PRIED
Policy Research Institute
for Equitable Development

Building a Sustainable Future

Transitioning to All-Electric Homes

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Abbreviations and Acronyms

LNG	Liquified Natural Gas
RLNG	Regasified Liquefied Natural Gas
UFG	Unaccounted-for Gas
TOE	Tons of Oil Equivalent
CO2	Carbon Dioxide
RETScreen	Renewable Energy and Energy Efficiency Technology Screen
MMBTU	Million British Thermal Units
MMCDF	Million Cubic Feet per Day
kW	Kilowatt (electrical power)
AC	Air Conditioner
GHG	Greenhouse Gas
kWh	Kilowatt-hour (electrical energy)
LED	Light Emitting Diode
CFL	Compact Fluorescent Lamp
HP	Heat Pump
TES	Thermal Energy Storage
FY	Fiscal Year
COP	Coefficient of Performance
CAPEX	Capital Expenditure

Executive Summary

Pakistan's gas sector is currently facing a critical supply and demand imbalance, driven by a heavy reliance on depleting indigenous gas reserves, compounded by rising costs of LNG imports and an unsustainable circular debt burden. This situation has created significant challenges for the energy sector, increasing the urgency for alternative solutions to meet residential energy demand. In light of these issues, the transition from natural gas to electric alternatives in household applications presents a viable pathway to reduce energy imports, mitigate the financial strain on the sector, and promote environmental sustainability. This report provides an in-depth analysis of the economic and environmental benefits of transitioning household appliances for space heating, water heating, and cooking from gas to electricity, presenting a compelling case for an electric-centric approach that supports Pakistan's long-term energy security and climate goals.

The report's findings highlight that such a transition, if executed through well-structured policy support, could not only alleviate current pressures on Pakistan's gas supply but also lay the foundation for a resilient and sustainable energy system. Transitioning to electric appliances offers substantial savings and emissions reductions across household types. Low-consumption households can save around $1,789 annually, cutting CO2 emissions by 5.7 tons. Medium-consumption households could see $3,203 in savings with a 34.8% reduction in emissions (10.1 tons CO2), while high-consumption households stand to save $4,403 annually, reducing emissions by 40.8% (13.9 tons CO2). These findings demonstrate meaningful financial and environmental gains for households of all sizes.

Our analysis with RET Screen software reveals that efficient electric appliances, particularly eat pumps, offer maximum savings, reducing annual costs by $3,219 and cutting energy consumption by 21,572 kWh for medium-consumption households. For low- and medium-demand households, instant electric geysers provide an affordable option with annual savings of $3,203 at high efficiency. This highlights that electric solutions can be economically beneficial across varied demand levels, with high-demand households gaining the most.

High upfront costs for appliances like heat pumps (around $1,000–$2,000) limit accessibility. Financial incentives such as targeted subsidies, zero-interest loans, and tax rebates for efficient technologies (e.g., electric geysers and solar heaters) can bridge this gap, especially for high-demand households. Additionally, fostering local production of efficient appliances could reduce import reliance and improve affordability.

A coordinated policy approach is essential. Tiered subsidies will help all household levels transition to electric options, while public awareness and technician training can ensure proper use and maintenance. Highlighting the environmental impact—up to 40.8% emissions reduction for high-consumption households—will drive public support for this shift. A prompt transition will address immediate gas sector pressures, contributing to Pakistan's long-term energy security, economic resilience, and climate targets.

Chapter 1

Introduction

Background: Gas sector crisis

Pakistan's natural gas sector has historically played a pivotal role in meeting the country's energy needs across diverse sectors, including households, industries, and power generation. However, the country's reliance on natural gas has become increasingly unsustainable. The demand for gas continues to rise, while indigenous gas reserves are depleting. As a result, Pakistan has had to turn to costly imports of Liquefied Natural Gas (LNG), which are subject to global supply chain issues and price volatility. Since 2015, the country has seen a dramatic increase in LNG imports. With LNG imports meeting only partial demand, the country continues to face chronic shortfall. Load-shedding of gas in the winter season—when demand peaks—has become a permanent feature since past few years.

Pakistan also faces Unaccounted-for Gas (UFG) losses, which, despite some improvement in 2022-23, remain a significant challenge. These losses contribute to the growing circular debt in the gas sector. Given the increasing complexity and cost of maintaining gas distribution infrastructure for residential and commercial consumers, it is becoming clear that alternative solutions must be pursued.

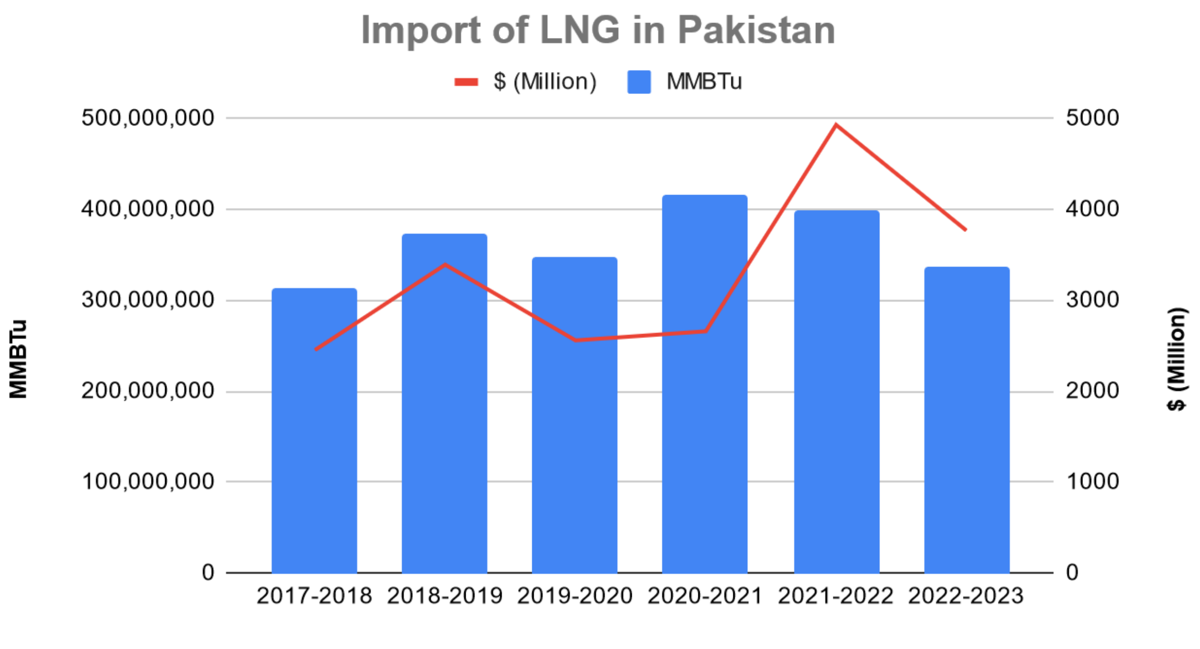


Figure 1: Liquified Natural Gas (LNG) Imports in Pakistan (Source: Energy Yearbook 2022-23 & Annual Reports)

Pakistan is the 21st largest user of gas in the world. Contributing to nearly 44% of the country's primary energy supplies, it plays a major role in several sectors. The domestic sector remains one of the largest consumers of natural gas in Pakistan. According to the 2022-23 Energy Yearbook, domestic gas consumption was 7,323,334 TOE (Tons of Oil Equivalent), further exacerbating the strain on gas imports. Over the past two years, the government has allocated substantial subsidies to mitigate the costs associated with RLNG diversion, totaling Rs 69 billion. As per State Bank's report subsidy amount to domestic gas consumers in FY 2022-2023 is 27 billion.

