix with greater integration of renewables
2 Supply side efficiency	Transmission and Distribution loss reduction
3 Demand side efficiency	Improving energy efficiency in the industrial, building, and transport sectors
4 Energy transition for industry/ transport	Change in the fuel mix towards alternate fuels, electrification and CCUS
5 Just transition	Fleet retirement, Mine closure

OVERALL INVESTMENT REQUIRED

- *Investment for end use asset:* Capacity addition, replacement/ retirement, operating costs (Supply and demand side)
- *Infrastructure costs:* Facilities for accommodating demand growth
- 5 *Just Transition:* Retirement cost, Mine closure cost, job loss, impact on community

ENERGY MODEL



Note: The study will build on Deloitte proprietary Integrated Resource Planning (IRP) tool

Exogenous inputs to the energy model Calculated outside the energy model

Gathering data for the energy model

Various data elements for energy modelling and associated assumptions

Key data sources used

Data inputs

Data elements for the model	Policy environment	Independent Secondary Research	Mapping the development of technologies
• Macro-economic growth, growth in population, income • Urbanization/ infra planning • Fuel prices, tariff and taxes • Pakistan Economic Survey • Housing-Population Census-2017 • Pakistan Energy Yearbook • PACRA Sector Studies- Steel, Cement, Home Appliances • NEPRA- State of Industry Report • MEPS For Window Type & Split Air Conditioner	• Updated Nationally Determined Contributions, 2021 • Sustainable Energy For All- National Action Plan till 2030 • NEECA Strategic Plan 2020-23 • Pakistan's National Electric Vehicle Policy • Indicative Generation Capacity Expansion Plan (IGCEP)- 2030 • National Electricity Policy 2021 • Alternative and Renewable Energy Policy, 2019	• Energy Saving in Pakistan, RAFTAAR Study • Sustaining Growth: Cleaner Production in Pakistan (IFC, CPI) • WB- Variable Renewable Energy-Integration and Planning Study • Policy review recommendations on the promotion of RE & EE- UNIDO-GEF	• Technology availability • Market acceptability- standardization phase, demo/ pilot phase • Availability of supporting infrastructure • Policy & regulatory support • Availability of finance and available funding sources

Data points for running the model

Availability of conducive policies and environment

Comparison with similar studies, & evaluating assumptions taken

Technology adoption trajectories

Evaluating model outputs

Evaluation and comparative analysis of model outputs

Intended Policy Scenario (IPS)

1. Based on today's policy setting and constraints, assuming that goals laid down by the Government are achieved, except in transport sector wherein adjustments were made on account of legacy as well as prevailing issues

2. Interventions considered under IPS towards decarbonization including:

- No thermal additions after 2030, and Gas-based plants to be used for peak demand
- Energy efficient appliances and uptake of PNG for cooking
- Adoption of energy efficient transport modes and solar water pumps
- Energy efficiency and Fuel mix change for industries towards grid electricity

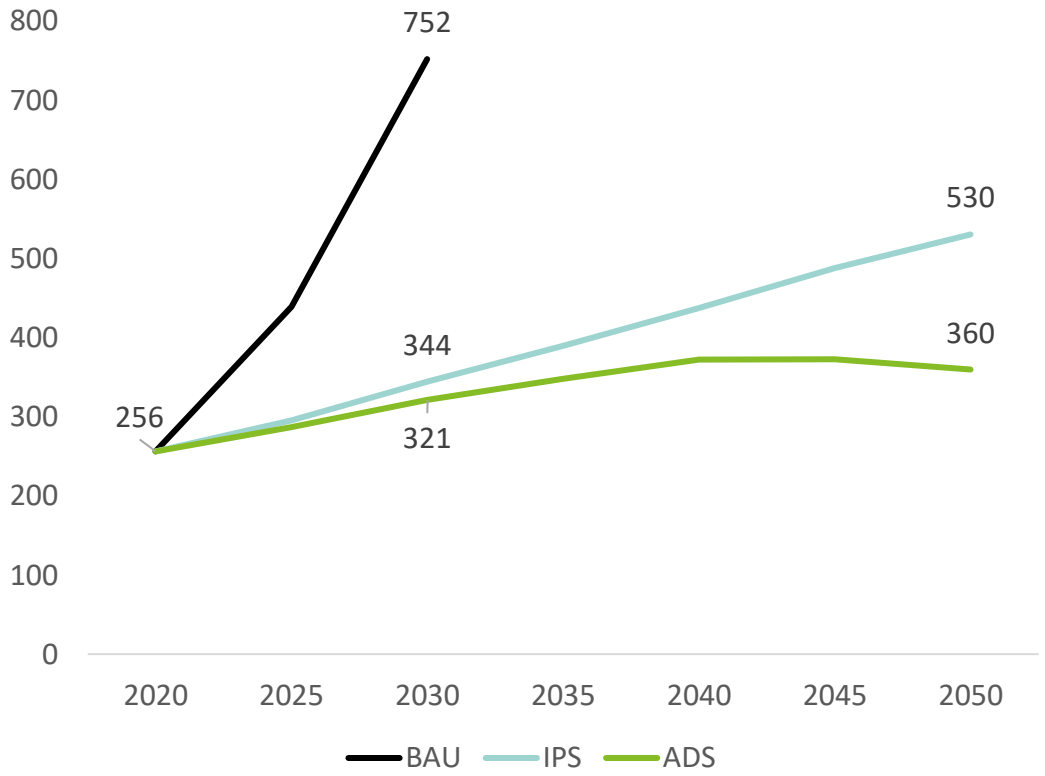
Accelerated Decarbonization Scenario (ADS)

1. Working backwards from an ambitious target to achieve peak emissions by the mid-2040s

2. Accelerated decarbonization scenario in addition to IPS scenario includes:

- No thermal additions after 2020 except for committed coal/gas plants till 2030
- Forced decommissioning of fossil-fuel based power generation viz Coal & Oil
- Deployment of green hydrogen and accelerated electrification in industries
- Accelerated adoption of mass transit and adoption of FCVs in freight

Under ADS Total Emissions would peak significantly earlier, and come down to nearly 32% below the IPS level by 2050 (MtCO2e)*



A comparative assessment of the alternative energy pathways (in addition to IPS) will help identify the interventions/ initiatives which have the maximum potential for impact on emissions

An accelerated decarbonization pathway has been modeled as a target scenario

Intended Policy Scenario may still result in emissions peaking until 2050s; more aggressive adoption of cleaner fuels, technologies and energy efficiency measures are required to achieve emissions reduction

