الصندوق الائتماني متعدد المانحين للنمو في الأردن
JORDAN GROWTH MULTI DONOR TRUST FUND

وحدة دعم تنفيذ الإصلاحات الاقتصادية
REFORM SECRETARIAT

GOVERNMENT OF JORDAN

THE WORLD BANK

Strategic Options for City Gas Distribution Networks in Jordan

By Quality Energy Developments Consulting Limited METAS Energy Limited

UKaid

Norwegian Embassy
Amman

Kingdom of the Netherlands

In partnership with Canada

التعاون الألماني

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وزارة الطاقة والثروة المعدنية

DEFINITIONS

AFOLU	Agriculture, Forestry, and Other Land Use
BAU	Business As Usual
BBL	Billion Barrels
BCM	Billion Cubic Meters
BOO	Build Own Operate
BOOT	Build Own Operate Transfer
BOT	Build Operate Transfer
CAPEX	Capital Expenditure
CCS	Carbon Capture and Storage
CNG	Compressed Natural Gas
CO2	Carbon Dioxide
CRN	Customer Reference Number
CSP	Concentrated Solar Power
DCF	Discounted Cash Flow
DSO	Distribution System Operators
EBRD	European Bank for Reconstruction and Development
ECA	Export Credit Agencies
EGAS	Egyptian Natural Gas Holding Company
ESIA	Environmental Social and Impact Assessment
EIB	European Investment Bank
EMRC	The Energy and Minerals Regulatory Commission
FSU	Floating Storage Unit
FSRU	Floating Storage and Regas Unit
GDZ	Gas Distribution Zones
GHG	Greenhouse Gas
HDD	Horizontal Directional Drilling
HSE	Health, Safety and Environment
HGV	Heavy Goods Vehicles
I&C	Industrial & Commercial
IFC	International Finance Corporation
IGEM	Institution of Gas Engineers & Managers
IPP	Independent Power Producer
IRR	Internal Rate of Return
JGTP	Jordan Gas Transmission Pipeline
Kg	Kilogram
Ktoe	Kilo Tonnes of Oil Equivalent
kWh	Kilowatt Hour
LDC	Local Distribution Company
LLCR	Loan Life Cover Ratio
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
MEMR	Ministry of Energy and Mineral Resources
MMBtu	Million British thermal units
MMscf/d	Million standard cubic feet per day
Mtpa	Million tonnes per annum

MW	Megawatt
MWh	Megawatt hour
NBP	National Balancing Point
NEPCO	The National Electricity Company
NDC	Nationally Determined Contributions
P&A	Property and Appliance
PPI	Private Participation in Infrastructure
PPP	Public Private Partnership
PRMC	Pressure Reduction and Metering System
OECD	Organisation for Economic Co-operation and Development
OPEX	Operating Expenditure
RAB	Regulatory Asset Base
ROE	Return on Equity
SWH	Solar water Heaters
t	tonnes
TPA	Third Party Access
TSO	Transmission System Operator
TTF	Title Transfer Facility
UKEF	UK Export Finance

2 JORDAN ENERGY SECTOR

2.1 ENERGY SECTOR OVERVIEW

MEMR seeks to optimize the use of natural resources and provide the suitable forms of energy needed to achieve sustainable development, through the development and implementation of appropriate policies, legislation and programs, diversification of sources and forms of domestic and imported energy, and the development and improvement of various local energy sources. The Energy and Minerals Regulatory Commission (EMRC) is the independent energy sector regulator.

Electricity Sector

The National Electric Power Company of Jordan (NEPCO) is the state-owned electricity company responsible for building, operating and maintaining the electricity transmission system within Jordan and connections to other countries and for expanding the construction of generating units through the private sector and/or the public sector investment. There are currently seven independent thermal power (natural gas and fuel oil) generation companies, which sell electricity to NEPCO:

- Central Electricity Generation Company (privatized in 2007 owned 51 percent by ACWA Power, and 49 percent owned by the Government) established in 1999 (394 MW)
- Al-Samra Electricity Generation Company (state-owned) established in 2004 (1571 MW including 274 MW solar and wind power plants)
- AES Jordan SEA Company (private) owned by AES and Mitsui established in 2009 (400 MW)
- Al Qatrana Electric (private) owned by KEPCO and Saudi XENEL established in 2010 (373 MW)
- Oman Asia Electric (private) owned by KEPCO and Mitsubishi established in 2014 (570 MW)
- AES Levant (private) owned by AES and Mitsui established in 2014 (241 MW)
- Zarqa Power Plant (private) owned by ACWA Power established in 2018 (485 MW)

In addition, more than 30 solar and wind powerplant companies are operational in Jordan with a total capacity of about 2,000 MW.

There are three Private electricity distribution companies (owned completely by the private sector), each with its own area for electricity distribution:

- Jordan Electricity Company distributes electricity in the Capital, Zarqa, Madaba and Balqa.
- Irbid Governorate Electricity Company distributes electricity in Irbid, Mafraq, Jerash and Ajloun.
- The Electricity Distribution Company distributes electricity in areas outside the licenced areas of the Jordan Electricity Company and the Irbid Governorate Electricity Company, specifically the southern and eastern regions and the Jordan Valley.

Petroleum Sector

The National Petroleum Company is state-owned and conducts research and exploration for its products in the licenced area located in the north-east of Jordan near the Iraqi border within the Risha gas field.

Jordan Petroleum Refinery Company is a public company responsible for refining and distributing crude and oil products within Jordan.

Three privately owned oil product distribution companies and nine privately owned LPG distribution companies operate in Jordan. There are three LPG filling stations in Jordan.

Natural Gas Sector

MEMR – through the NEPCO – has secured several sources of natural gas import. This includes pipeline imports from Egypt and Mediterranean fields with long term gas supply contracts agreed with EGAS (up to 220

MMscfd) and Chevron (225 MMscfd), for pipeline imports up to 2033 and 2035 respectively, in addition to LNG imports (up to 400 MMscfd import capacity) via the LNG import terminal at Aqaba. In the current structure, NEPCO is the single buyer of all imported natural gas.

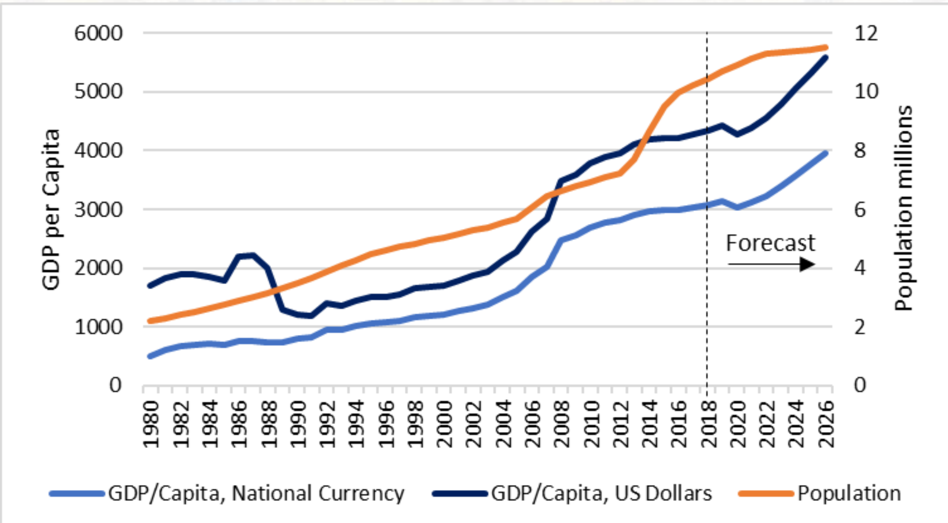
The Jordanian-Egyptian FAJR company owns and operates all the high-pressure (70 barg) 36 inch 393 km gas pipelines in Jordan through a BOOT scheme which expires in 2033. FAJR is responsible for connecting and supplying natural gas to the electric power plants with total 2020 consumption of around 337 MMscfd. Given the exclusivity rights conferred upon by NEPCO, the Jordanian-Egyptian FAJR company is also responsible for connecting and distributing natural gas to large industrial customers (>1000 MMBtu/annum). These exclusivity rights expired in December 2021 and have recently been extended. There are no other natural gas pipeline companies, however there are two CNG distribution companies in Jordan.

2.2 ECONOMY OVERVIEW

Gross Domestic Product and Population

The Jordanian economy has grown steadily since the 1980s, with more rapid growth seen in the 2000s, followed by slower growth more recently. Since 2010, GDP growth rate has fallen from 7.5 percent per annum in the 2000s to below 3 percent per annum after 2010 and below 2 percent per annum since 2016 (based on constant prices and in national currency). Jordan's GDP growth rate is expected to increase at close to 3 percent per annum from 2022 to 2026.

Figure 1 Jordan GDP/Capita and Population (1980-2026)



Source: IMF World Economic Outlook Database, October 2021, Knoema (population)

In 2010 the total population of Jordan was 6.9 million, increasing to 11.1 million by 2021 and is expected to reach 11.5 million by 2026. The population, number of households, and types of dwellings for Amman and Zarqa are shown in the table below.

Amman and Zarqa Households

Amman Qasabah, Marka, Alquaismeh and Zarqa are the most populated districts with Wadi Essier and Russeifa not far behind Al-Jami'ah. The vast majority of housing are apartments, with houses and villas making up a smaller share.

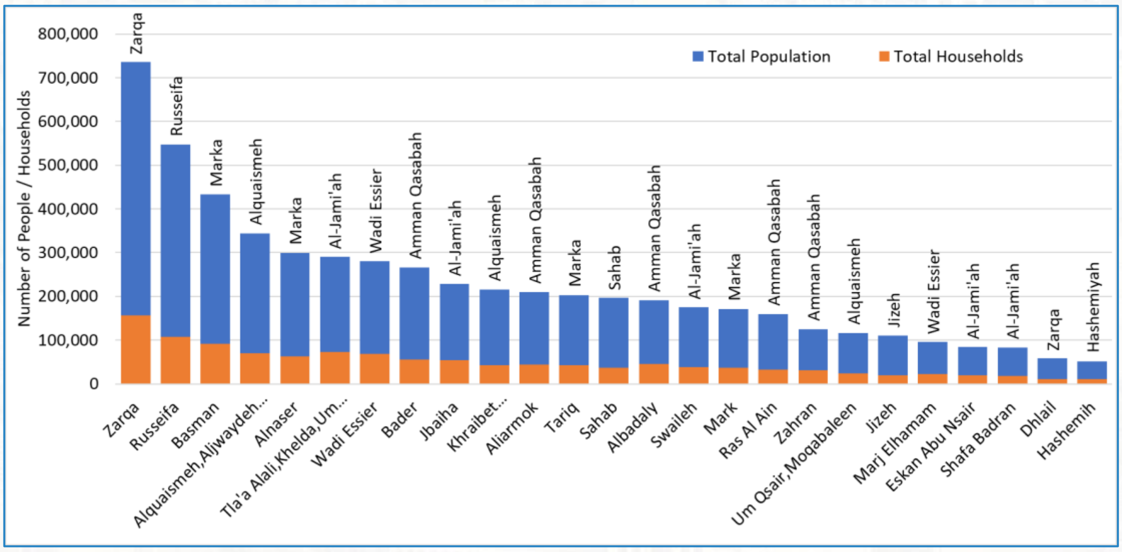
Figure 2 Amman and Zarqa Population and Housing by Locality and District

	Total Population	Total Households	Apart-ment	House	Villa	Brakia	Tent	Caravan	Work-place
Amman Qbh	991,470	217,989	205,826	5,762	1,935	43	7	37	750
Marka	1,107,470	234,463	233,298	5,026	695	123	20	60	109
Alquaismeh	674,910	136,217	130,944	5,466	757	164	185	90	398
Al-Jami'ah	861,770	202,433	238,311	5,298	3,281	111	121	95	648
Wadi Essier	425,530	100,213	110,904	4,474	2,306	66	15	53	223
Sahab	196,260	37,324	30,086	2,385	222	21	38	13	327
Jizeh	136,690	23,928	17,414	5,625	1,178	295	232	84	239
Muwaqar	97,730	18,239	22,580	5,143	94	44	53	16	63
Na'oor	150,170	31,534	27,287	4,442	1,048	12	29	21	23
Total Amman	**4,642,000**	**1,002,340**	**1,016,650**	**43,621**	**11,516**	**879**	**700**	**469**	**2,780**
Zarqa	929,300	195,506	164,258	15,576	561	152	256	14,125	505
Russeifa	558,210	109,666	89,316	7,360	45	400	3	8	16
Hashemiyah	93,490	19,148	13,986	4,260	39	54	21	4	4
Total Zarqa	**1,581,000**	**324,320**	**267,560**	**27,196**	**645**	**606**	**280**	**14,137**	**525**

Source: MEMR (Population and Households 2021 data, Dwellings 2015 data)

From about 170 Localities, the top 25 by population are shown in the chart below. In terms of Localities, Zarqa and Russeifa are largest, followed by Basman and Alnaser (in Marka) and Tla'a Alali and Jbaiha (in Al-Jami'ah) and several others in the districts of Amman and Alquaismeh.

Figure 3 Amman and Zarqa Population by Locality and District (2021)



Source: MEMR

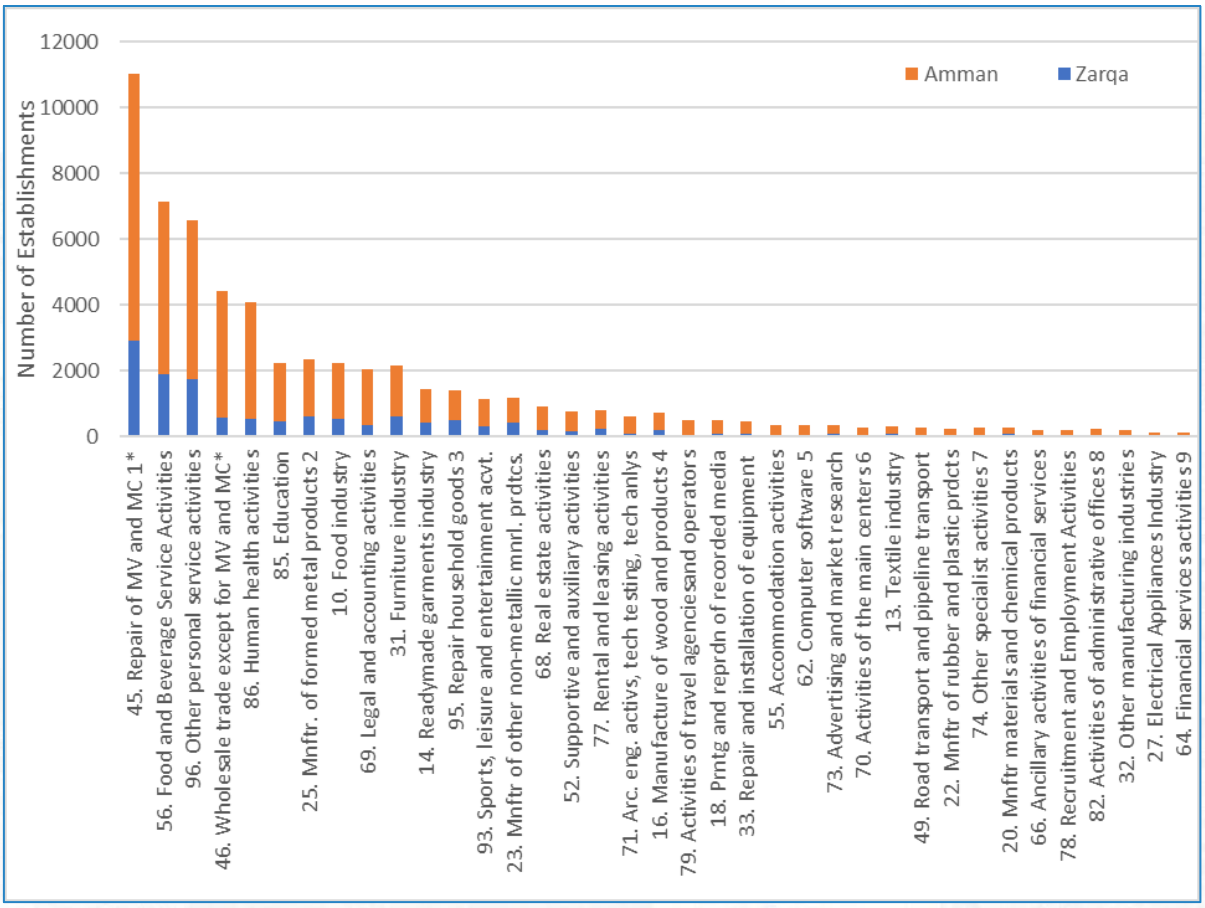
Jordan Economic Sub-sectors

The number of operating economic establishments by economic activity is shown below, excluding single trade entities (of which there are more than 10,000 in Zarqa and close to 30,000 in Amman). Out of 80 major economic sectors, we have focused on the first half with the largest number of establishments and energy consumption.

Entities specializing in wholesale and retail trade, food and beverage, service activities, healthcare services,, education, manufacturing of metal products and the food industry make up some of the largest sub-sectors in terms of number of entities operating in Amman and Zarqa, with most of this being in Amman.

Of these sub-sectors, some of the largest fuel consumers include mining, food industry, education, manufacturinge of materials and chemical products, and manufacturing of other non-metallic mineral products sectors. These sectors are key for gas to substitute other fuels such as oil products. Some of these sectors are also large consumers of electricity. Substitution of electricity by natural gas is more challenging – requiring onsite electricity generation, which is not likely to be the case in Jordan apart for very large users.

Figure 4 Amman and Zarqa Establishments by Economic Activity (2019)



*Source: MEMR *MV = motor vehicles, MC = motorcycles Note: Numbers denote category listing from source*

1 Wholesale and retail trade

10 *Except for machinery and equipment*

10 *Including computers*

10 *And cork, except for the manufacture of furniture and the manufacture of articles produced from straw and plaiting materials*

5 And consulting activities and related activities

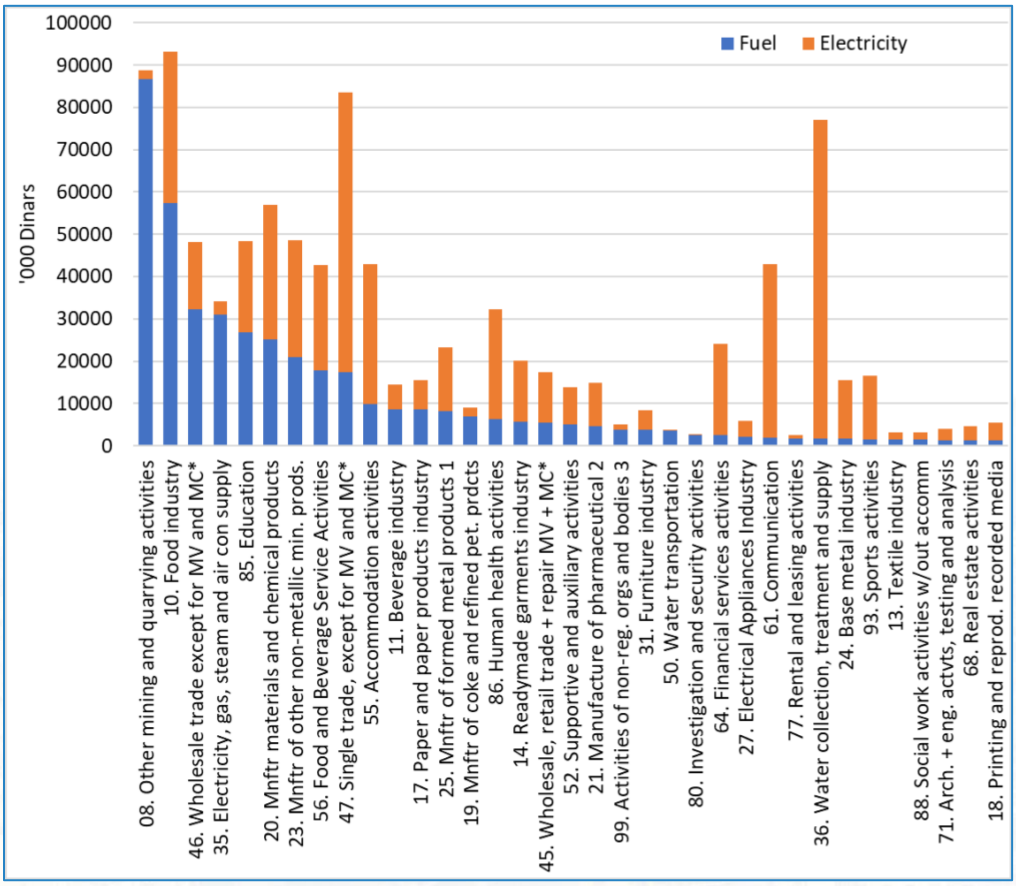
6 And management consultancy

7 Other specialized scientific, technical and professional activities

8 And support offices and other commercial activities

9 Except for insurance financing and pension funds

Figure 5 Fuel vs Electricity consumption (in Dinars) by Economic Activity (2019)



*Source: MEMR *MV = motor vehicles, MC = motorcycles Note: Numbers denote category listing from source*

1 Except for machinery and equipment

10 *Pharmaceutical and chemical products, and medicinal plants*

10 *Except for insurance financing and pension fund*

2.3 TOTAL PRIMARY ENERGY CONSUMPTION

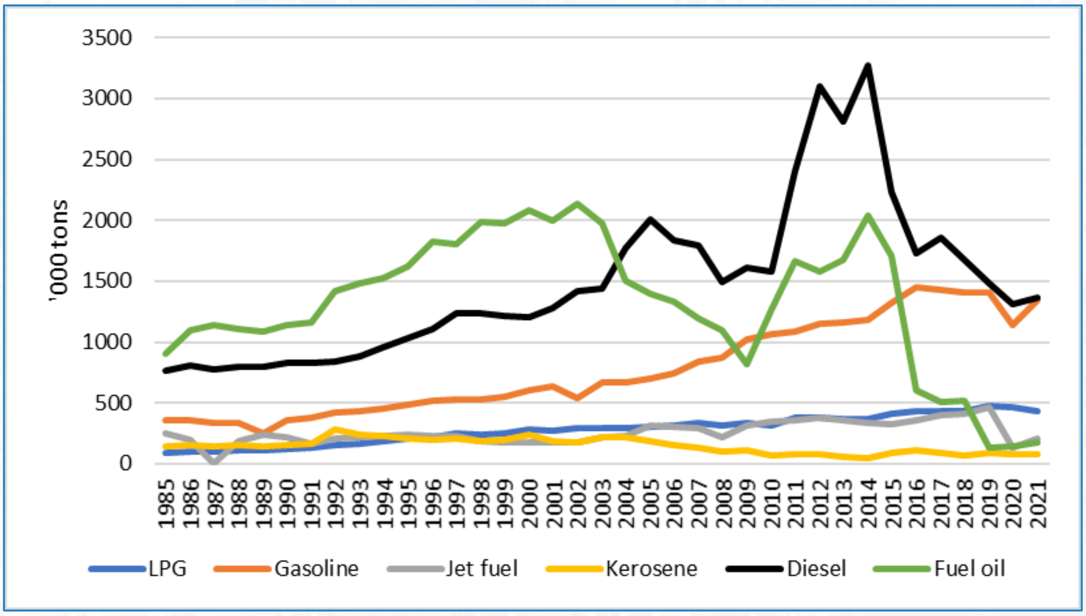
Jordan produces a very small amount of crude oil and imports most of the crude oil which it refines through the largely state-owned 60,000 bbl/day JPRC refinery. Production from the JPRC refinery is mainly distillates (gasoil 32 percent, jet/kerosene 14 percentof output), gasoline (22 percent of output) as well as fuel oil (18 percent of output) and LPG (3 percentof output).

Jordan imports the remaining share of its oil products, approximately 60 percent of demand for gasoil, 70 percent of demand for gasoline, 90 percent of LPG. Total oil consumption, oil imports, and refinery output are shown in the chart below. We do not have data on oil product exports, but comparing refinery output with imports and consumptions shows major expor likely to be only for fuel oil.

The increase in fuel oil and diesel consumption between 2010 and 2016 is attributed to the natural gas supply disruption from Egypt. During this period, Jordan switched back to fuel oil and diesel-fired electricity generation. Other major trends show the large decrease in fuel oil consumption, which is likely driven by the increase in electricity consumption in industry. Gasoline demand has also increased significantly, driven by the demand for road transportation. LPG demand, mainly for cooking and heating in the residential sector, has also increased.

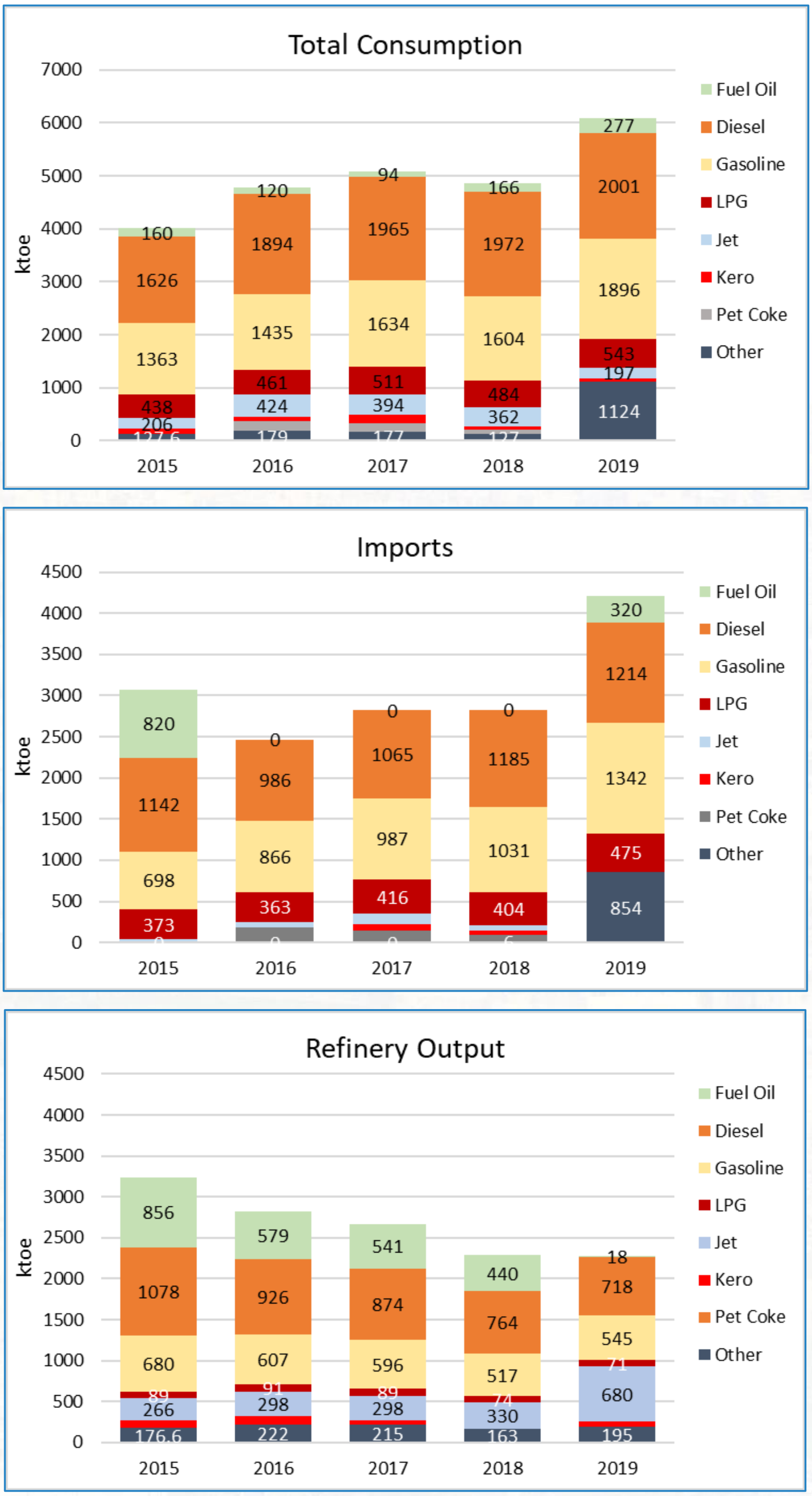
Jordan produces a small amount of natural gas from the Risha gas field. Local production makes up less than 5 percent of Jordan's gas supply (110 kt versus 3,311 kt consumption) with the remainder being imported as LNG and gas via pipelines from Egypt and Mediterranean fields. The majority of the gas consumed (~80 percent or 337 MMscfd) is by the electricity sector, with the remaining gas used by four major companies manufacturing potash, phosphate, bromine and paper (around 40 MMscfd total).