Seasonal Gas Consumption

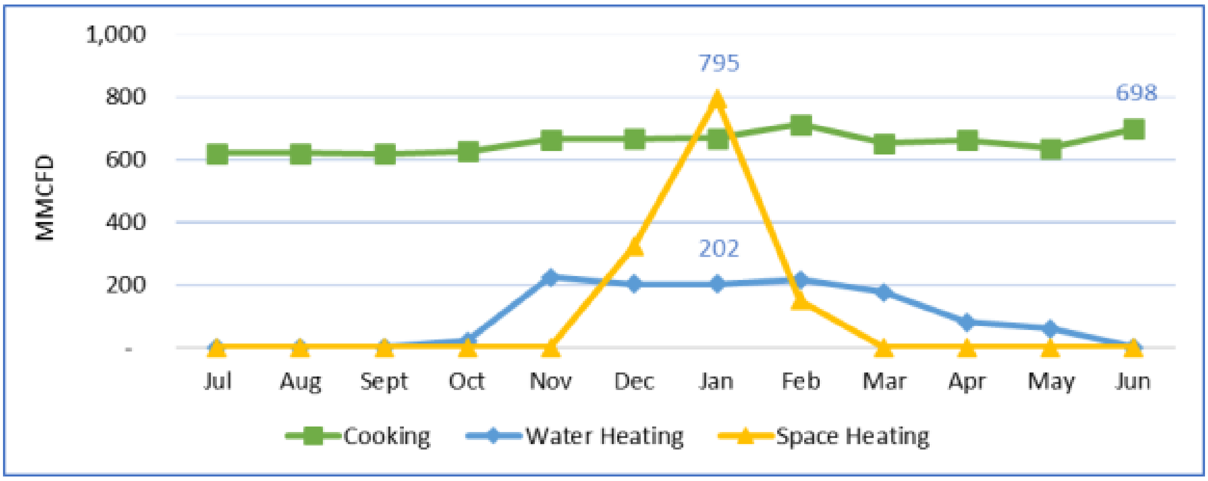


Figure 2: Seasonal gas consumption (Source: Pakistan Integrated Energy Planning for Sustainable Development)

While the subsidies insulate end-users from unfairly price volatility in global market, it has created significant financial sustainability challenges for the government. Adding to the problem of a low gas supply, a large share of gas is lost during delivery. The subsidy burden and the UFG losses together threaten the financial stability in gas sector. Uneven statistics show that financial arrears in gas sector—also denoted by Circular Debt—crossed Rs 2000 billion as of Jan 2024.

Energy Prices and Debt Trend

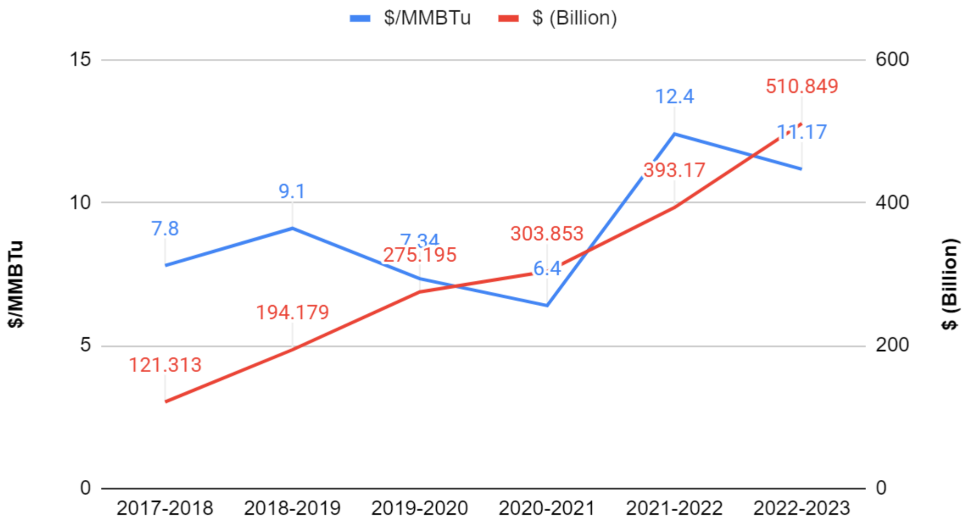


Figure 3: Energy Prices and Debt Trends (Source: Energy yearbook 2022-23 & Annual Reports)

In response to declining gas reserves, the government has recently announced plans to raise gas prices to encourage a shift from gas-based to electricity-based space heating during the winter season. A committee, headed by the petroleum minister, has been established to explore this transition and is expected to present its findings to the Prime Minister by September 2024.[1] The primary objectives are to reduce gas consumption

1 *https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/lng/021624-pakistan-raises-domestic-natural-gas-prices-for-second-time-in-four-months*

for heating, reallocate gas supplies to power generation, lower electricity tariffs, and address the surge in high-capacity payments within the power sector. The adjustments are part of broader gas market reforms, which will gradually end cross-subsidies for certain sectors and shift captive power reliance to the electricity grid. These steps are expected to ease circular debt and improve the financial viability of Pakistan's gas utilities.

Electrification an effective solution to avoid supply shortfall

Till a decade back, Pakistan had sizeable reserves of Gas. Reliance on it therefore enjoyed broader policy support by the government. However presently the gas shortfall is projected to increase substantially in the years ahead, stoking demand for further imports.

Amid the crisis, Pakistan has signed several pipeline trade agreements to secure its gas supply. This includes: Turkmenistan-Afghanistan-Pakistan-India (TAPI) Gas Pipeline; the Iran-Pakistan (I-P) Gas Pipeline; and the Pakistan Stream Gas Pipeline—most recently signed with Russia. All these projects have been facing delays due to geo-political conditions in the region. The latter one—which was signed only recently—is also shrouded in uncertainty due to the greater sanctions now imposed on Russia.

In addition to piped gas import strategy, Pakistan also started importing LNG in sizable quantities since 2015. Pakistan has been importing LNG from Qatar under a government-to-government 15-year agreement; as well as four other agreements with private suppliers in Italy on take-or-pay basis. To cater to demand in excess of the term contracts, LNG is also being sourced from spot markets.

The government is also stepping up initiatives to develop LNG import facilities. A new entrant in LNG market—the basic LNG import terminal capacity and infrastructure is still evolving. Presently only two LNG terminals are operational, which are inadequate to process massive domestic gas demand. The government is looking up to build a third terminal soon, to help meet soaring demand.

Overall, the government has primarily focused on gas imports to address the energy demand, yet this strategy risks deepening import dependence and exposing Pakistan to further price hikes. Compounding this issue, domestic gas exploration and production have declined, and the LNG operational and regulatory framework remains weak. These factors contribute to nationwide shortages and increase supply costs, emphasizing the need for a diversified energy strategy to secure long-term stability and affordability.

