Roadmap for Industrial Electrification in Pakistan

Transition from Gas to Grid & Renewables

26 Feb 2026

Agora Energiewende

Agora Industry

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for Equitable Development

Introduction, scope and method

GHG emissions profile in the industry sector

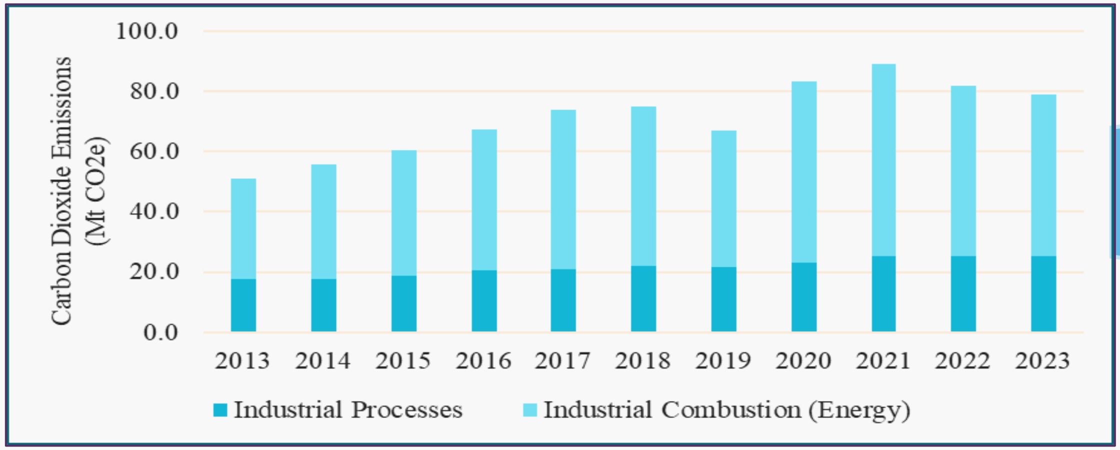


Figure 1. Industrial emissions in Pakistan (Source: World bank Database)

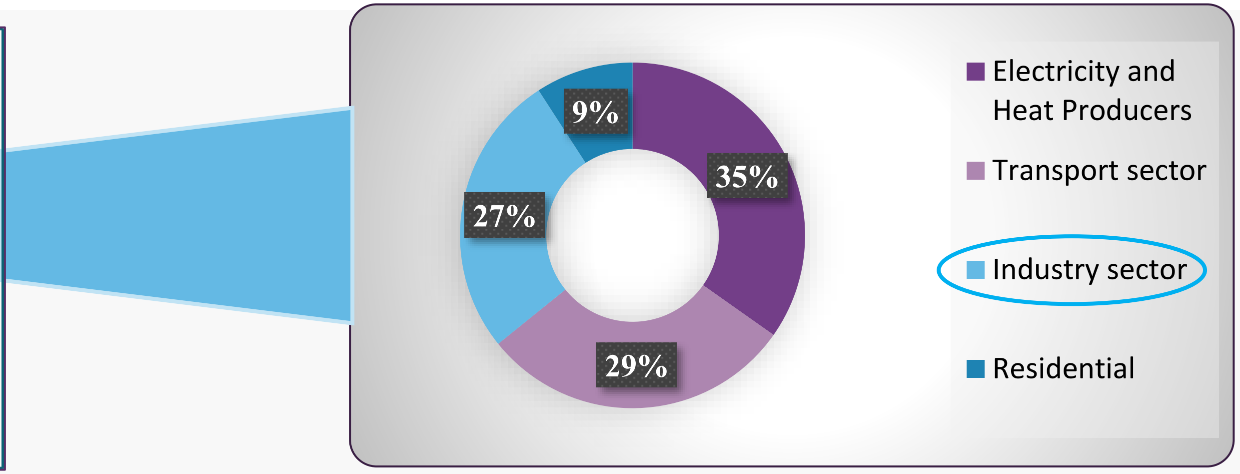


Figure 2. Sectoral emissions in Pakistan (Source: IEA, 2023)

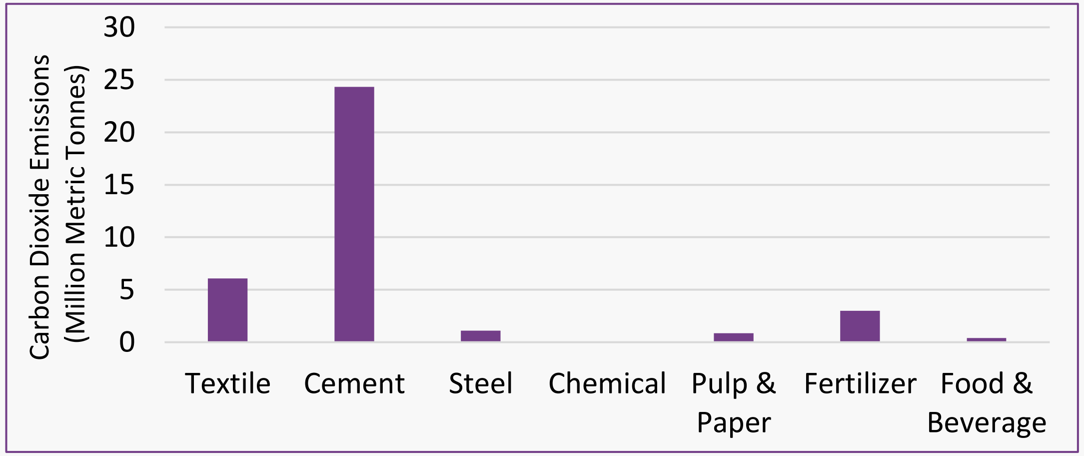


Figure 3. Industry-wise emissions in Pakistan in 2024. (Source: Author's own calculations)

- Pakistan's industry sector accounts for a significant share of total final energy use.
- The cement sector has the highest carbon dioxide emissions followed by textile sector and fertilizer sector.

Process-level gas use across industries

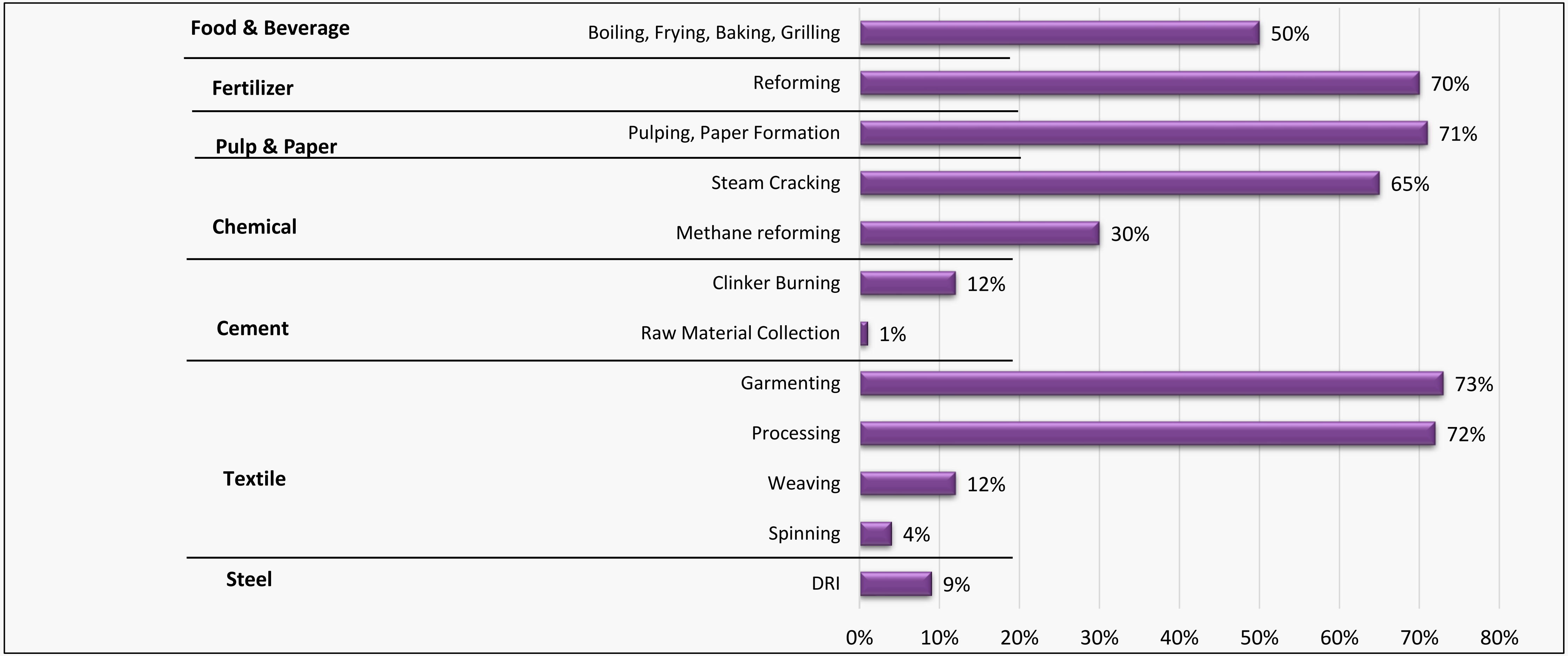
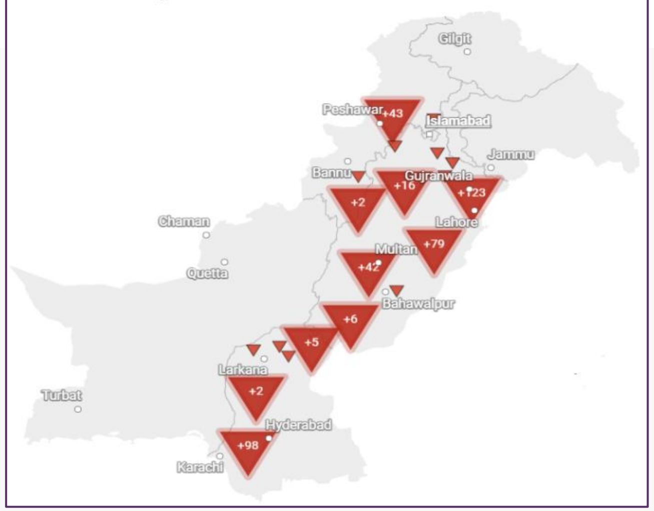


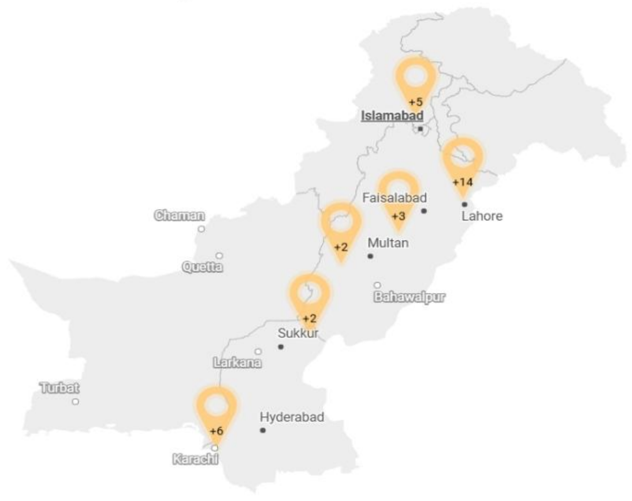
Figure 4. Process-wise gas consumption share (Source: Author's own analysis based on several research studies)