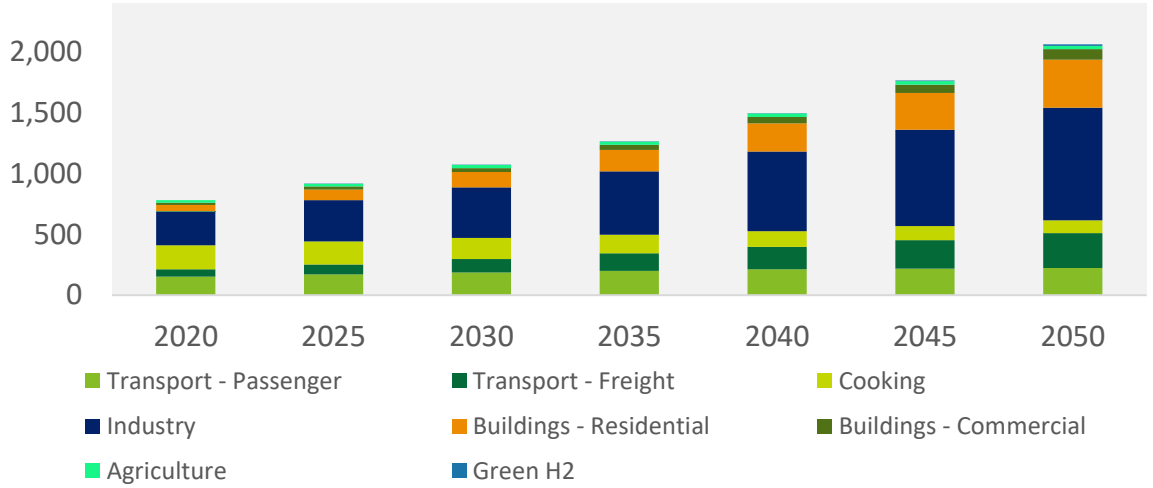
Intended Policy Scenario		Accelerated Decarbonization Scenario
Increases reliance on road-based modes for pax and freight; Unplanned urban growth leads to lock-in of unsustainable modes; Moderate adoption of EVs;	TRANSPORT	Increased investment in mass transit, bus, BRT; Compact land-use in cities; Aggressive adoption of clean transport fuels such as EV, FCV, LNG; increased investment in railway transport
Improvement in energy efficiency of industrial equipment, adoption of green hydrogen	INDUSTRY	Accelerated electrification, Improvement in SECs due to Energy efficiency measures, and more aggressive adoption of green hydrogen
Gradual adoption of energy efficient appliances, moderate adoption of smart building interventions	BUILDINGS	More aggressive adoption of energy efficient appliances, more stringent building codes; smart building interventions, especially in commercial establishments
Adoption of solar and electric pumps for irrigation	AGRICULTURE	Complete shift to solar from diesel-based pumps, adoption of highly efficient electricity pumps
Gradual shift towards electric, PNG and LPG for urban and rural cooking	COOKING	Dramatic shift towards PNG and LPG for urban and rural cooking. Adoption of electric cook stoves in rural areas
Greening of supply side in line with stated policy and potential	POWER SUPPLY	Retirement of coal-based generation, replacement with RE and integration with energy storage solutions

Results and Outcomes- Intended Policies Scenario (IPS)

The overall energy demand is expected to become 2.65 times, will reach ~2,060 TWh by 2050

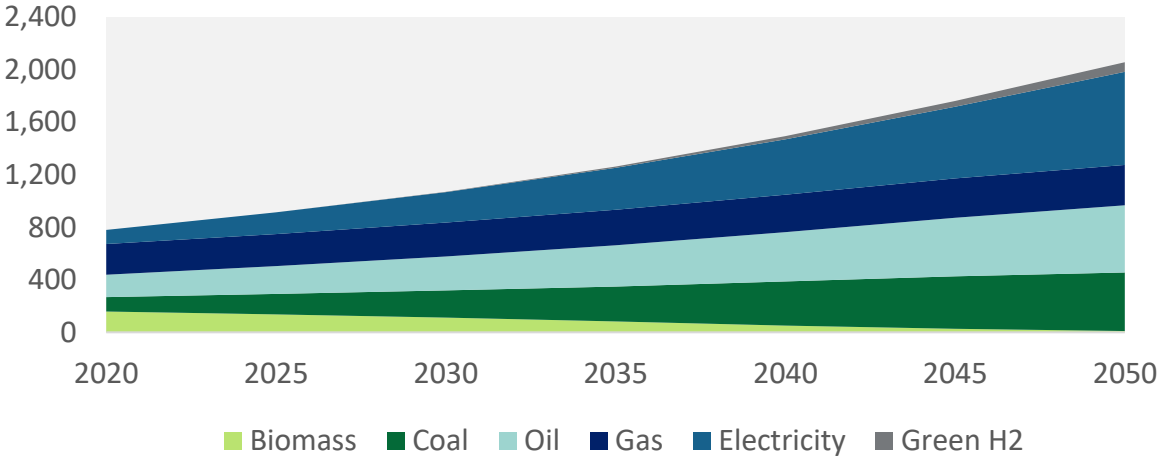
Final Energy Demand (TWh)

Final energy demand is expected to grow to 2.65x by 2050 (TWh)



Demand for Secondary Energy (TWh)

Share of electricity in demand side will increase to 34% by 2050



Pakistan's economy would grow almost 5 times by 2050

- Pakistan's economy would increase from $260 billion in 2020 to $1.3 trillion in 2050 over the next 30 years
- The overall industrial output is expected **to increase by 5 times and energy demand by 3.3 times** between 2020 and 2050. Major fuel usage is for coal & gas;
- Passenger transport demand is expected to increase two-fold between 2020 and 2050, from **1,100 BPKM** to **2,200 BPKM;** while energy demand will grow to ~1.5 times
- Energy demand would decouple from growth under current policies

Industry and transport sectors will drive the future growth

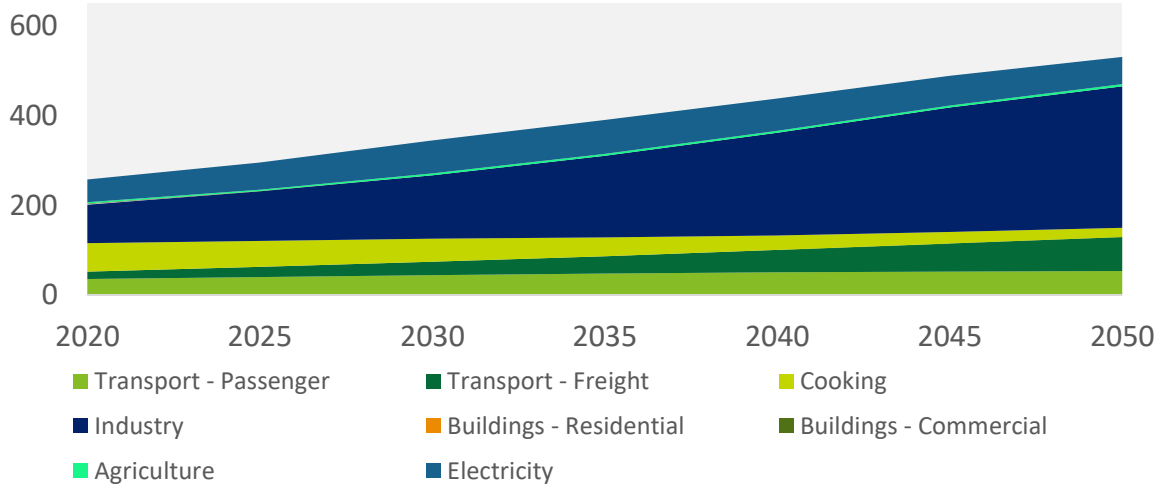
- Industry and transport segments will drive overall energy demand- with almost 3/4th (70%) share in 2050; Industry contributing 45%
- Share of coal in overall energy demand will increase from 14% to 22% by 2050, with industries such as cement and bricks driving growth