There is a compelling opportunity for Pakistan to shift from gas to electric appliances in the residential sector. This transition could reduce both the economic and environmental costs associated with fossil fuel reliance, while simultaneously fostering a more resilient energy framework. A 2023 World Bank study indicates that shifting gas consumption to electricity could yield efficiency gains exceeding Rs 250 billion annually. [2] The residential sector—second largest consumer of gas—could be an important sector to play a strong role in reducing reliance on gas. Switching from fossil gas to electricity offers a broad range of benefits for consumer energy bills and emissions that make it a highly attractive option for mitigating gas supply shortfalls. The residential sector is overall well-placed for accelerated transition to heat pumps and electric stoves. This could bring several benefits, and so immediate and concerted action is needed for faster electrification of current gas consumption. Overall, this needs timely tailored roadmap to reconfigure the traditional gas appliances and switching to renewable-based technologies for heating and cooking space is imperative

So far, few initiatives have been taken in this direction. For instance, National Energy Efficiency and Conservation Authority projects that transitioning to inverter air conditioners could result in 10-12% savings on winter utility bills and 20-25% savings in summer. [3] Specifically, the shift from gas heaters to inverter ACs could conserve approximately 46 million cubic feet of gas daily in winter. This project component aims to gradually transition heating needs from gas to electricity, particularly in targeted sectors. Based on current analyses, the project

2 https://www.dawn.com/news/1746875

3 https://www.dawn.com/news/1746875

will introduce a trade-in program for households and businesses to voluntarily replace inefficient gas-powered geysers, boilers, and space heaters with electric alternatives, primarily using heat pump technology. Additionally, the initiative will focus on upgrading inefficient heating technologies and processes, particularly in industrial sectors, by promoting a shift from gas to electricity. This will be supported by a revolving loan fund providing credit lines to households and businesses for these upgrades.

Delay risk worsening the current crisis

Natural gas remains a dominant feature of Pakistan's residential buildings. Gas is used as a primary cooking fuel in household sector of Pakistan. It is also widely used for heating. Whereas from an energy efficiency perspective, the country has some of the worst performing existing buildings, while presently new-build housing has no effective plans to change.

The ongoing gas crisis and dwindling indigenous reserves signifies the need for timely tailored roadmap to reconfigure the traditional gas appliances and switching to renewable-based technologies for heating and cooking space. To achieve this, policy makers should devise strategies responding to the circumstances of their populations, which vary markedly across socio-economic groups. The traditional gas-based cooking stoves should be swapped with electric stoves. Most users could afford to purchase electric stoves as it has a very low upfront cost. Further, renewable heating solutions such as solar heating pumps, and solar geysers could replace the conventional piped-gas geysers and heaters. It is only essential to put measures in place which can drive the transition toward these emerging solutions. A delay in implementing these changes risks exacerbating the existing energy crisis, deepening Pakistan's dependence on costly imports, and increasing exposure to volatile global markets. Without swift action, the country could face cost lock-ins and the stranding of gas-based assets, leading to financial losses and limited flexibility for energy reforms.

This report underscores the critical need for a timely transition from gas-based to electric solutions in Pakistan's residential sector. Chapter 2 of this report explores electric alternatives for residential needs, assessing the feasibility of solutions for heating, cooking, and water heating. Chapter 3 provides a cost-benefit analysis of different technologies carried out for a single household, detailing potential savings, emissions reductions, and economic impacts of electrification. Finally, Chapter 4 outlines policy recommendations, including incentives and regulatory actions, to support this transition and strengthen Pakistan's energy resilience. Overall the study highlights the urgency to switch to residential electrification and alternative ways of cooking, and space and water heating in the residential sector.

Chapter 2

Electric alternatives for residential energy needs

As Pakistan faces an urgent need to address its energy crisis, transitioning to electric appliances offer a path toward greater security and reliability. Electric technologies present a range of advantages, from reducing greenhouse gas emissions to increasing energy efficiency and decreasing energy costs for consumers. In this chapter, we zoom into alternative technologies which can feasibly replace traditional gas-based options. By gathering market insights, we examine each appliance's availability, cost, efficiency, and suitability for three primary use cases—space heating, water heating, and cooking. This analysis provides a comprehensive overview of the practical electric options that can address Pakistan's energy demands and support the transition toward sustainable energy consumption.

A- Space heating alternatives

Heat pumps

Heat pumps—specifically air-source and ground-source (geothermal)—stand out as efficient electric heating options for households. There are generally two types of heat pumps: (a) Air-Source Heat Pumps: These systems extract heat from outdoor air, suitable for Pakistan's moderate climates, and can reach up to 350% efficiency[4]. This means they deliver 3.5 times the energy output compared to the electricity consumed, significantly reducing heating costs; (b) Ground-Source Heat Pumps: Utilizing stable underground temperatures, ground-source heat pumps can reach up to 450% efficiency, delivering 4.5 times the energy used. Although these systems have higher upfront costs and complex installation needs, they are exceptionally efficient and well-suited for larger properties and new constructions[5].Although currently uncommon in Pakistan, heat pumps hold significant promise, especially with awareness initiatives and financial incentives to offset high upfront costs.

4 *https://www.greenmatch.co.uk/heat-pumps/efficiency*

5 *https://www.greenmatch.co.uk/heat-pumps/efficiency*

Table 1: Heat Pump Efficiency and Cost Comparison

	Technology/appliance	Price/Upfront Cost	Efficiency
Electricity	Air Source Heat Pumps (Heating Capacity: 8kW-39kW)	$600 to $38006,7	Coefficient of performance (COP) of 2 to 4. For mild climatic zones COP is above 4.5
	Ground Source Heat Pump (GSHP) (Heating capacity 8- 112KW)	$235089	COPs of 3 to 510 450% efficient11

Air conditioning inverters, a type of heat pump technology, are commonly used for space heating and cooling in Pakistan. These units feature advanced variable-speed compressors and smart sensors that optimize energy consumption and minimize heat loss, reducing energy use by up to 30% compared to traditional fixed-speed models. Prices range from Rs. 190,000 to Rs. 250,000 for a 1.5-ton unit, with power consumption between 800 and 2,500 watts. While inverter ACs and heat pumps operate on the same principle, inverter ACs primarily focus on space heating and space cooling. In contrast, modern heat pumps can provide both space heating/cooling and water heating, offering a more versatile solution for home energy needs.

Table 2: Inverters Upfront Cost & Efficiency

	Technology/appliance	Price/Upfront Cost	Efficiency
Electricity	Inverters Air conditioning units	Rs. 150000 to Rs. 300000[12]	COP above 4[13]

6 https://www.alibaba.com/product-detail/JIADELE-ROHS-CE-certification-Air-source_1600095067812.html?spm=a2700.galleryofferlist.wending_right.8.6de313a0Pmd9j6

7 https://www.theheatpumpwarehouse.co.uk/shop/heat-pumps/air-source-heat-pumps/riello-4kw-monobloc-air-source-heat-pump-nxhm-004/

8 https://www.alibaba.com/product-detail/geothermal-water-source-heat-pump-system_1600079922868.html?spm=a2700.7735675.0.0.6ddbhnz7hnz7Yn

9 https://www.alibaba.com/product-detail/Europe-10kw-13kw-16kw-20kw-25kw_1601007637128.html?spm=a2700.7735675.0.0.6ddbhnz7hnz7Yn&s=p

10 https://c03.apogee.net/mvc/home/hes/land/el?utilityname=novec&spc=hel&id=2312

11 https://www.greenmatch.co.uk/heat-pumps/efficiency

12 https://japanelectronics.com.pk/collections/air-conditioners

13 https://www.tcl.com/global/en/air-conditioners/freshin-2-0

Electric heaters

Another affordable option for space heating is electric heaters. These come in various forms, such as convection heaters, radiant heaters, and oil-filled radiators. Some of the widely available and used electric heaters are as follows

- **Infrared Heaters:** Infrared heaters are widely available across Pakistan, especially in urban markets. Known for their quick heat delivery, they are ideal for small spaces or targeted heating.
- **Fan-Forced Heaters:** Fan-forced heaters are also commonly found and affordable in Pakistan. These heaters use an electric coil and fan to distribute warm air quickly, making them effective for heating rooms in a short period.
- **Quartz Heaters:** Quartz heaters are affordable and easily accessible in both rural and urban areas. They are compact, lightweight, and suitable for small rooms or individual use.