Figure 6 Jordan Oil Product Consumption (1985-2021)



Source: MEMR

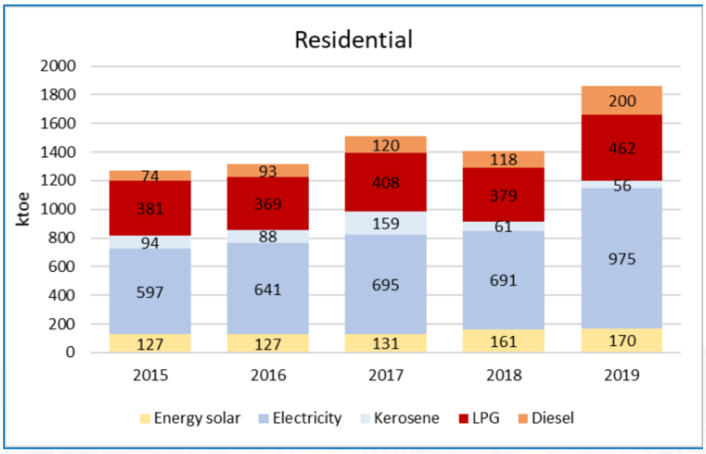
Figure 7 Jordan Oil Product Consumption vs Supply (2015-2019)



Source: MEMR

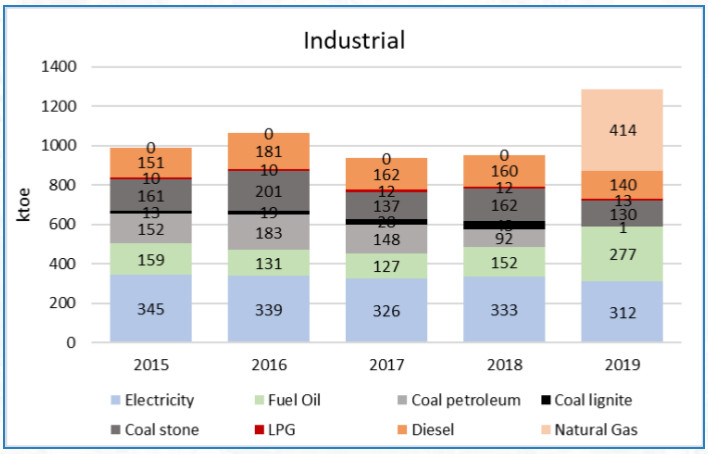
2.4 ENERGY CONSUMPTION BY SUB-SECTOR

Energy consumption by sector in the following analysis is based on the Energy Balances data provided by MEMR. Please note MEMR is currently finalising the energy balances for 2020.



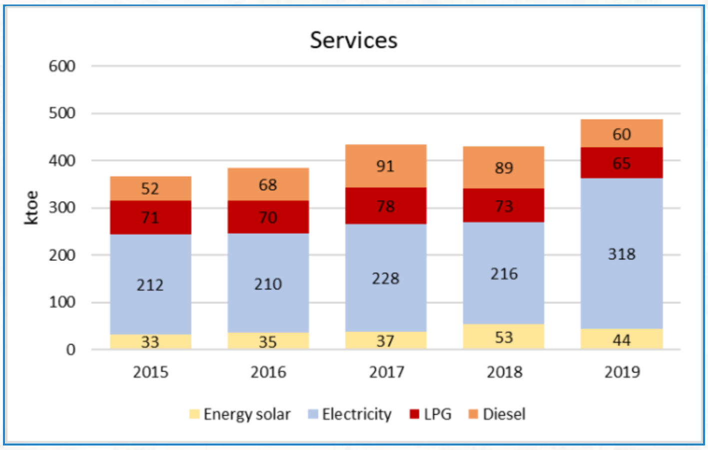
Residential sector:

- Electricity consumption in the residential sector has grown as the population and demand for electric appliances increased.
- There is still substantial demand for LPG in the residential sector for cooking and for space heating. The demand for LPG is therefore higher in winter than in summer.
- Diesel consumption has also increased. This is primarily due to heating needsand less likely for off-grid electricity generation.



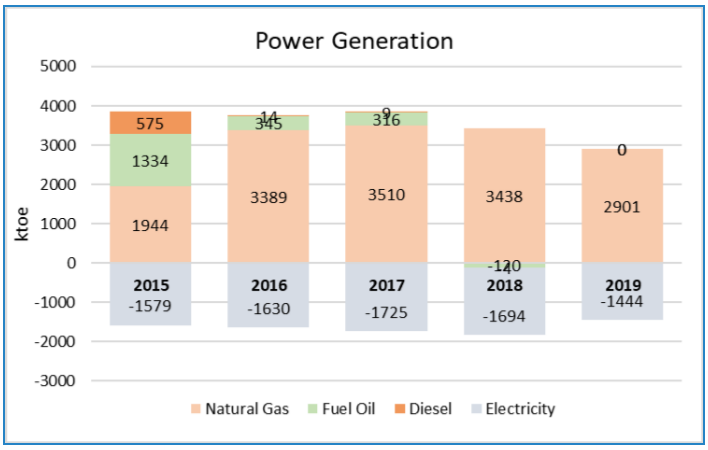
Industrial sector:

- Electricity, diesel and coal consumption in the industrial sector remained relatively constant over 2015-2019.
- Fuel oil consumption has been increasing and may have replaced pet coke and lignite use.
- Natural gas consumption in the industrial sector started in 2019 with supply to major potash, phosphate, bromine and paper manufacturing companies.



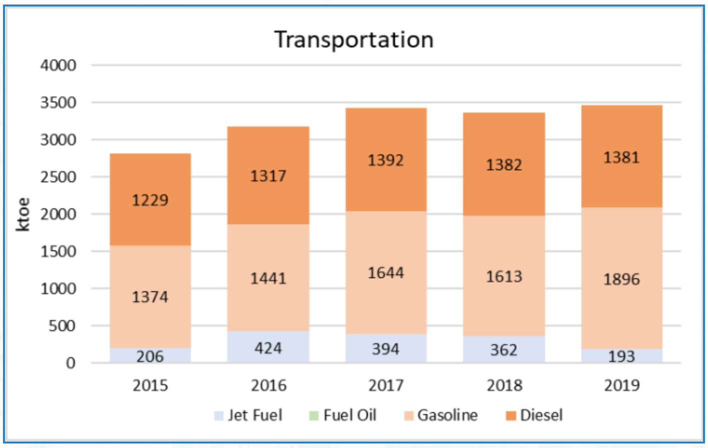
Commercial/Services sector:

- Similar to the residential sector, there is high and increasing reliance on electricity in the commercial sector.
- Also similar to the residential sector, a considerable amount of LPG and diesel is used for space heating and cooking.



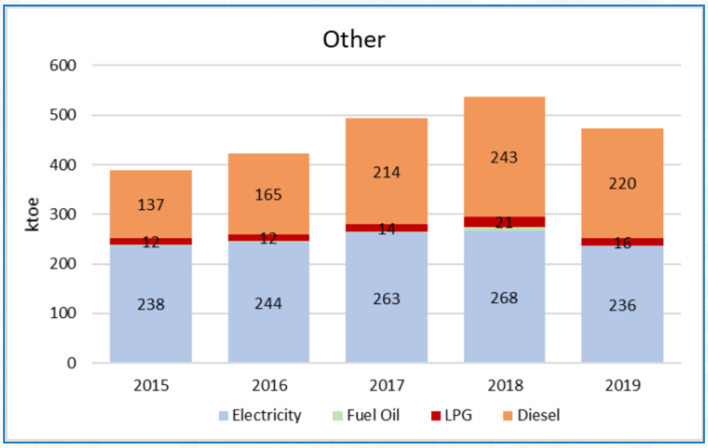
Electricity sector:

- The majority of electricity generation in Jordan is fueled by natural gas, although between 2010 and 2017 fuel oil and -to a less extent- diesel were also used due to gas supply disruption.
- Jordan is developing its renewable energy program..



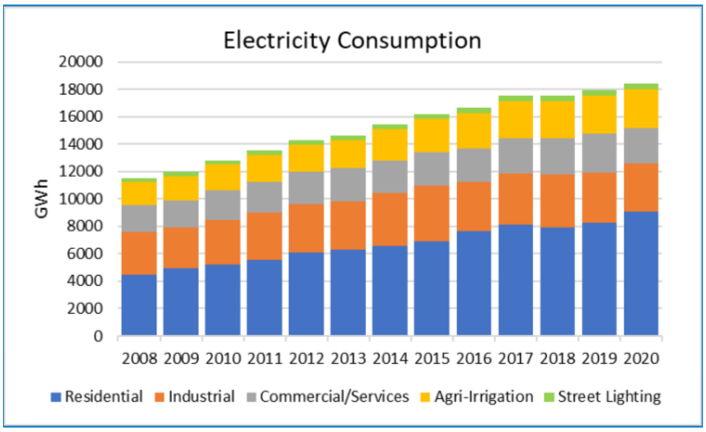
Transport sector:

- Fuel for transportation is mainly diesel and gasoline for road transportation.
- The shares of diesel and gasoline in the supply mix have stayed relatively stable in recent years.
- Fuel oil use in transportation is likely for shipping, and has decreased recently.



Other sectors:

- Fuel demand in other sectors is mainly electricity and diesel.
- This includes the following sectors: public administration, agriculture and miscellaneous.



Source: MEMR

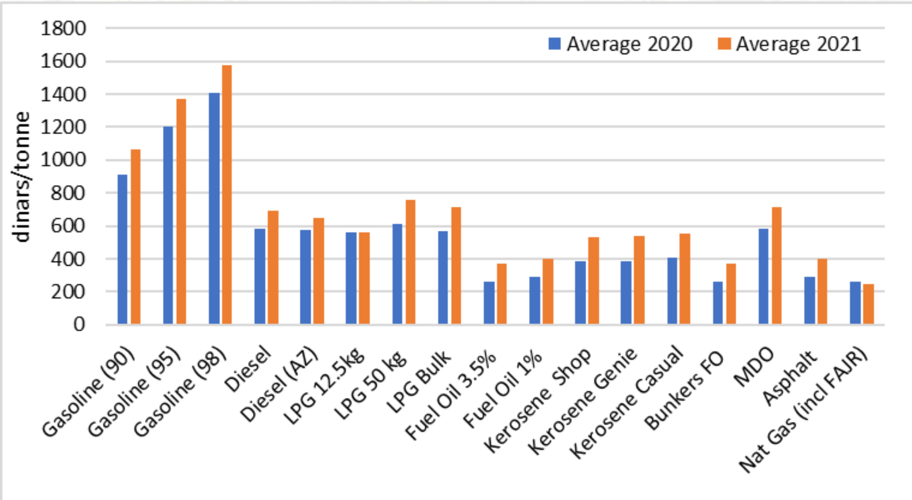
Electricity

- Electricity consumption has been increasing rapidly, particularly in the residential sector.
- This is driven by an increase in the population and the GDP per capita with increasing demand for electric goods.
- Consumption has also increased in the agri-irrigation sector and slightly in the commercial sector.
- Electricity consumption in the Industrial has remained relatively stable since 2008.

2.5 ENERGY PRICING

The chart below shows end-user prices in Jordan for various fuelsof. Prices include taxes which amount to 7 percent for natural gas, 60 dinars/tonne for LPG (~9-12 percent) and around 200 dinars/tonne for Diesel (~40 percent).

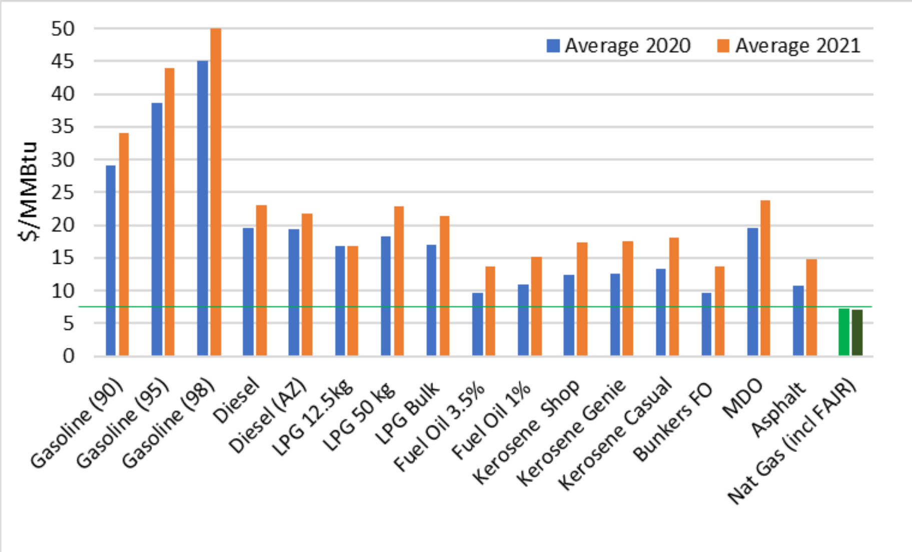
Figure 8 Jordan Oil Product Prices (2020-2021)



Source: MEMR

Prices converted to US$/MMBtu for all fuels as shown in the chart below.

Figure 9 Jordan Oil Product Prices ($/MMBtu)



Source: Consultant

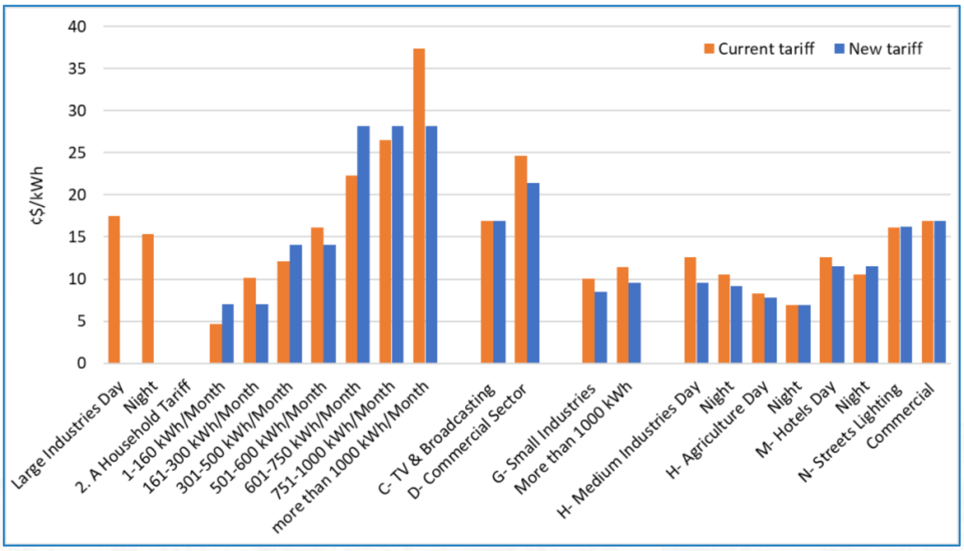
Fuel prices in Jordan are not subsidised except LPG cylinders, which are subsidised by around 25 percent to all residential sector customers based on 2021 prices.

Prices for LPG are around the same level as diesel and both are higher than fuel oil and kerosene prices. High sulphur fuel oil prices (3.5 percent) were in line with natural gas and all other oil product prices and other oil product prices increased, therefore making natural gas cheaper. Gasoline prices are considerably higher compared to other fuels, including diesel, but this fuel is mainly used in road transportation, whereas the other as used in the residential, commercial and industrial sectors.

The natural gas prices shown in the chart above are for large (industrial) consumers and include the cost of gas transmission by FAJR and the special 7 percent tax. However, this price excludes the cost of gas distribution typically charged for residential, commercial and smaller industrial customers (not directly connected to the transmission network).

Prices for subsidised LPG for all residential customers (12.5 kg cylinders) have stayed the same between 2020 and 2021, at more than double the price for natural gas. However, as mentioned above, the price for natural gas does not include distribution costs and therefore is not directly comparable. This is examined in the next part of the report.

Figure 10 Jordan Electricity Prices (¢$/kWh, 2021)



Source: Consultant

Electricity prices in Jordan have generally been subsidised for residential customers at the expense of high prices for industrial customers.

Prices were revised in late 2022 (New Tariff), increasing prices for residential customers and reducing prices for small-medium industrial customers.

New prices are similar between small and medium sized industrial customers (8.5-10 ¢$/kWh, down from 8.5-12 ¢$/kWh), which are much less than for large industrial users (24-33 ¢$/kWh, lower tariff is applied at night).

Residential customers consuming less than 300 kWh/month (~60 percent of the market) will pay around 7 ¢$/kWh (up from the current subsidised price of just under 5 ¢$/kWh). Customers who consume 300-600 kWh/month (~35% of the market) will pay around 14 ¢$/kWh (up from the 12-16 ¢$/kWh). The remaining 5% of the residential market consuming more than 600 kWh will pay 28 ¢$/kWh.

The electricity prices in Jordan are compared to those in other countries in the charts below. As shown, Residential power prices are currently at the bottom end of the scale and Industrial power prices at the top of the scale when compared to other countries.

Figure 11 Global Residential Sector Power Prices (¢$/kWh incl Tax, 2020)

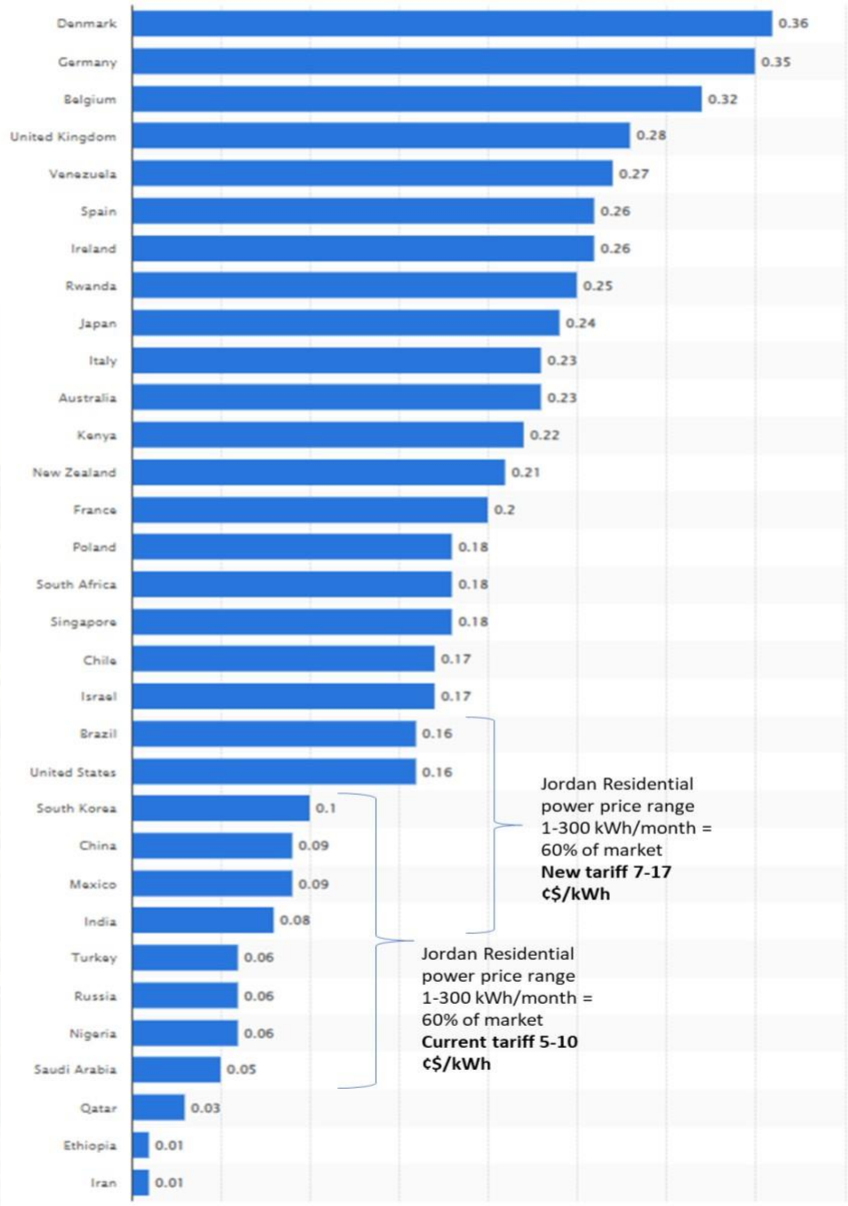
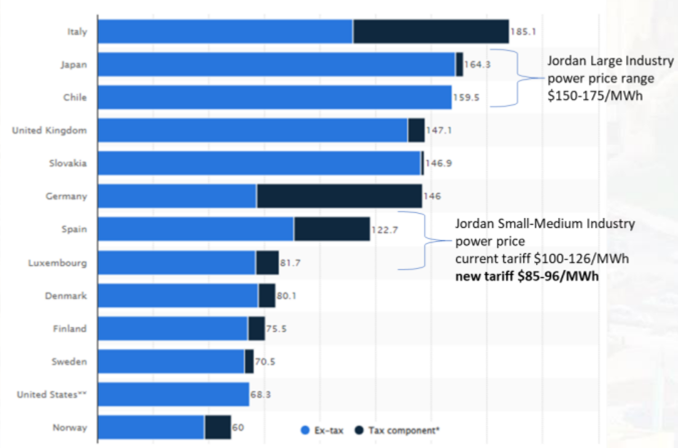


Figure 12 Global Industrial Sector Power Prices ($/MWh incl Excise Tax, 2019)



Source: Statista

2.6 ENERGY REGULATION

The key existing Regulation and Laws relevant to city gas project development include:

- The Petroleum Derivatives Law no. 11 for the year 2018
- The Petroleum Derivatives Pricing regulation no. 122/ 2019 (Bylaw)
- The Strategic Stock for Crude Oil and Petroleum Derivatives regulation no.58/2020 (Bylaw)
- The Public – Private Partnership Law no. 17 for the year 2020
- The Investment Law no. 30 for the year 2014
- The Energy and Minerals Regulatory Commission Law no. 8 for the year 2017
- The Applicable Electricity Law for the year 2002
- Municipality of Amman Law no. 18 of 2021
- Local Administration Law no. 22 of 2021

With respect to the legal and regulatory framework, Jordan does not have separate laws or regulations for natural gas. What does exist for natural gas and LNG is contained in specific articles, predominantly Article 2 of the Petroleum Derivatives law no. 11 2018. The law discusses the role of the Energy and Mineral Resources Regulatory Commission (EMRC) as the regulator for petroleum derivatives activities. According to the Licensing bylaw for activities related to the petroleum products sector for the year 2019, the EMRC is responsible for the following:

- Licensing By-Law for activities related to the petroleum products sector for the year 2019 and its amendments
- Instructions for submitting an application for a permit or license, renewing or amending them for importing, exporting, transporting, distributing, selling, and storing natural gas and liquefied natural gas and any related activity.
- Instructions for submitting an application for a permit or license, renewing or amending them for the activity of importing, exporting, transporting, distributing, selling, and storing natural gas and liquefied natural gas and any related activity.
- Instructions for permit/license fees of petroleum products including natural gas activities.
- Instructions for obtaining a permit and/or license for the activity of purchasing natural gas, compressing, degasification, transportation, filling, storing, unloading, distribution, and sale of bulk and retail.
- A template permit and/ or license for natural gas activities.

Unlike the Electricity Law,which gives the licensees Right of Way and electricity projects the status of Public Interest, the Petroleum Law does not mention Right of Way or anything on the status for the natural gas pipelines network or any pipelines for the petroleum sector.

The other two bylaws that were issued, The Petroleum Derivatives Pricing regulation no. 122/ 2019 and The Strategic Stock for Crude Oil and Petroleum Derivatives regulation no.58/2020 do not mention natural gas or LNG in any of their provisions. However, a Council of Ministers' decision was issued and gives the MEMR Pricing Committee the right to price natural gas from the Risha field as well as natural gas supply to the industrial sector.

Therefore, a new set of separate regulations are needed for the activities related to downstream natural that cover the conditions, qualifications and mechanisms for permits and licenses for natural gas related activities and for the construction, operation and maintenance of natural gas infrastructure projects.

Regarding the Right of Way and Status of Public Interest, amendment of the existing law is needed as it shall intersect with Local Administration Law no 22 of 2021 and Municipality of Amman Law no.18 of 2021. An Investment Environment bylaw concerning taxes, exemptions, and benefits is also being developed.

2.7 JORDAN ENERGY STRATEGY 2020-2030

Over the past few years, the Ministry of Energy and Mineral Resources (MEMR) has focused on developing an effective energy policy and strategic objectives towards sustainable energy and energy security by diversifying energy supply, developing and utilizing traditional and renewable local energy sources, improving energy efficiency and developing the energy sector system in Jordan to make it a regional centre for energy exchange. Further measures include liberalizing energy markets and encouraging private investment in energy infrastructure projects.