Increased share of Electricity in demand side

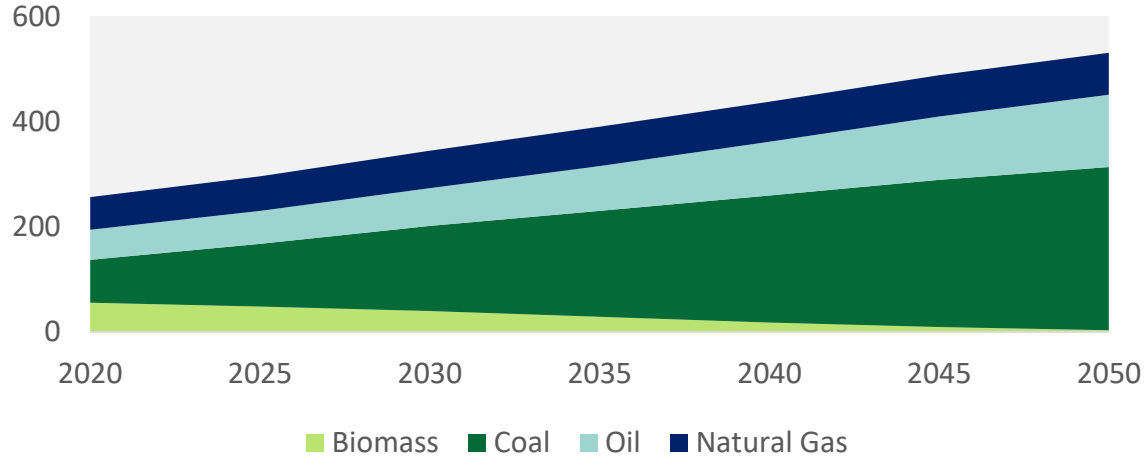
- Share of electricity demand will increase from 14% to 34% by 2050
- Share of biomass will reduce to zero with the development of PNG networks and increased adoption of electric cook stoves

Under the current government policy: both energy demand and emissions would more than double from now to 2050 – decoupling emission from growth already happening

GHG emissions are expected to grow to 2.1x by 2050 (Mt CO_2E)



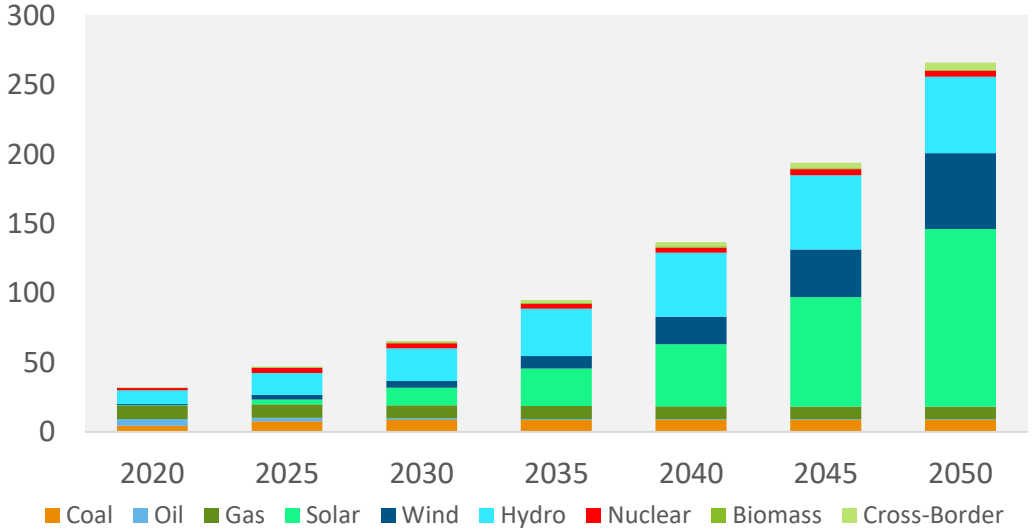
GHG emissions by fuel type (Mt CO_2E)- 256 to 530 (Mt CO_2E)-by 2050



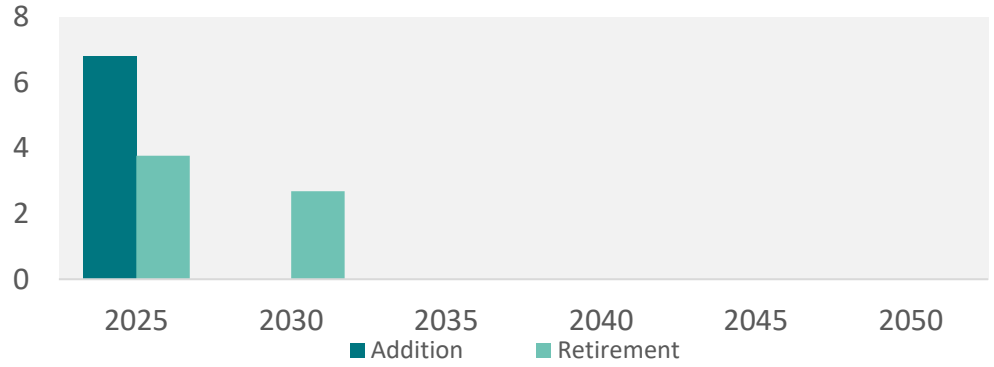
- **Emissions would partially decouple from growth under the current government policies:**
  - While, emissions would decouple from growth, it will still grow due to increasing reliance of industrial sectors (Cement, Bricks) on coal
  - Emissions from electricity sector will be stabilized by 2030 with incremental capacity addition through RE
- **Industry and transport sectors will drive the future growth of energy demand and emissions**
  - Emissions from industrial, and transport sectors will continue to rise, which drives up the GHG emissions (accounting for 84% of emissions in 2050)
- **Coal and Oil will be major driver of emissions growth**
  - With growing use of coal in industry, it will be the largest source of emissions.
  - Oil consumption will increase with growth in passenger and freight transport demand

Decoupling of emissions from energy is largely driven by transitioning towards Renewables

Pakistan will start focusing on solar/ wind/ hydro from 2025 (GW)
(Total Generation Capacity- 32 GW in 2020 to 265 GW in 2050)