Electric heaters are widely available in Pakistan and come with a low upfront cost, making them accessible to many households; however, the high electricity tariffs make them less viable for continuous use, leading to reluctance in their widespread adoption.

Table 3: Electric Heaters Efficiency & Cost Comparison

Technology/appliance		Price/Upfront Cost	Efficiency
Electricity	Infrared heaters (600W)	Rs. 3400	Provides up to 60% efficiency[14][15]
	Convection Heater (2000 W)	Rs.37,905.00[16]	Above 90%[17]
	Electric Ceramic Room space heater (700 W to 2000 W)	Rs. 2000 to Rs. 10000[18]	Above 90%[19]

14 *https://www.infralia.com/en/how-efficient-is-infrared-heating/*

15 *https://sbestore.com/product/electric-heater-infrared-heater-600w/?srsltid=AfmBOopCREPt75h2y00jE2CH_8tn2oN3olL0E8zYd6JGgzLTGPzrQc2*

16 *https://alfatah.pk/products/delonghi-convection-heater-3120fs?srsltid=AfmBOopcVVKL3EsETeZFz09iV9yiGykCm-LeenrWGFjUo8n3llu42FCv*

17 *https://www.theheatpumpwarehouse.co.uk/product-tag/4kw/*

18 *https://www.daraz.pk/catalog/?q=Electric%20heaters*

19 *https://www.theheatpumpwarehouse.co.uk/product-tag/4kw/*

Types of Electric Heaters

Figure 4: Electric heaters 1) Bar fire, 2) Convector heater, 3) oil-filled radiator, 4) Radiant fan heater, 5) Radiant halogen heater (Source: cse.org.uk)B-Water heating alternatives

Water heating is a crucial energy need in Pakistani households, particularly during colder months, when demand rises significantly for showers, cooking, and cleaning. Traditionally, gas geysers have been the primary choice, favored for their affordability and familiarity among consumers.

Priced at approximately Rs. 40,000 (average price) with an efficiency of around 30%, gas geysers provide a straightforward but limited solution for households[20] [21]. However, with the country facing gas shortages and price hikes, the reliability of gas-based water heating is increasingly uncertain, prompting a growing interest in electric alternatives that can offer more stable and potentially efficient options.

Heat pumps

Heat pumps offer a highly efficient electric alternative to traditional gas and electric geysers for water heating, significantly reducing energy consumption. Unlike electric geysers, which convert electricity directly into heat, heat pumps use electricity to transfer heat from the surrounding air or ground into the water, achieving efficiencies of up to 400%. This means they can provide four times the heating energy compared to the electricity consumed, making them a cost-effective option in the long run. Dual-application heat pumps, capable of both water heating and space heating, including air-source and geothermal options, are available on the market but have a high CAPEX component.

Table 4 – Heat Pumps (Dual application) Efficiency & Cost

Technology/appliance		Price/Upfront Cost	Efficiency
Electricity	Air-Sourced (4kw dual)	$1800-$3800	COP 4.5, 450% efficient

20 https://www.aysonline.pk/home-appliances/geyser/gas-geysers/

21 https://file.pide.org.pk/uploads/kb-083-gas-crisis-in-pakistan.pdf?_gl=1*lu8i7k*_ga*ODQ1OTIwNTIxLjE2NzQxOTYzMDc.*_ga_T5TLWHEVW9*MTcyNjEyODgxMC4yMi4wLjE3MjYxMjg4MTAuNjAuMC4yMDM1MTIwODEw

Electric geysers

These are standard electrical appliances for water heating. Available in instant and storage varieties, electric geysers are convenient and affordable but can be energy-intensive, especially in areas with limited electricity supply. **Electric geysers** are widely available in urban markets, ranging from 10-liter to 50-liter capacities. Instant water heaters are common for smaller households, while storage models cater to larger families.

Table 5: Conventional Electric Geysers & Instant Geysers Upfront Cost & Efficiency

	Technology/Appliance	Upfront Cost	Efficiency
Electricity	Conventional Electric Geysers: Traditional storage-type geysers with insulation (1000W to 2000W)	Rs. 20000 to Rs. 50000[22]	70 to 95%[23]
	Instant Electric Geysers	Rs 2000 to Rs 30000[24]	86%[25]

Solar water heaters

These use solar energy to heat water, with backup systems like electric or gas elements to ensure continuous hot water supply even in less sunny conditions. Solar water heaters are particularly effective in regions with consistent sunlight, such as Baluchistan and Sindh. In Pakistan, solar water heaters are available but less widespread, with installations more common in new housing zones. Their higher upfront costs as well as the need for professional installation are barriers to widespread adoption.

Table 6: Solar Water Heater Upfront Cost & Efficiency

Source	Technology/Appliance	Upfront Cost	Efficiency
Solar	Solar Water Heater (150 to 300 L)	Rs. 100k to Rs. 200k[26]	93 to 96%[27]

22 *https://www.daraz.pk/catalog/?q=electric%20geysers*

23 *https://www.e-education.psu.edu/egee102/node/2009*

24 *https://www.daraz.pk/catalog/?q=electric%20geysers*

25 *https://www.energy.wsu.edu/documents/aht_efficient%20water%20heating.pdf*

26 *https://alphasolar.com.pk/best-guide-on-solar-water-heater-in-2023/*

27 *https://www.poweredbydaylight.com/blog/what-is-the-most-efficient-solar-hot-water-system/*

C-Cooking alternatives

In Pakistan, cooking predominantly relies on gas stoves, especially in urban areas where gas infrastructure is well established. However, gas stoves are relatively inefficient, with energy efficiencies ranging between 30% and 47%, meaning a significant portion of energy is wasted[28]. As gas shortages and rising costs increasingly impact households, electric cooking alternatives are emerging as viable options. These alternatives, including electric stoves and induction cooktops, not only offer safer and cleaner cooking solutions but also improve energy efficiency, making them an appealing choice for households looking to reduce costs and reliance on gas.

Electric stoves

Electric stoves are widely available in the market, with coil, ceramic, and glass-top variants that offer safer and easy-to-maintain cooking options. These stoves operate similarly to traditional gas stoves but use electricity to heat the cooking surface. Although they tend to heat up and cool down more slowly, they provide an even distribution of heat, which can improve cooking results. While reliable, electric stoves may require some adjustments in cooking style compared to gas stoves. Their electricity consumption can vary based on factors like stove type, size, and usage. To better understand this, it's helpful to examine the common types of electric stoves and their respective power usage.

- **Coil Burner Stoves:** Coil burner stoves are traditional electric stoves with exposed heating elements. They tend to be less energy-efficient, taking longer to heat up and cool down. On average, a coil burner stove in Pakistan can consume approximately 1,500 to 2,000 watts per hour when used at high heat. These cooktops offer an efficiency of about 40%, making electric options like coil burners a viable but less efficient alternative for households transitioning to electricity.
- **Smooth-Top Stoves:** Smooth-top electric stoves have a glass-ceramic surface with hidden heating elements beneath. They are more energy-efficient than coil burners, consuming around 1,200 to 1,800 watts per hour at high heat settings. Electric-coil and standard smooth-top electric cooktops offer around 74 percent efficiency making them a more energy-efficient choice for households looking to optimize electricity usage compared to traditional coil burner models.
- **Induction Cooktops**: Induction cooktops are the most energy-efficient option. They use electromagnetic fields to heat the cookware, directly resulting in minimal heat loss. An induction cooktop in Pakistan typically consumes 800 to 1,300 watts per hour when operating at high temperatures. **Induction cooktops** represent the best alternative for energy-efficient and faster cooking, though their higher price and need for compatible cookware could hinder widespread adoption in the short term.