Industrial landscape—where industry is located in Pakistan

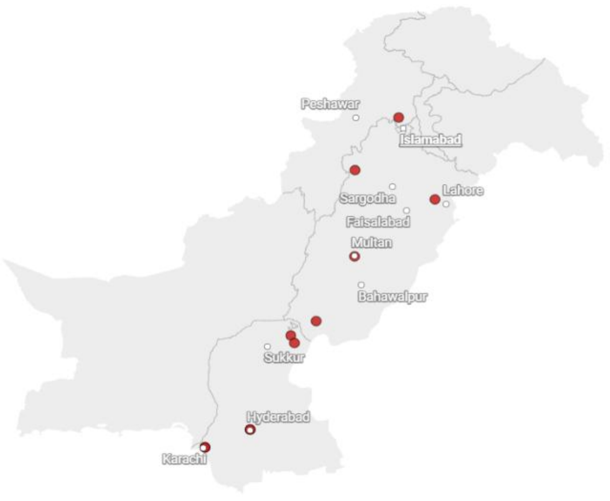
Textile Industry



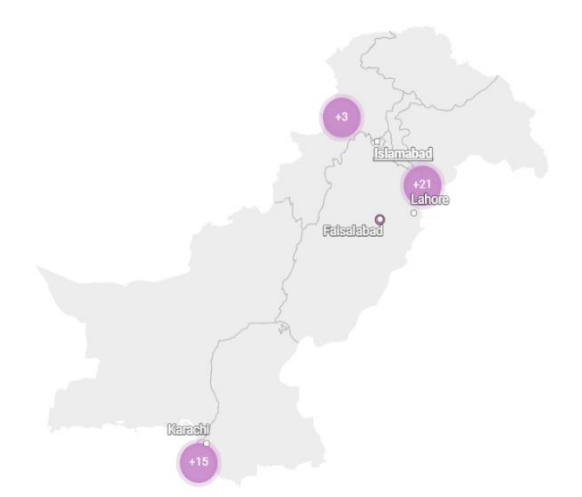
Chemical Industry



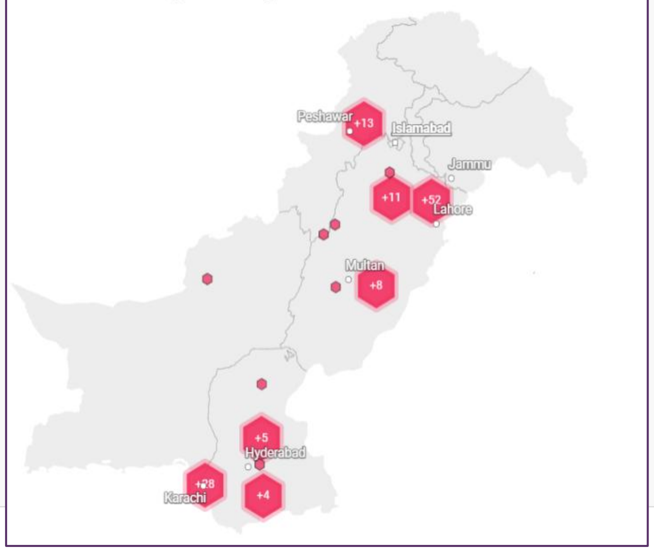
Fertilizer Industry



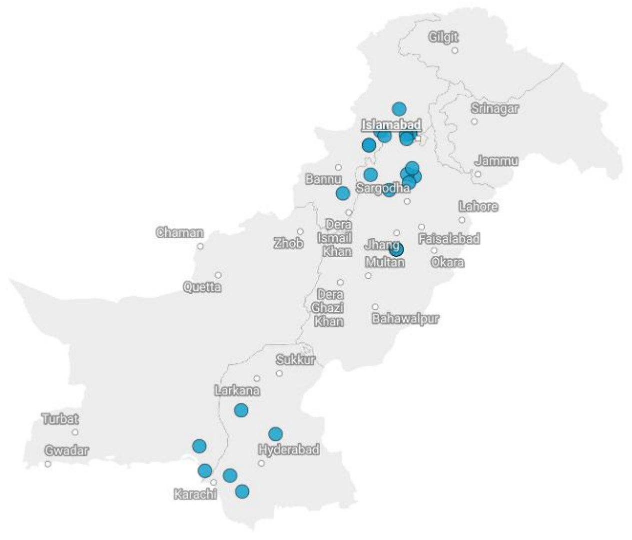
Pulp and Paper Industry



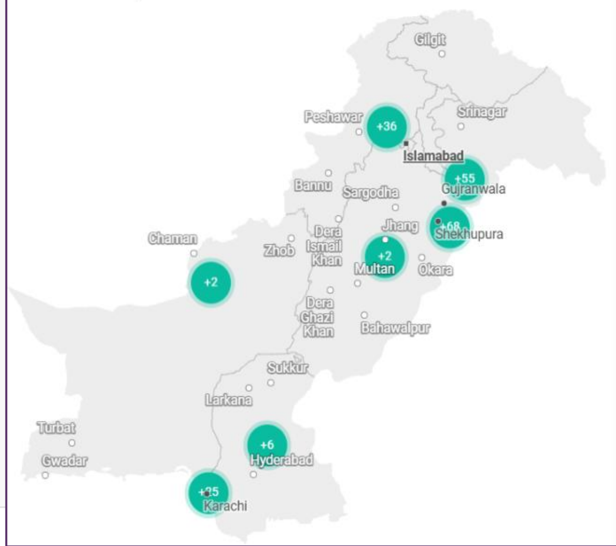
Food and Beverage Industry



Cement Industries



Steel Industry



Note: Numbers in the boxes indicate number of industries in that region.

Study objectives and rationale

- Pakistan's gas sector is increasingly stressed by a widening supply–demand gap, rising reliance on expensive imported RLNG, mounting circular debt, and higher emissions. In contrast, the power sector has surplus generation capacity that could be leveraged to electrify gas using industries and provide cleaner industrial heat.
- This study aimed to assess electrification potentials of process heat generation across industrial subsectors and processes in Pakistan.

1. To **map industrial gas usage** by process and temperature and **identify feasible alternative electrification technologies**.
2. To **model scenarios** to assess the **environmental, economic, and financial benefits** of replacing gas with **grid electricity or on-site renewables**.
3. To **analyze grid feasibility** for **industrial integration,** while ensuring **grid reliability** through a **phased implementation plan.**

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Technology mapping & market readiness

Most gas-based industrial processes in Pakistan, already have viable electric alternatives with moderate to high technology readiness.

Industry	Gas-based Process	Existing Technology			Alternative Technology (Electricity/RE)				
		Gas-based	Efficiency / COP	Temperature Ranges (°C)	Electricity-based	Efficiency / COP	Technology Readiness Index for Pakistan (1 to 10)		
							Low (1 to 5)	Medium (5 to 8)	High (9 to 10)
Steel Industry	Iron making	Direct Reduced Iron (DRI)		>1600	H_2DRI				
Textile Industry	Processing	Singeing Machine	70%	60	Electric Singeing Machine				
		Pre-Washing Chambers		50	Electric boiler	90%			
		Steamer	Up to 90%	98	Electric steamer	90%			
		Main Washing Steam Boiler	94 to 95%	450	Electric main washing boiler	99%			
		Dryer	35 to 40%	140	Electric dryer, Heat Pump	63 to 69%, 1.5 to 6.0			
		Mercerizing (Dryer)		140	Electric dryer, Heat Pump	63 to 69%, 1.5 to 6.0			
		Pad Steam Dyeing Unit	70 to 80% (Boiler)	50-98	Electric steam pad dying, Heat Pump				
		IR Burner	65%	760-900	Electric burner				
		Thermosol Monforts Dyeing		50 - 98	Electric boiler	90%			
		Stentering machine	69.37%	170	IR heating	85%			
		Sanforizing machine		130	Electric sanforising unit				
		Calendering machine	95%	200	Induction heated roller	87 to 92%			
	Garmenting	Iron Machine	93%	200					
		Steam Boiler	94 to 95%	100-450	Electric boiler	90%			
		Dryer	35 to 40%	120-170	Electric dryer, Heat Pump	63 to 69%, 1.5 to 6.0			

Table 3. Technology mapping

Cont.....

Industry	Gas-based Process	Existing Technology			Alternative Technology (Electricity/RE)				
		Gas-based	Efficiency / COP	Temperature Ranges (°C)	Electricity-based	Efficiency / COP	Technology Readiness Index for Pakistan (1 to 10)		
							Low (1 to 5)	Medium (5 to 8)	High (9 to 10)
Cement Industry	Clinker Production	Calciner – Partial Calcination	90%	850-1000	Resistive heating, plasma torches	90%, 70%			
		Rotary Kiln	23–27.5%	1450	Electrified kilns	40 to 50%			
		Clinker Cooler	49.2–59.2%	1450					
Chemical Industry	Chlor-alkali Separation	Chlor-Alkali Separator	75%	20- 80					
	Reforming	Steam Methane Reformer	70–85%	700-1000	Electrified reformers, green H_2	88.9%			
	Steam cracking	Steam Cracker	67–70%	750-900	Electrified steam cracking	97.1%			
Pulp & Paper Industry	Pulping	Fire Tube Water Heater	75–80%	201	Electric water heater	90%			
	Paper formation	Multicylinder Dryer	50%	190	Heat Pump	1.5 to 6.0			
Fertilizer Industry	Reforming	Haber Process / Primary Reformer Furnace	90%	400	Electric reformer furnace	88.9%			
Food & Beverage Industry	Baking & Processing	Gas Oven	70–75%	150-250	Electric oven	75 to 80%			
	Frying	Gas Fryer	Up to 70%	200	Electric fryer	75 to 87%			
	Grilling	Char-broiler	51.3%	232-482	Electric charbroiler				
	Cooking	Kettle/Boiler	84–89%	200	Electric kettle	70 to 80%			
	Sterilization	Sterilizer		140-150	Electric boilers, heat pump	90%, 1.5 to 6.0			

Table 3. Technology mapping

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Textile and food & beverage industry has the highest electrification potential

Existing Technologies and Temperature Bandwidths

	Low ($\leq$100°C)			Medium (100–400°C)				High (>400°C)				Electrification Potential (EP)	
Textile	Second Washing Chamber (50°C)	Singeing machine (60°C)	First Washing Chamber and steamer (98°C)	Dryer (140°C)	Burner (170°C)	Calendaring (200°C)	Steam Boiler (450°C)	IR Burner (769°C to 900°C)				Short-term	High EP
Food & Beverages		Pasteurizer (70°C)		Sterilizer (140°C to 150°C)	Industrial Fryers & Boilers (200°C)	Industrial Ovens (150°C to 250°C)	Pizza Ovens (20°C to 300°C)	Char broiler (232°C to 482°C)				Short-term	High EP
Pulp and Paper					Multi-cylinder Dryer (190 °C)	Fire-tube Boiler (201°C)						Medium-term	Medium EP
Cement								Calciner (850°C to 1000°C)	Rotary kilns and clinker cooler (1450°C)			Long-term	Low EP
Fertilizer							Haber Process (400°C)					Long-term	Low EP
Chemical		Chlor-alkali separator (20°C to 80°C)						Steam cracker (750°C to 900°C)	Methane Reformer (700°C to 1000°C)			Long-term	Low EP
Steel										Electric Arc Furnace (3500°C)	Induction Furnace (IF)) (2000°C)	Long-term	Low EP

Figure.5: Electrification potential based on temperature bandwidths of industries.

Source: Authors' analysis

Electrification Potential of an industry is identified using three key indicators:

I. Gas share in processes i.e. a high gas share means high opportunity to be electrified/replaced).

II. Temperature bandwidths where low-to-medium temperature ranges implies high electrification potential and vice-versa

III. Technology readiness or maturity of relevant alternative technologies available in the market for deployment (i.e., in Pakistan's market context).

Economics and impacts of industrial electrification

Food industry presently offers the highest short-to medium term potential for electrification

- The food industry accounts for ~19 percent of industrial GDP and relies heavily on natural gas, which supplies ~51 percent of its total fuel consumption.
- Electric ovens, fryers, and char-broilers use 42 percent, 17 percent, and 20.5 percent less energy, respectively, but have higher CAPEX.
- Due to subsidized gas prices ($0.29/m³) and unreliable grid electricity , gas-based equipment remains dominant; grid-only electrification raises operating costs by 18.7–43.2 percent, resulting in negative savings.
- When paired with solar PV (CAPEX ~$0.12/W), electric technologies become highly cost-effective, delivering cost savings from 96 -121 percent making electrification with solar the most viable pathway.