In the electricity sector, the construction of the Green Corridor Project connecting Ma'an to Eh-Qatraneh is one of the most important achievements, increasing the capacity of the electricity transmission from the south to the centre of the Kingdom from 500 MW to 1,400 MW. Jordan's electric connection with Egypt remains, which contributed to stability of Jordan's electricity. Agreements have been concluded for exports to Iraq and connections with the GCC countries. The introduction of solar energy to cover consumption of different sectors using net metering and wheeling systems led to significant rise in the share of renewable energy (solar and wind) in the electricity generation mix to about 1,130 MW by 2019 (11 percent of total electricity generated, compared to natural gas at around 80 percent of total generation).

In terms of natural gas, MEMR has set ambitious plans to (a) maintain the security of natural gas upstream supply and (b) promote use of natural gas in different sectors. The latter is split into two parts:

(i) Promoting natural gas in the industrial and transportation sectors to reduce dependency on heavy fuels, hence reducing harmful CO_2 emissions; and,
(ii) Establishing city gas distribution networks in major cities, with strong involvement from the private sector.

An important step for expanding natural gas use in industries was the identification of the regulatory, contractual and technical requirements to supply industries with natural gas. Efforts were also made to encourage industries switching to natural gas instead of using more expensive liquid fuels, in an effort by the Government to increase the competitiveness of industries and reduce production costs. This included the equipment associated with the connection of gas pipelines to factory premises being granted special investment exemptions, a special tax imposed on natural gas for industries reduced from 16 percent to 7 percent, and an exemption from the special tax for the first three years of use of natural gas.

Moving forward, Jordan has adopted the following conclusions and recommendations in the base case scenario for achieving its strategic objectives. This includes supporting and encouraging the use of natural gas in other sectors and the development of distribution networks in major cities (Point 7).

Electricity Sector

1. Diversification of power generation sources

1.1. Use natural gas to generate electricity alongside renewable energy projects in the Kingdom.
1.2. Increase the capacity of renewable energy projects from 2,400 MW in 2020 to 3,200 MW by 2030.

2. Enhance safety of the electricity system and upsurge system availability and reliability

2.1. Expand the electricity system to include required generating units and enhance the transmission and distribution networks and technical specifications to the best international practices per the system's requirements.
2.2. Expand the current interconnection projects and start new projects.
2.3. Introduce storage projects into the electricity system (batteries, water dams) to avoid the disconnection of the power generated from the renewable energy projects and sustain grid stability.

2.4. Reduce losses in the power system to keep pace with global practices.
2.5. Gradual transformation into smart grid networks.
2.6. Boost expansion by introducing electric modes of transportation.
2.7. Enhance integration between energy and water sectors to cover the water sector needs to electricity to the best alternatives and engage both sectors to develop joint ventures.

3. Sustain the financial situation of the electricity sector

3.1. Move from a single purchase model to a competitive system to improve the services provided to citizens.
3.2. Implement the roadmap for the financial sustainability of the electricity sector to reduce the electricity prices for consumers due to lowering electricity costs.

Oil Sector

4. Diversification of crude oil sources

4.1. Diversification of sources of crude oil imports via Aqaba terminal, land transport and the Iraqi oil pipeline.
4.2. Develop oil production of Hamza Oil Field.
4.3. Attract global companies to invest in oil exploration in open areas.
4.4. Attract global companies to invest in oil shale retorting and exploration in open areas.
4.5. Establish and construct crude oil and oil products pipelines. Enhance the current interconnection projects and start new projects.

5. Improve the performance of the oil sector

5.1. Open new markets for oil products.
5.2. Adopt the latest international specifications of oil products to the Jordanian market requirement.
5.3. Open the way for refining activity based on market pricing principles.
5.4. Strengthen Jordan's role in providing logistics services for transporting oil products to and from neighbouring countries.
5.5. Increase storage capacities of oil products to meet the international standards and improve domestic logistics services.
5.6. Move from a regulated market to an open market by liberalizing the prices of oil products.

Natural gas sector

6. Diversification of natural gas supply sources

6.1. Cover the Kingdom's natural gas needs with available natural gas supply from current sources, which cover the Kingdom's requirements up to 2030.
6.2. Develop production of Risha Gas Field.
6.3. Attract international companies to invest in traditional and non-traditional gas exploration in open areas.
6.4. Keep importing LNG via The Sheikh Sabah Al Ahmad Terminal in Aqaba as an option to ensure the security of energy supply, with an assessment of possible alternatives to replace the Floating Storage Regasification Unit (FSRU) with less expensive substitutes.

7. Use of natural gas in various sectors

7.1. Support and encourage the use of natural gas and compressed natural gas in the industrial and transport sectors to replace oil products and mitigate emissions.
7.2. Construct the distribution of natural gas networks in major cities.

Improve Energy Efficiency

8. Improve the use of energy efficiency in various sectors to range 9 percent by 2030 compared to 2018

8.1. Update and follow-up the legislations and The National Energy Efficiency Action Plans.
8.2. Implement and improve energy efficiency programs in the water sector to reduce the electricity demand to 15 percent by 2025.

8.3. Enhance and optimize public transportation, rapid Bus and railway transit systems.
8.4. Improve energy efficiency of the domestic, industrial, government, commercial and service sectors.

2.8 JORDAN CLIMATE CHANGE ADAPTATION PLAN

In October 2021, Jordan presented its updated 1st Nationally Determined Contributions (NDC) plan on the commitments to the international climate change governance system by raising its macroeconomic GHG emission reduction target from 14 percentto 31 percent by 2030 in the Business As Usual (BAU) scenario. The new GHG emission reduction target is based on a combination of national policies, programmes and actions, international support, and finance.

Figure 13 Jordan total GHG emission reduction (2nd NDC Update Oct 2021)

Selected Years	Baseline Scenario Emissions (BAU)	Mitigation Scenario	
		Mitigation Scenario Emissions	Avoided Emissions
	Gg CO_{2eq}		
2012	27,998	27,998	**0**
2015	33,516	33,443	**73**
2020	33,941	32,705	**1236**
2025	37,655	31,601	**6054**
2030	43,989	30,291	**13698**
*The Estimated Mitigation Target is 31%			
** Resulting target was calculated by dividing the accumulative emissions avoided till 2030 by the total emissions in 2030 resulting in the BAU scenario [target% = (accumulative emissions by 2030/BAU-2030 emissions)* 100]			

Source: The National Climate Change Adaptation Plan of Jordan, 2021

Based on the most recent national GHG Inventory (2012), Jordan contributed around 28 million tonne CO2eq of emissions to the atmosphere in 2012. A breakdown of Jordan's total emissions of GHG by sector indicated that the energy sector was the major emitter with 81 percent of total national emissions followed by the industrial sector with a contribution of 12 percent, then the waste sector and Agriculture, Forestry, and Other Land Use (AFOLU) with 6 percent and 1 percent respectively.

The measures that are considered necessary to achieve the NDC target for the energy sector include:

- Increased percentage of electricity generated from renewables to have a share of more than 35 percent by 2030
- The Aqaba Amman Water Desalination and Conveyance Project (AAWDCP) – Wheeling Project, 185 MW PV (50 percent of the overall needed power demand)
- Introduction of concentrated solar power (CSP) of 100 MW and CSP 300 MW
- Improving efficient energy consumption in all sectors by 9 percent
- Energy measures in the Residential sector
  - Natural gas distribution in the main cities (Amman, Zarqa, Aqaba)
  - Solar Water Heaters (SWH) Project for 90,000 houses
- Energy Efficiency Projects in industry:
  - Returning Un-Returned Condensate to the Feed Water Tanks in the food industry
  - Insulating the un-insulated pipes, fittings and tanks in food industries
  - Using Regenerative burners instead of conventional burners in steel manufacturing

2.9 JORDAN NATURAL GAS MARKET AND OUTLOOK

In 2020, Jordan consumed a total of around 380 MMscfd. 337 MMscfd was for electricity generation and an estimated 40 MMscfd for industry. Most of the gas supply has been from Egypt via a long-term supply contract with EGAS (up to 220 MMscfd) and since January 2020 from Mediterranean fields with the start-up of a long-term contract with Noble Energy (now Chevron) and its partners for 290 MMscfd, with LNG imports (capacity of up to 400 MMscfd) now making up a smaller share of the supply. With the flexibility of reducing pipeline purchases down to take-or-pay levels when international LNG prices are depressed, Jordan can optimize gas supply to ensure lower overall gas prices.

Imports from Egypt are via the Jordan Gas Transmission Pipeline (JGTP) which is the 2nd phase of Arab Gas Pipeline developed on a BOOT basis and under a long-term license agreement with Jordanian-Egyptian FAJR Co. Imports started up in 2006 but between 2011-2015 was subject to pipeline attacks on the Egyptian side preventing gas supply. The length of the pipeline is 393 km and it has a diameter of 36 inch and capacity of around 970 MMscfd. Currently gas supply is on an as required basis but has also operated in reverse flow when Egypt was short of gas between 2016 and 2020.

Imports from Mediterranean fields are via the 65km North Gas Pipeline Project (capacity of 300-500 MMscfd) to Rihab with gas sales from the Leviathan field for 15 years ending 2035. The Jordanian-Egyptian FAJR Company also developed the pipeline under a BOOT arrangement; the start-up of commercial operations was in January 2020. LNG imports are via the Golar Eskimo FSRU at Aqaba port (Sheikh Sabah Al Ahmad Terminal) which started up in July 2015 to help alleviate the supply disruption from Egypt. MEMR, NEPCO and Aqaba Ports Corporation are currently planning the replacement of the FSRU with a Floating Storage Unit (FSU) to help reduce costs.

Figure 14 Jordan total GHG emission reduction (2nd NDC Update Oct 2021)

Source: MEES

Jordan also produces a small amount of gas from the Risha gas field which started up in the late 1980s and currently produces around 16 MMscfd. Recent additional discoveries in the field will lead to an increase in production to 27 MMscfd. All gas sales are to the 150 MW Risha Power Plant. National Petroleum Company in their strategic plans aim to increase local gas production to 200 MMscfd through more exploration in order to reduce the reliance on imports.

As discussed above, since May 2018, the Council of Ministers approved the reduction of the special tax imposed on natural gas from 16 percent to 7 percent for all industries, with exemptions from this special tax for the first 3 years, in order to promote the use of natural gas. Moreover, MEMR also granted special natural gas prices for industries. Despite these efforts, only four industries have switched their facilities to use natural gas: potash and bromine companies, Nuqul group (paper manufacturing) and Jordan Phosphate Mines Company (JPMC).

With the diversity achieved on upstream natural gas supply sources, the Government of Jordan wants to bring the benefits of natural gas to customers in the residential, commercial, transportation and industrial sectors, many of which are currently using higher priced and less convenient LPG and oil-fuelled equipment. This would be achieved through the development of gas distribution network facilities in Amman and Zarqa (starting by the city gate all the way to end user connection and conversion).

Gas distribution to smaller users is expected to deliver many benefits including:

- Providing a lower cost alternative to liquid fuels
- Use of a lower environmental impact energy source
- Utilizing the skills and resources of the private sector to the fullest extent in: (i) design, implementation, operation and maintenance of the Network Facilities and (ii) development of the retail Natural Gas market (including training new skills for gas engineers)
- Providing an opportunity for investment by Jordanian companies and investors, and for the creation of employment and skills transfer to Jordanian nationals.

The Government aims to do this by maximising private sector participation in the project, either through a fully private operation or a PPP model. The stability of business and operations as well as the continuity of supply to consumers must be ensured, and the different risks through the project lifetime are considered and managed. This is key to the long-term success of such projects, as once users switch to gas, they are then dependent on the reliability of the connection and supply.

Jordan is also considering establishing a dedicated gas company taking over responsibilities from NEPCO and to allow for a gradual gas market opening. These plans are discussed in more detail in the Gas Market Design study, the key findings of which are provided below.

2.10 SUMMARY OF PREVIOUS STUDIES

2.10.1 CRA – FEASIBILITY OF GAS DISTRIBUTION BUSINESSES

In 2005, Charles River Associates International (CRAI) undertook a study for MEMR on the Feasibility of Gas Distribution Businesses in Amman and Zarqa. The conclusion was that gas distribution was feasible, but the economics were marginal, and the project would have to be structured carefully to attract investors. It was found that demand in Amman and Zarqa was relatively low and there was nosizeable industrial sector to underpin infrastructure costs due to a problem with the definition of Exclusivity Rights for Large Industrial Customers with Fajr (>1000 MMBTU), which potentially removed load from the Local Distribution Company (LDC). However, the study also found that the gas price for supply to an LDC was low and gas could be priced to end consumers at a level which would make switching from their current fuels attractive. The difference in purchase and sales prices would leave a good margin for the LDC company. In the longer term (15 years of payback period), gas distribution in Amman and Zarqa would present a profitable business and project returns would be reasonable and could be improved through debt financing. If the payback period could be reduced through more favorable taxation and tax holidays and adding more demand from industrial customers (and as a priority to residential connections), the project would bemore attractive to investors.

On the technical aspects of the gas network, CRAI recommended the cities of Amman and Zarqa to be supplied from a single steel feeder central system, operating at 16 bar. The supply would initially come from a single city gate station at Zarqa. The feeder main system should be constructed to initially supply key market areas in the western and northern parts of Amman, and should be extended in phases in line with market development to eventually connect to city gate stations at Sahab and / or at the international airport, creating a loop, and thus providing improved security of supply. Distribution networks, supplied via district regulator stations from the steel feeder main system, would be constructed in polyethylene, and operated typically at pressures of 4 bar.

The two major technical issues impacting the economic viability are:

1. High annual variability of residential and commercial energy demand resulting from a relatively low annual cooking and water heating demand combined with a high space heating demand which occurs for a few hours each day for around three months each year during the winter.

2. The heating demand, although occurring for a short period each year, represents the major part of the potential residential market. The cost of converting the high-capacity diesel fired boilers was very high. This would result in relatively high peak-hour flows which dictate system sizing and thus capital costs, while low average annual consumption results in low revenues and large negative impact on project economics.

2.10.2 METAS – NATURAL GAS MARKET DESIGN FOR JORDAN

In mid-2019, a study was initiated to look at the design of the operating structure of NEPCO's Gas Segment and its Gas Market Operating Environment. The study looked at changes that could enhance market growth and liberalization. The study suggested that a separate gas entity be formed that could focus on gas growth and initially manage gas supply and demand, including greater domestic use as evaluated in this current study. The separate gas entity would take over the long-term gas supply contracts from Mediterranean fields and Egypt as well as look for opportunistic purchases via LNG to balance the market. Based on the arbitrage between LNG and the pipeline contracts, it could initially create value for itself. Over time, a mechanism of market release could be initiated that would offer third parties the opportunity to supply gas to customers. This was evaluated to provide substantial savings to Jordanian customers due to supply competition. As the market release expanded, part of the pipeline supply contracts could also be opened to third parties. The key assumption in the analysis was that seasonal LNG pricing would enable summer arbitrage opportunities for supply to Jordan. Whilst in early 2020 LNG prices dropped due to the pandemic, current international LNG prices do not offer arbitrage opportunities versus supply from Jordan's existing long term contract. However, by forming a separate gas entity, the focus on growth will help reduce overall energy costs for Jordan as commensurate international oil prices are also high. This offers greater savings for Jordan in converting to greater gas use for growth. If future international oil and gas prices drop, they can offer market opening and arbitrage opportunities.

3 TECHNO-ECONOMIC ASSESSMENT OF CITY GAS DISTRIBUTION

3.1 SWITCHING TO NATURAL GAS

3.1.1 BENEFITS OF SWITCHING TO NATURAL GAS

Natural gas is widely seen to be a cleaner burning (lower emissions) and more efficient fuel when compared to oil products and charcoal. In Jordan, natural gas supply will not only provide customers with a more environmentally friendly energy source compared with oil product alternatives, but should also be able to provide significant energy cost savings versus LPG (even with subsidies) and also Fuel oil and Diesel. Therefore, switching to natural gas should support the growth of the economy by using a cheaper source of energy.

On top of gas' cleaner, more efficient properties and lower price, the delivery of gas via distribution pipelines provides a safer, more reliable and environmentally friendly form of energy transportation than delivery of fuel by truck to retail stations or for bulk residential supply. Natural gas is lighter than air, so releases dissipate easily whereas LPG is much heavier and can pool at low levels increasing the risks of flammability. In addition, for households, piped natural gas reduces the need to store and refill household fuels such as LPG cylinders or kerosene. LPG cylinders contain liquefied gas at high pressures and are often stored close to or within residential properties meaning they have higher potential for causing major explosions. Kerosene is less clean-burning than LPG and natural gas and its use leads to health problems. Furthermore, kerosene is a flammable liquid and is therefore dangerous to handle and store.

It is important to note that industrial customers will not represent sufficient gas demand to be able to assume a role of anchor load. Consequently, customers will need to be within reasonable reach of a lower pressure distribution network and the feasibility of this will depend on the ability to facilitate switching many more medium and small demand customers. This is not likely to be an issue in Amman and Zarqa with densely populated areas and clusters of industrial demand in key areas.

Gas pricing policy for all customers connected to the distribution network will be important to encourage switching and gas demand growth. One of the key areas of government policy support is for the development of the distribution networks. The distribution networks can be planned on a franchised or licensed basis. It is important to balance the needs of the licence holder having the level of security over customers in that area and the returns on investment with the needs and rights of customers to have secure access to competitively priced gas. The government can determine areas which are suitable to be designated as Gas Distribution Zones (GDZ). In deciding on the areas, key factors should be considered including geographic location in terms of distance to the gas transmission system and the projected gas demand within the zone.

Larger industrial users may also be able to offtake gas directly from the transmission network (70 barg) with the customer investing in the required pressure reduction and metering system (PRMS). Groups of large industrial customers in the same geographic area can also share the same PRMS infrastructure. In Jordan there are not many very large industrial users, but there are several large industrial clusters (e.g. King Abdullah the Second Industrial Area and Muwaqar Industrial Area) where connection can be directly to the 16 barg network with distribution networks (4 barg network) within their Industrial clusters.

It will be critical for secure gas supply to be established before residential and industrial customers can start to take up gas use in a large way. Once switched to natural gas, no easy alternative supply is available for these users (compared with power, where other fuels and forms of generation are available if one power plant were to go offline due to lack of natural gas supply). Delivery of gas from multiple supply sources into the market via the gas transmission system will provide a strong diversity of supply, as is already the case in Jordan. However, just as important will be to ensure the development of a well-planned gas distribution system.

3.1.2 CONNECTIONS AND SWITCHING APPLIANCES

In Jordan, switching from LPG or diesel to natural gas may require retrofits to industrial boilers or furnaces and communal boilers for central heating systems for households. However, household boilers for water or space heating – and even the cooking stoves in the case of LPG – can be more easily converted.

In the residential sector, conversion of LPG cooking stoves and boilers to natural gas is likely to need burner replacement if the appliance has been designed specifically for LPG use because of flame stability issues. As LPG is higher in calorific value and heavier in specific gravity than natural gas, the conversion of domestic appliance to natural gas is usually done by conversion kits by enlarging the existing LPG gas jet by a controlled procedure. Conversion kits are available and retrofitting an appliance for gas is a relatively straightforward job. Portable LPG space heaters are not suitable for conversion due to the lack of pipe connections and flue system for the exhaust emissions.

Diesel-fuelled residential central heating boilers require complete replacement of fuel train, controls and burners but are likely to remain very inefficient after conversion. In order to increase energy efficiency, replacement of the whole boiler with a modern condensing boiler should be considered. However, the central heating piping and vents may remain the same. This needs a case-by-case assessment that shall include the customer and the technical agent of the boiler. Detailed surveys to understand the appliances and pipework in current use is vital.

As with the diesel-based residential central heating, switching to natural gas for use in industrial applications can be challenging. This is because the financial circumstances and operational life of the equipment are more significant factors in determining the economic viability for industrial applications compared to the residential sector. However, this needs to be studied in more detailto understand the existing connections within buildings and the types of appliances in use.

If the natural gas can be more easily supplied for existing appliances, then the upfront cost of installation, conversion and flues can be paid by the distribution companies and recovered through the tariff. However, where new connections are required in the building/factory, this may prove more challenging, adding costs and potentially requiring permission from the landlord/management for it to be done. In cases when new appliances are needed to be bought this will impact on the overall decision to switch to natural gas. Whatever works, parts and/or modifications needed to make the appliance ready for natural gas shall be the co-responsibility of the customer and the appliance manufacturer/technical authorized agent. Once the appliance is declared ready for gas by the technical agent, the gas supply company shall connect the gas flanges and test for leaks.

Some low-income households may prefer to manage costs through the use of LPG for mobile space heating and LPG cylinders for cooking and solar for hot water heating, thereby avoiding having to invest in new natural gas appliances. Furthermore, electric appliances are becoming more popular with lower upfront costs despite the higher electricity cost versus natural gas. Electric heaters are increasingly common, for example. Some air conditioning units with inverters can also provide heating in winter periods as well as cooling in summer periods. Where the demand for heating is not too large versus the demand for cooling this may be a preferred option with electric or LPG cookers and electric boilers complimenting solar water heating.

In Jordan, safety related issues linked to current space heating options in Amman and Zarqa (including kerosene and LPG mobile heaters versus diesel and LPG central heaters) is a key issue. Once connection is available natural gas should be able to replace LPG and Diesel for central heating just from a cost saving perspective, especially if much of the heating infrastructure is already in place within buildings, as is the case in the districts in West Amman. Furthermore, no onsite fuel storage or refuelling is required unlike for LPG and Diesel.

Some residential areas mainly in East Amman are located at higher elevations, built with little planning or with buildings adjoining or closely adjacent to each other in congested areas. Such type of areas represents a challenge not only for the construction of a gas network but more also on the requirements of safe gas connections set by the international codes. Housing in Zarqa may also provide some challenges and hence a lower number of connectivity is assumed (65 percent of households versus 80 percent in Amman).

Pictures of East Amman and Zarqa are shown below. Switching to natural gas across these areas requires a more in-depth study on a case-by-case assessment to fulfil the necessary requirements set by the international standards and related local governing regulations.

Figure 15 East Amman residential area example

Source: Consultant

Figure 16 Zarqa residential area example

Source: Consultant

The table below summarises some of the key considerations for residential customers switching from LPG and Diesel to natural gas versus electricity.

Figure 17 Customer Choices on Gas vs Electric vs Diesel/LPG

Factor	Natural gas vs LPG	Natural Gas vs Diesel	Electric vs Gas
Fuel Cost	Cost of natural gas is lower compared to LPG	Cost of natural gas is considerably compared to diesel	Cost of electricity is much higher compared to gas (less so in Jordan with subsidised power prices)
Appliance Cost	Costs of new gas or LPG appliances are comparable. Switching from LPG to gas would need appliance conversion kits and a technician.	Diesel is typically for whole building use for central heating. Switching to natural gas is likely to need complete boiler conversion.	Cost of new electric appliances is much less than for gas. It can be a preferred option for new housing.
Efficiency	Slightly lower appliance efficiency for gas compared to LPG	Lower appliance efficiency for diesel compared to gas	Electric appliances are more efficient – 100 percent (excluding the generation) versus 75 percent for gas, which decreases over time
Ease of Connection	Piped gas and LPG connections are similar. bottled LPG connection is simpler than gas connection	Cost of switching from diesel to gas may be lower given use of existing piping within buildings	Widespread and low cost. Close to 100 percent of households or areas are connected.
Ease of Service	Gas requires more servicing than LPG appliances – once a year	Requires less servicing than diesel boilers	Electricity easy to service. Needs less servicing than gas appliances.
Other costs	LPG requires additional transport to get it to the consumer.	Diesel must be supplied regularly and stored onsite. Storage tanks add to costs and take up space and can be hazardous	No other costs for consumer. Smart metering is an added cost to suppliers.
Other considerations	Low-income households prefer LPG/kerosene to help	Replacement of diesel by natural gas may require new	Electric appliances are cheaper upfront compared to gas

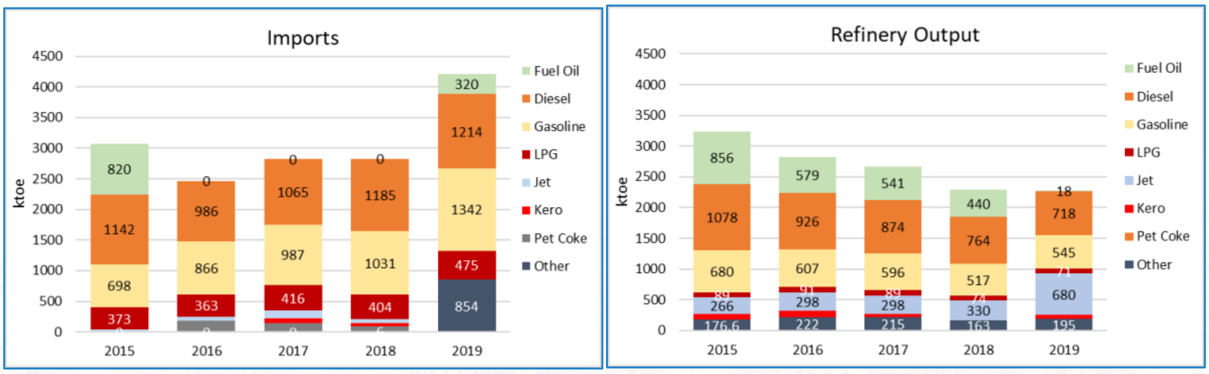
	manage costs. Natural gas is relatively easy to replace LPG in existing boilers and cooking stoves. Piped natural gas is safer than bottled LPG.	boilers but has major cost, supply efficiency and safety benefits.	appliances which offsets the higher electricity cost. Accesories with inverters can also provide moderate heating. Electric supply is more secure.

3.2 CURRENT FUEL SUPPLY

3.2.1 LIQUID FUELS, LPG AND ELECTRICITY

Liquid Fuels and LPG

Figure 18 Jordan Oil Product Supply (2015-2019)



Source: MEMR

Jordan imports most of its oil products supplementing the production from the Jordan Petroleum Refinery Company (JPRC). JPRC plans to expand the refinery doubling the current refining capacity to 120,000 barrels per day (bpd). This has been in planning for many years and recently, at the end of 2021, JPRC issued a tender and received bids from several companies interested in expanding the refinery. However, the final investment decision has not been made and would be subject to funding the estimated US$2.6 billion cost of the expansion. Investment to expand the refinery will need to ensure production is competitive versus oil product imports. JPRC also owns and operates the associated oil terminal and storage facilities in the city of Aqaba.

Two other companies, Manaseer and Total Energies, now directly import most of the fuel required in Jordan.. Domestic sales of gasoline, eiesel and kerosene are also undertaken by these three players with JPRC (JO Petrol) holding around 50 percent market share and Manaseer and Total sharing the remainder approximately evenly. The majority of LPG is also imported into the country. JPRC owns three LPG bottling and storage facilities, located in Amman, Zarqa and Irbid. Downstream sales are by nine privately owned LPG distribution companies currently operating in Jordan.