The adoption of electric cooktops in Pakistan remains relatively low, with gas stoves still being the dominant choice in most households. Several factors contribute to this low uptake. First, the initial cost of electric cooktops, particularly induction models, is higher compared to traditional gas stoves, making them less accessible for price-sensitive consumers. Additionally, widespread gas infrastructure in urban areas makes gas stoves more convenient, as many households are already connected to the gas grid. Further, there is also a general lack of awareness about the energy efficiency, safety, and environmental benefits of electric cooktops, leading to limited demand. Furthermore, Pakistan's inconsistent electricity supply and high tariffs discourage consumers from transitioning to electric options for cooking, particularly when gas is perceived as a more stable and affordable option.

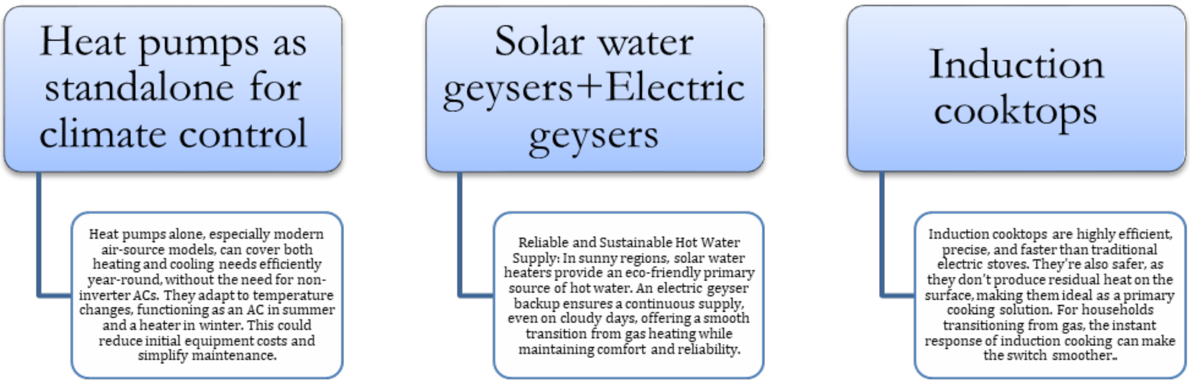
28 https://www.researchgate.net/publication/237897196_Emissions_and_efficiency_of_a_domestic_gas_stove_burning_natural_gases_with_various_compositions

Table 7: Induction Stoves Upfront Cost & Efficiency

Source	Appliance	Upfront Cost	Efficiency
Electricity	Induction stove (2000W) (2 plate stove)	Rs. 25000 to Rs.30000	84%[29]
	Conventional electric stoves with coil, ceramic (2000W)	Rs. 4000 to Rs. 500030	70%[31]

Efficient transition technologies for home heating, water heating and cooking

To enhance energy efficiency and reliability, choosing the right technology as well as combined approach using electric and renewable technologies presents an optimal path forward for Pakistani households. By choosing efficient technologies right from the start, households can maximize functionality, reduce energy costs, and lessen dependence on gas. The following technology are particularly promising for achieving these goals.



Overall, a range of electric and renewable technologies are available to meet the consumption load from residential gas needs. Traditional gas-based cooking stoves could be swapped with electric stoves. Most users could afford to purchase electric stoves as it has a very low upfront cost. Further, alternative heating solutions such as heating pumps, inverter ACs, and solar geysers, electric heaters etc could replace the conventional piped-gas geysers and heaters. It is only essential to put measures in place which can drive the transition toward these emerging solutions. In conclusion, this chapter outlined the range of electric and renewable technologies available to meet the residential gas needs, focusing on space heating, water heating, cooling, and cooking. Each of these alternatives presents distinct benefits in terms of energy efficiency, cost savings, and environmental impact. By adopting these solutions, Pakistani households can significantly reduce reliance on gas, cut down energy expenses, and support national energy security. This exploration serves as a foundation for informed decision-making on transitioning to a sustainable and resilient energy future.

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29 *https://www.leafscore.com/eco-friendly-kitchen-products/which-is-more-energy-efficient-gas-electric-or-induction/*

30 *https://www.daraz.pk/catalog/?q=induction%20stoves%5C*

31 *https://home.howstuffworks.com/gas-vs-electric-stoves.htm*

Chapter 3:

Cost benefit analysis: Residential sector electrification

In this chapter, we examine the costs, efficiency, and emissions associated with shifting from gas-based to alternative technologies using cases such as space heating, water heating, and cooking. Using RET Screen—a specialized clean energy software—the analysis focuses on various single household consumption levels—low, medium, and high—assessing both the economic and environmental impacts of electric alternatives. Ultimately, this chapter demonstrates how residential electrification can contribute to cost savings and sustainability goals for Pakistan.

To conduct the analysis, we focused on three primary household categories:

Space Heating

Examining the shift from gas-based systems to more efficient electric options.

Water Heating

Comparing costs and performance when adopting electric or high-efficiency alternatives.

Cooking

Evaluating the transition from traditional gas stoves to electric or energy-efficient cooking appliances.

Additionally, we expanded our analysis to address:

1. **Consumption Patterns**: Modelling energy use across households categorized as low, medium, and high consumption, helping us assess how household size, efficiency, and lifestyle affect transition costs.
2. **Cross-Appliance Comparison**: Analysing how various electric appliances—such as electric water heaters, solar geysers, and heat pumps—perform financially and environmentally across the three categories.

Cost and fuel savings under Low, Medium and High consumption

Our analysis through RET Screen provides a detailed comparison of the cost benefits of shifting from gas-based to electricity-based appliances for typical household needs like space heating, water heating, and cooking. By examining low, medium, and high-consumption households, we illustrate how the transition to electric systems benefits a range of demand levels.