Technology Comparison	Gas Oven	Electric Oven	Gas Fryer	Electric Fryer	Gas Char broiler	Electric Char broiler
Technology efficiency comparison: Gas equipment Vs electric alternative						
ANNUAL ENERGY CONSUMPTION OF EQUIPMENT (kWh)	292,000	168,192	70,080	58,400	205,568	163,520
ENERGY SAVINGS	42.2%		16.7%		20.5%	
CAPEX COST ($)	7,370	10,000	5,700	7,000	815	1600
Cost case A: Only grid backed electrification						
ANNUAL ENERGY COST ($)	24,605	33,601	24,605	29,204	24,605	35,243
COST SAVING ($)	**-8,996 (-36.56%)**		**-4,599 (-18.70%)**		**-10,638 (-43.24%)**	
Cost case B: Renewable integrated electrification						
ANNUAL ENERGY COST ($)	24,605	-800	24,605	-5,197	24,605	842
COST SAVING (AFTER SOLAR)	**25,405 (103.25%)**		**29,801 (121.10%)**		**23,763 (96.58%)**	

Table 4. Food Industry: Process-wise Transition Analysis

Electric heating and load offsetting to Solar PV enables 90 % + cost savings with a payback of 2.2 years in the food industry

Parameter	Gas heating	Electric heating-Grid only	Electric heating with Solar PV integration
Annual Energy Consumption (kWh) - Process	**567,648**	**390,112**	**101,032** *(after integrating on-site solar)*
Energy Savings (%)	–	31.3% (relative to gas)	82.2% (relative to gas + grid)
Annual Energy Cost (USD) - Process wise	**73,815**	**98,048**	**6,839**
Cost Savings (%)	–	–36.5% *(higher cost)*	+90–95% *(very high savings)*
Total CAPEX (USD)	13,835	22,400	41,150 *(Electrification + Solar)*
Payback Period (Years)	–	>10 years	2.2 years
Benefit–Cost Ratio (B/C)	–	0.8 *(Uneconomic)*	4.2 *(Highly viable)*
CO_2 Emission Reduction	–	Moderate	High
Overall Outcome	High fuel cost, inefficient, carbon-intensive	More efficient but higher OPEX	Efficient, low-cost, low-carbon pathway

Table 5. Food Industry: Energy use, cost and investment viability

Paper & pulp industry demonstrates strong medium term (2030-2045) economic viability

- The paper and pulp industry is the second-largest industrial consumer of natural gas, accounting for ~60 percent of its fuel use and 2.54 percent of industrial GDP.
- Electric boilers and dryers deliver the same heat, with 87.5 percent and 10 percent lower energy use, respectively, but require higher upfront investment, reflecting an efficiency upgrade rather than a direct cost switch.
- Given Pakistan’s high industrial electricity tariffs, grid-based electrification is mixed: the electric boiler reduces costs by 33.7 percent, while the electric dryer increases costs by 86.5%, highlighting the risk of electrification without cheap power.
- When powered by solar PV, electric equipment replaces costly grid electricity, delivering ~165 percent cost savings for boilers and ~45 percent for dryers, while also avoiding gas shortages and load-shedding—making renewable-backed electrification the most cost-effective and reliable pathway.

Technology Comparison	Gas Based Boiler	Electric Boiler	Multicylinder gas dryer	Electric Fryer	Gas Charbroiler	Electric Charbroiler
Technology efficiency comparison: Gas equipment Vs electric alternative						
ANNUAL ENERGY CONSUMPTION (kWh)	166,746	20,843	111,111	100,000	205,568	163,520
ENERGY SAVINGS	87.5%		10%		20.5%	
CAPEX COST ($)	5,600	8000	18,000	25,000	815	1600
Cost case A: Only grid backed electrification						
ANNUAL ENERGY COST ($)	10,458	6,938	10,458	19,498	24,605	35,243
COST SAVING ($)	3,520 (33.7% cheaper)		-9,040 (86.5% more expensive)		**-10,638 (-43.24%)**	
Cost case B: Renewable integrated electrification						
ANNUAL ENERGY COST (AFTER SOLAR)	10,458	-6,822	10,458	5,738	24,605	842
COST SAVING (AFTER SOLAR)	17,280 (165% less than gas)		4,720 (saves energy cost by ~45%)		**23,763 (96.58%)**	

Table 6. Pulp & Paper Industry: Process-wise Transition Analysis

Unlocking ~95% cost savings in the paper & pulp industry with a ~4.5-year payback

Parameter	Gas Heating	Electric heating-Grid only	Electric heating with Solar PV integration
Total Annual Energy Consumption (kWh)	277,857	120,843	5,211
Energy Savings (%)	—	56.5%	~94.1%
Total Annual Energy Cost (USD) *(Scenario Level – Added)*	20,916	26,436	1,084
Cost Savings (%)	—	–26% (higher cost)	~95% savings
Total CAPEX (USD)	23,600	37,300	44,800
Payback Period (Years)	—	>10	4.5
Benefit–Cost Ratio (B/C)	—	0.8 *(Uneconomic)*	2.2 *(Highly Viable)*
CO_2 Emission Reduction	—	Low (8.2%)	High (87.3%)
Overall Outcome	High fuel cost, inefficient, carbon intensive	More efficient but higher OPEX	Efficient, low-cost, low-carbon pathway

Table 7. Paper & Pulp Industry: Energy use, costs & Investment viability

Textile industry also shows a strong potential for electrification in the short term.

- The textile industry consumes **~23 percent of its fuel** and contributes **~28 percent to industrial GDP**, making it the largest industrial sector in Pakistan.
- Electric equipment reduces energy use by **8–25 percent**, but **higher CAPEX and slower resistance-based heating** increase operating costs when powered by the high-tariff grid (≈97 percent for drying chambers, 64 percent for steam, and 2–3 percent for washing/dryers).
- On-site **solar PV** largely replaces expensive grid electricity, delivering **annual savings of 100,000 dollars – 137,000 dollars per process** (≈250–350 percent higher than gas),making electrification **highly profitable and reliable**.

Technology Comparison	Thermosol Drying – Chambers	Electric Drying – Chambers	Gas Steamer	Electric Steamer	Gas Based main washing	Electric main washing	Gas based prewashing	Electric prewashing	Gas based dryer	Electric dryer
Technology efficiency comparison: Gas equipment Vs electric alternative										
ANNUAL ENERGY CONSUMPTION (KWH)	512,071	469,303	400,398	327,657	18,000	13,500	18,000	15,000	14,000	11,000
ENERGY SAVINGS	8.4%		18.2%		25%		16.7%		21.4%	
CAPEX COST ($)	150,000	180,000	11,600	20,000	8,000	12,000	35,000	78,000	90,000	105,000
Cost case A: Only grid backed electrification										
ANNUAL ENERGY COST ($)	39,011	77,042	39,011	63,825	39,011	39,972	39,011	40,160	39,011	39,821
COST SAVING ($)	-38,030 (-97%)		-24,814 (-64%)		-961 (-2.5%)		-1,149 (-2.9%)		-810 (-2.1%)	
Cost case B: Renewable integrated electrification										
ANNUAL ENERGY COST (AFTER SOLAR)	39,011	-60,560	39,011	-73,776	39,011	-97,629	39,011	-97,441	39,011	-97,780
COST SAVING (AFTER SOLAR)	99571 (255%)		112,787(289%)		136,640(350%)		136,452(350%)		136,791(351%)	

Table 8. Textile Industry: Process-wise Transition Analysis

The electric heating and Solar PV load offsetting scenario in textile industry demonstrates a strong economic performance with ~6.3-year payback and a B–C ratio of 1.7.

Scenario	Gas heating	Electric heating-Grid only	Electric heating with Solar PV integration
Total Annual Energy Consumption (kWh)	962,470	836,461	-319,859
Energy Savings (%) vs Gas	–	13.1%	133%
Total Annual Energy Cost (USD)	195,095	260,820	–427,186
Cost Savings (%) vs Gas	–	–33.7% (cost increase)	+318%
Total CAPEX (USD)	294,600	450,000	525,000
Payback Period (Years)	–	>10	6.3
Benefit–Cost Ratio (B/C)	–	0.7 (Uneconomic)	1.7 (Highly Viable)
CO_2 Emission Reduction	–	Moderate	High
Overall Outcome	High fuel cost, inefficient, carbon-intensive	More efficient but higher OPEX	Efficient, low-cost, low-carbon pathway

Table 9. Textile Industry: Energy use, costs & investment viability

The fertilizer industry shows limited electrification potential compared to other sectors due to the extensive use of natural gas as a feedstock rather than solely as a fuel.

- The fertilizer industry is Pakistan's largest industrial consumer of natural gas, accounting for ~70 percent of its total fuel use and contributing ~8 percent to industrial GDP.
- Energy use fell by 35.7 percent for electric reformers and 10.4% for electric boilers compared to gas-based systems.
- Grid-only electrification is economically unattractive; annual operating costs rise by 47.7 percent for reformers and 112.2 percent for boilers due to high industrial electricity tariffs and operational limitations, despite higher efficiency.
- Electrification becomes financially viable only when coupled with renewable energy. Integrating solar PV reduces costs dramatically.
- In Pakistan's fertilizer sector, grid-based electrification raises operating costs, while solar-powered electrification enables both decarbonization and net economic benefits.

Technology Comparison	Gas Based Primary Reformer	Electric Reformer	Gas Boiler	Electric Boiler
Technology efficiency comparison: Gas equipment Vs electric alternative				
ANNUAL ENERGY CONSUMPTION (KWH)	4,391,400	2,823,046	5,644,566	5,055,903
ENERGY SAVINGS	35.7%		10.4%	
CAPEX COST ($)	59,000	230,000	88,000	110,000
Cost case A: Only grid backed electrification				
ANNUAL ENERGY COST ($)	376,547	556,016	376,547	799,179
COST SAVING ($)	-179,469 (47.7% increase in cost)		-422,632 (112.2% increase in cost)	
Cost case B: Renewable integrated electrification				
ANNUAL ENERGY COST (AFTER SOLAR)	376,547	-581,031	376,547	-337,868
COST SAVING (AFTER SOLAR)	957,578 (254% cost reduced)		714,415 (189.7% cost reduced)	

Table 10. Fertilizer Industry: Process-wise Transition Analysis

Fertilizer industry achieves high energy savings (92.4%) but low economic returns under electric heating and Solar PV load offsetting scenario

Parameter	Gas heating	Electric heating-Grid only	Electric heating with Solar PV integration
Total Annual Energy Consumption (kWh)	10,035,966	7,878,951	758,813
Energy Savings (%)	–	**21.5% ↓**	**92.4% ↓**
Total Annual Energy Cost (USD)	753,094	1,175,726	-918,899
Cost Savings (%)	–	**+56.1% ↑ (cost increase)**	**222.0% ↓ (cost reduction)**
Total CAPEX (USD)	147,000	340,000	537,300
Payback Period (Years)	–	>50 (not viable)	>20 (long but positive)
Benefit–Cost Ratio (B/C)	–	<1 (uneconomic)	**0.3**
CO_2 Emission Reduction	–	Low	High
Overall Outcome	High fuel cost, inefficient, carbon intensive	More efficient but economically unattractive	**Efficient, costly, high savings, low-carbon pathway**

Table 11. Fertilizer Industry: Overall Energy use, costs & Investment viability

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Comparative insights across industries

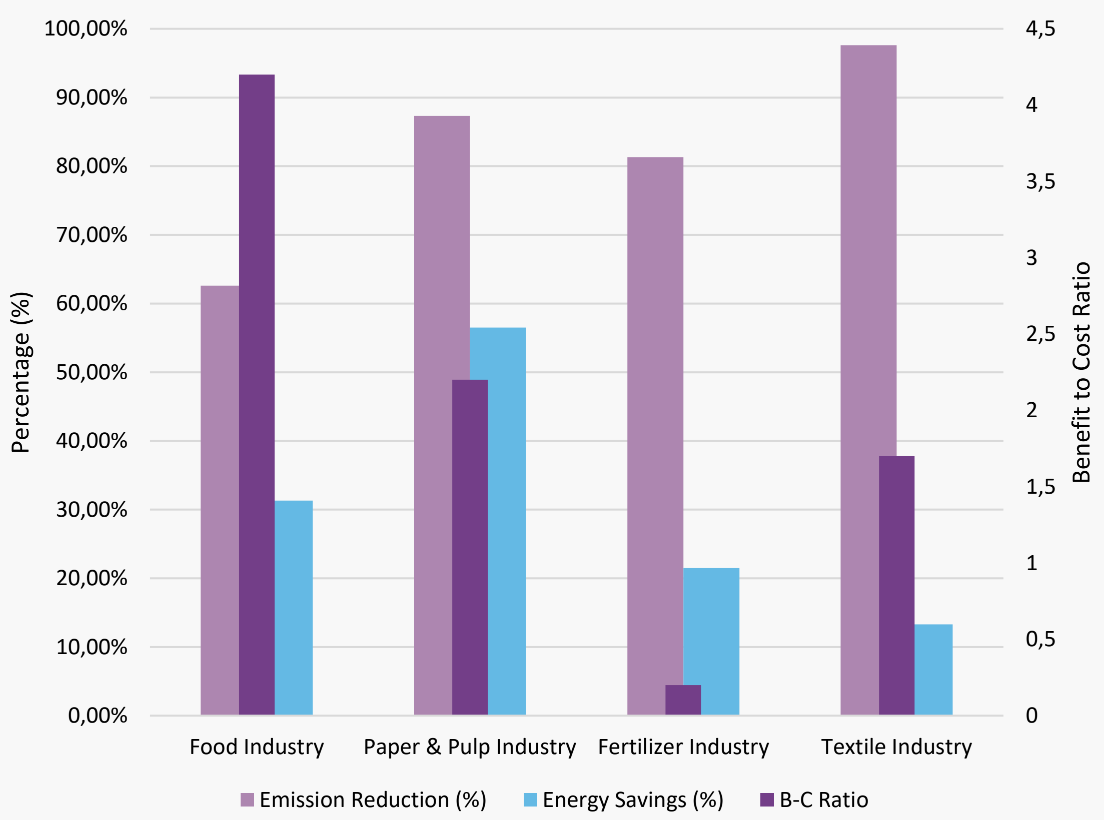

Figure 6. Economic & Environmental benefits of industrial electrification.