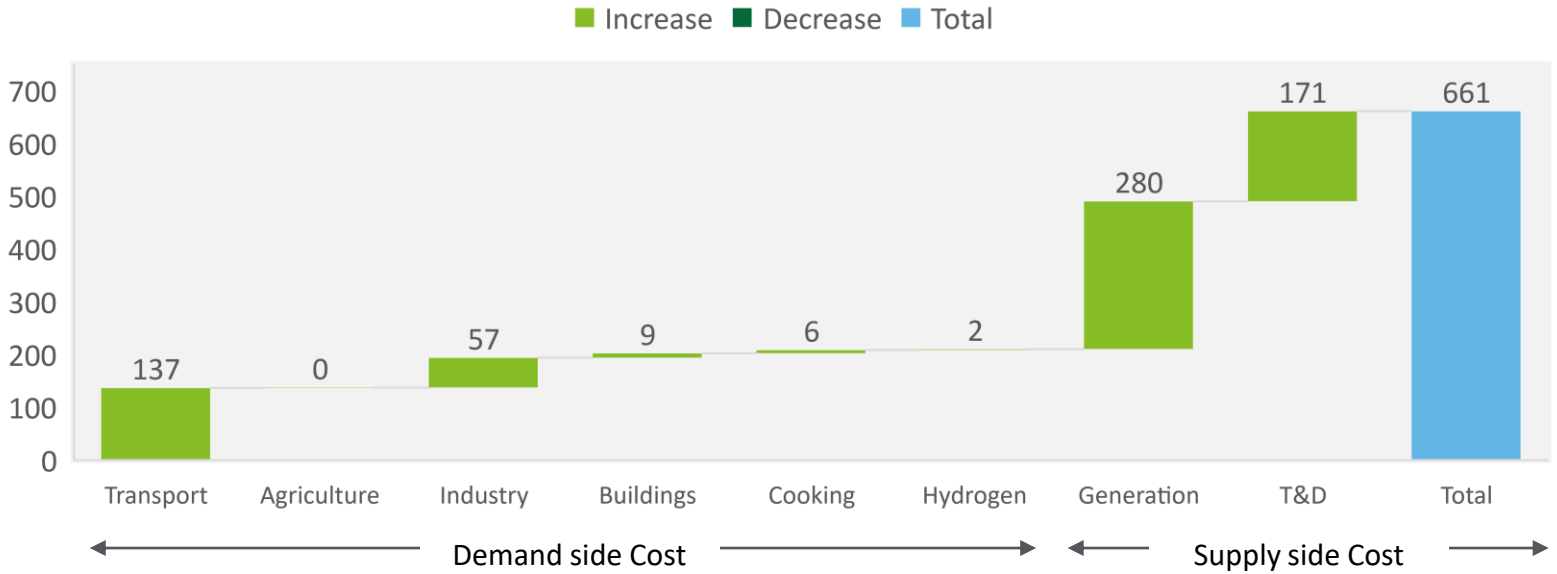
New fossil fuel-based power will be built until 2025 (GW)



- **Pakistan will no longer build new coal power plants after 2025**
  - 5.5 GW of under construction coal capacity is expected to be completed between 2020-2025, and no new coal will be added afterwards
  - Gas-based power plants will continue to be used to provide peaking power
  - However, Gas and coal-based power will drop from 60% of generation capacity in 2020 to 8% by 2050 due to the faster uptake of solar and wind
- **The incremental power demand after 2025 will be met by renewable energy**
  - 45 GW of additional hydro will be required to meet the demand, and it remains the largest renewable energy source until 2040
  - 180 GW of solar and wind power will be installed over the forecast period

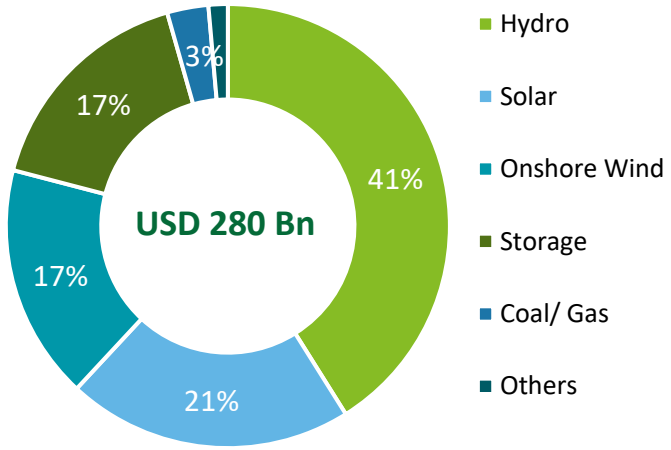
The government policies are ambitious and require a cumulative investment of USD 661 billion from now to 2050

Total investment costs under IPS would require ~$661 billion* (USD Bn)



- **~USD 393 billion** required for greening the demand and supply – new electricity generation, energy efficient vehicles, appliances and equipment, fuel switchover cost etc.
- **~USD 268 billion** of investment required for developing the supporting infrastructure for the transition – Transport infrastructure, T&D network, H2 electrolyzer etc.

Power sector investment will be dominated by renewables, but significant investment into fossil fuels will remain



- 40% of the investment will be in hydro; another 38% will be into wind and solar
- USD 47 billion (17%) will be required for grid-scale pumped/ battery storage
- T&D investment will expand the grid and reduce losses from 20.3% to 11.3% in 2050

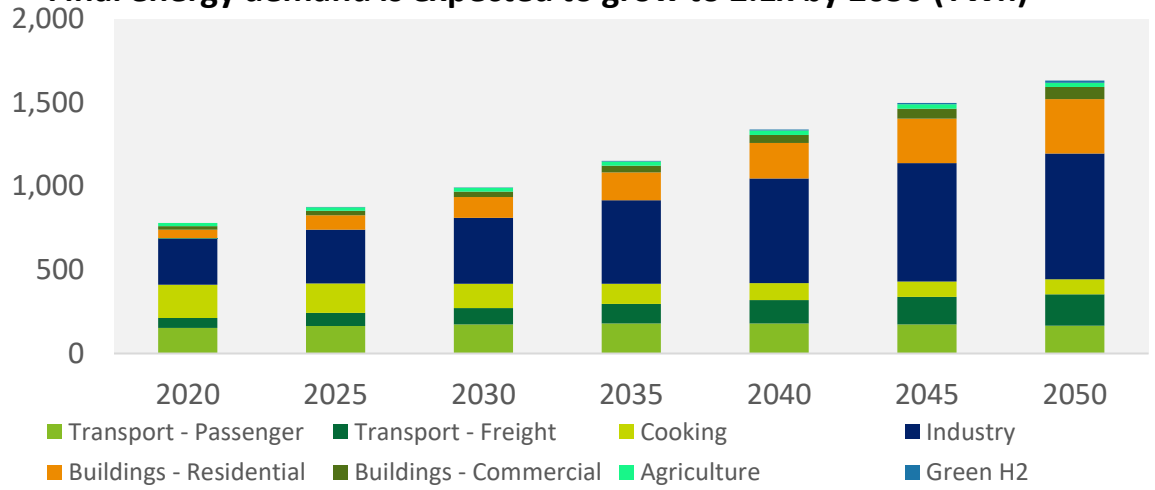
 # The above transport estimates primarily consider the incremental cost of technology improvement. Other aspects to foster systematic mode shift to meet the demand are not included here.
** The investment made in new generation and T&D represents the cost of the policy decision to move towards RE and is not purely attributable to energy transition*