Production from the refinery is priced at oil import parity. Oil imports are expected to be competitive given competition between the three importers and with nearby sources of competitively priced oil product supply (e.g. Saudi Arabia and India). The cost of storage, distribution, wholesale and retail margins, as well as duties and taxes, are then added on to the import price to arrive at the end user price according to a pricing formula set by MEMR.

Figure 19 Jordan Oil Product Prices (2021)

$/tonne	Average Retail 2021	Estimated Import 2021	Margin
Gasoline (90)	1500	664	126%
Diesel	1000	644	55%
LPG (unsubsidised)	1072	555	93%
Fuel Oil 3.5%	519	353	47%
Fuel Oil 1%	568	361	57%
Kerosene	785	686	14%
Natural Gas (incl FAJR)	353	250	41%

Source: MEMR, Consultant

As shown in the table above, average retail prices are around 50 percentto 100 percent higher than the import price. This margin includes the supply costs discussed above as well as taxes and duties. Taxes for diesel are around 40 percent but lower for LPG (12 percent) and natural gas (7 percent). LPG prices are subsidised by around 25 percent to all residential sector customers (92 percent of the market). The price of natural gas has and is expected to remain competitive versus oil products. This is discussed in more detail below.

Electricity

100 percent of the population has access to electricity supply in Jordan. All major power generation in Jordan is via natural gas (close to 5,000 MW of capacity). In addition, there are more than 30 solar and wind power generation companies operating in Jordan with a total capacity of about 2,000 MW. Electricity prices in Jordan have generally been subsidised for residential customers at the expense of industrial customers. Prices were revised in late 2022, increasing for residential customers and reducing for small-medium industrial customers.

Figure 20 Jordan Power Prices (2021)

¢$/kWh	Average Retail (New tariff)	Estimated Cost of Production 2021	Margin	Market share
Small industrial	8.5-10	11	-10% -20%	**13%**
Medium industrial	9-10	11	-10% -20%	**17%**
Large industrial	24-33	11	120%-200%	17%
Residential <300 kWh	7	11	-40%	**32%**
Residential 300-600 kWh	14	11	30%	18%
Residential >600 kWh	28	11	150%	3%

Source: Consultant

As shown in the table above, over 60 percent of the Jordanian market will be paying prices below the estimated average cost of production (which even excludes the cost of transmission and distribution). This impacts on natural gas' potential as it may be cheaper to consume subsidised power rather than switching to natural gas for cooking, hot water and space heating especially in the residential sector.

3.2.2 NATURAL GAS AND LNG

MEMR – through NEPCO – has secured several sources of natural gas imports. This includes pipeline imports from Egypt and Mediterranean fields with long term gas supply contracts agreed with EGAS (up to 220 MMscfd, 35 MMscfd which is firm) and Chevron (290 MMscfd) for pipeline imports up to 2033 and 2035 respectively, as well as the option for LNG imports via the existing terminal at Aqaba (up to 400 MMscfd). Jordan also produces around 15-30 MMscfd from the Risha gas field.

Gas supply and hence pricing for 2020 and 2021 are mainly based on gas pipeline imports from Mediterranean fields, which is indexed to crude oil prices. The average price for natural gas to the industrial sector has been around US$7/MMBtu (around 250 JD/tonne) for 2020 and 2021. This includes an estimated US$0.7/MMBtu for the FAJR gas transmission tariff and 7 percent special sales tax. Excluding these elements, the prices for natural gas is estimated to be US$6/MMBtu or around US$5/MMBtu netback to Mediterranean fields. With the average price of crude oil at US$70/bbl in 2021, prices for natural gas supply (including tax and FAJR charges) at more recent higher crude oil prices levels (around US$100/bbl for 2022) is estimated to be around US$10/MMBtu (also assuming a proportional increase in the gas price for increases in the crude oil price).

This is considerably cheaper than spot market LNG imports, which have increased to over US$20/MMBtu due to a sharp increase in demand from the European markets given reduced Russian gas supply following the conflict in Ukraine. If Jordan were to import LNG on an oil-indexed contract (as previously with Shell) this would be lower compared to the spot market LNG prices (estimated to be around US$12-15/MMBtu), but would still be at a significant premium to the prices agreed with Noble/Chevron. The impact of higher gas prices is considered as a sensitivity in in the economic modelling further below.

Jordan therefore has a good level of medium-term well-priced gas supply security provided by the pipeline imports from Mediterranean fields and Egypt. Once the pipeline import contracts expire in 2033 and 2035, it is likely they can be extended given the abundant gas resources in the region. By 2035, global LNG supply is also expected to double from the current level of 372 mtpa. Imports via Jordan's LNG terminal will provide added security and optionality when renegotiating deals with Egypt and Mediterranean fields. Jordan is also aiming to increase its local production through additional exploration. Furthermore, as the renewable power generation increases, this may reduce the amount of gas required for power generation, freeing up gas for supply to the residential and industrial sectors. It will be important for the Government to manage this reallocation of gas supply from the power sector to the industrial and household sectors through the Gas Aggregator.

In summary, the Government of Jordan should aim to review and consider its options for gas supply and go out to the suppliers for extension of contracts and for any new contracts (e.g. long-term LNG) much in advance, around 2030, and once demand is also more certain. However, the pricing and other terms agreed will be dependent on the state of the market at the time, which should also be considered when (re)negotiating supplies (i.e. avoid negotiations in a strong sellers' market - the currently prevailing conditions).

The introduction of hydrogen will also reduce dependence on natural gas either through blending with gas supply (~20 percent, or more if appliances allow this) or replacing gas supply. As the pipeline infrastructure would be suitable for hydrogen (discussed below) the main requirement would be for household and industrial appliances to be able to use both natural gas and hydrogen (during the transition – preferred) or switch to hydrogen (which will need more detailed planning). The introduction of hydrogen on an economical basis is currently expected by the industry to approximately coincide with the timing of renegotiating the pipeline contracts (2033-2035) and is discussed in more detail below.

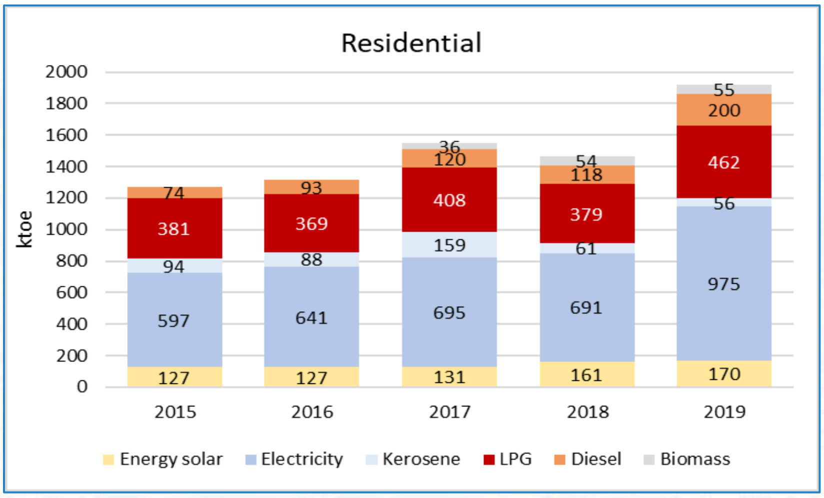
3.3 OPTIONS TO MEET ENERGY DEMAND IN AMMAN & ZARQA

In considering the case for gas supply to the residential, commercial and industrial sector in Jordan, different scenarios have been assessed to help consider the impact from current and alternative fuels and the role for gas in the short, medium and long term.

3.3.1 BASE CASE SCENARIO

The Base Case scenario assumes the current trends in energy use will continue into the medium and long term. Current trends and fuel use is discussed in more detail below.

Figure 21 Jordan Residential sector Total Fuel Consumption



Source: MEMR

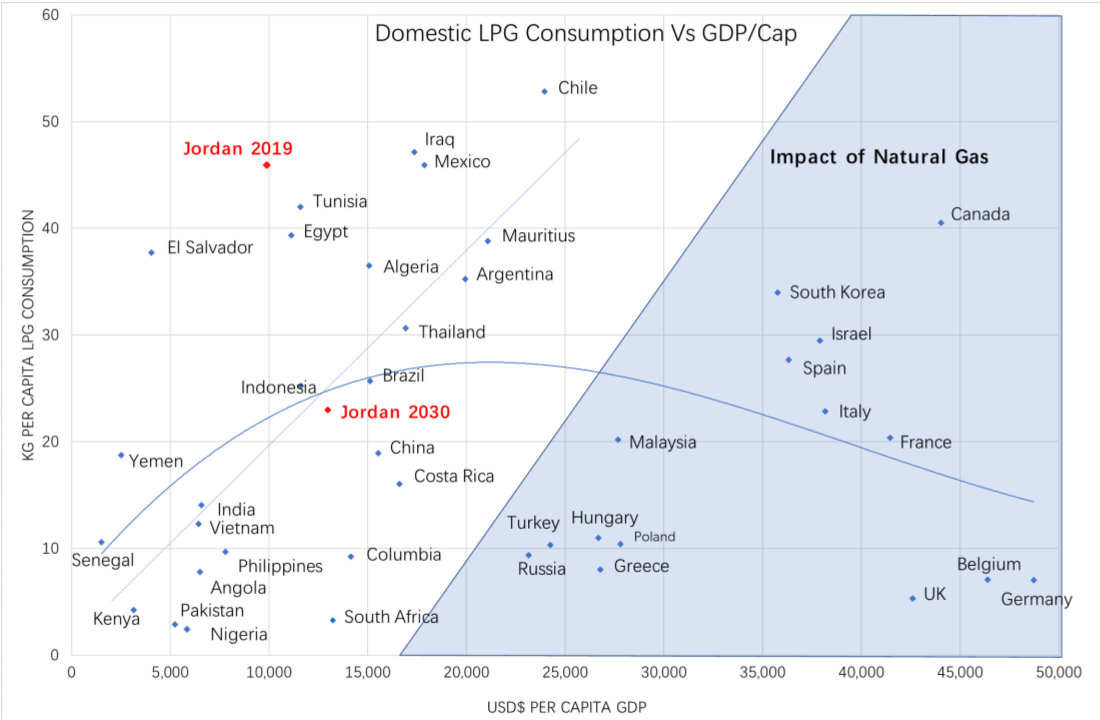
Residential sector

Electricity supply from the grid currently dominates energy consumption in the residential sector, accounting for roughly 45-50 percent of demand. In addition, solar energy (mainly rooftop) accounts for another 10 residential of consumption. Residential sector electricity demand was around 597 ktoe in 2015 and increased to 747 ktoe in 2019. Solar energy was 127 ktoe in 2015 and increased to 170 ktoe in 2019. Recent increases in electricity consumption have been driven by increasing demand for white goods and new technology, supported by both economic expansion and an increase in population. With the demand for lighting aside, in the Base Case Scenario, as the population increases and economic expansion continues, growth in electricity usage in the residential sector is expected to see further gains as new appliances, including those for cooking and heating will continue to be electric as opposed to those fuelled by oil products. Electric air conditioning units for space heating in the winter will continue to increase for minor heating, though demand for alternative fuels for central heating will increase by a larger extent.

In terms of oil products use in the residential sector, LPG is more common than Diesel and Kerosene. LPG's share in the residential fuel mix was 24 residential in 2019 (462 ktoe) down from 30 percent in 2015. Kerosene has also been declining and now makes up only 3 percent of residential fuel demand. In contrast, diesel demand has been increasing from 6 percent in 2015 to 10 percent (200 ktoe) in 2019. In Jordan LPG is used for cooking as well as for space heating. Portable space heaters as well as central space heating in buildings are used. Diesel and kerosene are also used mainly for space heating with Kerosene used mainly in mobile heaters and diesel mainly in central heating. Given the demand for heating, consumption of diesel, kerosene and LPG are higher in winter months. Seasonality would be less for LPG as this is also used for cooking.

Natural gas would primarily be for space and water heating but once available can also provide cost efficient fuel for cooking. Given the benefits of switching to natural gas, in the Base Case scenario we assume if a connection to gas is available, most residential customers would opt to switch to gas as has been seen in many other markets with high demand for space heating (as shown in blue shaded area in the chart below, where the LPG consumption is much lower in these developed countries).

Figure 22 LPG consumption vs GDP/capita and the impact of natural gas



Source: Consultant

We assume connection rates of 50-80 percent for households in each district, with Amman Qasbah and surrounding districts in West Amman being more densely populated and having more modern housing, and hence easier to connect being at the top of this range. The more industrial, remote districts with less housing, such as Jizeh, Muwaqar and Na'oor, would be at the bottom end of the range, and with Zarqa and other districts with less planning and older housing would be more difficult to connect and those would be in the middle of the range. It will not only be difficult to connect all customers, but some customers will also prefer to continue to use current fuels and appliances, where additional costs are incurred, especially in less affluent areas.

Industry

In the industrial sector, demand for electricity makes up the largest share (>30 percent) with diesel, coal and fuel oil making up the remaining share approximately evenly split. Consumption of these fuels have been broadly flat in recent years.

The introduction of gas to the sector in Jordan in 2019 has only been to a few major potash, phosphate, bromine and paper manufacturing companies located away from Amman and Zarqa. Similiar to what has been seen in other markets, where gas is available and can be used in existing industrial appliances and processes or even onsite electricity generation, it tends to rapidly replace oil products consumption given gas' cleaner, more efficient properties and cost competitiveness. We assume this would be the case in the Base Case Scenario. However, electricity use in the industrial sector has been steady and is less likely to be replaced by gas going forward for onsite power generation. This would have to be for a very large industrial customer wanting to generate its own power onsite which assumed to be limited in Jordan versus gas use for heating and feedstock. Therefore, natural gas would only replace liquid fuels provided that the equipment would allow for retrofitting or investment in new equipment can be justified by the medium-long term cost savings.

Commercial sector

The commercial sector is much smaller than the residential and industrial sectors and is mainly served by electricity (300 ktoe), most notably in 2019 when electricity consumption increased by 47 percent compared to 2018, with some demand met by LPG and diesel (60 ktoe each). With demand for lighting aside, the increase in electricity consumption is likely to be driven by increases in new end user appliances, supported by economic expansion. Like the residential sector, the increased use of electricity in the sector is a trend which is expected to continue and not be replaced by gas other than for some heating. Being slightly cheaper, currently diesel is likely to be predominantly used for heating and LPG predominantly used for cooking. As with the residential sector, there will be opportunities for some commercial customers to switch to gas for cooking and heating where new connections are available.

Transportation

Road transportation is largely served by diesel and gasoline, with gasoline becoming more popular despite the higher prices. EVs have already been introduced in the market and now make up 2 percent of the overall vehicle fleet. There is potential for the introduction of gas via CNG-fuelled vehicles. However, CNG use in road transportation is highly dependent upon access to gas and the policy and regulations which are put in place. In any case demand for CNG is usually a small part of the overall gas market limited to public sector vehicles and taxis where refilling is at a central depot. With the push for EVs in Jordan, we assume the focus will be on EVs and with gas only playing a small role as a fuel in road transportation.

3.3.2 POTENTIAL FOR HIGHER ELECTRIFICATION SCENARIO

Electricity demand has been growing in Jordan and is expected to continue to do so. In general, the increased use of electricity can be driven by users switching from alternatives, typically oil products, supported by economic expansion and increasing population. In the residential and commercial sectors, improvements in technology and household appliances may support a switch to power in space heating and cooking. New building regulations may require electric heating and cooking given their greener credentials, and developers tend to also prefer this due to lower upfront costs for electric mains and appliances versus natural gas (despite the usually higher fuel costs).

In the industrial sector, increased use of electricity can be supported by advances in technology and switching to electric powered machinery, furnaces, boilers and appliances. Electrification of industry is costly requiring modifications to equipment, but is one of the key recommended energy transition activities for Jordan. Industry has been reliance on oil, gas and coal given the lower fuel costs versus electricity. But with increasing fuel costs and, in some regions, costs added for carbon emissions, electrification has more benefits which also include falling electricity prices brought about by cheaper renewable power. However, where a fuel is required as feedstock, it cannot be replaced by electricity (apart from green hydrogen which is unlikely to be economic in the short to medium term – see section below). Onsite electricity generation using oil products is not common in Jordan, therefore major substitution of oil products with grid power is not expected.

In the road transportation sector, the introduction of electric vehicles (EVs) is already underway in Jordan and Compressed Natural Gas (CNG) as a fuel in road transportation is not expected to play a major part. Therefore, estimating the impact of higher EVs is less significant compared to the residential or industrial sectors. CNG demand for road transportation versus EVs is discussed in more detail further below.

Government policy is key to shaping national energy market. As the drive for emission reductions continues to influence the priorities for government policies and national energy strategies, some countries are looking to higher levels of electrification, and the replacement of oil products and natural gas use with electricity. Netherlands provides an example of a mature, developed energy market looking to utilize switching to electricity as one of the ways to support emissions reductions. Netherlands was a major gas producer for many years, but is not only working to reduce its domestic consumption of gas, but also its domestic production. The Dutch government has set ambitious targets for renewable electricity generation to support the switch to electricity, including plans for 11.5 GW of offshore wind capacity by 2030.

As part of the drive for both more secure and sustainable electricity generation, the Government of Jordan has actively supported renewable (wind and solar) energy projects. Efforts in this have seen the share of renewable generation rise to roughly 25 percent of total electricity output in 2021. In addition to increasing the share of renewables in the electricity generation mix, the Government is also supporting efforts to increase energy efficiency to support meeting the country's emission goals.

As discussed above, given the relatively simple switch from LPG and diesel to natural gas, this may be a preference versus a complete change to electric appliances. However, where a new appliance is required or needs to be replaced, competition with electricity will be high especially for the residential sector with subsidised electricity prices.

A higher electrification scenario would see a larger shift in demand for electric appliances for cooking and heating, especially in the residential sector. Electric heaters would replace diesel and LPG central heating and those using LPG and kerosene mobile heaters and cookers can also switch to electric appliances. This would be supported by the lower upfront costs of electric appliances, especially if subsidised power prices were to continue for the residential sector. A higher electrification scenario would therefore lead to a larger drop in potential demand for gas as a substitute for LPG and diesel in the residential and commercial sector. In industry we also assume higher electrification with furnaces, boilers and industrial heating fuel use shifting to electrical power.

The impact of higher electrification on potential gas demand and the economics of the city gas network is considered in more detail in economic modelling below. It is worth stressing that the costs of increasing the capacity of power transmission and distribution systems is often overlooked when considering total electrification costs; these can be very significant. Increased generation capacity is rarely sufficient on its own to support electrification.

3.3.3 POTENTIAL FOR HYDROGEN SCENARIO

There are different types of hydrogen categorized by colour based on how the hydrogen is produced and how emissions, if any, are managed. A brief overview of hydrogen production types is provided below:

- Black and brown hydrogen: Produced from black or brown coal (lignite) without the use of carbon capture and storage (CCS). The most common today.
- Grey hydrogen: produced by steam reforming which uses natural gas and heated steam to produce hydrogen without using CCS. This is also common today, especially in refineries.
- Blue hydrogen: Same process as grey hydrogen. However, emissions related to hydrogen production are managed via CCS.
- Turquoise hydrogen: The gas is used to produce hydrogen in the same way as grey and blue hydrogen, but the resulting carbon is solidified and stored or used.
- Green hydrogen: Produced from renewable energies (solar/wind) and therefore emission-free. Renewable electricity is used to electrolyze water, through which hydrogen and oxygen are split.
- Pink hydrogen: Produced from nuclear energy and therefore emission free.

- White Hydrogen: Hydrogen naturally present in underground fracturing deposits. However, there is currently no way to capture this form of hydrogen.

Similar to natural gas, hydrogen can be transported by pipeline, by truck in pressurized tube containers or liquefied and transported by truck or ship (like LNG although at lower temperatures). The truck and transmission pipelines used must be suitable for hydrogen requiring certain grades of steel. The blending of hydrogen in gas pipeline systems is being trialled in multiple countries across Europe, Asia as well as in the US. There are generally tolerance ranges for the percentage of hydrogen that can be mixed with gas given the strong steel specifications of current gas pipelines. This is expected to be at between 10-20 percent of hydrogen. Other types of mild steel pipelines may be suitable for 100 percent hydrogen. Although hydrogen can be transported in liquid form, the liquefaction process is expensive and energy-intensive. Hydrogen can also be transported and consumed via the production of green ammonia and methanol.

In Jordan, green hydrogen/green ammonia/e-methanol could enter the energy mix in the medium term as an alternative to fossil fuels. The technology to support the development of these green fuels exists, but is at an early stage of large-scale commercial development and costs are still much higher than for fossil fuel alternatives. Green ammonia and methanol can be used directly in industry and, as fuels, are easier to store and transport versus hydrogen. In terms of production in Jordan, unless it is being developed for exports, green hydrogen gas or liquefied would be suitable.

The production of green hydrogen from combined solar (during the day) and wind (at night) is likely to be the most attractive option for hydrogen in Jordan. However, in order to producegreen hydrogen in economically viable way, there must be solar and wind generation capacity much in excess of the market's requirements. Another major requirement is the availability of sufficient amounts of clean and fresh water supply in a suitable location, which does not impact other water users. Desalination is an option, but one which adds to the investment requirement and involves around 5 percent additional electricity consumption.

Approximately 5 GW of renewable electricity generation would be required to produce 1 million tonnes of green hydrogen. Costs for solar and wind power generation would need to be as low as ¢$1.5/kWh. At these prices, and with reduction in electrolyser costs in the medium term, and assuming high electrolyser utilisation factors (>80 percent), green hydrogen can be produced at ¢$4- 5/kWh. This is higher than the 2021 price for natural gas in Jordan of US$7/MMBtu (or ¢$2.4/kWh). Assuming a carbon price of US$50/t, if applied, adds another ¢$1/kWh to the gas price (assuming 0.2 tonne of CO2/MWh). The conversion of green hydrogen to green ammonia/methanol, via the Haber- Bosch (Haber) process (and adding carbon monoxide for methanol) would then add additional costs.

Jordan's 2020-2030 Energy Strategy outlines targets for the increased share of renewable energy in both the total energy mix and electricity mix. In the power sector, the share of renewables is targeted to rise to 31 percent of the electricity mix from around 21 percent currently. However, at present, there are no plans or targets for the introduction of hydrogen, ammonia or methanol in the Energy Strategy, though we understand MEMR are working on a hydrogen strategy and roadmap. In addition to government policy support and strategy, the costs for renewable power and electrolysers would still need to drop considerably for hydrogen production to be economically viable. Consequently, the roll out of green fuels in Jordan is not expected in the short to medium term. Therefore, it is unlikely that hydrogen will replace natural gas, but it may be possible for hydrogen to be introduced through blending with natural gas for use in the residential and commercial sectors, somewhat lowering carbon emissions.

It Is anticipated that, going forward, the incentives to introduce hydrogen for blending will increase in Jordan. As the drive for decarbonisation continues, technological advantages will lead to a drop in green hydrogen production costs in the medium term. Jordan, like Egypt and other countries with good solar and wind conditions, is expected to be able to introduce green hydrogen and potentially green ammonia and e-methanol (e.g. for transportation) into the local economy, as well as develop major export projects. Concurrently, natural gas will become an increasingly unacceptable fuel due to its emissions as the world aims to become net zero carbon by 2050. Therefore, when planning the development of long-term natural gas infrastructure project like a city gas distribution network with an operational life of >50 years, designing the infrastructure for full replacement (rather than just blending) with hydrogen will be important not only to encourage switching to a cleaner and potentially cheaper fuel, but also to prolonging the life of the infrastructure beyond the medium term.

Hydrogen pipeline transportation can cause problems with some higher strength steel pipes but some mild steel grades, e.g. API 5L Gr.B (as is planned for the 16 barg network in Jordan – see technical section below), are unlikely to have any problems. Furthermore, polyethylene pipelines (as planned for the 4 barg and 100 mbarg networks) are understood to be completely suitable for hydrogen operation at lower pressure. However, if hydrogen is to be considered for the future, it is important that pipe jointing techniques and materials are carefully chosen at the design stage. For example, galvanized/black iron pipe and mechanical jointing (other than flanges) should be avoided wherever possible. Special consideration also needs to be put into the materials used to reduce leakages through gaskets, valves or any sealing locations as hydrogen is much lighter and smaller molecules than natural gas and leaks more easily.

Switching to hydrogen would also mean that the gas appliance will have to be compatible with hydrogen. Recently, hydrogen cooking and heating appliance prototypes have been put into operation in the UK and central heating boilers which are capable of being operated efficiently on both natural gas and hydrogen will be available from European manufacturers in the near future. For Jordan, the full use of hydrogen in the residential sector is still some years away, by which time a replacement of the existing or even new appliance would be needed. The replacements can be to appliances which are suitable for both gases.

Within the industrial sector, the steel, aluminium, chemicals and refining industries are the largest users of energy. As with the residential and commercial sectors, hydrogen blending with natural gas may be possible. There are some heavy industries where the introduction of hydrogen is unlikely to be the best option for achieving carbon emission reductions. In the cement sector, for example, a combination of bio energy and CCUS could offer a more cost effective and technically advantageous way to meet emission reduction targets. Hydrogen production and supply directly to industrial zones could be an option instead of blending with natural gas as the industrial sector aims to significantly reduce its carbon emissions in the medium to long term. This may include local green hydrogen production located close to and for the sole use of the site. This would be dependent on the sun/wind conditions near the site and the cost of production versus production elsewhere and cost of transportation.

There is good potential to supply hydrogen to the existing mining sector for heavy machinery as well as more generally to the transport/mobility sector. The transport sector, namely road, trains, mining, shipping and aviation, is estimated to represent 25-40 percent of the demand for hydrogen by 2040. Hydrogen is likely to be deployed at scale in markets where it reaches cost-parity with fossil fuel applications, specifically forklifts, cars, mining trucks and rail (in specific geographies) expected in the late 2020s and trucks by 2030/mid-2030s. Therefore, there will be opportunities for the introduction of hydrogen in the transportation sector in Jordan, however, as discussed above, natural gas is not expected to play a major part in this sector and hence substitution of natural gas by hydrogen is a less significant issue when considering city gas networks, other than one day these networks may also be able to transport additional hydrogen for refuelling in transportation within the city.

As hydrogen would be directly replacing demand for natural gas initially through blending and eventually full replacement, the projected demand for natural gas (on an energy equivalent basis) would also serve as a projection for demand for hydrogen. However, because hydrogen is so much lighter, or less dense (1,000 Btu/scf for natural gas versus 300 Btu/scf for hydrogen), it will be necessary to transport around 3 times the volume of hydrogen compared to natural gas in order to get the same amount of energy. This could be managed in the planned pipeline system by changing the compressor stations and increasing the pressure at the time of switching to hydrogen.