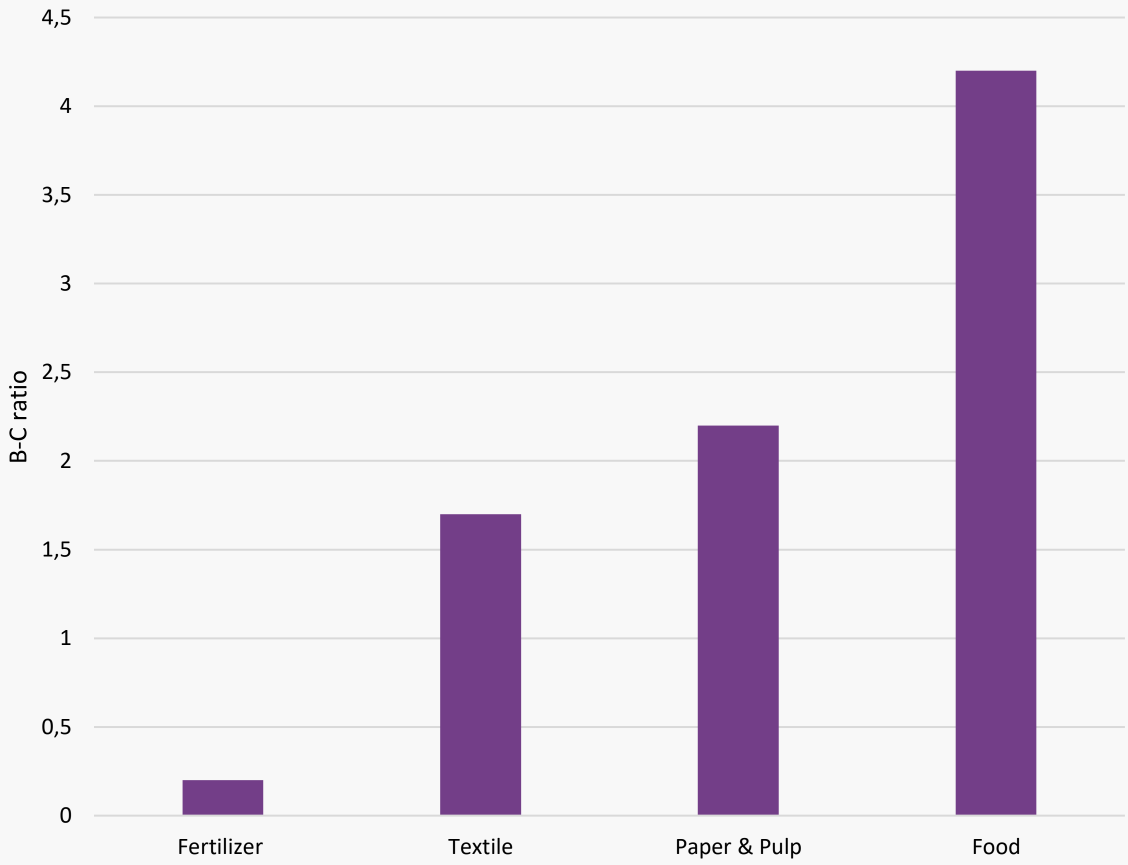

Figure 7. Industries benefit to cost ratio.

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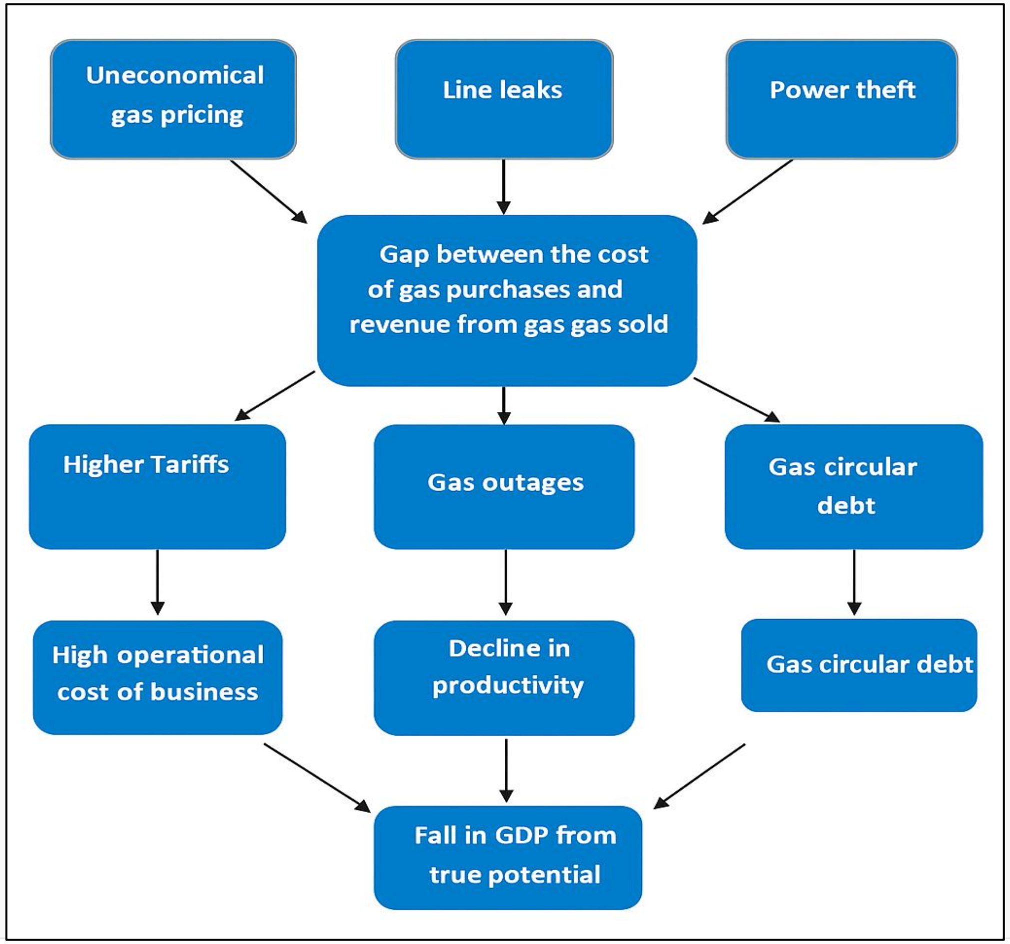
Electrifying just these four major industries could significantly lower Pakistan's fuel import bills, strengthen the currency and reduce circular debt.



Parameter	Result	Implications
Total Energy Saved	2.4GWh= 2,461,083 kWh/year (as per cost-benefit analysis)	Based on four major industries (fertilizer, textile, paper & pulp, food).
Average Energy Reduction	20.01 percent	Indicates overall efficiency improvement from electrified systems.
National Industrial Gas Consumption	1300 MMCFD	Combined volume for General Industry and Fertilizer (Economic Survey of Pak FY24-25)
Imported RLNG (Industrial sector FY24-25)	288 MMCFD	Current RLNG consumption in Industry (FY24-25)
Equivalent Gas Savings/year	98.460 million MMBtu	Assuming 20.01 percent savings across major gas-consuming sectors.
Avoided Fuel Import Value (USD)	109.01 million MMBtu / year.= 1.199 billion dollars / year	Assuming imported RLNG is fully replaced, Based on imported RLNG gas cost of (11 dollars/MMBTU)
Avoided Fuel Import Value (PKR)	336.95 billion rupees / year.	Using exchange rate of 281 rupees/US dollars.
Impact on Gas Circular Debt (Reduction)	-12.96 percent	Reduction equivalent to this share of 2,600 billion rupees total gas circular debt.
Macroeconomic Implication	Lower fuel import bill, reduced external pressure on dollar reserves, and improved fiscal sustainability through significant (percent per year) circular debt containment.	

The transition from BAU to industrial electrification provides energy savings of 36.1% by 2050