Results and Outcomes- Accelerated Decarbonization Scenario (ADS)

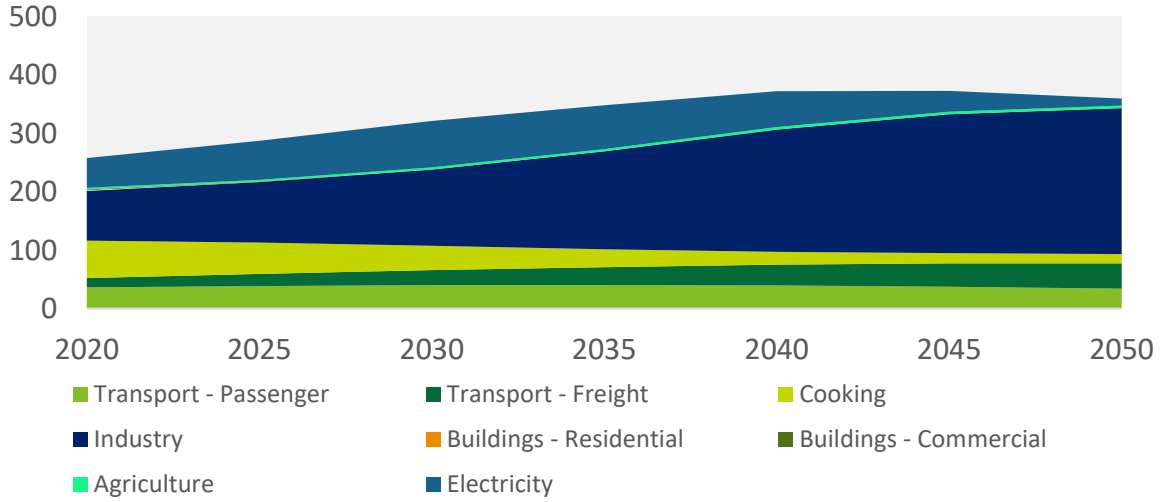
Tapering demand and accelerating retirement of coal power plants would reduce emissions by 32%

Final Energy Demand (TWh)

Final energy demand is expected to grow to 2.1x by 2050 (TWh)



GHG emissions are expected to stabilize by the 2040s (Mt CO_2E)



Tapering demand would reduce energy consumption by 20% of the IPS demand

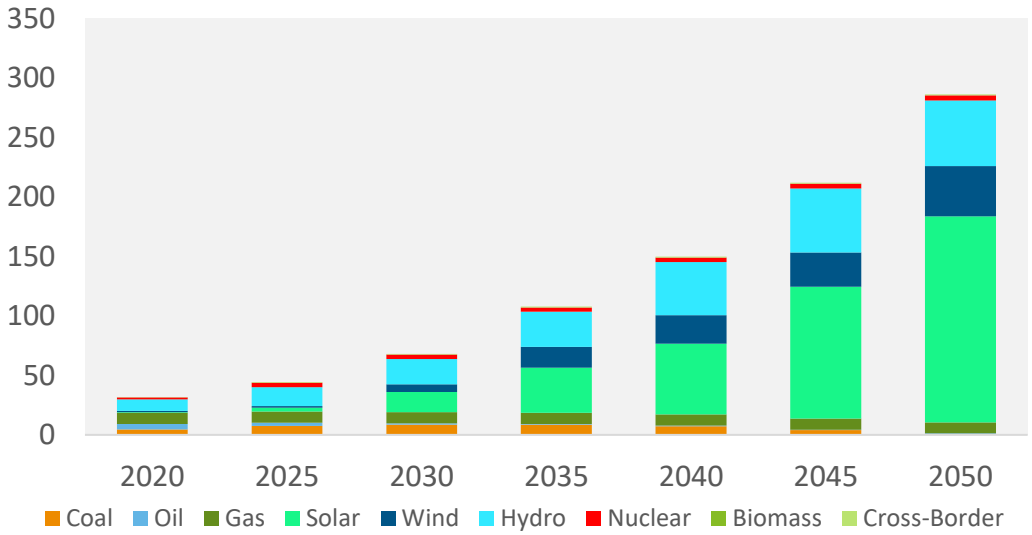
- Final energy demand is ~1,630 TWh, which is 80% of the IPS
- Share of electricity in demand side consumption will increase by 3 times (from 14% in 2020 to 42% in 2050)
- Adopting Green H2 in the Fertilizer and Refineries sector, will stabilize the emissions in hard-to-abate industrial sectors

Emissions would fully decouple from growth due to accelerated decarbonization

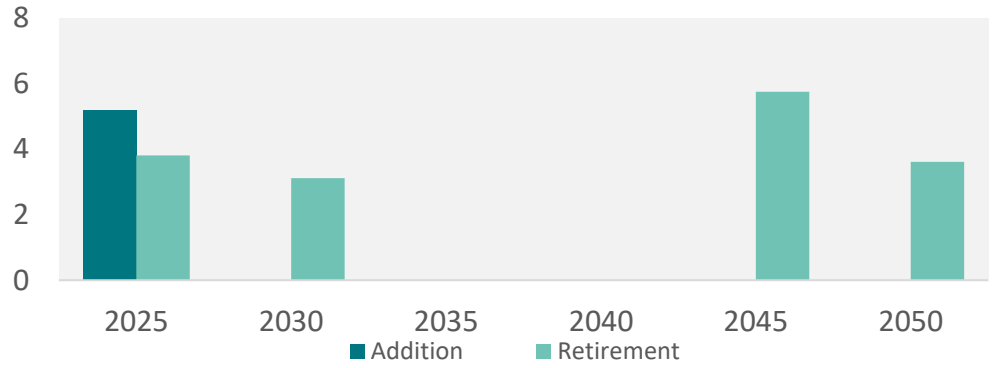
- Decline of fossil-fuel based power and electrification of transport will lead to non-industry emissions peaking in the 2040s
- Phasing out of coal plants will result in substantial reduction in the emissions from power generation after 2040
- Emissions from industrial and transport sectors will make up nearly all of the remaining GHG emissions (accounting for 91% of GHG emissions in 2050)

Renewable electricity will become the dominant source, with only 3% of generation coming from fossil fuels

Pakistan will start focusing on solar/ wind/ hydro from 2025 (GW)
(Total Generation Capacity- 32 GW in 2020 to 286 GW in 2050)