Switching over would need to be done one area at a time, shutting off the area from natural gas supply and connecting to the hydrogen supplied network, or through increasing the hydrogen content in the network until it reaches 100 percent hydrogen. At such time, customer appliances are expected to be compatible with both natural gas and hydrogen as part of the transition. If the percent hydrogen can be simply increased this would make the network transition much easier.

This would mean all existing gas customers on the network would need to switch to hydrogen as there would be no option for natural gas supply through the network once switched to hydrogen. This may be more challenging for some industrial customers within residential sectors, as hydrogen compatible appliances may not be as common. For these customers, switching to electricity may be preferred or to a fuel which can be delivered by truck and contained in onsite storage.

It may be the case that the 3 times higher volumes required to be transported because of hydrogen's lower energy density may offset any reduction in demand for customers moving away from the city gas network to electricity, for example. This would, of course, need to be reflected in the updated transportation tariffs. By this point, the capital costs for the pipeline should be repaid, with mainly operational costs to be recovered, so the impact on end user prices will likely be limited.

A more detailed study is needed to plan the change in network operations for a transition from natural gas to hydrogen and the feasibility of hydrogen use, particularly for industrial customers located in the residential areas.

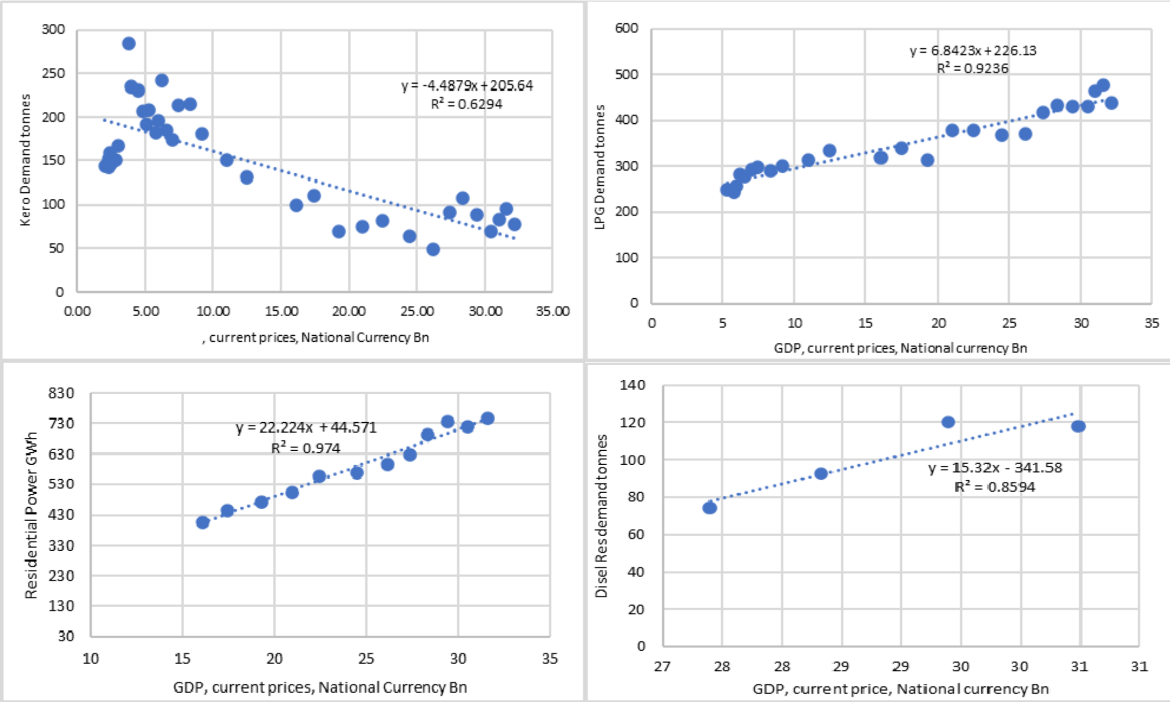
3.4 POTENTIAL FOR GAS SUPPLY SCENARIO

3.4.1 MARKET ANALYSIS (BASE CASE SCENARIO)

3.4.1.1 RESIDENTIAL SECTOR POTENTIAL GAS DEMAND

In order to estimate residential gas demand in Amman and Zarqa, we started by analysing and projecting the demand for all fuels consumed in the residential sector across Jordan. Generally, fuel consumption in most sectors of the economy is closely linked to changes in GDP and population. As the population increases and incomes of families increase then energy consumption also increases and vice versa. For cleaner, more practical and hence more costly fuels, such as electricity and LPG, as GDP increases, people switch away from other less efficient and more polluting fuels such as kerosene and diesel. Historical trends between GDP and fuel consumption in Jordan is shown in the chart below.

Figure 23 Correlation between Residential fuel consumption and GDP



Source: Consultant (1997-2021 for LPG+Kero (total), 2008-2019 for Electricity, 2015-2019 for Diesel (residential))

We project fuel demand based on this historical trend with GDP and population. We assume GDP and population continue to grow at rates seen historically. For the period until 2026, we use the projections provided by the International Monetary Fund, World Economic Outlook (October 2021). Projections are provided in the table below.

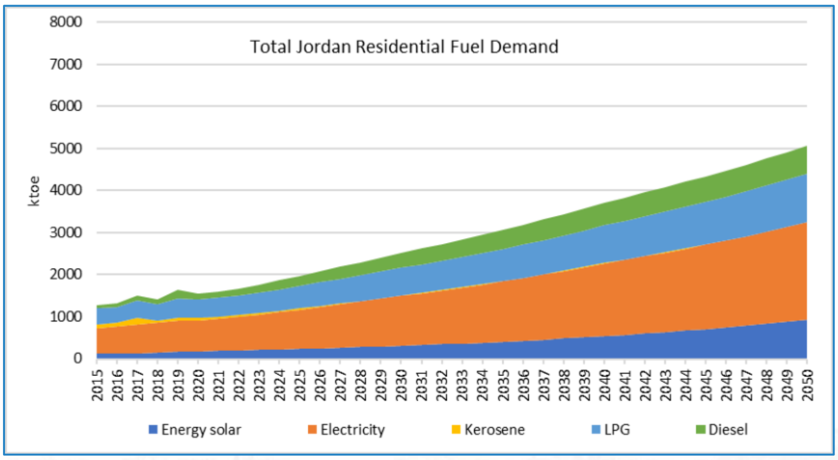
Figure 24 Historical and Projected Jordan GDP (Current prices) and Population

2025+ = Forecast	2018	2019	2020	2025	2030	2035	2040	2045	2050
GDP, JD Billion	30.5	31.6	31	39.9	51.4	62.5	76	88.1	102.2
Population, million	10.5	10.7	10.9	11.4	11.9	12.5	13.2	13.8	14.5
GDP/Capita	2,905	2,953	2,844	3,500	4,319	5,000	5,758	6,384	7,048
GDP growth rate	4%	4%	-2%	5%	5%	4%	4%	3%	3%
Population growth rate	3%	2%	2%	1%	1%	1%	1%	1%	1%

Source: Consultant

Base Case Scenario projections of fuel demand using the above GDP and population growth rates are shown in the chart below. Total residential sector fuel demand is projected to increase from around 1,600 ktoe in 2020 to 2,500 ktoe by 2030 reaching just over 5,000 ktoe in 2050. Electricity and Solar are projected to make up over 60 percent of total demand with close to 25 percent provided by LPG, assuming no gas substitution.

Figure 25 Total Residential Sector Fuel Demand in Jordan – Base Case



Source: Consultant (2015-2019 = Actual, 2020-2050 = Projection)

The next step to estimating gas demand for Amman and Zarqa is to estimate how much of the total Jordan fuel consumption would be within Amman and Zarqa and within each of the districts in Amman and Zarqa. Without the detailed breakdown of this data, we have used 2021 population and household data as a proxy to split fuel demand. We assume 60 percent of the Jordan population resides in Amman or Zarqa, and of this 75 percent is in Amman and 25 percent in Zarqa, based on current estimates. Then we proportionately split the projected demand for each fuel by the number of households within each district in Amman and Zarqa. The number of households are projected to increase in line with assumed growth in population keeping the proportion unchanged across and within Amman and Zarqa.

Figure 26 Total Households in Districts in Amman and Zarqa

	2015	2021	2025	2030	2035	2040	2045	2050
Amman	188,194	217,989	222,347	232,815	244,691	257,172	270,291	284,078
Marka	202,417	234,463	239,150	250,409	263,183	276,608	290,717	305,547
Alquaismeh	117,598	136,217	138,940	145,481	152,902	160,702	168,899	177,515
Al-Jami'ah	174,764	202,433	206,480	216,201	227,229	238,820	251,002	263,806
Wadi Essier	86,516	100,213	102,216	107,029	112,488	118,226	124,257	130,595
Sahab	32,222	37,324	38,070	39,862	41,896	44,033	46,279	48,640
Jizeh	20,657	23,928	24,406	25,555	26,859	28,229	29,669	31,182
Muwaqar	15,746	18,239	18,604	19,479	20,473	21,517	22,615	23,769
Na'oor	27,225	31,534	32,164	33,679	35,397	37,202	39,100	41,094
Zarqa	168,781	195,506	205,436	215,108	226,080	237,613	249,734	262,472
Russeifa	94,674	109,666	115,236	120,661	126,816	133,285	140,084	147,230
Hashemiyah	16,531	19,148	20,121	21,068	22,142	23,272	24,459	25,707
Total Amman	865,339	1,002,340	1,022,377	1,070,511	1,125,118	1,182,510	1,242,830	1,306,227
Total Zarqa	279,986	324,320	340,792	356,837	375,039	394,170	414,277	435,409

Source: MEMR

We then assumed a percentage of each fuel which can be switched to natural gas, as shown below, based on our own estimates taking into account switching rates in other countries as well as the estimates in the 2005 CRA study. *Note these estimates should be refined through a more detailed survey.*

Figure 27 Percentage of Fuel Substitution by Natural Gas

Fuel	Substitution to gas	Fuel	Substitution to gas
Energy solar	0%	LPG	65%
Electricity	20%	Diesel	80%
Kerosene	20%		

Source: Consultant

This assumes no substitution of solar energy (mainly for hot water heating), 20 percent substitution of kerosene (for mobile space heating) as well as for electricity (from air conditioner and similar appliances), 65 percent substitution of LPG (for central and mobile space heating as well as cooking) and 80 percent substitution of diesel (for central space heating). The substitution rates are higher for diesel as the investment in a new communal boiler across a number of apartments would be easier to make given the large savings of gas versus diesel. The substitution rates are lower for LPG and much lower for kerosene as some demand for these fuels (most in the case of kerosene) is for mobile space heating and therefore it is less likely that natural gas can replace those other than switching to natural gas for central space heating. Unlike LPG cylinders or CNG for vehicles, compressed natural gas (CNG) cylinders are not common for household use. Part of the issue is the challenges of refilling the CNG cylinders which can be done at petrol stations for vehicles and at special bottling plants for LPG, but are not common for household cylinders for CNG (as natural gas is usually piped to households). Substitution is very low for electricity as only a small proportion of electricity is assumed to be for AC inverter household heating which can be replaced by gas. No substitution of solar heating is assumed as with the upfront investment made this is essentially free.

We also assumed a total percentage of households that can switch to natural gas in a given district and the roll-outfor each year, as shown in the table below. This is based on the phasing of the network development driven the development of the 16 barg pipeline network and more generally the different types and number of housing as well as the ease of pipeline connections in each district. Switching to natural gas is assumed to start in Zarqa, Hashemiyah, followed by Alquaismeh, Muwaqar, Sahab and then Russiefa, Marka and Amman. The connection of existing households is assumed to be over a 4-6 year period for each district, reaching an assumed maximum connection by 2031. Post 2031 new connections are assumed from growing population and new households, but this is less than demand from existing households.

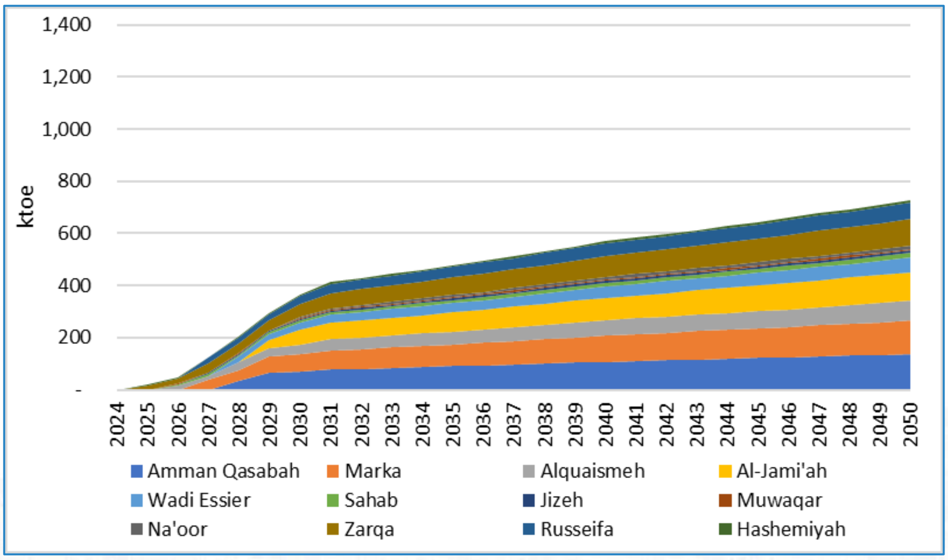
Figure 28 Percentage of Existing Households Substitution to Natural Gas

	2025	2026	2027	2028	2029	2030	2031
Amman	0%	0%	0%	42%	74%	74%	80%
Marka	0%	0%	43%	43%	65%	65%	70%
Alquaismeh	0%	32%	32%	59%	59%	65%	70%
Al-Jami'ah	0%	0%	0%	0%	37%	65%	70%
Wadi Essier	0%	0%	0%	56%	56%	65%	70%
Sahab	0%	37%	37%	37%	37%	56%	60%
Jizeh	0%	0%	46%	46%	46%	46%	50%
Muwaqar	0%	46%	46%	46%	46%	46%	50%
Na'oor	0%	0%	0%	0%	0%	46%	50%
Zarqa	27%	27%	48%	48%	48%	58%	65%
Russeifa	0%	0%	47%	47%	47%	63%	70%
Hashemiyah	54%	54%	54%	54%	54%	54%	60%

Source: Consultant

Applying the fuel demand split for each district and assuming a substitution of each fuel by natural gas as well as the percentage of households switching over time gives the natural gas demand projections for each district as shown in the chart below.

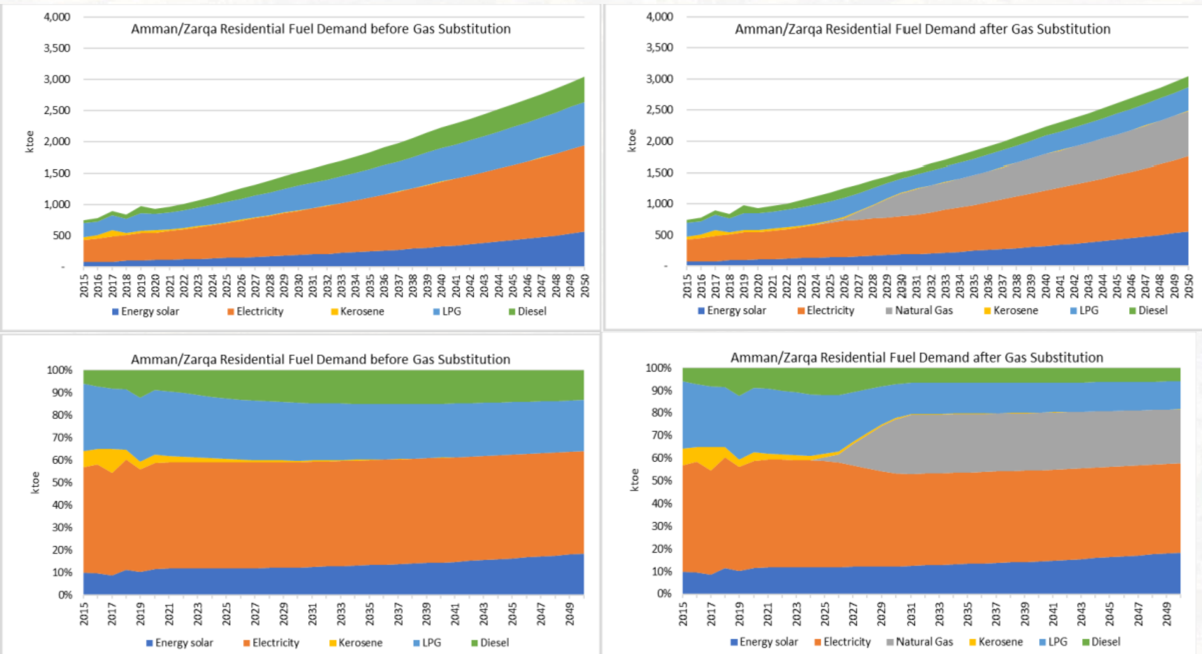
Figure 29 Natural Gas demand by district in Amman and Zarqa



Source: Consultant

Comparing residential fuel demand in Amman and Zarqa before and after switching to natural gas is shown below. We project that natural gas can make up around 25 percent of total fuel demand in the residential sector substituting mainly LPG and diesel. Demand for electricity will still be key. Note that the analysis does not include switching from LPG and diesel to other fuels (mainly expected to be electricity). Therefore, the LPG and diesel remaining after gas substitution could be lower than shown in the charts below.

Figure 30 Natural Gas demand versus Other Fuels in Amman and Zarqa



Source: Consultant

A separate scenario for higher electrification is considered further below.

3.4.1.2 INDUSTRIAL AND COMMERCIAL SECTORS POTENTIAL GAS DEMAND

Estimating gas demand in the industrial sector has been more challenging due to the lack of data on the breakdown of fuel consumption for each customer (generally not available) or for each district or for Amman versus Zarqa. A more detailed assessment of industrial demand needs to be undertaken.

We have estimated industrial demand for each district in Amman and Zarqa based on benchmarking to similar major industrial clusters in Egypt and taking into account the relative industrialisation (versus residential/commercial) within each district. The assumed pipeline design capacity and daily consumption is shown below.

Figure 31 Estimated Industrial Demand for Natural Gas

District	Assumption	Peak Load m^3/hr	Peak Load m^3/day	Demand MMscfd
	Total Industry within residential zones	*11,500*	*115,000*	
Amman	10% x within residential zones	1,150	11,500	0
Marka	25% x within residential zones	2,875	28,750	1
Alquaismeh	30% x within residential zones	3,450	34,500	1
Al-Jami'ah	3% x within residential zones	345	3,450	0
Wadi Essier	17% x within residential zones	1,955	19,550	1
Russeifa	5% x within residential zones	575	5,750	0
Na'oor	10% x within residential zones	1,150	11,500	0
Sahab	King Abd Alla the Second Industrial Area	5,000	50,000	2
Jizeh	Al Qastal, Airport & Al Mashatta Factories	13,000	130,000	5
Muwaqar	Muwaqar Industrial Area plus Northern Cement	30,000	360,000	13
Zarqa	Zarqa free zone and planned plus Wadi Al Osh IA	20,000	200,000	7
Hashemiyah	Steel factories plus Arabia Cement (White)	20,000	320,000	11
	Total	**99,500**	**1,175,000**	**41**

Source: Consultant

We undertook a cross-check using a list of around 120 manufacturers and their locations provided by MEMR including cement, steel and other metals factories and pharmaceuticals (and cosmetics) and Chemicals (including fertiliser, plastics, soap) manufacturers. We benchmarked typical gas demand for these customers in each sub-sector to more detailed customer data obtained by the Consultant from other countries to provide an approximate gas consumption for a medium sized customers in these industries.

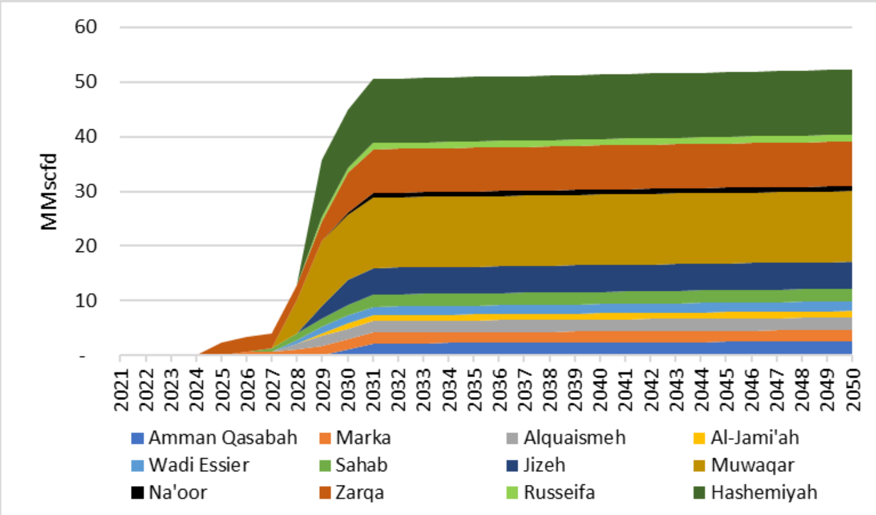
Both approaches give similar results of existing industrial demand of around 40 MMscfd or around 300 ktoe, which is about 50 percent of total fuel oil (277 ktoe), diesel (140 ktoe), coal (130 ktoe) and LPG (13 ktoe) demand in industry based on 2019 data.

The connection of existing industrial customers, similiar to residential customers, is assumed to be over a 6 year period, and largely following the development of the 16 barg pipeline (discussed in the technical analysis in the next section). In places where industrial clusters are more easily connected, such as Sahab and Muwaqar, we assumed this would be prioritised in order to provide larger gas volumes, which can reduce costs for smaller consumers in the early years.

In terms of new industrial gas demand, this is assumed to take place mainly in the new Industrial Zones being planned. Further growth in demand may be through new Industrial Zones which are likely to be located in new areas along the planned 16 barg transmission line and therefore impact less on any city gas distribution network within the existing developed areas, other than to improve the cost of supply initially via the 16 barg pipeline.

In terms of Commercial demand, this has been estimated at 250,000 m^3/day, based on data provided by MEMR on number of hotels and commercial customers, and is split across the various districts with Amman assumed to make up 20 percent of demand, and 10 percenteach from Marka, Alquaismeh, Al-Jami'ah, Wadi Essier, Zarqa and Russeifa, with the rest making up the rest of the share (less than 5 percent each). This gives a total Commercial demand of 9 MMscfd, which is about 50 percent of total LPG (65 ktoe) and diesel (65 ktoe) consumption in the services sector based on 2019 data. Commercial demand is assumed to increase slightly with the increase in the number of households in each district.

Figure 32 Industrial and Commercial Natural Gas Demand in Amman and Zarqa



Source: Consultant

3.4.1.3 TRANSPORTATION SECTOR POTENTIAL GAS DEMAND

Natural gas use as a fuel in the transport sector is mainly through CNG or LNG. LNG and CNG differ in how they are stored on the vehicle. In terms of distribution and fuelling infrastructure, CNG and LNG differ considerably. CNG uses natural gas in a gaseous state and typically requires a well-developed natural gas pipeline transmission and distribution network. It is more widely adopted than LNG as a fuel in transport as it is used in cars and buses with more options for fuelling points in and around populated areas. Where gas pipelines are not in place, LNG trucking (via LNG road tanker) to LNG storage depots around the country is an alternative to CNG. As this may be less economical, LNG as a fuel in transport is better suited to Heavy Goods Vehicles (HGVs) travelling long distances without having to stop to refuel so often.

Figure 33 Examples of Natural Gas Demand in Road Transportation, 2018

Country	Number of NGVs	Gas consumption (MMscf/yr)	NGVs as % of total vehicle population
China	6,080,000	734,905	3.70%
Iran	4,502,000	285,345	31.90%
India	3,090,139	104,886	1.50%
Pakistan	3,000,000	69,217	14.00%
Argentina	2,185,000	101,001	9.50%
Brazil	1,859,300	63,214	2.30%
Italy	1,004,982	47,675	2.00%
Uzbekistan	815,000	3,532	40.80%
Colombia	571,668	25,074	4.70%
Thailand	474,486	101,707	1.50%

Source: IANGV, Oxford Institute for Energy Studies (Apr 2019)

As shown above, CNG in road transport is significant in many countries and has been growing globally driven by government programs and investment mainly in fleets of CNG-based buses and taxis. CNG refuelling is easier for these vehicles as they tend to be based at central depots where the refuelling can take place. In some countries CNG use in private passenger vehicles has also taken off given the significant savings compared to diesel and gasoline. The major challenge would be refuelling as services stations across the city or country would need to offer CNG refuelling.

In order to project gas demand for road transportation in Jordan we start by projecting the demand for new vehicles each year based on the historical trend with GDP and using the same GDP projections discussed above. Then, we made an assumption about the percentage of electric vehicles or CNG-fuelled each year with some historical data for EVs. Note that there are already close to 32,000 EVs in the Jordan market based on 2021 data from MEMR.

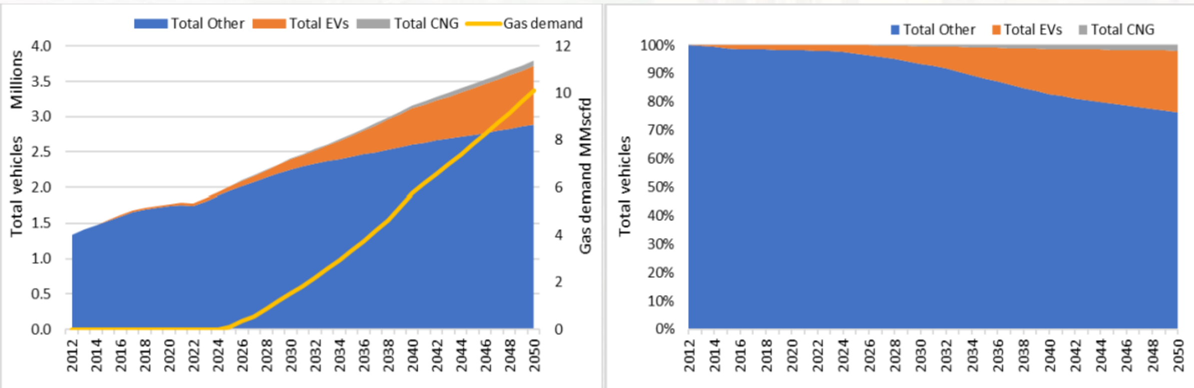
Figure 34 Percentage of new vehicles assumed to be CNG or LNG Fuelled in Jordan

	2017	2018	2019	2020	2021	2025	2030	2040	2050
Total vehicles	1,681,327	1,720,331	1,749,029	1,771,541	1,788,442	2,112,945	2,527,459	3,294,790	3,947,063
% of new vehicles which are EVs or CNG									
Total Evs	7%	4%	6%	5%	4%	15%	30%	50%	50%
Total CNG	0%	0%	0%	0%	0%	1%	3%	5%	5%
Total number of EVs and CNG vehicles									
Total EVs	26,472	28,191	30,041	31,098	31,803	61,270	148,324	504,678	830,814
Total CNG	-	-	-	-	-	8,315	49,767	126,500	191,727
EV, CNG and Petrol vehicles share of total fleet									
Total Other	98%	98%	98%	98%	98%	97%	93%	83%	76%
Total EVs	2%	2%	2%	2%	2%	3%	6%	16%	22%
Total CNG	0%	0%	0%	0%	0%	0%	0%	1%	2%
CNG demand	MMscfd				-	0.4	2	6	10

Source: Consultant

Based on these assumptions, we project that there could be 12,000 CNG vehicles in Jordan 2030 rising to 40,000 by 2040 and 75,000 by 2050. This is still a small share of the overall fleet at 2 percent by 2050. Assuming gas consumption of 1,375 m^3/year (1 tonne per year) for smaller vehicles this would require gas supply of around 2 MMscfd in 2030, rising to 6 MMscf in 2040 and 10 MMscfd by 2050.