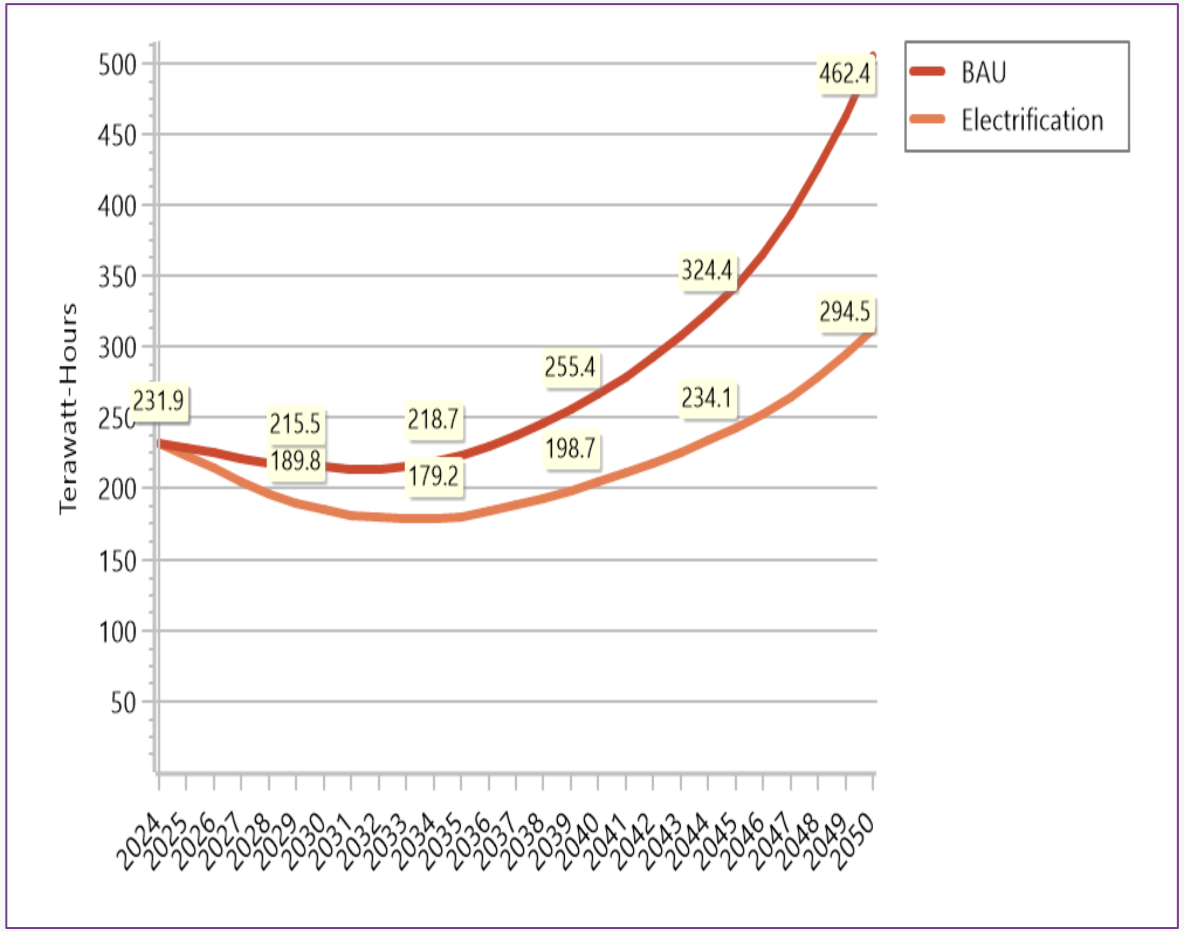


Figure 8. Final Energy Demand comparison

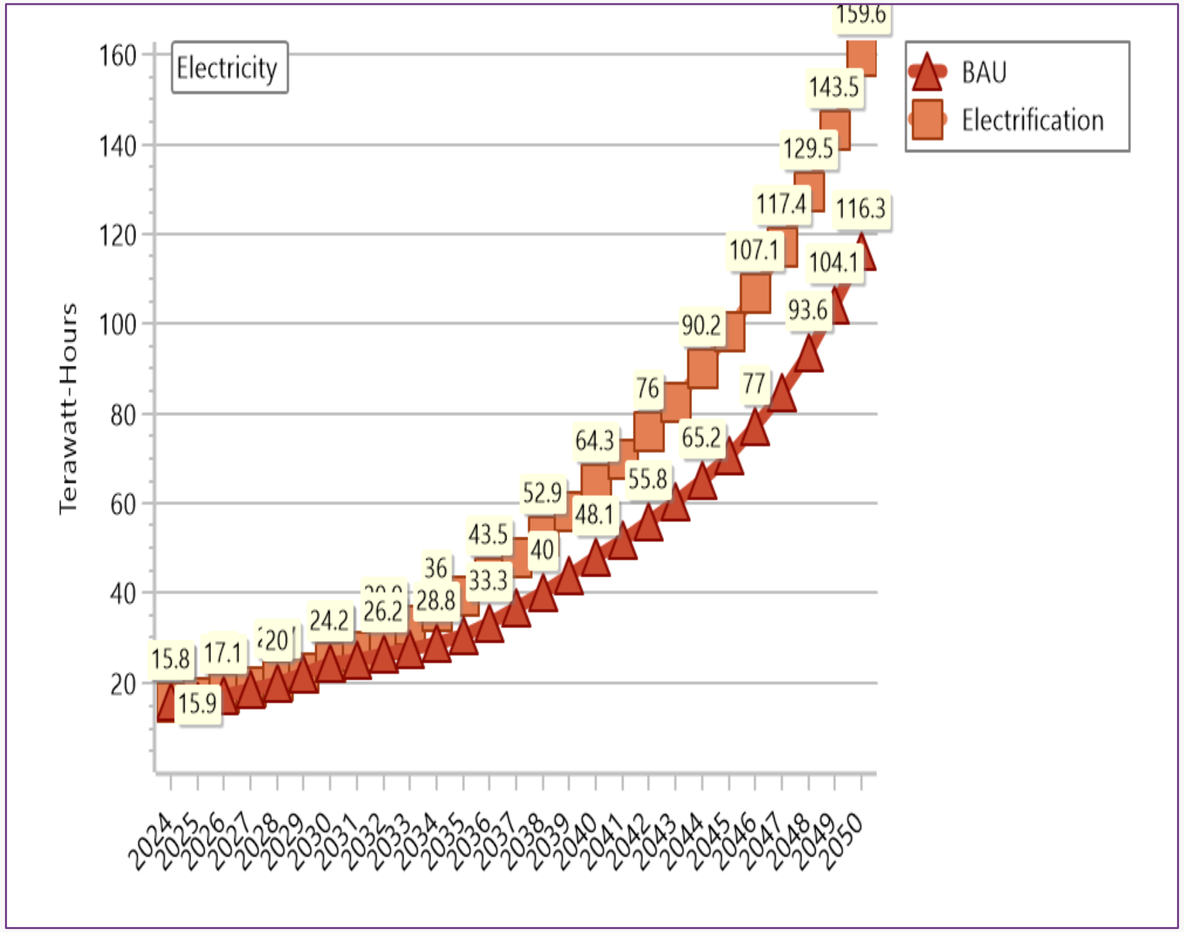


Figure 9. Electricity Demand Comparison

 *The electricity demand in the base year (2024) i.e. **15.8 TWh** aligns with the total electricity consumption by the industrial sector as mentioned in the Power System Statistics Report 49th edition.

In the short term (2024 to 2030), electrification cuts total industrial energy use by 19 percent in 2030, even though electricity consumption increases slightly (by 0.4 TWh) as fossil-fuel processes shift to electric technologies

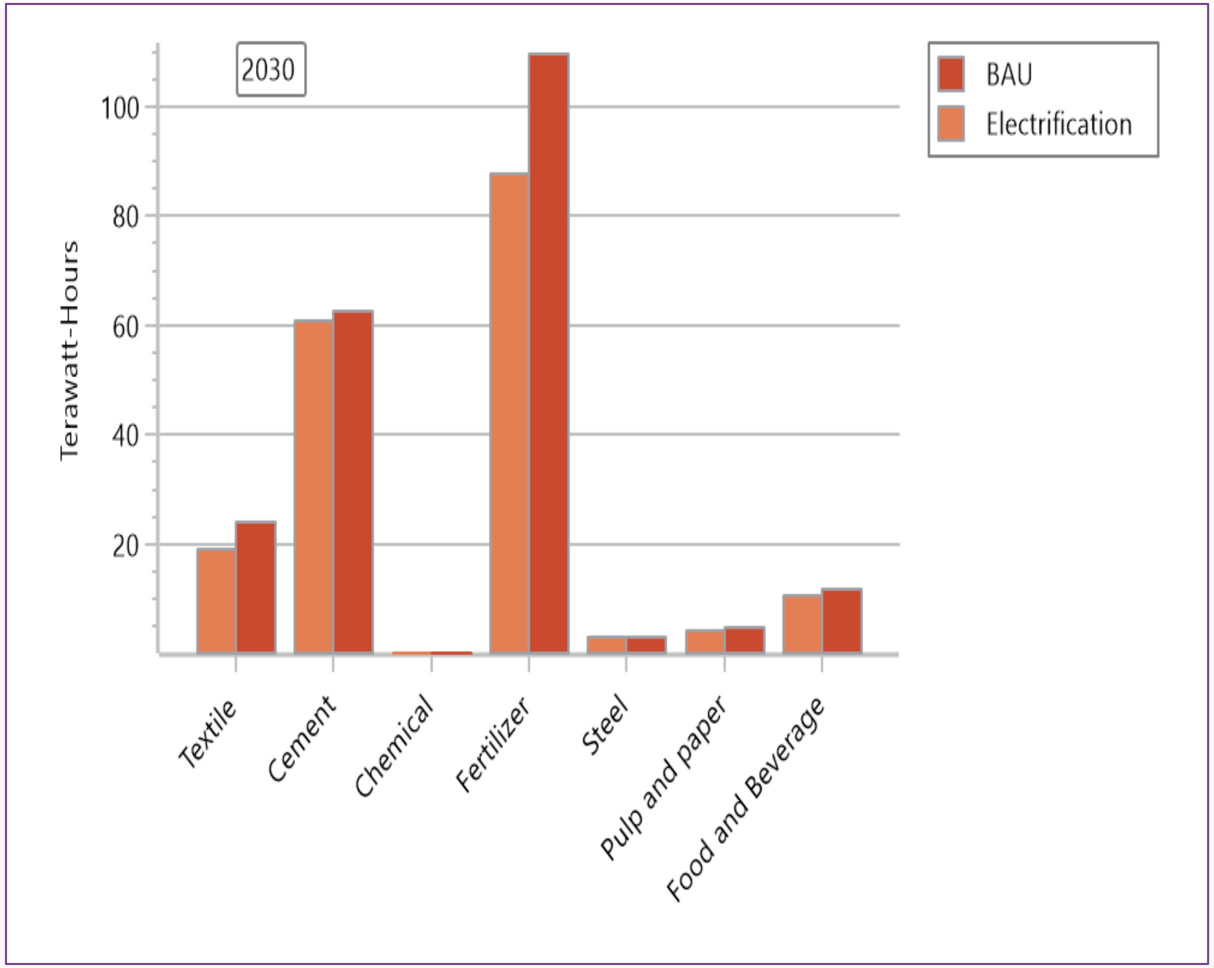


Figure 10. Industry-wise final energy demand in short-term (2025-2030)

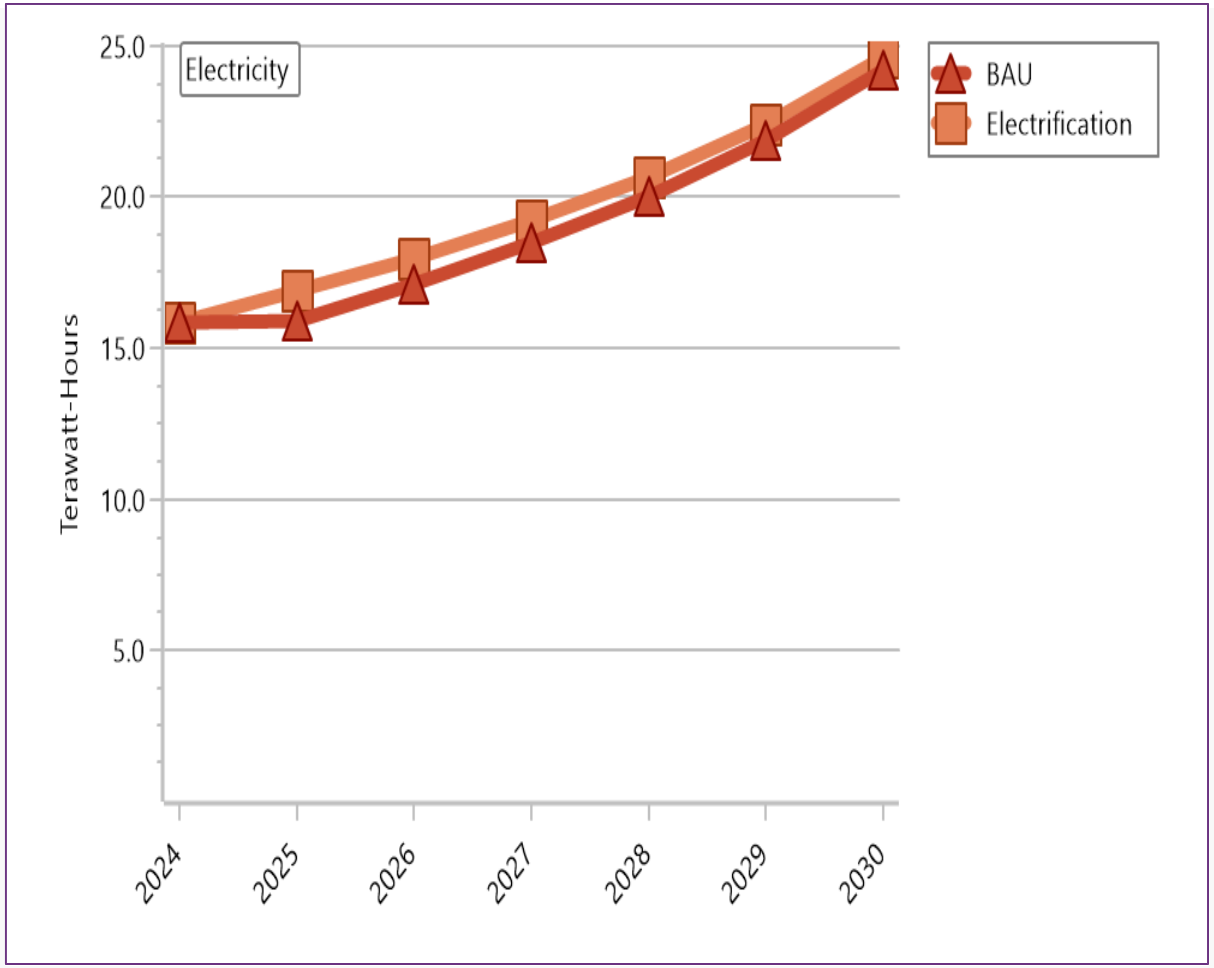


Figure 11. Electricity demand in short-term.