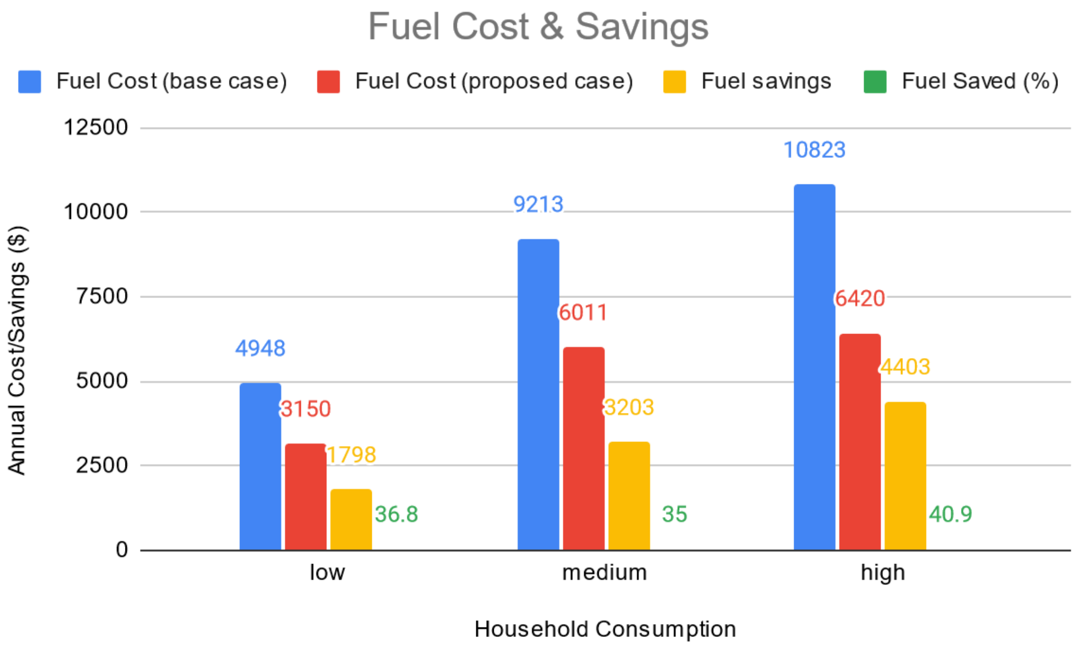


Figure 5: Cost vs Fuel Savings with Transition

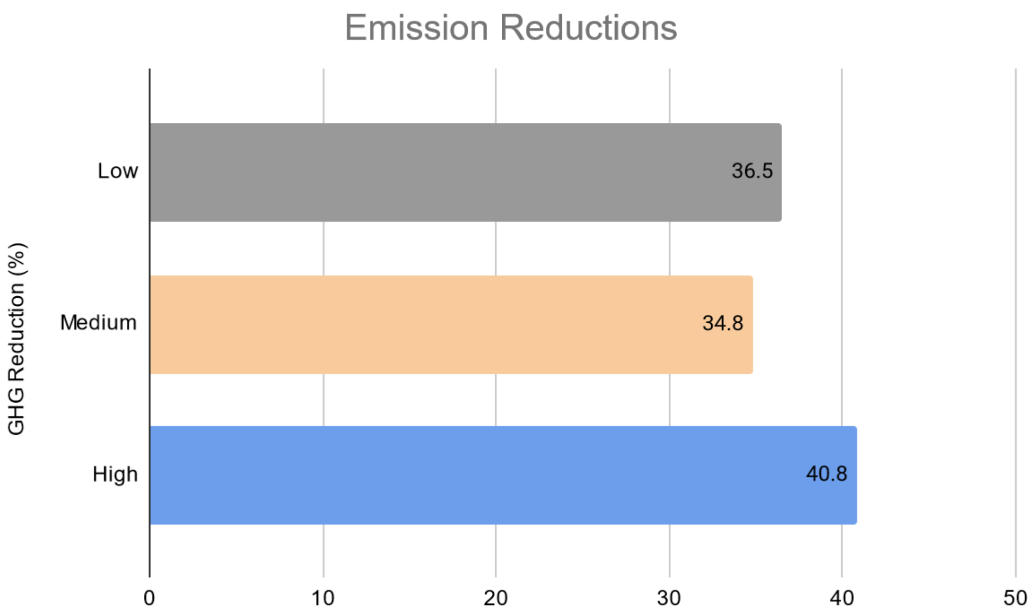


Figure 6: Emission savings with transition

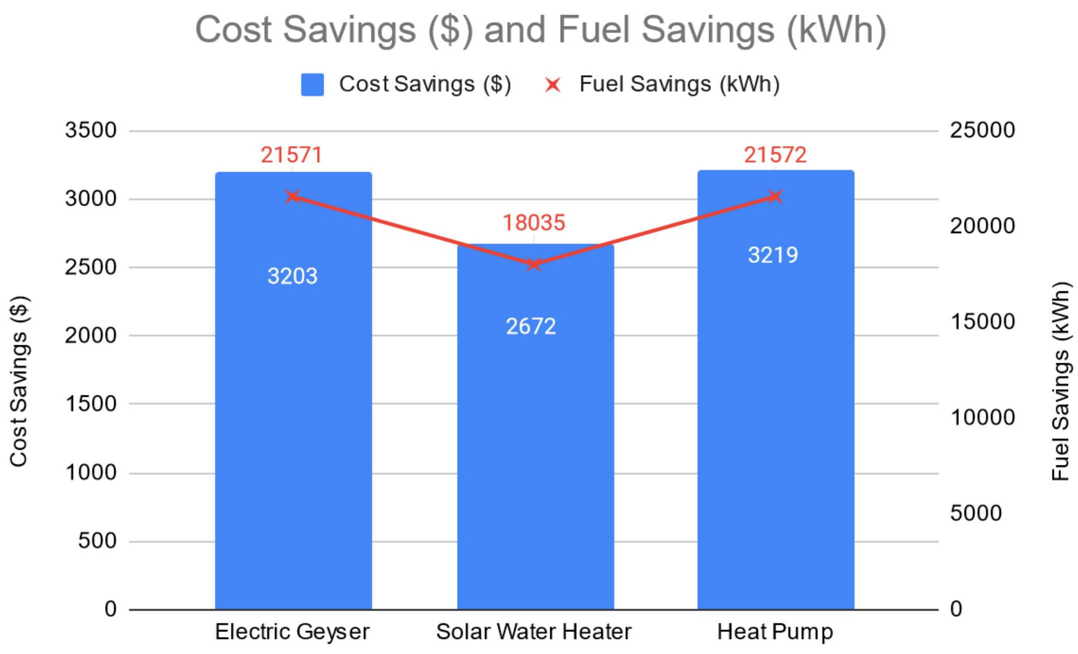
Fig 5. illustrates the benefits of transitioning from tradition gas-based technologies to alternative technologies for three household demand levels i.e low, medium, and high-consumption households. The base case here refers to the current scenario where households rely on natural gas-based appliances for space heating, water heating, and cooking. This case includes traditional technologies, such as gas heaters, gas geysers, and gas stoves, which are less efficient and often require higher maintenance. The proposed case represents a transition to more efficient, electricity-based appliances. In this scenario, households use electric geysers, and electric stoves (See Annexure A for details). The proposed case evaluates the economic and environmental benefits of shifting to these electric alternatives.

In the case of low consumption households, the transition from natural gas to electricity yields annual savings of $1,789 and a notable reduction in greenhouse gas emissions, equivalent to 5.7 tons of CO2. In the case of medium-demand households, the benefits of switching to electricity are even more pronounced. This category experiences annual savings of around $3,203, alongside a reduction in fuel consumption of 34.8%, which translates to an emission cut of approximately 10.1 tons of CO_2. High-demand households can also reap significant rewards by switching from natural gas to electricity, saving $4,403 annually while slashing greenhouse gas emissions by 40.8% - equivalent to 13.9 tons of CO2. This category illustrates the compelling case for electrification, where higher consumption levels amplify the efficiency and economic advantages of electric systems.

The environmental impact is also substantial, as high-consumption households contribute disproportionately to emissions, making their transition a critical factor in achieving national emissions targets. Fig 6. illustrates the greenhouse gas (GHG) emissions reduction achieved by households with different levels of consumption (low, medium, and high) when transitioning from gas-based appliances to electric or efficient technologies for space heating, water heating, and cooking. High-consumption households show the largest reduction, achieving a 40.8% decrease in GHG emissions. Low-consumption households follow with a 36.5% reduction, while medium-consumption households realize a 34.8% decrease. This suggests that high-consumption households have the greatest potential for emissions reduction when switching to more efficient technology, likely due to their higher baseline emissions from gas usage. However, even low-consumption households can achieve substantial reductions, highlighting the effectiveness of electric and efficient appliances across various consumption levels.