Figure 35 Projected Vehicle Fleet in Jordan including EVs and CNG



Source: Consultant

Projecting gas demand for road transportation is challenging in a new market as much of this would be dependent upon government policy. In most cases, gas use in transportation will only make up a small share of the overall gas consumption. The costs of vehicle conversion are too high and hydrogen (fuel cells) or EVs are the future for decarbonisation of this sector. Nevertheless, some distribution/logistics and public vehicle companies and governments are still investing in CNG fuelled vehicles. This may continue for up until EVs and hydrogen are fully adopted expected post-2040.

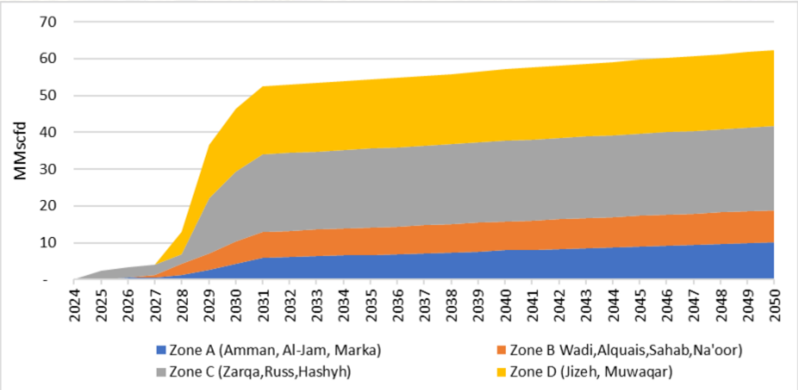
3.4.1.4 TOTAL POTENTIAL GAS DEMAND

The residential, industrial, commercial and transport gas demand estimates discussed above are aggregated and shown below. We further assume grouping of districts within Amman and Zarqa into a few different Gas Distribution Zones (GDZs). This is based on the proximity to the main and 16 barg transmission pipeline and attempts to evenly split the overall expected gas demand across each zone to provide potential city gas network developers with incentives to bid for more than one major franchise zone. The zoning which has been assumed is as follows:

- Zone A – Amman Qasabah, Al-Jami'ah and Marka
- Zone B – Wadi Essier, Alquaismeh, Sahab and Na'oor
- Zone C – Zarqa, Russeifa and Hashemiyah
- Zone D – Jizeh and Muwaqar

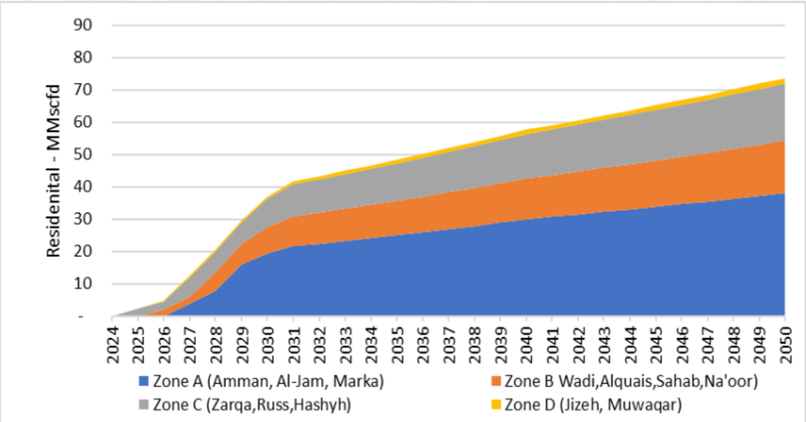
As shown below, Zone C and D are mainly industrial versus Zone A and Zone B which are mainly residential. The impact of this will be discussed in more detail in Business Model section of the report.

Figure 36 Industrial, Commercial and Transport Demand in Amman and Zarqa by Zone



Source: Consultant

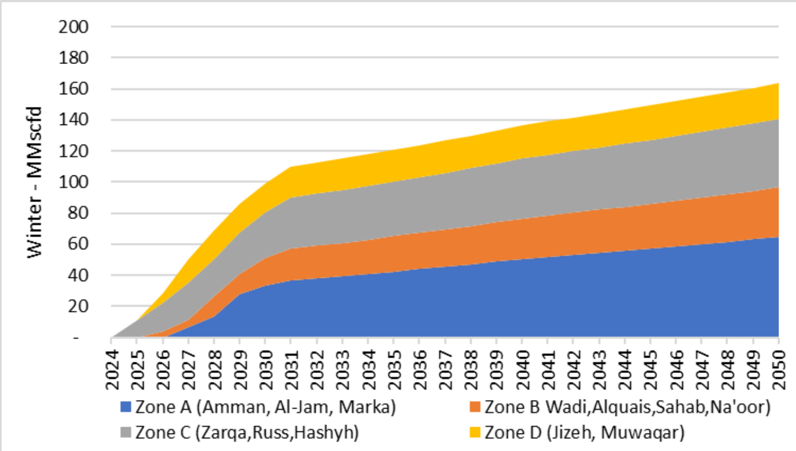
Figure 37 Residential Demand in Amman and Zarqa by Zone



Source: Consultant

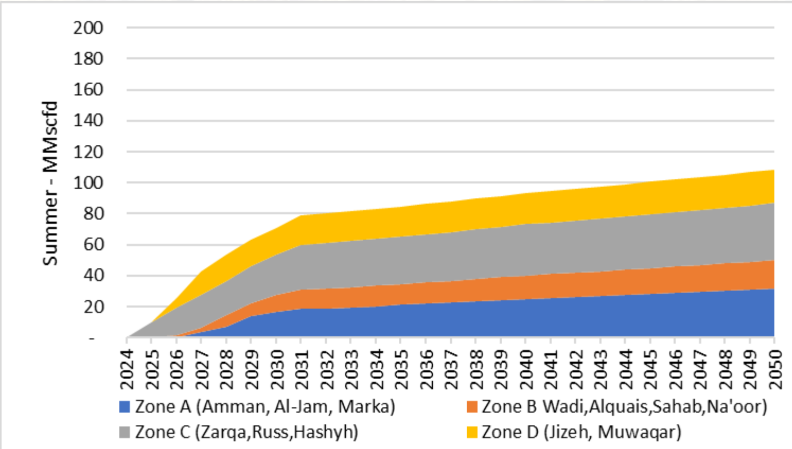
We further disaggregated demand into winter and sumer demand, with the demand in Amman being a bit more seasonal than in Zarqa. The summer/winter demand split for Amman is assumed at 70:30, whereas it is 60:40 for Zarqa. The summer/winter demand split is undertaken mainly to understand the impact on the technical design and operations of the pipeline network. This would not impact on the economics which is based on average demand aiming to keep tariffs as constant as possible over the year. Total gas demand for Amman and Zarqa for winter and summer is shown in the charts below.

Figure 38 Total Gas Demand in Amman and Zarqa by Zone – Winter



Source: Consultant

Figure 39 Total Gas Demand in Amman and Zarqa by Zone – Summer



Source: Consultant

3.4.1.5 CARBON EMISSION REDUCTION

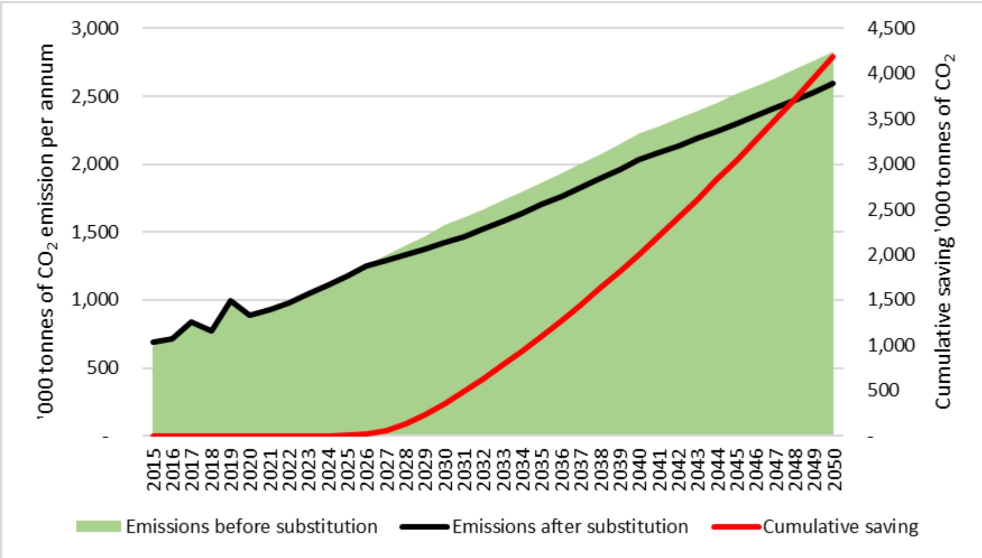
We have undertaken further analysis to estimate the carbon emission savings from customers located on the city gas network moving from current liquid fuels to natural gas. As discussed above, we project fuel demand by fuel and by sector and assume how much of this can be switched to natural gas. We estimate the emission savings from switchable fuel demand based on the following assumptions for tonnes of CO_2 produced for a tonne of fuel consumed.

Assumptions	kg CO2/TJ	toe/t	MJ/t	t CO2/t
Electricity	56600	1.332	55788	2.37
Kerosene	71400	1.056	44,196	2.99
LPG	63100	1.126	47,156	2.64
Diesel	73300	1.034	43,308	3.07
Fuel Oil	76000	0.985	41,236	3.18
Coal	94600	0.665	27,842	3.96
Natural Gas	56600	1.332	55,788	2.37

Source: Consultant, Sustainable Energy Authority of Ireland

As discussed above, residential sector emission reductions are based on reduced consumption of electricity, diesel and LPG. Industrial sector emission reductions are based on reduced consumption of diesel, fuel oil and coal. This gives the following annual and cumulative carbon emission savings.

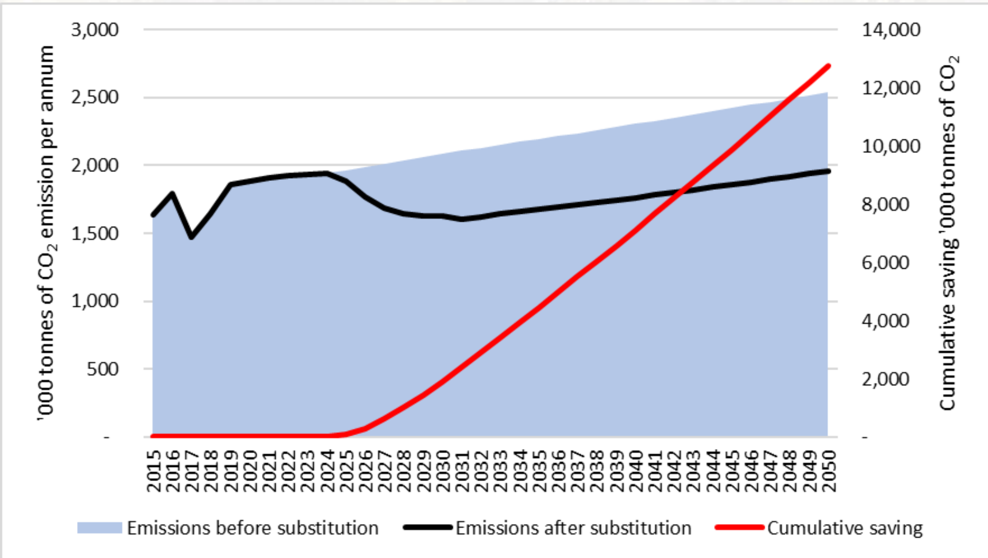
Figure 40 Residential Sector Carbon Emissions Reductions



Source: Consultant

For the residential sector this amounts to a savings of around 10 percent every year or from 100,000 tonnes per year growing to 240,000 tonnes per year by 2050.

Figure 41 Industrial Sector Carbon Emissions Reductions



Source: Consultant

For the industrial sector this amounts to a savings of around 20-25 percent every year or from 400,000 tonnes per year growing to 580,000 tonnes per year by 2050.

In 2021, Jordan's total CO_2 emissions was estimated at 24.3 million tonnes. Therefore, the development of the city gas project would save Jordan 2 percentto 4 percent of total CO_2 emissions.

3.4.2 TECHNICAL ANALYSIS (BASE CASE SCENARIO)

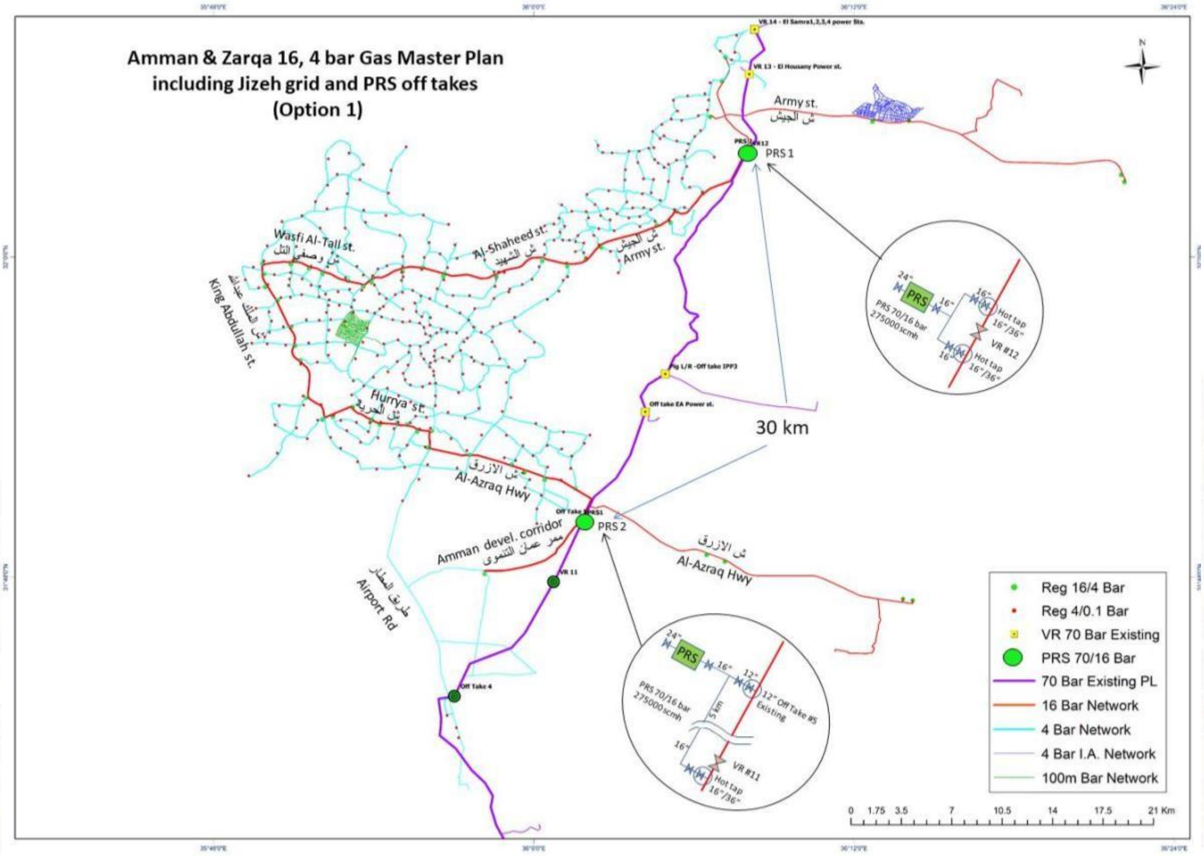
3.4.2.1 TECHNICAL SPECIFICATIONS OF CITY GAS PIPELINE NETWORK

The city gas distribution network in Amman and Zarqa is assumed to comprise of two city gate stations (one located at Zarqa, the other at Sahab) where gas is received from the 70 barg FAJR gas transmission pipeline and be subjected to filtration, regulation (70/16 barg), odorization, and metering processes. The natural gas is then further distributed to the industrial, commercial and residential customers through:

5) Carbon steel high pressure distribution network (MAOP 16barg) – for large industrial and 4 barg network
    - With District Pressure Regulators (DRS 16/4 barg, 10,000 m^3/hr, and 5,000 m^3/hr)
6) Polyethylene (PE) networks (nominally 4 barg) – for small industrial customers and 0.1 barg network
    - With Service Regulators (SR 4/100 mbarg, 1,000 m^3/hr)
7) Polyethylene (PE) networks (nominally 100 mbarg) – for residential customers
8) Galvanized/black iron pipes, and/or copper tubes, and household meters and regulators (50-100/20 mbarg) for gas supplied at 20 mbarg for household appliances.

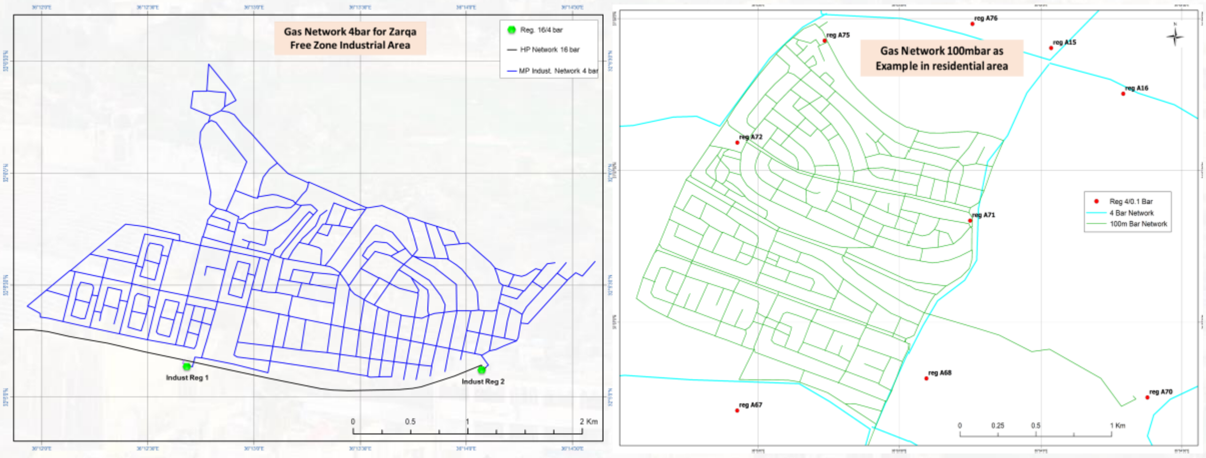
The 16 barg, 4 barg and 100 mbarg pipeline networks are shown in the map below and have been modelled using Synergi Gas software. A 7 barg network was found to be sub-optimal as a replacement for the 16 barg or the 4 barg network. Versus the 16 barg network a pipeline diameter in excess of 36” of HDPE- PE100 would be required, while the maximum size currently approved for use in natural gas is 400 mm (equivalent to 13” internal diameter). Versus the 4 barg network, the 4 barg PE pipes are more flexible in operation due to the difference in pressure level and PE material and require less proximity than the 7 barg network.

Figure 42 Amman and Zarqa Gas Pipeline 16, 4 and 0.1 barg Pipeline Network



Source: Consultant

Figure 43 Examples of the 4 and 0.1 barg Pipeline Network



Source: Consultant

The two Pressure Reduction Stations (Zarqa and Sahab) are assumed to have control systems registering all data, 24 hrs a day (flow, pressures, temperatures and gas analysis) and can be connected to the FAJR SCADA system. The design outlet flow from each PRS is around 275,000 m^3/hr.

District Pressure Regulators and Service Regulators are installed along the networks at appropriate locations to cater to the loads and pressure requirements of domestic commercial and industrial customers in the area. Isolation valves are installed along the networks at designated points/locations to provide control and isolation means as may be needed during operation. A SCADA system would register the pressure data and temperatures at inlet and outlet of the 16/4 barg regulators as well as data of large industrial consumers (flow, pressures and temperatures).

Security of gas supply to end users is ensured by dividing the gas network into loops that are linked through minimum of two service regulators. Therefore, in case ofregulator malfunction, the second regulator can still compensate for the demand till repair is completed orcorrective action is taken.

Detailed maps including the exact pipelines network information (such as location, depth, crossing with other utilities, …etc.) to locate any part/parts of the underground installations (such as pipes, valves, crossings, etc.) will be developed as part of the construction planning and handed over to the operations entity upon completion. A summary of the technical pipelines specifications includes:

- City gate pressure reduction stations (40-80/16 barg, capacity 275,000 m^3 /hr)
- Number of the city gate reduction stations (2)
- Maximum allowable operating pressure for the underground steel grid (16 barg)
- Material of the underground steel piping (API-5L- Gr.B, ERW, 3L PE coated – suitable for hydrogen)
- Wall thickness of the underground steel piping considering proximity (0.5")
- Diameters of the underground steel grid (24", 12", 10", 8")
- Estimated total length of the underground steel grid (142 km)
- Estimated number of 16/04 barg twin stream district regulators (65)
- Estimated number of 04/0.1 barg twin stream service regulators (400)
- Operating pressures of the underground polyethylene network (4 barg, and 100 mbarg)
- Polyethylene material with operating pressure (4 barg and 100 mbarg) are Medium Density polyethylene (MD-PE80 – suitable for hydrogen)
- Diameters of the 4barg polyethylene network (315mm, 250mm, 180mm, 125mm), SDRs (11)
- Estimated total length of the 4barg underground polyethylene network (440 km)
- Diameters of the 0.1 barg underground polyethylene network (250mm, 180mm, 125mm, 90mm, 63mm, 32mm), SDR (17.6)
- Estimated total length of the 0.1 barg underground polyethylene network (11,151 km)

Key safety standards for developing gas pipeline networks are provided by Institution of Gas Engineers & Managers (IGEM) below. An Environmental and Social Impact Assessment (ESIA) for the gas networks in Amman and Zarqa needs to be conducted. Description of environmental and social risks is provided in the Appendix.

Figure 44 Safety proximities for gas pipelines

PE					
Type of Main	Diameter of Main (mm)	Minimum Building Proximity Distance (m)			
		≤ 75 mbar	> 75 mbar ≤ 2 bar	> 2 bar ≤ 5.5 bar	> 5.5 bar ≤ 7 bar
PE Non-Inserted	Up to 125	0.25	2	4	6
	126 to 355	1	2	4	6
	356 to 500	1	2	4	8
	501 to 1000	1	5	13	15
PE Inserted	Up to 125	0.25	1	2	3
	126 to 355	0.5	1	2	3
	356 to 500	0.5	1	2	3
	501 to 1000	0.5	1	3	3
STEEL					
Type of Main	Wall Thickness of Main (mm)	Minimum Building Proximity Distance (m)			
		≤ 75 mbar	> 75 mbar ≤ 2 bar	> 2 bar ≤ 7 bar	> 7 bar ≤ 16 bar
Steel	t ≤ 9.52	0.25	1	3	13
	9.52 < t ≤ 11.91	0.25	1	3	6
	11.91 < t	0.25	1	3	3

Source: IGEM/TD/3 Edition 5

A property and appliance survey (P&A) would be conducted by the project/licenced company during which each building and property in the project area shall be visited by a well-trained technician to assess its apparent suitability for gas connection. Assessment factors shall include apparent condition of the building, number of accessible properties, potential route of external gas piping (skylight, staircase, or external wall), the condition of consumer's appliance(s), location of appliance(s), fluing, and ventilation possibilities (especially for water heaters), and potential route of piping inside the property. The technician would be able to advise the potential consumer(s) what needs to be done to be ready for gas connection.

Each customer shall have a unique "customer reference number – CRN" which is a number driven from "City-District-Sector-Block/cluster of buildings-Building-Apartment". This shall be crucial data for customer billing, operation, and further customer service purposes.

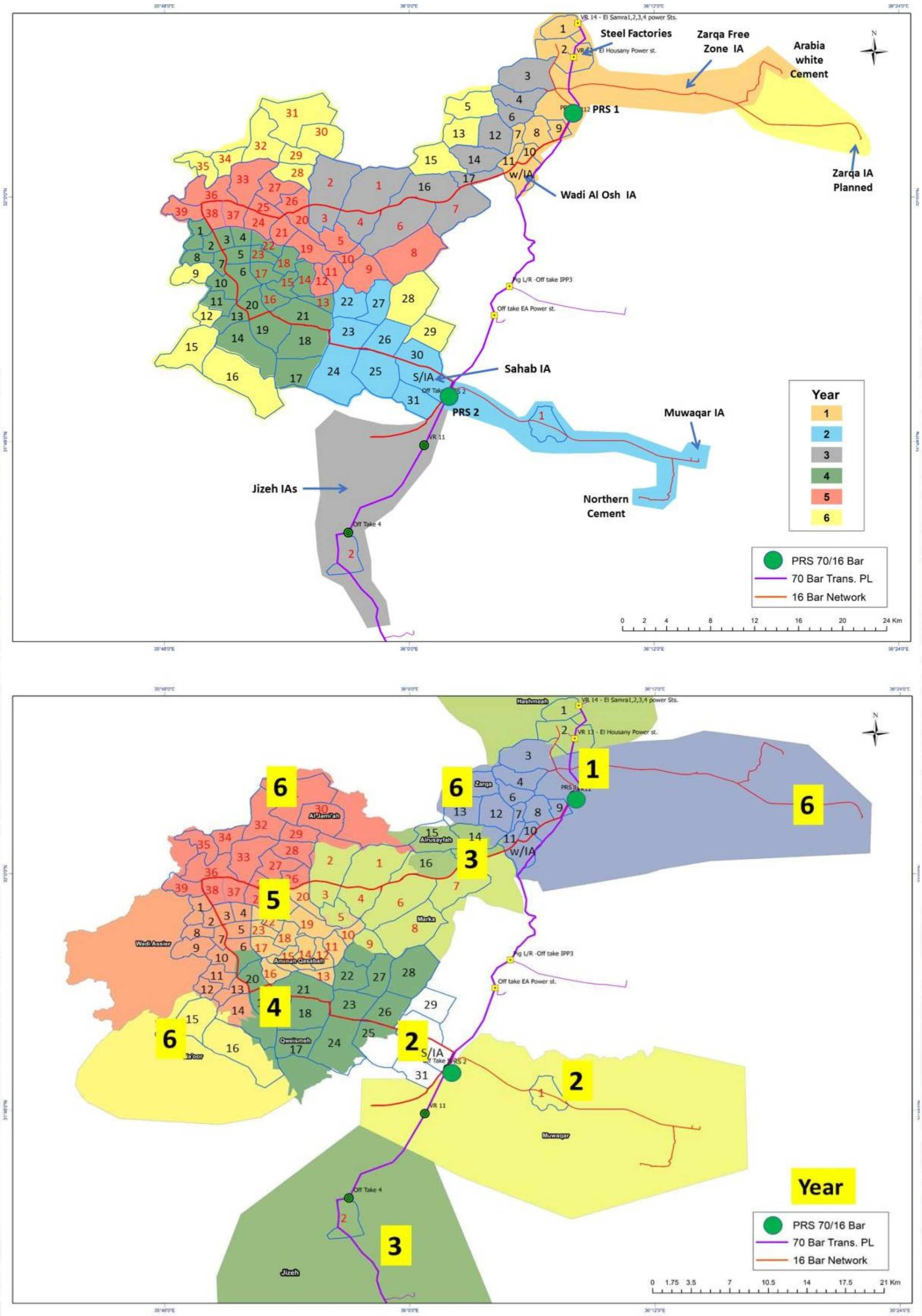
3.4.2.2 PIPELINE ROUTING AND PHASING

The connection of residential customers will be driven by the development plan for the 16 barg pipeline. As this pipeline is extended to new districts the 4 barg pipeline networks can be added and residential customers in these areas can be connected to gas supply.