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Textile and Food & Beverages sectors have the highest electrification potential in medium term (2031 to 2045)

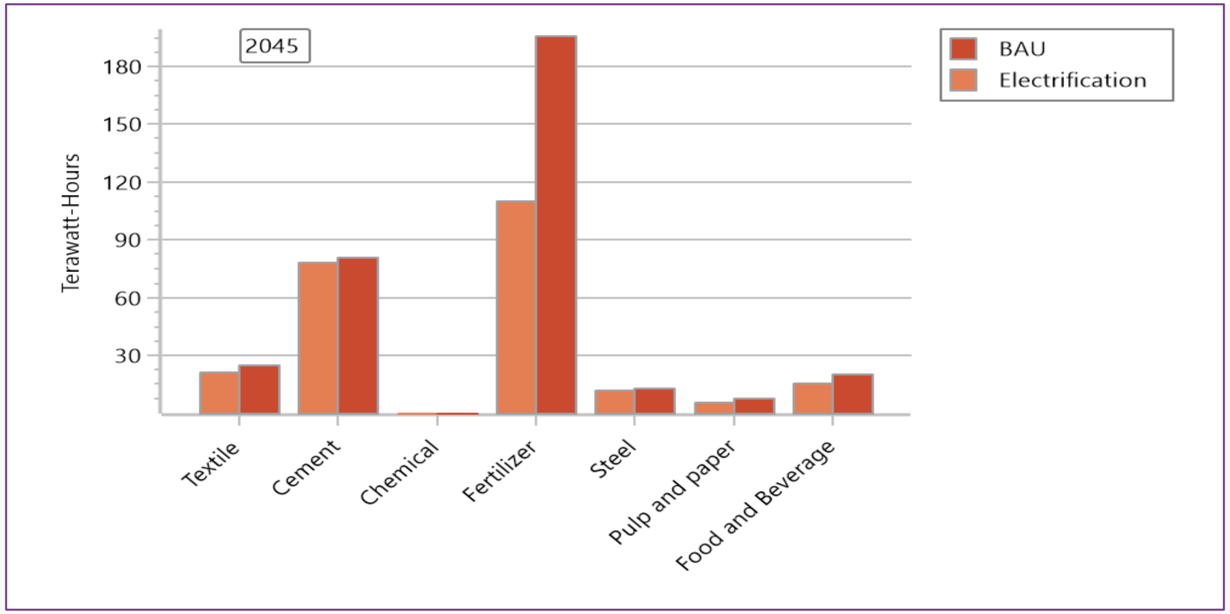

Figure 12. Industry-wise final energy demand in medium-term (2031-2045).

- By 2045, total energy demand under the electrification pathway decreases from **342.5TWh in BAU** to about **243TWh**, representing **29.1% energy savings**.
- **Pulp & paper** also has medium temperature processes so we assume it can be electrified up to **58%** in **medium term** and **65%** in **long term (2050).**
- Textile and Pulp & Paper achieved **4TWh (16%)** and **2.1TWh (26.25%)** energy savings in **2045**.

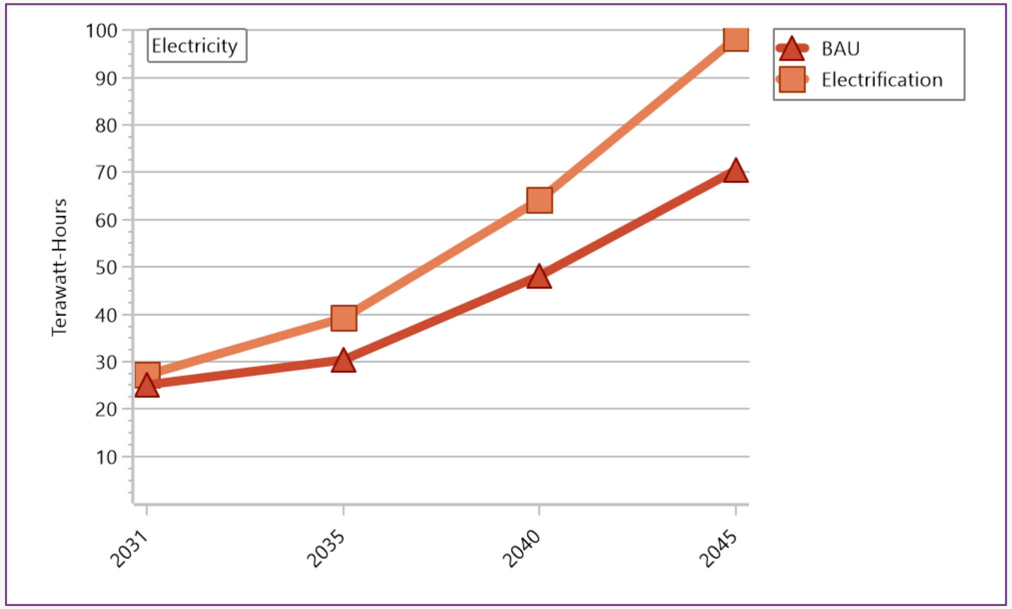

Figure 13. Electricity demand in medium-term.

- In Medium-term (2031 to 2045), the electricity demand increases significantly in electrification scenario.
- The **increase** in electricity demand after electrification as compared to BAU is **27.7 TWh** reflecting a **39.2% addition.**

Industrial electrification raises electricity demand by ~37 percent in the long term (2046 to 2050)

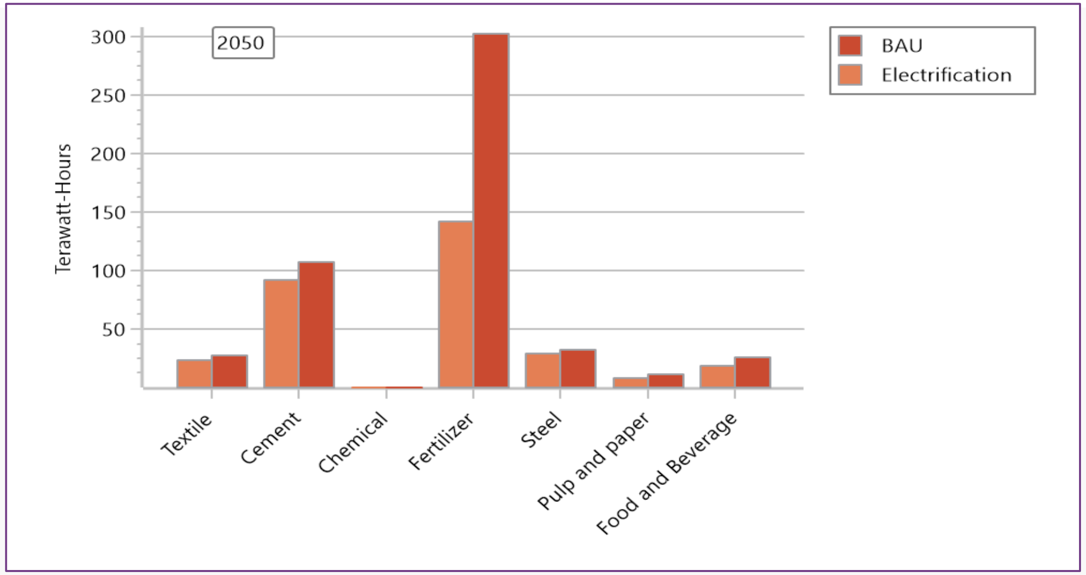

Figure 14. Industry-wise final energy demand in long-term (2046-2050).

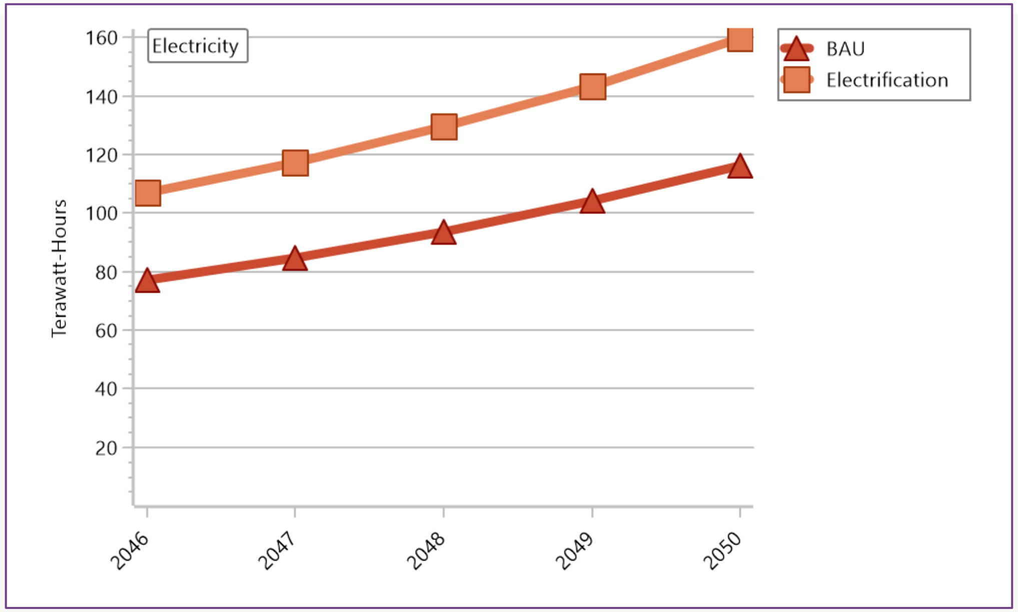

Figure 15. Electricity demand in long-term.

•**System-wide impact:** By 2050, electrification reduces total energy demand from ~504.7 TWh (BAU) to ~312.5 TWh, delivering ~38% cumulative energy savings over 2024–2050.
•**Sectoral potential:** The chemical industry reaches ~35% electrification by 2050, mainly in low-temperature processes, while cement (20%) and fertilizer (26%) remain constrained by high-temperature requirements and limited technology readiness.
•**Energy savings & limits:** By 2050, cement and fertilizer achieve ~2.6 TWh (3.2%) and ~85.3 TWh (43.7%) energy savings, respectively; the steel sector shows limited additional electrification, with energy demand stabilizing after 2040 due to rise in hydrogen-DRI technologies.

- The electricity demand of the industrial sector increases from 15.8 TWh in 2025 to 159.6 TWh in 2050 in the electrification scenario.
- The increase in electricity demand after electrification as compared to BAU is 43.3 TWh, reflecting a 37.2 percent addition of electrification technologies.

Industrial electrification can cut CO_2 emissions by up to 52 percent by 2050

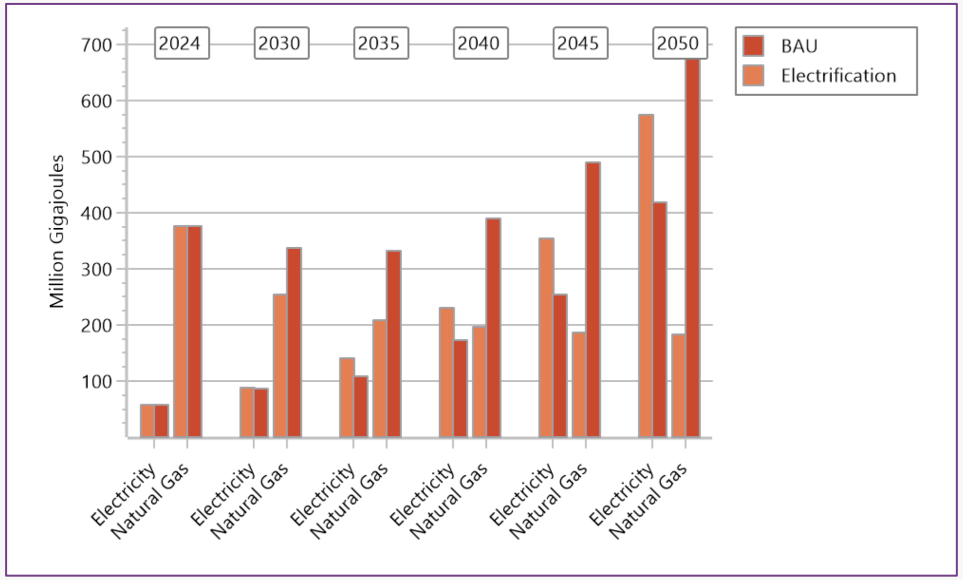

Figure 16. Natural gas and electricity trends before and after transition.