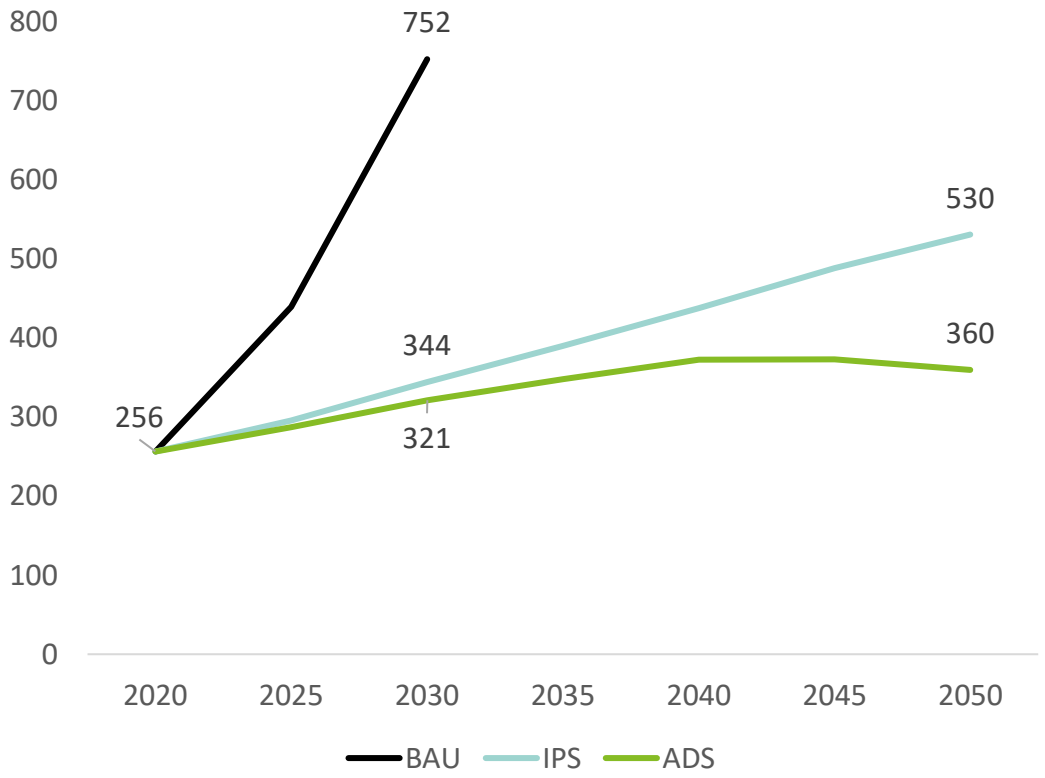
No new fossil fuel-based power will be built after 2025 (GW)



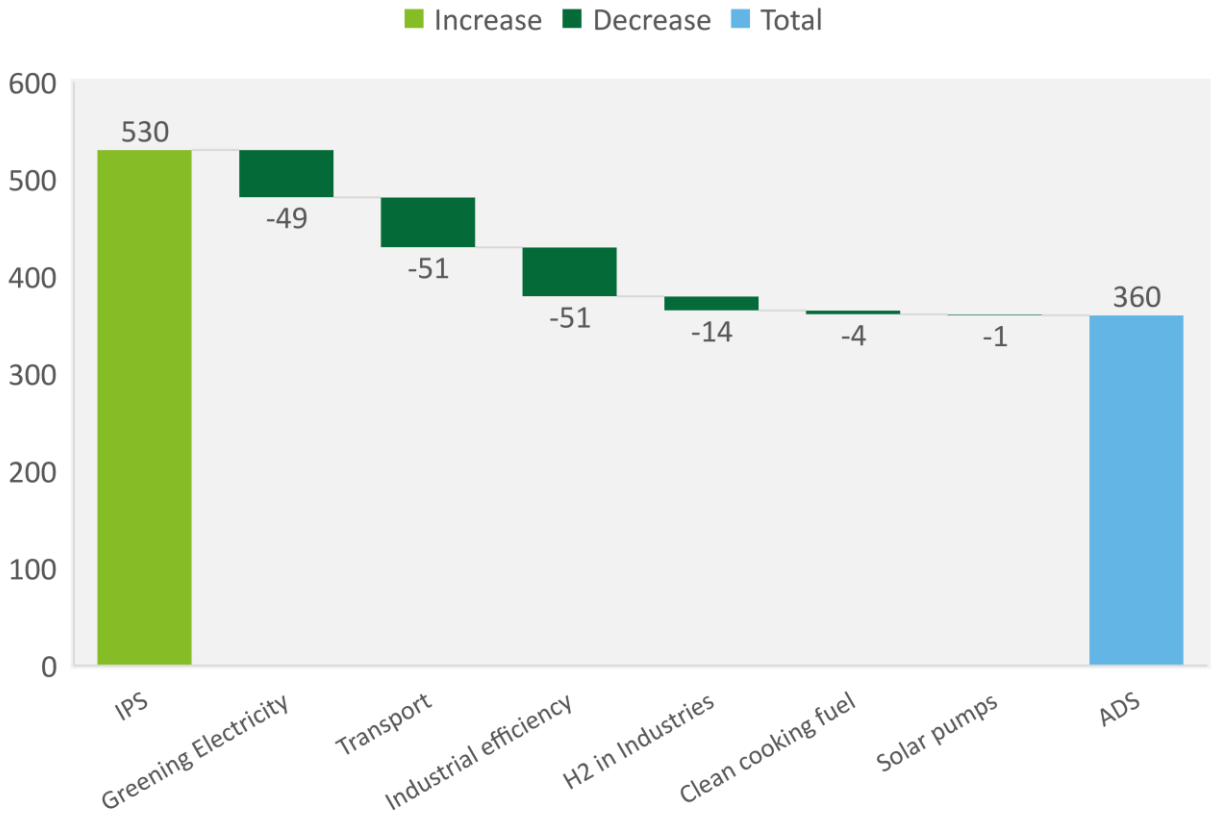
- **No further thermal additions and forced decommissioning of coal-based plants**
  - No thermal additions considered except for already committed coal plants
  - Coal will be decommissioned between 2020 and 2050, and gas will used for peaking power
  - Gas and coal-based power will drop from 60% of installed capacity in 2020 to ~4% by 2050 due to the uptake of RE
- **Solar, wind, Hydro will become mainstream power generation source of installed power capacity by 2050**
  - 45 GW of hydro will be required to meet the demand, becoming the second-largest renewable source
  - 215 GW of solar and wind power will be installed over the forecast period **(35 GW more than IPS)**
  - **RE integration** will be important – substantial energy storage technologies (87 GW) will be required to mitigate the high penetration of variable RE

Emissions would stabilize in the 2040s and decline after, mainly due to green electricity, electric vehicles, and use of green hydrogen

Total Emissions would peak significantly earlier, and come down to nearly 34% below the IPS level by 2050 (MtCO2e)*