Cross appliance analysis for water heating for a medium consumption household

After thoroughly reviewing the various alternative technologies available for household in Chapter 2, we also conducted an assessment of these in the Retscreen software. We analyzed the fuel cost savings (in kWh) and cost savings (in USD) if a medium-consumption household (260 sq meter) transitions from gas-based water heater to more efficient alternatives such as electric geyser, solar water geyser or heat pumps.



	Electric Geyser	Solar Water Heater	Heat Pump
Cost Savings ($)	3203	2672	3219
Fuel Savings (kWh)	21571	18035	21572

Figure 7: Cross Appliance Analysis for medium household water heating purpose

The cross-appliance analysis, depicted in Fig 7. reveals that the air-source heat pump provides the highest annual cost savings, with $3,219 saved (approximately Rs 894,295) and 21,572 kWh in fuel savings. In comparison, electric geysers deliver close savings of $3,203 annually, while solar water heaters save around $2,672 per year. This analysis demonstrates that while heat pumps offer the most substantial savings and highest efficiency (300-400%), they come with a higher initial cost, typically between $1,000-$2,000, and are often imported in Pakistan. Electric geysers, however, present a more affordable initial investment ($100-$250) and achieve similar annual savings, making them a viable option for consumers seeking both efficiency and cost-effectiveness.

To conclude, this analysis demonstrates that transitioning from gas-based to electricity-based appliances yields substantial economic and environmental benefits across different household types. The analysis also reveals that medium- and high-consumption households, in particular, achieve significant cost savings and emissions reductions, with electric solutions like heat pumps and electric geysers offering the highest efficiency. Overall, this shift is a financially viable and environmentally impactful strategy, underscoring the importance of supporting policies and incentives to facilitate widespread adoption.

Chapter 4

Conclusion and policy recommendations

The current gas crisis is a sharp reminder of the urgency to switch to residential electrification and alternative ways of cooking, and space and water heating. The preceding analysis has demonstrated that transitioning household energy use from gas to electricity—especially for cooking, space heating, and water heating—offers substantial potential for reducing greenhouse gas emissions, decreasing reliance on imported fuels, and enhancing household energy efficiency.

Pakistan has a clear opportunity to transition to a more secure and sustained pathway. It is only essential to put measures in place which can drive the transition toward these emerging solutions. Policy plans should direct the transition to residential electrification and large expansion of the use of alternative technologies.

A Well-defined roadmap to transition from gas to electrification: As a first step, Pakistan urgently needs a well-defined roadmap and strategy for a planned transition from gas to electrification. A coherent and holistic strategy would be taking concrete steps steering the adoption of energy-efficient electric appliances and technologies and ensuring a sustainable energy future. If we look at some examples globally, many countries have now implemented comprehensive plans to gradually cut down consumption on gas, focusing on retrofitting homes with electric heating systems and promoting renewable energy sources. For instance, in Netherlands, where about 90% of homes depend on natural gas for heating—the government introduced a holistic plan which aims at phasing out natural gas in all households by 2050. Similarly in Germany where fossil fuel-powered heating systems are still the norm, the government has taken concrete steps to switch to energy-efficient retrofits. These initiatives include topping up subsidies for acceptable alternatives to traditional fossil fuel heating in homes such as heat pumps that run on renewable electricity, electrical heating or solar thermal systems, as well as banning most new oil and gas heating systems from 2024. Likewise, in France, where heat represents 45% of final energy consumption and almost two thirds of this heating is generated from fossil fuels—President Emmanuel Macron in 2023 set an ambitious goal to produce 1 million heat pumps by the end of 2027. For a comparative overview of other countries' approaches and progress in transitioning to electric appliances, please refer to Table A4 for Global Policy Landscape for Transitioning Appliances in the annexure[32]. By drawing on these international examples, Pakistan can develop a tailored strategy that not only reduces dependence on diminishing gas reserves but also promotes environmental sustainability and energy efficiency in the residential sector.

Financial incentives and low-interest loans: Offering incentives especially that lowers upfront cost of alternative technologies such as heat pumps to replace less-efficient gas appliances is imperative. With appropriate support to manage the upfront costs, can meaningfully address steer the transition. Further, additional incentives for early adopters could accelerate the transition, particularly in medium and higher-consumption households that would benefit most. A well-designed incentive program in terms of low-interest loans at flexible terms or installation grants could motivate quicker adoption of these electric alternatives.

Tailor-made incentives for Pakistan's heating and cooling needs: Recognizing that Pakistan has a high cooling demand, it is essential to prioritize appliances and systems optimized for cooling, such as air conditioning inverters and reversible heat pumps. Heat pump solutions can be adapted to the local climate needs, ensuring that investments align with the dominant cooling requirements while still offering versatility for limited heating needs.

Solar thermal systems are a feasible, cost-effective solution for water heating in areas with high solar availability. The government should incentivize the adoption of solar thermal technology through subsidies or grants,

32 *https://www.sciencedirect.com/science/article/pii/S2352152X24023818*

particularly in regions where space heating is necessary. Promoting solar thermal systems can reduce gas dependency and energy demand on the electric grid.

Enhancing import support and local production for affordable electric heating solutions: Since heat pumps are largely imported, government support for their import and distribution would reduce dependency on gas water heaters. Additionally, incentives for local manufacturing and assembly of heat pumps would improve affordability. Partnering with suppliers to ensure a stable supply of cost-effective electric geysers, with rebate programs, could make these solutions accessible to households with limited budgets. Implementing clear energy efficiency standards and labeling for electric geysers would further help consumers choose the most energy-saving models.

Encouraging startups: working in energy efficiency, renewable technologies, and carbon footprint reduction will foster innovation and market competition, especially in the appliance sector. Government-backed grants, incubation programs, and financing options for startups can accelerate the development of solutions tailored to Pakistan's unique energy and climate needs. Few startups such as GeoAircon, EzGeyser, Eimex are selling such efficient appliances in Pakistan and have seen highly optimistic response from the households. These startups can play a key role in pioneering energy-efficient and climate-friendly solutions that reduce dependence on gas appliances.

Conduct a detailed load analysis: to assess how the demand profile and peaks will shift year-on-year as gas appliances transition to electric. This analysis should evaluate the impact of increasing electricity demand and changing demand patterns, focusing on potential demand surges. Based on these insights, develop targeted mitigation strategies to manage demand shifts effectively. This approach aligns with the concern of potential challenges in balancing demand fluctuations and capacity.

Tariff reforms to encourage electric appliance use A restructured tariff system can make electricity a more cost-effective choice for residential heating and cooking. Offering lower rates during off-peak hours or creating winter-specific tariff reductions would incentivize households to use electric heating when demand on the grid is lower. Additionally, implementing a tiered tariff system with discounts for energy-efficient appliances would further encourage households to choose sustainable options while managing grid demand effectively.

Establishing a tiered subsidy programs based on consumption levels: Given that households with higher consumption have greater savings potential, a tiered approach to subsidies and financial incentives should be applied:

- **High-Consumption Households:** Prioritize higher subsidies or zero-interest loans for electric heating and water heating solutions, enabling significant energy and cost savings.
- **Low- to Medium-Consumption Households:** Provide moderate subsidies or rebates to encourage investment in cost-efficient solutions like electric geysers, which offer strong savings relative to cost, even at lower usage levels.