Each district is divided into sectors to help with the planning of the 4 bar network, with customers in a number of sectors within a district to be converted each year. The connection of commercial customers and industrial customers within residential zones will be in line with the residential outreach.

For the industrial zones/industrial areas, such as at Sahab and Muwaqar, as these provide a large load and relatively easy connections to customers within the area/zone (often with site management services), we assume these sites can be connected directly to the 16 barg pipeline with their own investment in a common pressure reduction station and metering and therefore assume gas supply to these customers ahead of gas supply to the largely residential areas. This will be important to the economics of the 16 barg network in the early years of market development and provides some early cashflow for the LDCs. The 16 barg phasing and residential customer connection planning is shown in the map and table below.

Figure 45 Amman and Zarqa Sectors in each District and Construction Plan



Source: Consultant

Figure 46 Pipeline Network Construction Phasing and Customer Connections

Year	Residential Customers				Industrial
	District	no. of sectors	no. of customers	Total customers / year	Area
1	Zarqa	5	57,765	69,253	Wadi Al-Osh, Zarqa Free Zone, Steel fac. Hashemiyah, Arabia Cement
	Hashemiyah	2	11,488		
2	Sahab	2	7,465	71,726	Sahab (King Abd Alla the Second IA), Muwaqar IA, Northern Cement in Muwaqar
	Alquaismeh	6	14,930		
	Muwaqar	1	47,676		
3	Russeifa	3	57,576	225,168	Jizeh IAs (Al Qastal, Airport, Al Mashatta), Marka industrial cluster
	Marka	6	109,416		
	Jizeh	1	11,964		
	Zarqa	4	46,212		
4	Wadi Essier	12	60,132	199,518	Alquaismeh industrial cluster, Wadi Essier industrial cluster
	Amman Qasabah	8	99,656		
	Alquaismeh	5	39,730		
5	Al-Jami'ah	9	79,704	209,154	Al-Jami'ah industrial cluster
	Marka	3	54,708		
	Amman Qasabah	6	74,742		
6	Zarqa	2	23,106	145,491	Zarqa future planned, Amman Qasabah industrial cluster
	Al-Jami'ah	7	61,992		
	Alquaismeh	1	7,946		
	Wadi Essier	2	10,022		
	Na'oor	2	15,768		
	Sahab	1	7,465		
	Russeifa	1	19,192		
Total		**89**	920,310		

Source: Consultant

3.5 CAPEX AND OPEX COST ESTIMATE OF THE CITY GAS NETWORK

3.5.1 CAPEX & OPEX ESTIMATE – 16 BARG NETWORK

The costs for the 16 barg gas pipeline network will be based on the phasing of the network as discussed above. Costs include connections to the 70 barg pipeline and pressure reduction stations at Sahab and Zarqa and the 16 barg pipeline itself,SCADA and exclude the cost of the r right of way. Costs are based on actual quotes and estimates from Egyptian companies carrying out construction activities in Jordan (2022). OPEX estimates are assumed to be 2.5 percent of total CAPEX per annum estimated at US$3.7m/year.

Figure 47 Pipeline Network Construction Phasing and Customer Connections

Year	Residential Customers		Industrial	70 bar	PRS 70/16 bar	16 Bar network		
	District	no. of sectors	Area	Cost MM$	Cost MM$	Length KM	Size inch	Cost MM$
1	Zarqa	5	Wadi Al-Osh, Zarqa Free Zone, Steel fac. Hashemiyah, Arabia Cement	0.28	6	8	24”	10
						3	12”	2
	Hashemiyah	2				24	10”	15
						3	8”	2
2	Sahab	2	Sahab (King Abdullah the Second IA), Muwaqar IA, Northern Cement in Muwaqar	0.1	6	13	24”	16
	Alquaismeh	6				19	12”	14
	Muwaqar	1				8	10”	5
	Zarqa	0				2	8”	1
3	Russeifa	3	Jizeh IAs (Al Qastal, Airport, Mashatta), Marka industrial cluster			17	24”	21
	Marka	6						
	Jizeh	1				7	10”	5
	Zarqa	4						
4	Wadi Essier	12	Alquaismeh industrial cluster, Wadi Essier industrial cluster			17	24”	21
	Amman Qasabah	8						
	Alquaismeh	5						
5	Al-Jami’ah	9	Al-Jami’ah industrial cluster	3		11	24”	13
	Marka	3						
	Amman Qasabah	6						
6	Zarqa	2	Zarqa future planned, Amman Qasabah industrial cluster			11	10”	7
	Al-Jami’ah	7						
	Alquaismeh	1						
	Wadi Essier	2						
	Na’oor	2				1	8”	1
	Sahab	1						
	Russeifa	1						
Total		**89**		**3**	**12**	**144**		**133**

Source: Consultant

3.5.2 CAPEX & OPEX ESTIMATE – 4 BARG AND 100 MBARG NETWORK

The costs for the 4 barg and 100 mbarg gas pipeline network will be based on the phasing of the sectors within each district and the number of customers connected. Costs include regulators (including SCADA to register pressures and temperatures at inlet and outlet of regulators 16/4 barg), the total length of the 4 barg (440 km, PE 80 SDR 11) as well as the 0.1 barg underground polyethylene networks (PE 80 SDR 17). Costs for land right of way are not included. Costs are based on actual quotes and estimates from Egyptian companies carrying out construction in Jordan (2022).

Costs include materials plus 20 percent for fittings and 25 percent for customs and logistics and another 125 percent of this total is added for construction followed by 14 percent for VAT. As with the 16 barg pipeline, based on industry rules of thumb, OPEX estimates are assumed to be 2.5 percent of Total CAPEX per annum of US$4.2million/year. Total CAPEX cost estimates and spend profile for the 4 barg and 100 mbarg network is shown below. Post Year 6 costs are assumed to continue based on the growth of the population and new households added at a **cost of around US$180/customer** or around US$2 million per annum. Costs for the 4 barg and 100 mbarg network are split by zone based on the gas demand in each zone versus total gas demand.

Figure 48 Pipeline Network Construction Phasing and Customer Connections

		No. of Gas	4 Bar network	Regulators	LP network 100 mbar
	District	Customers	Cost $m	Cost $m	Cost $m
1	Zarqa 5 sectors Hashemiyah 2 sectors	69,253	2	1	9
2	Sahab, Muwaqar, Alquaismeh 6 sectors	71,726	3	1	10
3	Russeifa 3 sectors, Marka 6 sectors, Zarqa 4 sectors, Jizeh	225,168	8	3	30
4	Wadi Essier 12 sectors, Amman Qasabah 8 sectors, Alquaismeh 5 sectors	199,518	7	2	27
5	Al Jami’ah 9 sectors, Marka 3 sectors, Amman Qasabah 6 sectors	209,154	7	3	28
6	Zarqa 2 sectors, Al-Jami’ah 7 sectors, Wadi Essier 2 sectors, Na’oor	145,491	5	2	20
	Total	**920,310**	**32**	**12**	**124**
	Total CAPEX $m				**166**

Source: Consultant

3.5.3 CAPEX & OPEX ESTIMATE – INSTALLATION, CONVERSION AND FLUE

The costs for Installation, Conversions and Flues have also been estimated including:

- Installations (Pipes (1/2”, 3.4”, PVC pipes), equal T, sockets, meters, elbows, brass ball values, Union FF/MF, etc) = US$140 per customer
- Conversions (piping to appliance, meters, adapters, copper elbows, etc) = US$108 per customer
- Flue (exhaust flue, vent, connectors, etc) = US$10 per customer
- **Total cost of US$260 per customer**

All costs include costs for materials, logistics, construction and VAT as discussed for the 4 and 100 mbarg pipelines above. Costs are based on estimates from the Egyptian gas market. OPEX estimates are assumed to be US$10/customer per year based on utility costs in the UK (adjusted for population and GDP versus Jordan). This excludes any costs for servicing of gas appliances within the household. Total CAPEX cost estimates and spend profile for the installations and conversions is shown below. Post Year 6 costs are assumed to continue based on growth of the population and new households added at a cost of around US$260/customer or around US$3 million per annum. Costs for the installation/conversion/flue are split by zone based on the number of households in each zone converted to gas versus total number of households converted to gas.

Figure 49 Cost of Installation, Conversion and Flues

	District	No. of Gas Customers	Installation Cost $m	Conversion Cost $m	Flue Cost $m
1	Zarqa 5 sectors Hashemiyah 2 sectors	69,253	10	7	1
2	Sahab, Muwaqar, Alquaismeh 6 sectors	71,726	10	8	1
3	Russeifa 3 sectors, Marka 6 sectors, Zarqa 4 sectors, Jizeh	225,168	32	24	2
4	Wadi Essier 12 sectors, Amman Qasabah 8 sectors, Alquaismeh 5 sectors	199,518	28	21	2
5	Al Jami'ah 9 sectors, Marka 3 sectors, Amman Qasabah 6 sectors	209,154	30	22	2
6	Zarqa 2 sectors, Al-Jami'ah 7 sectors, Wadi Essier 2 sectors, Na'oor	145,491	21	16	1
	Total	**920,310**	**131**	**98**	**9**
	Total CAPEX $m				**238**

Source: Consultant

Adding the 4 barg and 100 mbarg gas pipeline network costs (US$180/customer) and the installation, conversion and flue costs (US$260/customer) results in a total upfront cost of US$440/customer to be connected to gas supply. This excludes the cost of the 16 barg network (~US$150 million) which, when split across all potential existing customers (1 million), is equivalent to around US$150/customer. We assume the utility would incur all upfront costs for the network development and recover this through the tariff or gas price. This is discussed in more detail in the next part of the report.

In reality, the cost for installation/conversion/flues would differ from building to building and form household to household depending on whether connections, flues and central heating are available in the building or the types of existing appliances being used. Therefore, the above costs for installation/conversions/flues should be considered as an upper bound average estimate.

A more detailed study and survey would be required to assess the requirements for installation/conversion/flues for different types of buildings in the different areas of Amman and Zarqa.

Note: the estimated conversion costs provided above do not include required modifications or potential maintenance and repair costs for appliances. Any additional modifications needed for an appliance will typically require approvals or consent from the manufacturer and will be an additional cost for the consumer. Maintenance and repair costs generally depend on the type of appliance (there are a wide range of types and models on the market in Jordan), the appliance condition and the availability of *spare parts. Maintenance and repair works are not required for all appliances, but only for malfunctioning or faulty appliances. The maintenance and repair costs for an appliance can be negligible, or equivalent to the cost of a new appliance. However, regardless of the cost, distribution companies are not typically responsible for maintenance or repair, and these works will generally be carried out by agents, specialized companies and/or workshops.*

3.6 NETWORK COSTS AND GAS PRICING – BASE CASE

3.6.1 ECONOMIC ASSUMPTIONS

We have undertaken an financial discounted cash flow (DCF) analysis to determine a competitive tariff for each pipeline network and the installations etc based on assumptions relating to costs (CAPEX and OPEX estimates), level of gearing (with a simple debt equity split) and revenue (tolling charges, capacity) and other financial/commercial assumptions. Key modelling assumptions are shown below.

Figure 50 Economic Model Financial Assumptions

Assumption	Scenario 1 – 100% Equity	Scenario 2 – Debt Guaranteed
Equity share	100%	30%
Return on Equity	16%	16%
Debt share	0%	70%
Cost of Debt / Interest	-	8%
Cover ratio	-	1.3
Term	25 years	25 years
Taxation	20% corporate tax, no tax holiday assumed	20% corporate tax, no tax holiday assumed

Source: Consultant

Unit costs or tariffs are estimated for two financial scenarios assuming: 1) 100 percent equity financing, and, 2) a leveraged scenario 70 percent debt:30 percent equity, with debt guaranteed by the project partners. Unit costs/tariffs are determined by dividing the minimum annual revenue required to cover CAPEX and OPEX costs (from the DCF Model) by the throughput volume in each year. For the 16 bar network, this is based on total gas demand and for the 4 barg/100 mbarg and installations/conversions this is based on the demand for each GDZ. Furthermore, volumes and CAPEX distribution for the 4 barg and 100 mbarg was based on total gas demand within each zone, whereas for installations/conversions/flue this is only based on residential demand. Note we assume a real interest rate of 8 percent, which we regard as a reasonable assumption. This is based on the traded yield on Jordan's Eurobond issuances in June 2022 of 8 percent (including country risk premium), less 3 percent for inflation (assumed by the Federal Bank of New York), plus a project margin of 3 percent. 16 percent return on equity is based on ongoing solar PV and wind projects in Jordan where equity IRRs are between 13 percent and 18 percent.

3.6.2 NETWORK COSTS

The estimated unit costs/tariffs for the 16 barg network, 4 barg plus 100 mbarg network and the costs for installation/conversion/flues are shown in the charts below. The unit cost/tariff for use of the 16 barg network would be paid by all customers similar to the workings of a gas transmission network. The unit cost/tariffs for the 4 barg and 100 mbarg networks would be paid for by residential and commercial as well industrial customers in each zone. Some industrial customers would only require connection to the 4 barg network. Therefore, grouping the costs and requiring industrial customers to pay for both the 4 barg and 100 mbarg connections would essentially be industry subsidising the costs for smaller users. Finally, the unit cost/tariff for installation, conversion and flue would be paid for by only residential and commercial customers in each zone. This assumes the installation/ connections/flue will be developed and paid for by the LDC within each franchise zone and recovered as part of the tariff charged to customer. The details of how this could work, the tariff mechanisms and the financing of investment will be determined by policy and the GDZ franchise structure, which is discussed later in the report. This would differ from household to household and depending on whether central heating exists in the building, for example. We have assumed all customers would incur the same average cost of installation/conversion/flues. This would essentially be subsidising customers who need more work done for connections versus those who do not.

Figure 51 Pipeline and Installation Unit Cost Estimates – 100% Equity

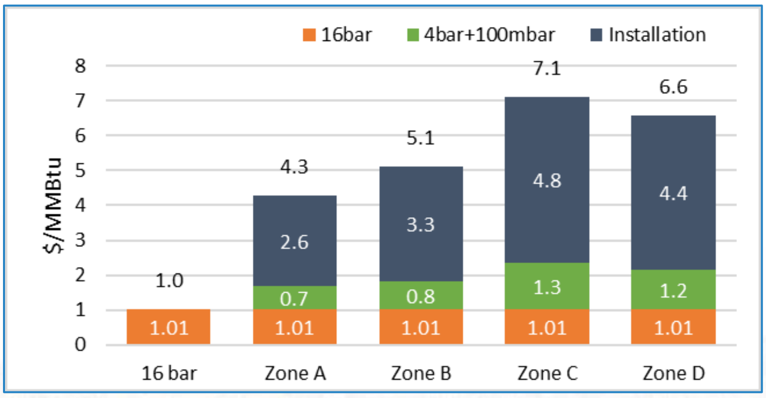


Figure 52 4barg, 100 mbarg and Installation Cost Estimates – 100% Equity

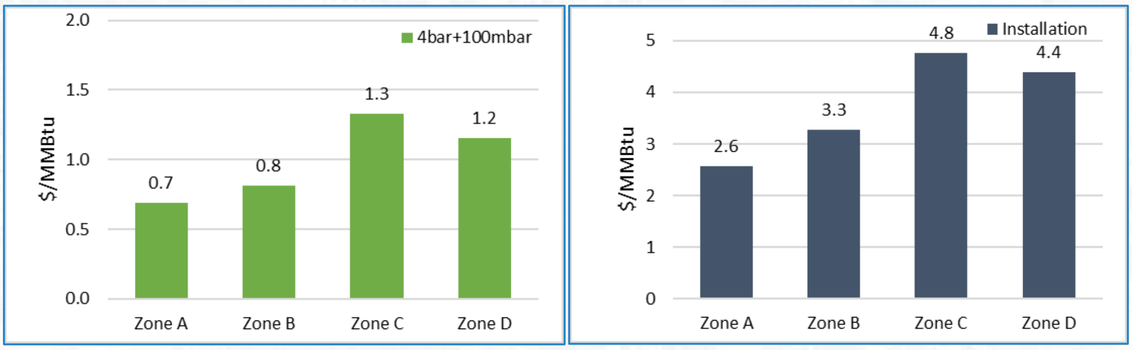


Figure 53 Pipeline and Installation Unit Cost Estimates – Debt Guaranteed

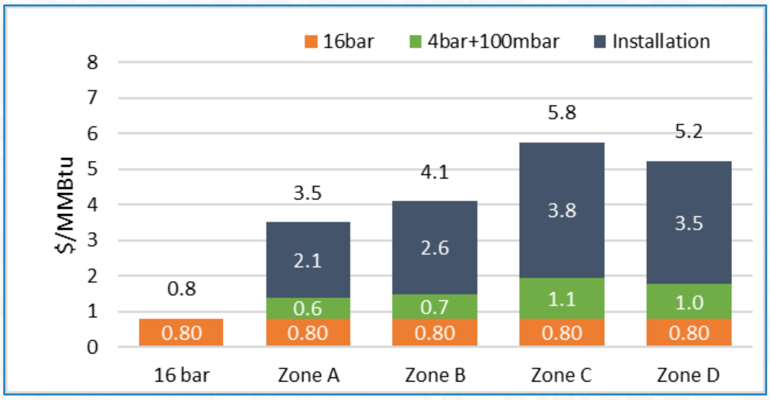
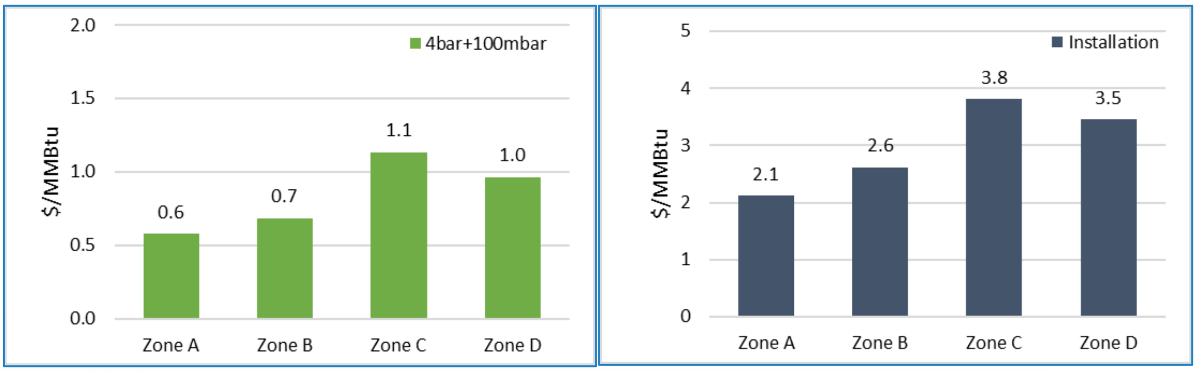


Figure 54 4 barg, 100 mbarg, Installation Cost Estimates – Debt Guaranteed



Source: Consultant

As demonstrated above, unit costs for the 16 barg pipeline are estimated to be US$0.8-1.0/MMBtu and the costs for the 4 barg and 100 mbarg pipeline are estimated to be between US$0.6-1.2/MMBtu. The unit costs for installation, conversions and flues have a wider range between US$2.6-4.4/MMBtu in the 100 percent equity case and US$2.1-US$3.5/MMBtu in the leveraged case.

Under the leveraged case, given the financial assumptions in the table above and cover ratio of 1.33 (i.e. principal and interest repayment rate of 75% of operating cashflows), the payback period for all pipelines is estimated at about13 years.

Reducing the cover ratio reduces the payback period. Assuming a cover ratio of 1.17 (85 percent repayment rate), the payback period drops to 10 years. The impact on the tariff is relatively small, increasing the tariff by around US$0.2/MMBtu. Assuming operations start-up date of 2025, a payback period of 10 years would allow for the repayment of the capital investment in the pipeline network by 2035.

Figure 55 Pipeline and Installation Unit Cost Estimates – 85% repayment rate

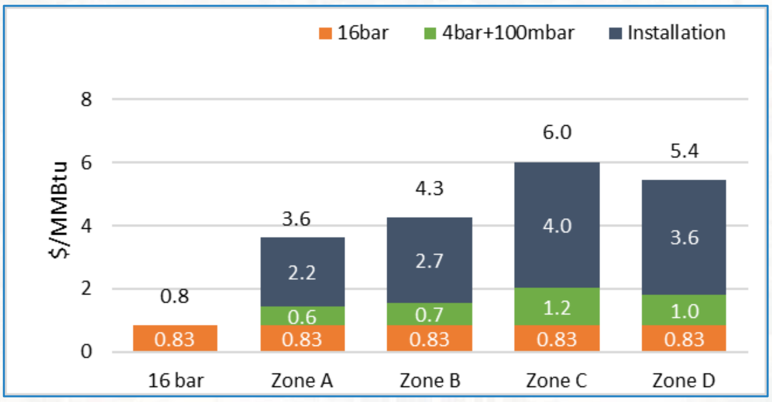
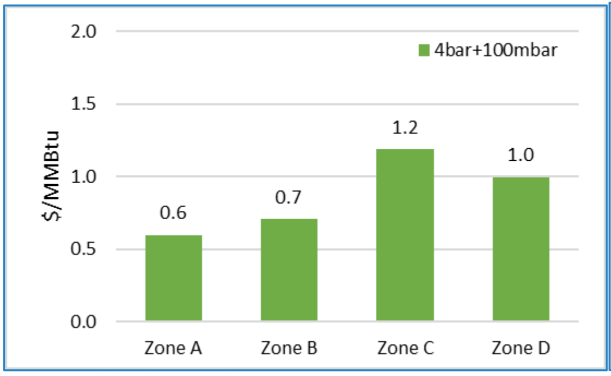
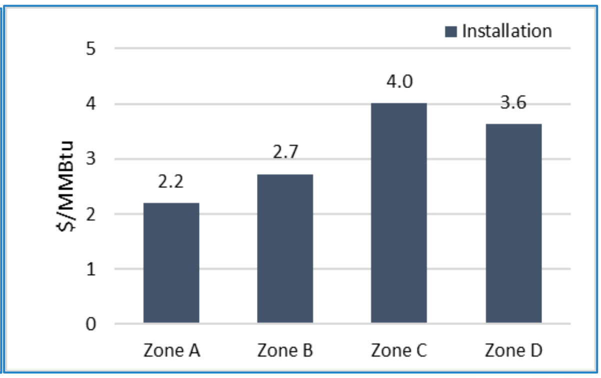


Figure 56 4 barg, 100 mbarg, Installation Cost Estimates – 85% repayment rate





Source: Consultant

3.6.3 END USER PRICING

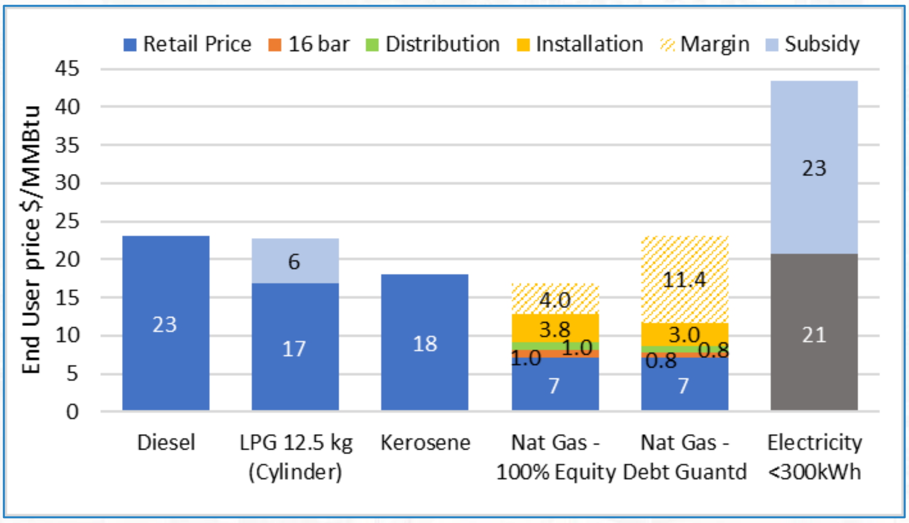
3.6.3.1 RESIDENTIAL SECTOR

Natural gas prices to residential sector customers would be based on the sum of:

1. Gas import cost including the FAJR transmission pipeline costs and 7 percent tax = US$7/MMBtu (2021)
2. Cost of 16 barg pipeline = US$0.8-1.0/MMBtu (estimated above)
3. Cost of the 4 barg and 100 mbarg pipeline network = US$0.6-1.2/MMBtu (estimated above)
4. Cost of installation, conversion and flues = US$2.1-3.5/MMBtu or US$2.6-4.4/MMBtu (estimated above)

Taking the simple average of costs across zones, this gives a total gas cost of US$11.7-12.8/MMBtu, and a saving of US$4/MMBtu versus LPG (subsidised but including 12 percent special tax) and US$10/MMBtu versus LPG (unsubsidised but including 12 percent special tax) in the 100 percent equity case and US$11/MMBtu versus diesel (used for central heating) in the debt guaranteed case, based on 2021 average pricing for natural gas and other fuels.