Emission reduction in 2050 would be largely due to green electricity, electric vehicles, and industrial efficiency (MtCO2e)

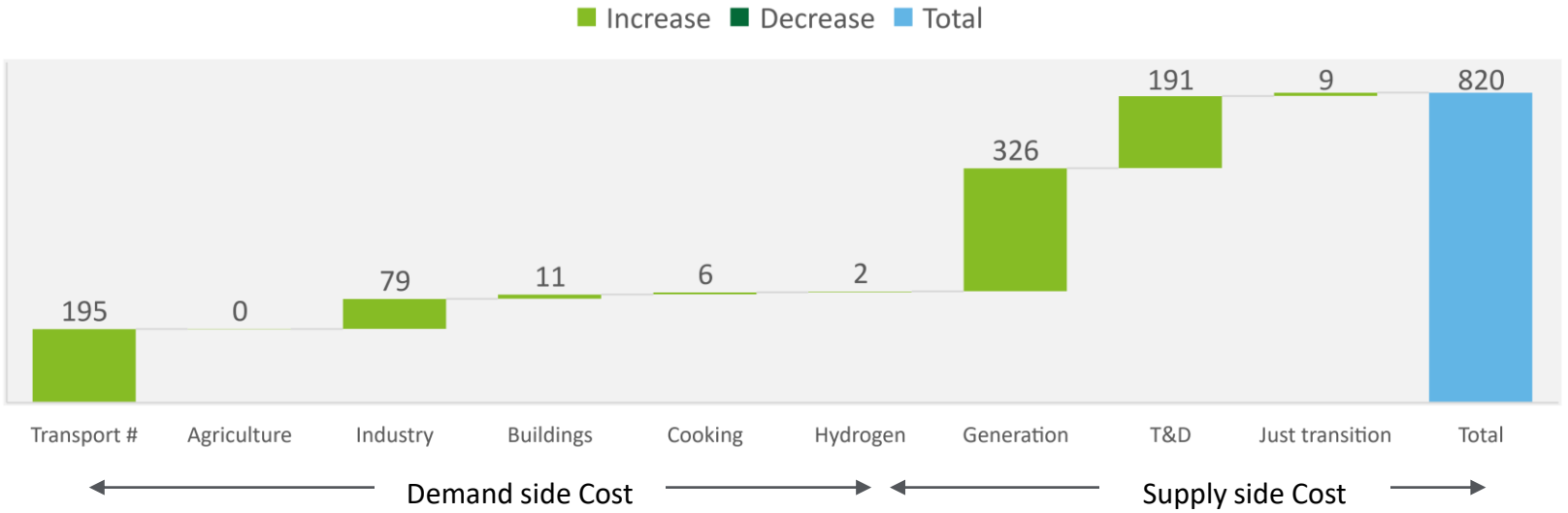


If no decarbonization efforts are made, emissions could reach up to ~863 $MtCO_2e$ by 2050. Emissions would grow much more slowly under the Intended Policy and Accelerated Decarbonization Scenario

Accelerated decarbonization would require an incremental cumulative investment of $160 billion over the IPS from now to 2050

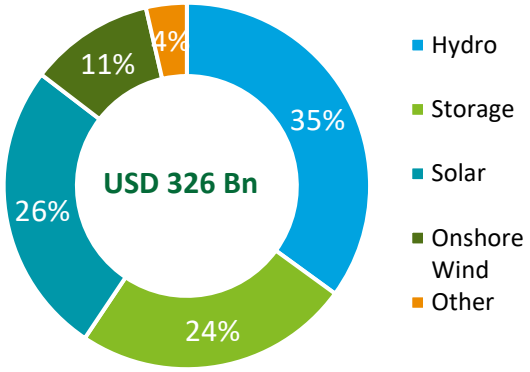
Requires a total of USD 820 billion investment; incremental investment of $160 billion over the Intended Policy Scenario

Total investment costs of ADS * (USD Bn)



- **~USD 433 billion** required for greening the demand and supply – new electricity generation, EVs, appliances and equipment, fuel switchover cost etc.
- **~USD 378 billion** of investment required for developing the supporting infrastructure for the transition- Transport infrastructure, T&D network, H2 electrolyzer etc.
- **Just transition-** Social and Economic cost for early closure of coal mines and power plants

Power sector investments will be dominated by solar and wind



- 35% of the investment will be in hydro; another 37% will be into wind and solar
- USD 78 billion (24%) in pumped/ battery storage will be necessary for grid stability
- T&D investment will expand the grid and reduce losses from 20.3% to 9.3% in 2050

 # The above transport estimates primarily consider the incremental cost of technology improvement. Other aspects to foster systematic mode shift to meet the demand are not included here.
** The investment made in new generation and T&D represents the cost of the policy decision to move towards RE and is not purely attributable to energy transition*

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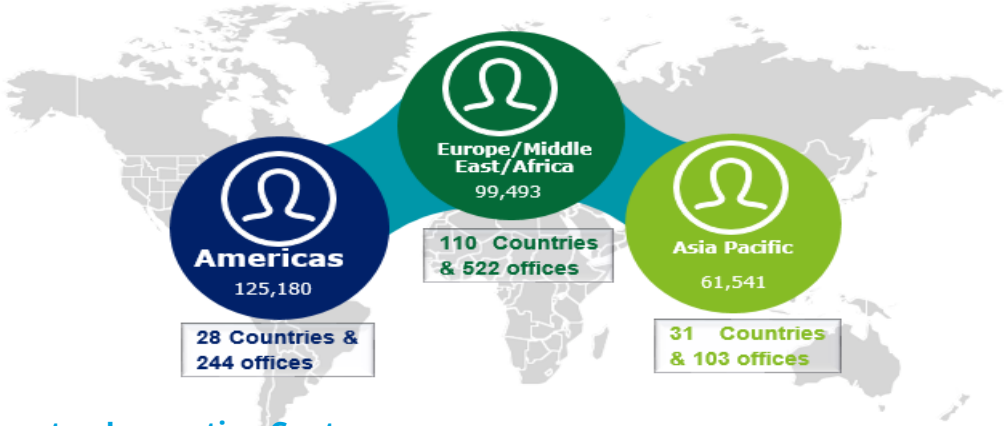

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Innovation Center for Energy & Industrials