Awareness programs with help of third-party organizations: Presently lack of information is also holding back consumers from shifting to more energy-efficient appliances. Educating households on the environmental benefits of switching to electric appliances, such as reducing greenhouse gas emissions by 34.8% to 40.8% (equivalent to up to 13.9 tons of CO_2 annually for high-consumption households). Training and education for contractors on proper installation and for homeowners on good applications for use of heat pumps. Presently, the market is characterized by lack of trained workers especially when it comes to installing heat pumps. Effective public awareness campaigns led by third-party organizations can facilitate unbiased information sharing, social acceptance of newer technologies, and community engagement as done in the case of Europe. This approach will foster a more informed public, build social acceptance, and encourage participation in adopting sustainable energy solutions.

Building Codes and Standardization: Further, building codes for transitioning from gas to electric appliances should address a comprehensive range of considerations, from upgrading electrical infrastructure to ensuring energy efficiency and safety. Codes can encourage one fuel or another in a variety of direct or indirect ways. By setting clear standards and providing guidance on retrofitting existing buildings, these codes can facilitate a smooth and safe transition towards electrification in the residential sector. Existing building codes guidelines for sustainable architecture such as the one carried by LUMS Energy Institute and currently being implemented in government policy also lacks the guidelines on the incorporation of efficient electric appliances in households or buildings. These updated codes should incorporate efficiency and renewable integration, drawing on models like China's, and be enforced with rigorous inspections and compliance checks.

The regulatory authority must have adequate resources, technical expertise, and independence to guide, monitor, and enforce this transition effectively. A strengthened regulatory body will introduce targeted regulations, ensure compliance, and actively steer the market toward energy-efficient electric appliances, facilitating smooth implementation and corrective actions where needed.

Several governments have taken action to adjust building codes (such as in the Czech Republic), create "one-stop shops" for consumers (such as in Ireland) and encourage alternative business models to address the split incentive – notably in North America, the United Kingdom and Germany – though stronger efforts are required.

To conclude, accelerating Pakistan's residential electrification transition will require coordinated efforts across government, private sectors, and civil society. A strategic policy approach, underpinned by a well-defined roadmap and coordinated plan for planned transition can enhance energy security and efficiency, economic and environmental sustainability and build a more resilient future for its citizens. The pathway to a cleaner, cost-effective energy landscape not only aligns with national priorities but will also provide lasting socio-economic benefits.

ANNEXURE

This section details the RETScreen input variables used to simulate the economic and technical impact of transitioning household appliances from gas-based to electric alternatives. Each table organizes data by appliance type, with financial and technical parameters clearly outlined for reference.

Table A1: Basic Household Appliances

This table lists the household appliances considered in the analysis, which encompass basic energy-consuming equipment commonly used across Pakistani households. These items represent the baseline electrical load and are critical for estimating the overall energy demand and potential savings.

Appliance Category	Items Included
Lighting	Indoor and outdoor lighting sources (e.g., LED, CFL, incandescent bulbs)
Electrical Equipment	Refrigerator, Freezer, Ceiling Fans, Washing Machine, Iron, Oven, TV, Water Pump, Vacuum Cleaner
Cooling	Air Conditioning (AC)

Table A2: Financial Parameters

The following financial assumptions were used to assess the economic feasibility of transitioning from gas to electric household appliances. These parameters are critical for evaluating the long-term cost savings and financial impact of the transition.

Financial Parameter	Value
Discount Rate	0%
Inflation Rate	20%
Fuel Escalation Rate	40%

Note: The high inflation and fuel escalation rates are reflective of current economic conditions and are essential for accurate cost-benefit analysis.

Table A3: Technical Parameters for Water Heating, Space Heating, and Cooking

This table presents the technical specifications for water heating, space heating, and cooking appliances in both the base (gas) and proposed (electric) cases. These parameters include the appliance source, capacity, fuel rate, and efficiency, which influence energy consumption and cost comparisons.

Appliance	Source	Capacity	Fuel Rate ($/kWh)	Efficiency (%)
Water Heating	Natural Gas (Base Case)	1.65 kW	0.056	30%
	Electric Geyser (Proposed)	2 kW	0.15	86%
Space Heating	Natural Gas (Base Case)	8.8 kW	0.056	60%
	Electric Heater (Proposed)	2.5 kW	0.15	100%
Cooking	Gas Stove (Base Case)	3 kW	0.056	40%
	Electric Stove (Proposed)	2.5 kW	0.15	80%

Note: The proposed electric alternatives feature higher efficiencies compared to their gas counterparts, which supports reduced energy usage and potential cost savings.

Table A4: Global Policy Landscape for Transitioning Appliances

Examining successful policies from Germany, Japan, the Netherlands, and South Korea highlights practical approaches that could scale up Pakistan's transition efforts. The table below summarizes the incentives, and regulatory frameworks driving the transition to a more sustainable heating and cooling sector, alongside notable projects promoting heat pump technology in these countries.

Country	Policy/Program	Description
China	Renewable Energy Law	Encourages development/utilization of renewable energy
	Golden Sun Demonstration Project	Financial incentives for solar PV installations, including solar-powered HPs
	National Solar Water Heater Subsidy Program	Financial incentives for solar water heater installations, including HPs
	Special Fund for Energy Saving Technology Reform	Supports energy-saving technology reform, including HP development
	Demonstration and Promotion of Energy-Saving Technologies	Promotes energy-saving technologies, including high-efficiency HPs

Germany	German Renewable Energy Act	Supports renewable energy development, establishes feed-in tariffs
	Market Rebate Program	Financial incentives for energy-efficient heating/ cooling systems, including HPs
	Energy Efficiency Strategy 2050	Promotes energy efficiency, includes measures for HP adoption
	National Action Plan on Energy Efficiency	Sets targets for energy efficiency improvement, includes HP promotion
	Building Energy Act	Sets energy efficiency standards for buildings, requires HP installation
	Heating Networks 4.0 Program	Supports innovative heating networks using renewable energy, including HPs
USA	Federal Tax Credit	30% tax credit for residential geothermal HP installation
	Weatherization Assistance Program	Funds energy efficiency improvements, including HP installation
	State Energy Program	Funds energy efficiency and renewable energy projects, including HP installation
Japan	Top Runner Program	Subsidies for energy-efficient products, including HPs
	Feed-In Tariff Program	Financial incentives for renewable energy installations, including HPs
	Home Energy Management System	Subsidies for HEMS, including HP and TES systems
	Next-Generation Energy System Demonstration	Subsidies for innovative energy systems, including HPs
	Eco-Point Program	Provided points redeemable for energy-efficient products, including HPs
	TES Technology Project	Rock-based TES project by Toshiba and Marubeni

UK	Renewable Heat Incentive	Financial incentives for renewable heating technologies, including HPs and TES
	Green Homes Grant	Vouchers for energy-saving home upgrades, including HPs and TES
	Energy Company Obligation	Requires energy suppliers to deliver energy efficiency measures, including HPs
	Low Carbon Heat Support Scheme	Grants for low-carbon heating systems, including HPs and TES
Italy	Conto Termico	Financial incentives for renewable energy systems, including HPs and TES
	Ecobonus	Tax credits for energy-efficient home renovations, including HPs and TES
	Sismabonus	Tax credits for seismic renovations, including HPs and TES
	Fondo Kyoto	Financial incentives for renewable energy systems, including HPs and TES
Canada	Smart Renewables and Electrification Pathways Program	Funding for smart renewable energy systems, including HPs and TES
	Manitoba Hydro Geothermal Program	Incentives for geothermal HP installations
	ecoENERGY for Renewable Heat Program	Grants for renewable heating, cooling, and water heating
	CIB Growth Plan	Focuses on building retrofits and storage techniques for green infrastructure

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