Figure 57 Natural Gas versus Other Fuels – Residential Sector



Source: Consultant

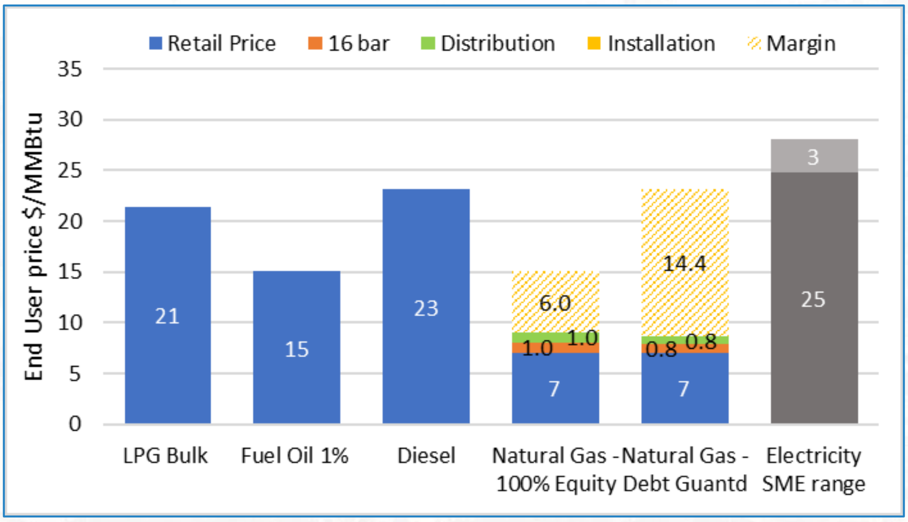
3.6.3.2 INDUSTRIAL SECTOR

Natural gas prices to industrial and commercial sector customers would be based on the sum of

1. Gas import cost including the FAJR transmission pipeline costs and 7 percent tax = US$7/MMBtu (2021)
2. Cost of 16 barg pipeline = US$0.8-1.0/MMBtu (estimated above)
3. Cost of the 4 barg and 100 mbarg pipeline network = US$0.6-1.2/MMBtu (estimated above)

Taking the simple average of costs across zones, this gives a total gas cost of US$8.7-9.1/MMBtu, and a saving of US$6/MMBtu versus Fuel Oil in the 100% equity case and US$14/MMBtu versus diesel (including 40 percent tax) in the debt guaranteed case, based on 2021 average pricing for natural gas and other fuels.

Figure 58 Natural Gas versus Other Fuels – Industrial Sector



Source: Consultant

This leaves considerable room to factor in any risk of an increase in natural gas prices, which is not due to an increase in crude oil prices – for example in case of need for additional LNG imports. The average cost of natural gas can rise to US$11-13/MMBtu, and it would still be competitive compared to subsidised LPG in the residential and fuel oil in the industrial sectors. The above comparison between natural gas and electricity (shown in the grey bar) is not directly implementable because it would still need to be converted to energy in the appliance. The higher cost of the gas versus the electric appliance would need to be factored in.

The natural gas costs shown above do not include the cost of purchasing or maintaining new gas appliances (boilers, stoves, radiators) or the cost of replacing diesel fuel injectors, gas train controls and chimneys (mainly for space heating boilers and industrial boilers/furnaces), if required. These costs would typically be borne by customers. In Jordan, many residential customers already using LPG can relatively easily switch to natural gas. The requirement for new appliances is mainly for diesel-based central heating, where a replacement to a more efficient boiler may be needed rather than just changing the fuel intake. Customers who would need new appliances, include kerosene users for mobile heating, make up less than 5 percent of the market, of which we assume only 20 percent would switch to natural gas, and those using electricity (50 percent) and solar heating (10 percent), of which we assume only 20 percent of only electricity users but no solar heating would switch to natural gas, giving a total proportion of around 11 percent.

3.6.4 ECONOMIC SENSITIVITIES

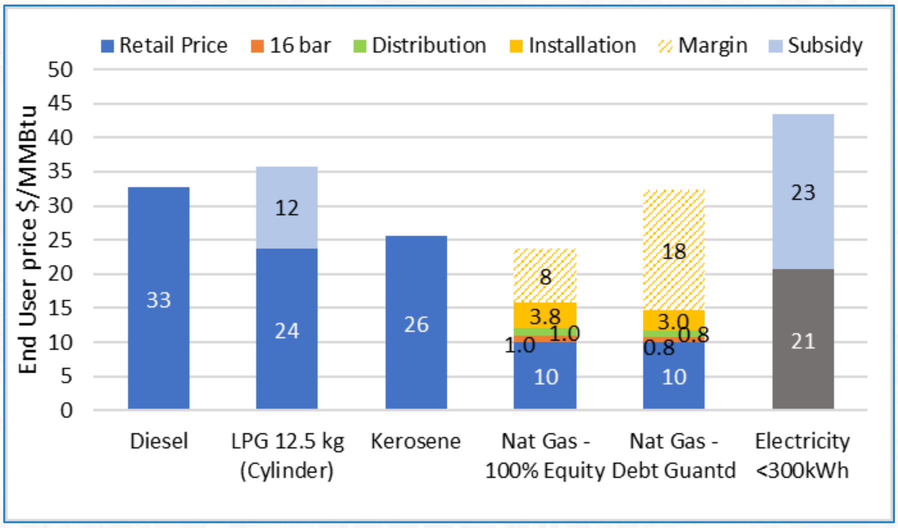
Gas vs Oil Prices

The gas commodity cost makes up majority of the of the overall gas price to end users. If gas import cost were to increase/decrease, this would be the main factor impacting on the overall gas price to end users with the cost of pipeline transmission and distribution and the installations remaining the same. The wholesale gas price of US$7/MMBtu based on the average price in Jordan to industrial consumers in 2021 is relatively low in comparison to gas prices in other regions and to alternative fuel prices. Starting from 2021, oil and gas prices have both increased significantly.

As discussed earlier, gas supply and hence pricing for 2020 and 2021 are mainly based on imports from Mediterranean fields, which is indexed to crude oil prices. With the average price of crude oil at US$70/bbl in 2021, prices for natural gas supply, considering the more recent higher crude oil prices (around US$100/bbl for 2022) is estimated to be around US$10/MMBtu. This is lower than prices in other regions with oil-indexed pricing estimated to be around US$12-15/MMBtu. It should be noted that in Europe, where prices are largely indexed to traded gas markets (such as NBP in the UK and TTF in the Netherlands), gas prices have reached US$30/MMBtu in Q4 2021 following the Russia-Ukraine crisis (Russia is the supplier of around 35 percent of European gas).

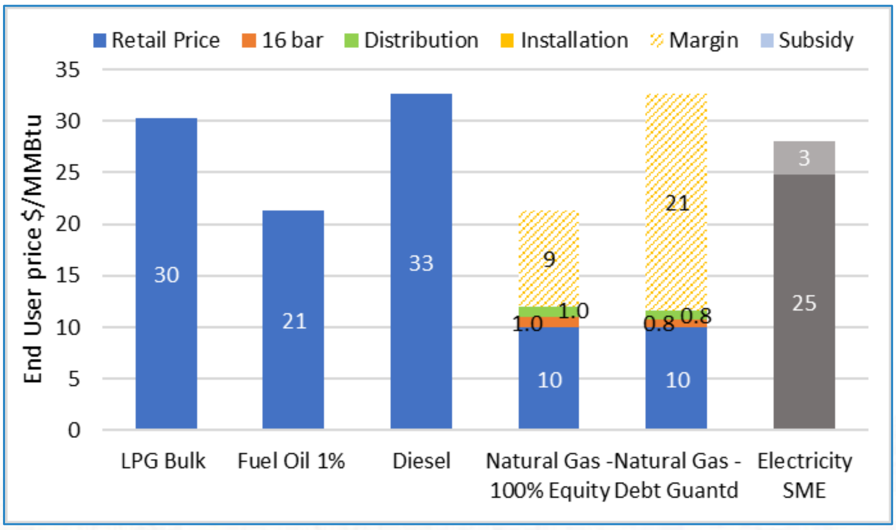
Oil product prices are also directly linked to crude oil prices. With crude oil prices rising above US$100/bbl in 2022 and assumed to average around US$100/bbl in 2022, the end-user oil product prices would also increase. A comparison between estimated gas and oil product prices at US$100/bbl is shown below. This assumes the same level of taxation and subsidy as for 2021. As discussed, the costs of gas transportation and connection would be the same and not impacted by changes in the gas commodity cost.

Figure 59 Natural Gas versus Other Fuels – Residential Sector (@$100/bbl)



Source: Consultant

Figure 60 Natural Gas versus Other Fuels – Industrial Sector (@$100/bbl)



Source: Consultant

As shown above, as the crude oil price increases, the differential between the gas price and oil product prices also increases. This is due to the discount between the crude oil and gas price versus oil product prices. When converted to price per tonne, natural gas import prices in Jordan are around 50 percent of the crude oil. This compares to fuel oil at 70 percent, diesel at 120 percent, LPG at 105 percent and Kerosene at 130 percent of the crude oil price. Assuming US$100/bbl, the average cost of natural gas can rise to US$18-19/MMBtu, and still be competitive versus subsidised LPG for the residential sector and fuel oil for the industrial sector.

Increasing Equity to 40 Perent and Return on Equity to 25 Percent

Increasing the equity funding to 40 percent (from 30 percent in the Base Case) and assuming Return on Equity of 25 percent(compared to 16 percent in the Base Case) leads to an increase in tariffs and the overall gas price. The overall increase in price is about US$2/MMBtu (US$1.4/MMBtu of which is for the cost of installation/conversion), reducing the savings versus the subsidised LPG price to US$3/MMBtu.

Figure 61 Pipeline and Installation Unit Cost Estimates – 25% ROE

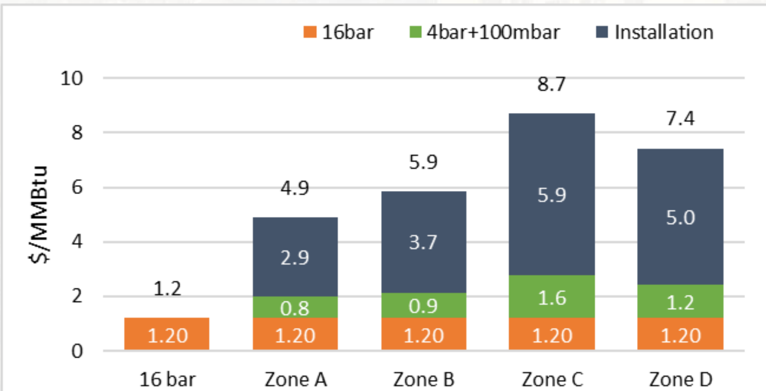


Figure 62 Natural Gas versus Other Fuels – Residential Sector (25% ROE)

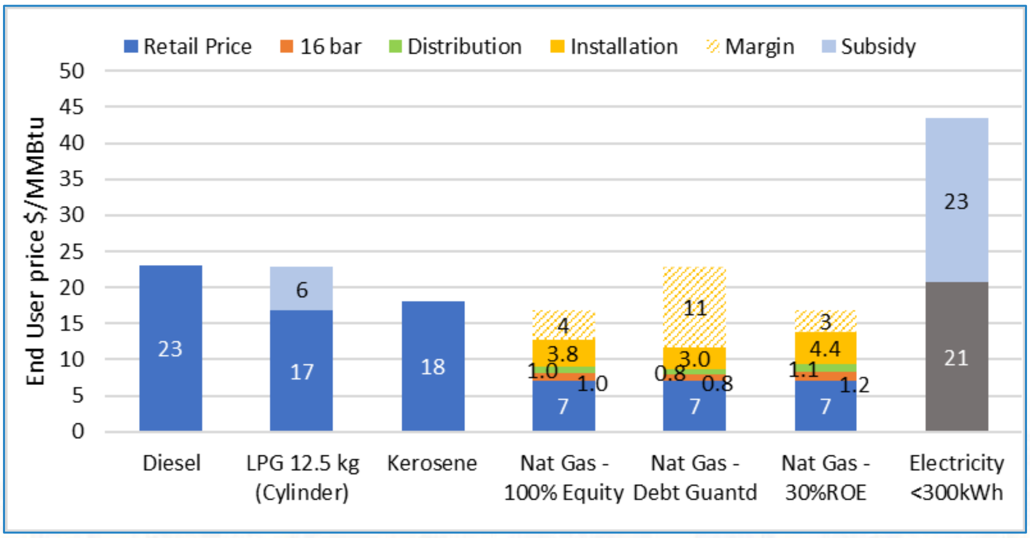
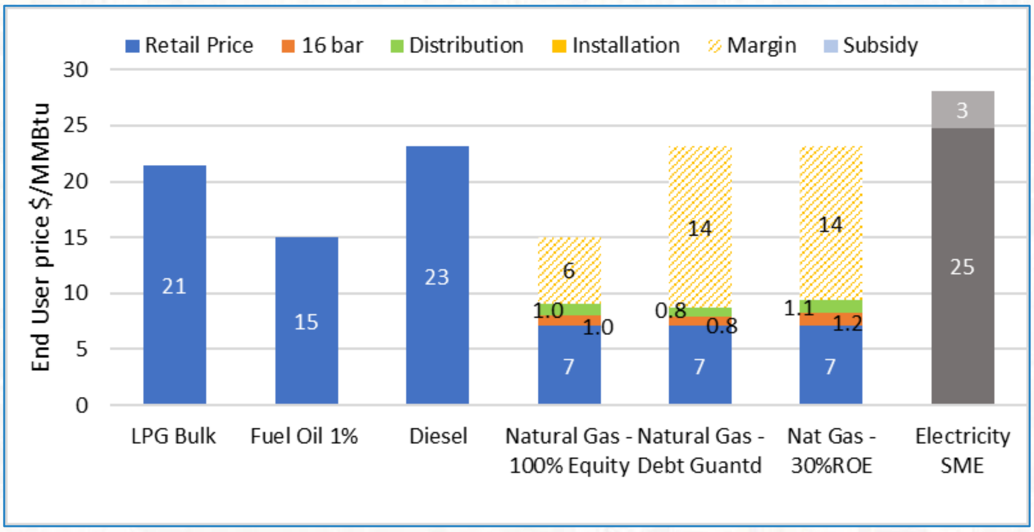


Figure 63 Natural Gas versus Other Fuels – Industrial Sector (25% ROE)



Source: Consultant

3.7 NETWORK COSTS AND GAS PRICING – ALTERNATIVE SCENARIO

3.7.1 InCREASED RELIANCE ON ELECTRICITY

In Jordan, switching from LPG or diesel to natural gas does not require significant change in the types of appliances. This applies toindustrial boilers or furnaces, communal boilers for central heating systems, household boilers for water or space heating or even the cooking stoves in the case of LPG. However, where a new appliance or equipment is required , competition with electricity will be high especially for the residential sector with cheaper electric appliances and below cost-recovery electricity prices.

As discussed earlier, electric appliances are becoming more popular with lower upfront costs despite the higher energy cost versus natural gas. Electric heaters are increasingly common. Some air conditioning units with inverters can also provide heating in winter periods as well as cooling in summer periods.

The following assesses the impact of the scenario with increased reliance on electricityon potential gas demand and what this means for the economics of the city gas distribution network and the overall gas pricing versus alternatives. Note that this should be treated as a stress-test scenario in order to understand the impact on costs and on the economics of city gas distribution.

3.7.2 MARKET ANALYSIS (HIGH ELECTRIFICATION SCENARIO)

In the Base Case, we assumed a percentage of each fuel which can be switched to natural gas as shown below.

Figure 64 Percentage of Fuel Substitution by Natural Gas

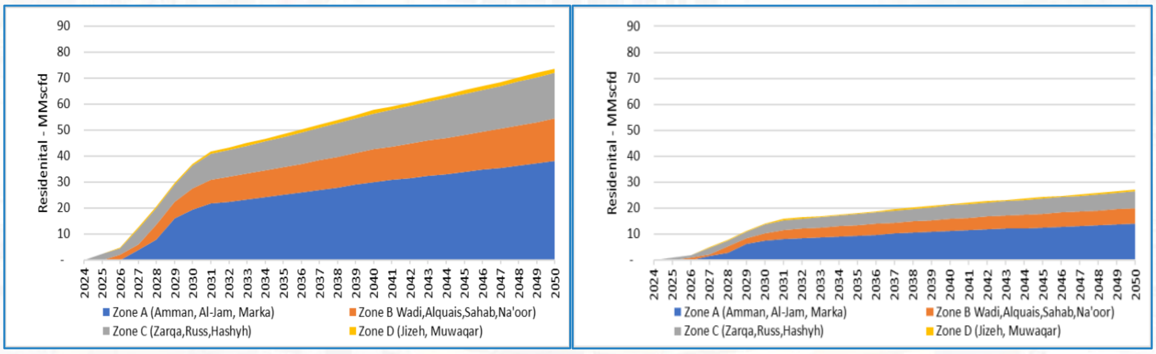
Fuel	Substitution to gas	Fuel	Substitution to gas
Energy solar	0%	LPG	65%
Electricity	20%	Diesel	80%
Kerosene	20%		

Source: Consultant

In the High Electricity Use scenario in the residential sector, we assumed no switching from electricity (from air conditioner and similar appliances) to natural gas. Furthermore, we assumed only half of the 65 percent substitution of LPG (for central heating and cooking) and half of the 80 percent substitution of diesel (for central space heating) assumed in the Base Case would switch to natural gas. The impacts on estimated residential sector gas demand are shown below.

Figure 65 Residential Demand in Amman and Zarqa by Zone

Base case scenario High Electrification scenario

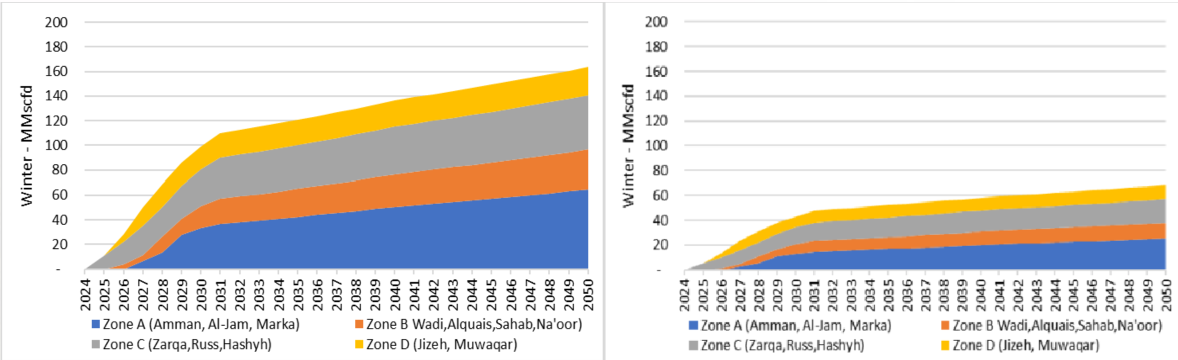


Source: Consultant

For the industrial sector, as discussed above, electrification of industry is one of the key recommended energy transition activities in Jordan. In a High Electricity Use scenario, we assumed half of the potential demand for natural gas to replace diesel, fuel oil and LPG compared to the Base Case. This resulted in the total gas demand projections shown in the chart below. Overall, this resulted in 57 percent reduction in potential gas demand (61 percent reduction in Zone A, 59 percent in Zone B, 55 percent in Zone C and 51 percent in Zone D).

Figure 66 Total Demand in Amman and Zarqa by Zone – Winter

Base case scenario High Electrification scenario



Source: Consultant

3.7.3 TECHNICAL ANALYSIS (HIGH ELECTRICITY USE SCENARIO)

We assumed no changes in the technical assumptions for the 16 barg and 4 barg pipeline networks versus the Base Case. The capital costs were assumed to be the same since: (a) there may not be material benefits in decreasing pipeline diameter, and (b) a larger size pipeline would be required to meet demand growth and to transport higher volumes needed when switching to hydrogen (hydrogen requires transporting 3 times as much volume as natural gas for the same equivalent energy). For 100 mbarg networks as well as the cost of installations/conversions/flues, this was based on the number of customers switching to gas. We reduced the total number of households switching to natural gas (and hence costs) proportional to the decrease in demand for natural gas versus the Base Case scenario (around 60 percent reduction). The reduced number of customers and costs are shown below. The overall decrease in capital costs is US$227 million.

Figure 67 Pipeline Network Construction Phasing and Customer Connections

Original No.	New No. of	**16 Bar**	4 Bar network	Regulators	100 mbar network	Installation	Conversion	Flue
Customers	Customers	Cost $m	Cost $m	Cost $m	Cost $m	Cost $m	Cost $m	Cost $m
69,253	25,901	35	2	0.9	3	4	3	0
71,726	26,826	42	3	0.9	4	4	3	0
225,168	84,213	25	8	2.8	11	12	9	1
199,518	74,620	21	7	2.5	10	11	8	1
209,154	78,224	16	7	2.6	11	11	8	1
145,491	54,414	7	5	1.8	7	8	6	1
920,310	**344,196**							
	HE Cost	147	**32**	**12**	**46**	**49**	**37**	**3**
	Original Cost	147	**32**	**12**	**124**	**131**	**99**	**9**

Source: Consultant

3.7.4 END USER PRICING (HIGH ELECTRICITY USE SCENARIO)

Using the above demand projections and cost estimates for the High Electricity Use scenario and applying the same economic/financial assumptions as shown in Figure 50 resulted in the below tariffs for the city gas network and overall gas price.

Figure 68 Pipeline and Installation Unit Cost Estimates – Debt Guaranteed

Base case scenario

High Electrification scenario

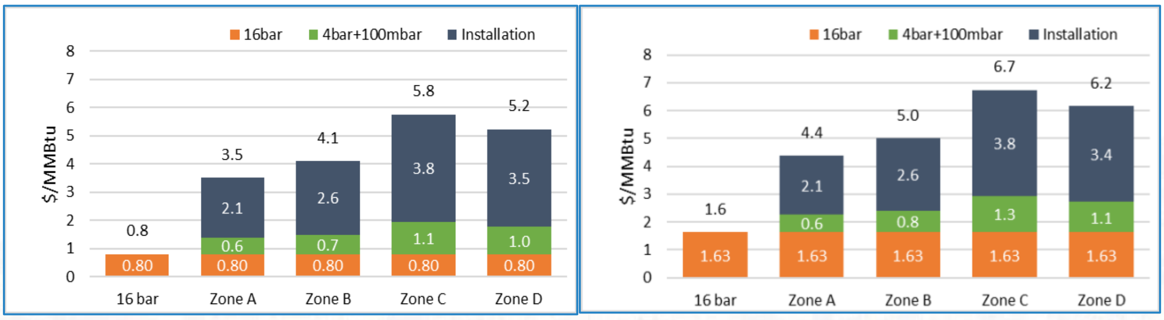


Figure 69 Natural Gas versus Other Fuels – Residential Sector (High Electrification)

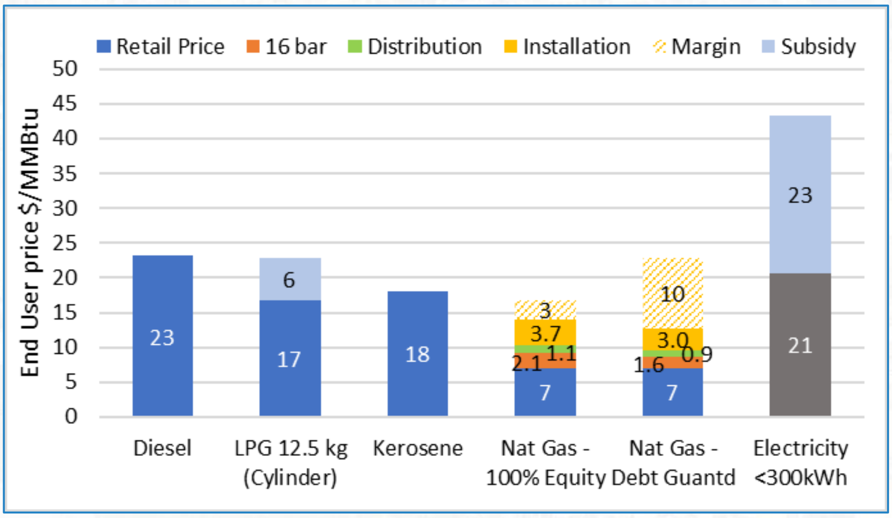
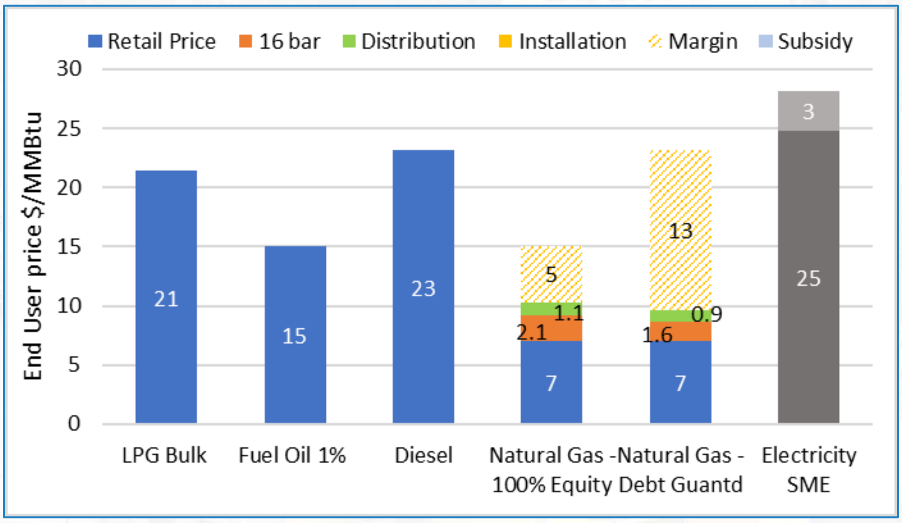


Figure 70 Natural Gas vs Other Fuels – Industrial Sector (High Electrification)



Source: Consultant

The tariffs for the various pipeline networks are overall similar except for the 16 barg pipeline. The capital costs for the 16 barg pipeline were assumed to be the same, but with lower volumes the unit cost would increase from US$0.8/MMBtu in the Base Case to US$1.6/MMBtu in the High Electricity Use Case. The unit costs of the 4 barg and 100 mbarg are similar to the Base Case due to the reduction in the costs of the 100 mbarg network directly linked to the number of customers whilst keeping the costs of the 4 barg network the same. The unit costs of installation/conversion/flues are the same as in the Base Case as these are determined directly in proportion to the number of customers.

Therefore, even if residential and industrial demand was considerably lower than in the Base Case, the city gas networks can be economically justified as the reduction in demand is largely compensated by the reduction in capital costs. Keeping the size of the pipelines unchanged will be important if a switch to hydrogen is to be done in the future.