- A visible decline in natural gas consumption occurs in the electrification scenario as electricity replaces it for process heating and mechanical drives.
- Natural gas demand in **BAU** is **716.8 million GJ** by 2050. However, in the **electrification** scenario, it reaches **183.8 million GJ by** 2050.
- Total natural gas consumption has reduced by **74.4 percent** after electrification as compared to BAU in 2050.

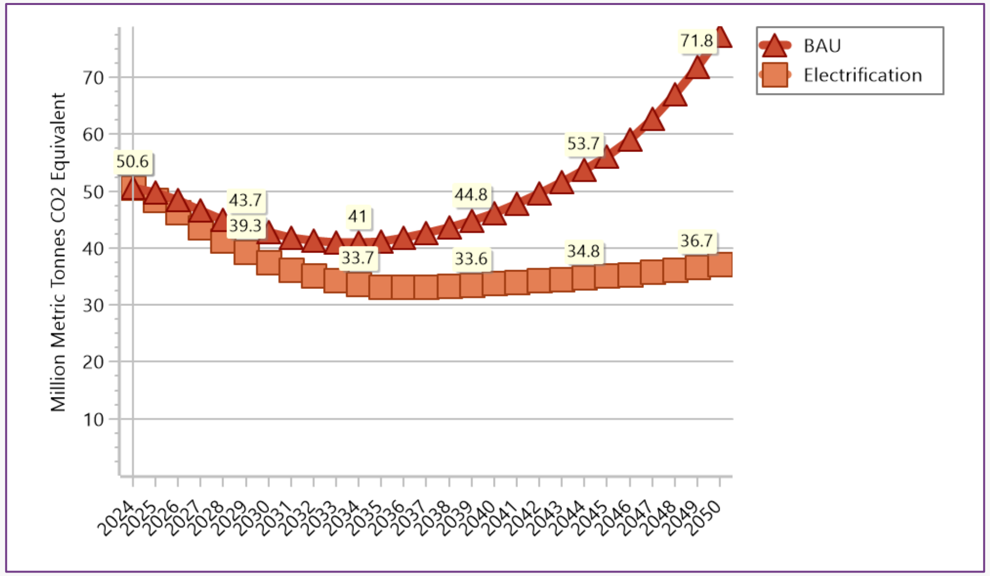

Figure 17. Carbon Dioxide Emissions from fossil-based energy sources (Scope I emissions).

- By 2050, total carbon dioxide emissions from fossil fuel-based energy sources, including coal, natural gas, and oil under the **electrification** pathway decrease from around **76.5 million metric tonnes in BAU** to about **36.9 million metric tonnes.**
- The adoption of electrification technologies can lead to approximately **52 percent emission reductions** in the industrial sector of Pakistan.

Power system readiness for industry electrification

Indicative Generation Capacity Expansion Plan (IGCEP) projections show that national grid has surplus capacity

- The NTDC's projected installed capacity remains significantly higher than demand across all Indicative Generation Capacity Expansion Plan (IGCEP) growth scenarios throughout the projection period (2024–2035).
- While peak demand in the High-Growth Scenario rises from 26,913 MW in 2024 to 43,069 MW by 2035, the installed capacity expands from 41,516 MW to 62,657 MW over the same period (Source: IGCEP 2025-35).
- From a system level perspective, electricity supply is sufficient to support industrial electrification.

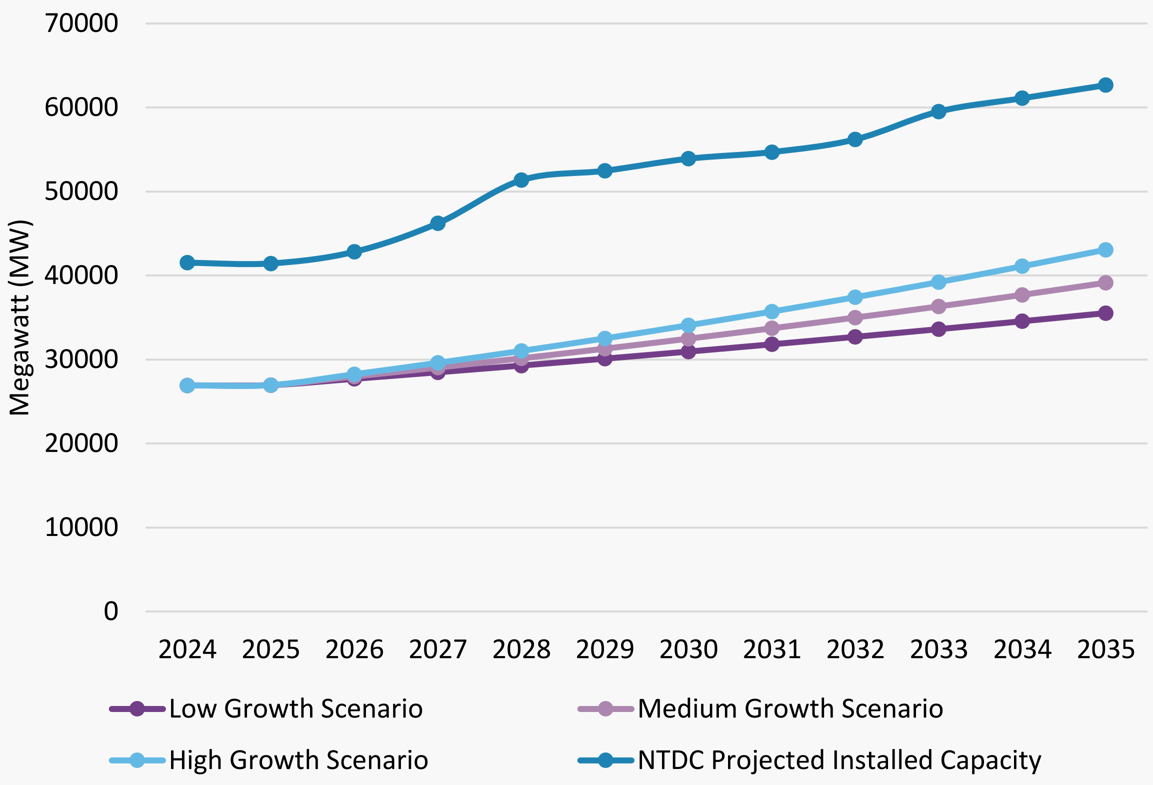

Figure 18. Growth scenario vs. NTDC capacity additions . Source: IGCEP 2025-2035

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However current IGCEP projections underestimate future demand

- Existing IGCEP projections does not fully account for industrial demand projections.
- In the IGCEP, three long-term load forecast scenarios are developed, i.e., Low (Business-as-Usual), Medium, and High demand scenarios
- Our LEAP based demand analysis shows higher electricity demand post 2030 when electrification is included— by 2031, demand (47,718.69 GWh) exceeds even the IGCEP High case (45,384.5 GWh).
- This creates a mismatch between future demand realities and current planning assumptions

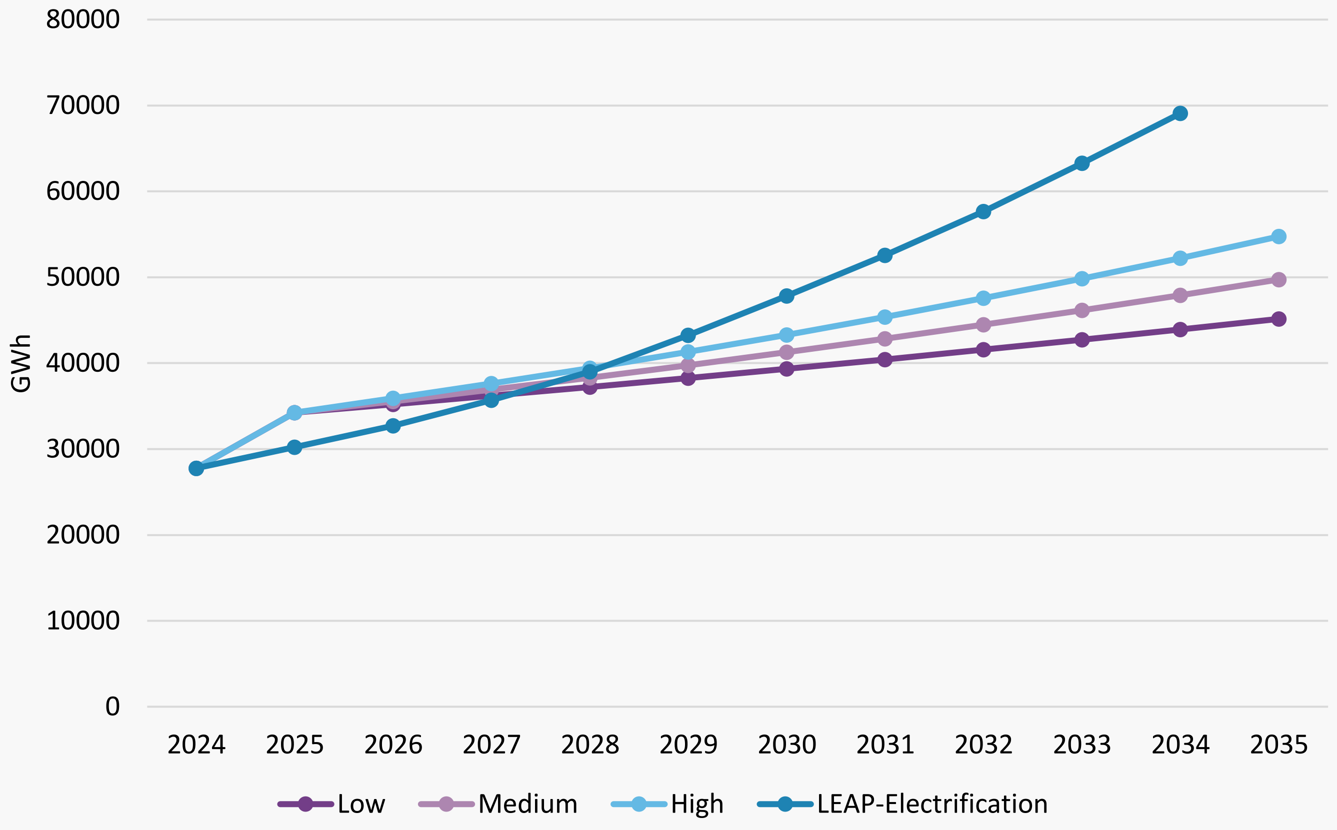

Figure 19. Industrial demand comparison (IGCEP vs. LEAP) (Source: Authors own calculations)

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Industrial electrification could push demand beyond the baseline, existing IGCEP demand forecast