Deloitte's Sustainability Commitments

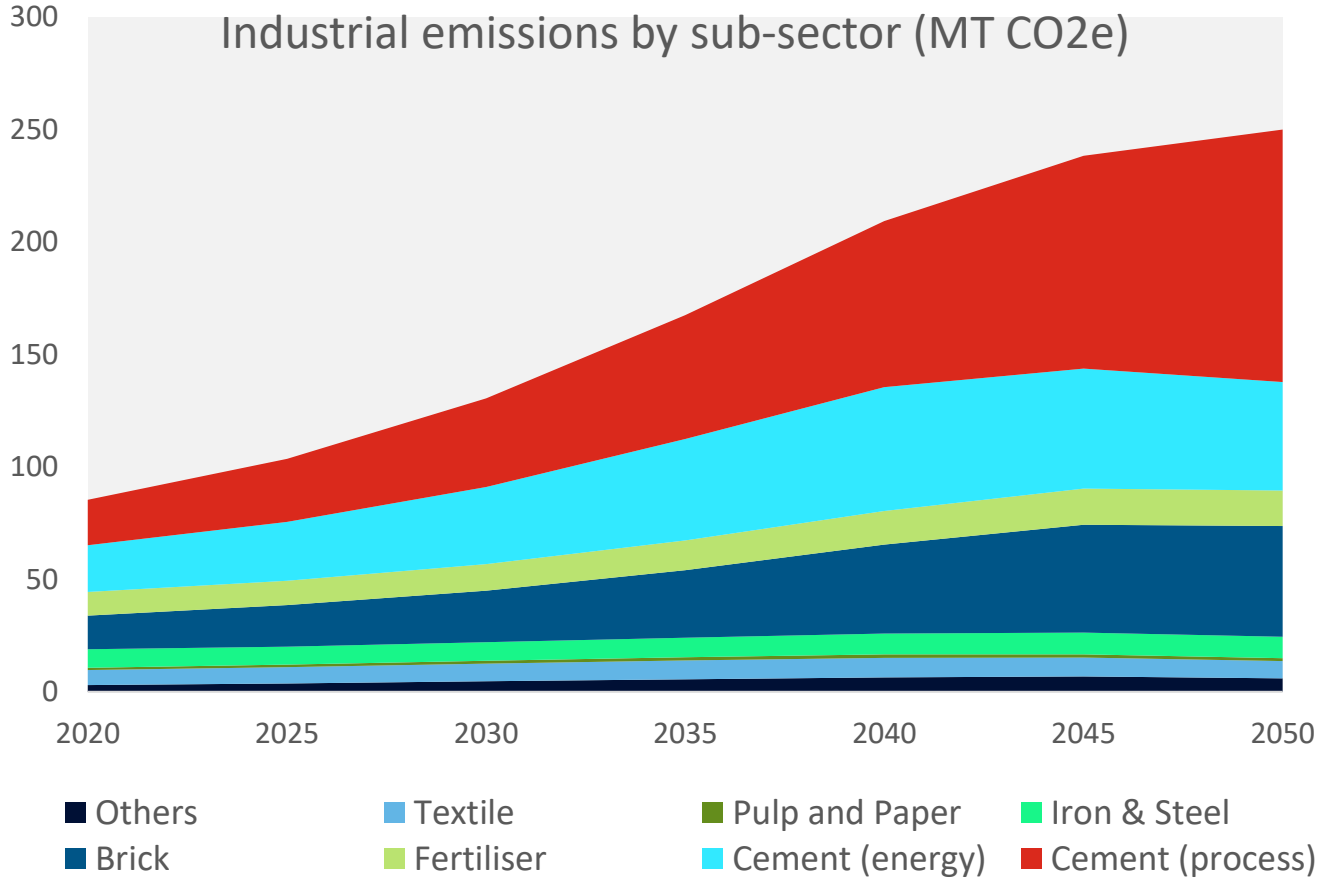
- **Cutting Emissions** - Net-zero by 2030
- **Operating Green** - Address internal policies and practices

Extensive experience in Energy Transition & Decarbonization Studies

- *A Sustainable Energy Model for Spain in 2050: Policy Recommendations for the Energy Transition*
- *China Energy and Low Carbon Economy Programme (CELCEP)*
- *Potential of hydrogen in South Korea to assess entry strategies*
- *Vietnam Low Emission Energy Program (V-LEEP)*

Annexure- Industry Sector

Industrial emissions by sector – ADS scenario



Process emissions from cement will account for nearly half of industrial emissions, and 1/3rd of total emissions by 2050

- Industrial energy use and emissions will grow rapidly in initial years (2020-35) as it would be the major driver for GDP growth
- Emissions growth would reduce in later years due to efficiency measures and lower industry growth (due to shift towards the service sector)
- In all industrial sectors (except cement), emissions would peak in the 2040s and decrease later
- Emission reductions will mainly be driven by- adoption of efficient equipment, fuel switch, higher electrification, and adoption of Green H2 in industry
- However, **process emissions from cement** can only be reduced through Carbon capture and storage, hence CCUS will be required for complete decarbonization
- Capturing 20% of process emissions from cement would cost $2 billion/annum and cumulative **$30 billion from 2035-50** (at a cost of $80/ tonne of CO2 capture). Hence government support would be required.

Detailed Assumptions

Key assumptions – Assessment of future energy use on the supply side under IPS

Source3	2020 baseline capacity	2050 – IPS Scenario (No thermal additions after 2040)	2050 – AD Scenario (Moratorium on coal, No constraints on VRE)	Notes/ Sources
Coal	4.63	25.2	0.00	• Coal/ gas-based plants will be needed in later years for grid stability
Oil	6.5	0.35	0.00	• Oil-based power will be retired in the 2020s due to high operating costs
Gas	9.7	23.8	9.4	• New gas construction is expected to continue until the 2030s
Solar	0.5	120.0	145.0	• Largest source of RE, alongside hydropower
Wind	1.1	51.0	51.0	• Pakistan has the highest potential for onshore wind in the SAR, significant addition is planned
Hydro	9.9	40.3	55.0	• Pakistan has 60 GW of potential for Hydro, and significant addition is planned in coming decades
Nuclear	1.5	4.41	4.41	• No new construction after 2030 due to regulatory issues
Biomass	0.3	1.00	1.00	
Storage	0.0	55.0	86.1	• Storage estimated from IRP model, required for grid stability

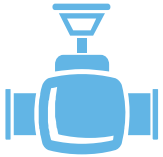
Growth in the energy demand will be fueled by growth in demographic and economic factors

Passenger transport demand is expected to increase two-fold between 2020 and 2050, from **1,064 BPKM** to **2,123 BPKM**; Freight transport demand will rise nearly five-fold from **188 BTKM** to **970 BTKM**. Transport will continue to be a significant contributor to energy demand

Pumping demand for irrigation is expected to increase by **40%** between 2020 and 2050 from **10 TWh** to **14 TWh**. Ground water availability constraints will necessitate adoption of micro irrigation techniques

73% of rural households depend on biomass for cooking. With the development of PNG networks and improved electricity access, cleaner cooking fuels are expected to replace biomass

Residential and commercial establishments account for 10% of the total energy demand. Pakistan's population is expected to increase from 220 Mn to 338 Mn by 2050. Share of energy efficient appliances will increase from **10% to 40% in 2030** and 56% by 2050



The overall industrial consumption is expected to increase **three-fold** between 2020 and 2050. Major fuel usage is for coal and gas grid electricity accounts for only **11%** of total energy demand; many industries rely on coal/ gas based captive generation for electricity due to reliability concerns with the grid

Deloitte.