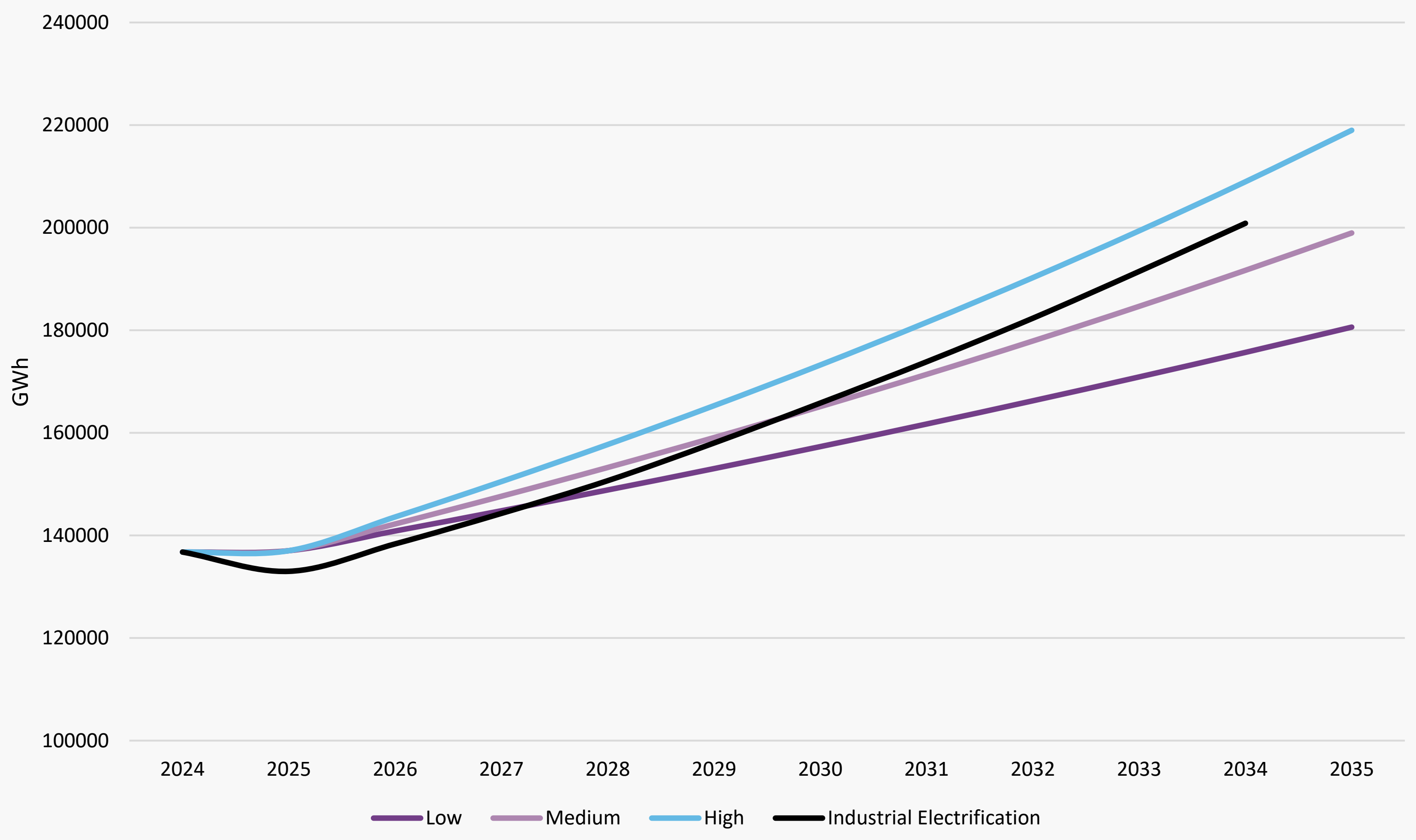

Figure 20. Country's peak demand comparison inclusive of all the sectors (Source: authors own calculations)

- Under the LEAP-based total demand, electrification exceeds both the Low and Medium growth scenarios by 2031.
- However, demand growth is gradual , allowing time for planning and system adaptation

The ability to absorb electrified industrial loads will also depend on location specific distribution readiness which presently varies significantly across utilities

- Most DISCOs have surplus transformer capacity at peak demand, but localized overloading persists, showing that capacity alone does not prevent congestion.
- Daily tripping's occur across multiple DISCOs; MEPCO and K-Electric experience the highest rates (>300/day), reflecting chronic network stress and reliability issues.
- These issues impact power quality and supply continuity, and these constraints will worsen with integration of higher load from industrial electrification.

DISCO	Power Transformers , Capacities (MVA)/2024	Required Power Transformer capacity at peak demand/ 2024	% Distributed transformer Overloading percentage at peak demand (sep 2024)	% Power transformer 100% or above Overloaded 2024	Capacity to require ment ratio 2024	No. of tripping' s across all feeders	Duration of tripping's (Minutes)	Avg. tripping's per day
PESCO	7,707	2,732	5	18	2.8	55390	7484171	152/day
TESCO	1,302	601	12	23	2.2	22271	2655576	61/day
IESCO	7,349	2,979	0	3	2.5	86343	8327842	236/day
GEPCO	5,542	2,553	2	0	2.2	50703	4902595	139/day
LESCO	14,094	5,807	11	0	2.4	3658	267761	10/day
FESCO	6,747	3,121	4	0	2.2	57969	2208344	159/day
MEPCO	9,312	4,618	7	0	2.0	135703	8250413	372/day
HESCO	3,189	1,237	0	1	2.6	66578	1616239	182/day
SEPCO	3,096	1,112	9	0	2.8	36989	16622388	101/day
QESCO	4,112	1,135	2	8	3.6	39129	1022167	107/day
K-Electric	7,095	3,640	15	1	1.9	123710	7029701	339/day

Table 12. DISCO-wise transmission network statistics

 (Source: State of Industries report, Performance Evaluation report – Transmission

Transition framework and implementation plan

Opportunities and barriers for industrial electrification

Barriers	Opportunities
Policy and Regulatory Gaps: Fragmented industrial energy policies and lack of a clear electrification roadmap; limited coordination between Ministry of Energy, NEPRA, and provincial departments.	**Policy Alignment and Mandates:** IMF-driven gas reforms and the National Electricity Plan (2023–2028) push industries toward grid-based and renewable energy adoption.
Financial Constraints: High upfront CAPEX for electric boilers, heat pumps, or solar integration; limited access to concessional finance.	**Access to Climate and Green Finance:** CBAM and global decarbonization pressures create an investment case for low-carbon technologies, unlocking **green credit lines** and **blended finance**.
Infrastructure Limitations: Weak grid reliability and limited 11–33 kV feeder capacity for industrial clusters; low penetration of distributed solar plus storage.	**Underutilized Grid Capacity:** Pakistan's **falling grid demand** creates an opportunity to utilize surplus capacity through industrial electrification and demand recovery.
Dependence on Captive Gas: Industries reliant on subsidized or dedicated gas supply face adjustment risks under **IMF conditionalities** removing gas concessions.	**Energy Security Transition:** Gas rationalization under IMF reforms incentivizes industries to shift toward **stable, diversified electricity sources** (grid + renewables).
Technology Awareness: Limited knowledge and technical capacity regarding high-temperature electric heat options (e.g., electric boilers, resistance heating, hybrid solar-thermal systems).	**Emerging Technologies:** Rapidly falling costs of **heat pumps, induction heaters, and solar-thermal hybrids** make electrification more feasible and efficient.
Competitiveness Concerns: Industries fear higher production costs during the transition, particularly for export sectors.	**Trade Advantage under CBAM:** Early adoption of low-carbon technologies can protect export access to EU markets and enhance Pakistan's competitiveness.
Institutional Silos: Lack of coordination between energy, industry, and climate ministries in planning and implementing electrification programs.	**Integrated Planning Opportunity:** Aligning **industrial electrification** with **NDCs 3.0**, the **National Climate Finance Strategy**, and the **ARE Policy 2019** ensures cohesive national implementation.

Transition Framework and Implementation Plan

Phase	Strategies	Actions
Short-Term (2025–2030)	• Electrify gas-based processes in the **Textile and Food & Beverage industries**. • Strengthen **CBAM readiness** and the **carbon governance framework**. • Establish foundational **carbon pricing and MRV systems**. • Expand access to **green finance and innovation support.** • Reform **energy market** for **renewable access and affordability**.	**Technology Transition:** • Form a CBAM Taskforce under the Ministry of Commerce & Climate Change for industry coordination. • Textile Industry: Replace the gas-based technologies with feasible and low-cost electrification alternatives including heat pumps, electric steamers etc. • Food & Beverage Industry: Replace the gas-based technologies to feasible electrification alternatives including electric ovens, electric fryers, and electric char-broiler. **Policy Needs and Market Signal:** • Enhance capacity building for industries and regulators on MRV, GHG accounting, and CBAM reporting. • Develop robust MRV and traceability systems for industrial exports. • Launch a Green Innovation Fund (GIF) connecting academia, research, and industry. • Introduce green procurement standards and low-carbon operational benchmarks for industries. **Governance & Institutional Coordination:** • Reduce industrial electricity tariffs to make electrification viable. • Mobilize technical and financial assistance for SMEs to adopt low-cost decarbonization measures. • Strengthen international cooperation for carbon markets, technology transfer, and climate finance investment for industrial decarbonisation projects as a tool. • The government should provide a detailed roadmap with specific targets for each industrial sub-sector for industrial electrification in Pakistan.

Cont.

Phase	Strategies	Actions
Medium-Term (2031–2045)	• Electrify gas-based processes in Paper and Pulp industry. • Deepen electrification through renewable integration. • Align industrial transformation with Pakistan's NDC 4.0 and net-zero pathway. • Scale innovation, circular economy, and data-driven carbon transparency. • Strengthen institutional, financial, and infrastructural capacity for decarbonization.	**Technology Transition:** • Pulp & Paper Industry: Replace the gas-based technologies with feasible electrification alternatives including heat pumps, electric boilers and electric dryers. • Integrate renewables into industrial processes for low- to medium-temperature needs. • Develop national baseline emission datasets and standardize industrial carbon reporting. • Establish shared utilities and common infrastructure (wastewater, steam, power) to reduce emissions intensity. **Policy Needs and Market Signal:** • Expand sector-specific green financing schemes for emission-intensive industries. • Strengthen CBAM registry systems and exporter-level compliance frameworks. **Governance & Institutional Coordination:** • Foster public-private partnerships (PPPs) to scale decarbonization projects. • Promote regional carbon market collaboration and green hydrogen cooperation in South Asia. • Continue grid modernization and enhance renewable power flexibility. • Support R&D commercialization of local clean technologies through GIF and innovation grants. • Maintain policy coherence between energy, trade, and climate strategies.

Cont.

Phase	Strategies	Actions
Long-Term (2046–2050)	• Achieve full **industrial electrification** and **deep decarbonization**. • Transition hard-to-abate sectors **to hydrogen and electrification alternatives and CCUS-based systems**. • Enforce national and global **net-zero compliance standards**. • Institutionalize **low-carbon industry certification** and **international competitiveness**.	**Technology Transition:** • Chemical & Fertilizer Industry: Replace the gas-based technologies with feasible electrification alternatives including electric reformers and electric boilers. Adopt Green H_2 electrolysis to replace natural gas as feedstock. • Steel and cement Industry: Replace the gas-based technologies with feasible electrification alternatives including H_2DRI and electric kilns, respectively. • Electrify hard-to-abate sectors (cement, steel, fertilizer) through hydrogen integration and CCUS deployment. • Transition industrial operations to zero-emission technologies eliminating Scope 1, 2 & 3 emissions. **Policy Needs and Market Signal:** • Establish national low-carbon certification systems for verified products. • Expand shared hydrogen and renewable infrastructure (green hubs, CCUS clusters). • Mandate green procurement and trade standards for domestic and export industries. • Advance circular economy systems (waste recovery, heat reuse, material recycling). **Governance & Institutional Coordination:** • Align all industrial policies with Pakistan's net-zero and climate resilience frameworks. • Encourage private sector leadership and PPPs in innovation and climate finance. • Replicate global best practices (HYBRIT, Japan's hydrogen model, Germany's pilots) to enhance competitiveness. • Ensure just transition by protecting industrial employment and supporting SME adaptation.

Key Findings

By electrifying industrial heat, Pakistan could cut industrial emissions by up to 50 percent by 2050 compared to the current trajectory, while delivering energy savings of around 36 percent. This would help close the widening gas supply gap, reduce reliance on costly imported liquid natural gas and ease circular debt by replacing inefficient gas use with more cost-effective electric heat. To maximise benefits, electrification should align with growing renewable capacity – especially on-site solar – and improve utilisation of existing generation assets.

Industrial process heat electrification is economically viable for low- and medium-temperature applications, particularly in food and beverages, textiles, paper and pulp, and fertilisers. These sectors account for about half of industrial GDP and play a major role in Pakistan's energy use. Electrification can cut operating costs, improve energy reliability and reduce exposure to volatile gas supply and pricing. As the grid integrates more renewables, especially solar PV, flexible industrial demand can also absorb surplus generation, easing grid congestion.

Key Findings

3 **Boosting electric heat in industry requires supportive electricity tariffs, financing incentives for appliances and regulatory reforms to modernise power grids.** Industrial electrification must go hand in hand with solar integration, coordinated investment in both technologies and grid upgrades to ensure widespread uptake. Stable policy signals and clear regulations can de-risk projects, mobilising joint investment in grids, renewables and industry electrification.

4 **A phased national strategy sequenced by technoeconomic readiness can position industrial electrification at the core of Pakistan's energy transition and industrial modernisation.** This could begin with textiles and food processing this decade, expand to paper and pulp in the medium term and reach energy-intensive sectors like chemicals, fertilisers and steel by 2050. Coupled with coordinated industrial and energy planning, this approach can boost competitiveness and resilience, safeguarding Pakistan's export access in carbon-regulated markets.

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Thank you for your attention!

Do you have any questions or comments?

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