



# **Assessment of Pipelines as the Preferred Mode for Transporting Crude/Oil Products within SAARC Member States**

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## Foreword

Petroleum, Oil, Lubricants (POL) are widely consumed energy products globally and are considered to be the lifeblood for all sectors of economy. Economic growth in the SAARC region has led to strong demand for POL products primarily from transportation and power sectors. However, most of the SAARC Member States are heavily dependent on imports for meeting their requirements of petroleum products. Additionally, Crude Oil reserves are limited and relatively less explored in the region. Hence, huge volumes of Crude Oil and Petroleum products are transported each year through sea, rail and road to meet the fuel requirements of the Member States. The lack of suitable and adequate infrastructure for Inter-country and intra-country has made the movement of Crude oil and Petroleum products inefficient in terms of transportation cost and delivery time. Therefore, it is important to highlight the benefits of developing pipeline networks for the transportation of Crude Oil and Petroleum products.

In this context, SEC carried out the study on “**Assessment of Pipelines as the Preferred Mode for Transporting Crude/Oil Products within SAARC Member States**” to identify and assess the prospects of commercial operation of Crude/Oil pipeline in SAARC Member States. In this study, country-wise demand-supply outlook of each Member State for Crude Oil and Petroleum Products by 2030 has been analyzed considering the macroeconomic factors and end use of Petroleum products in various sectors. Moreover, economic feasibility of pipelines compared to other alternate modes of transport (road, rail and sea trade routes) of crude oil and petroleum products has been assessed.

The study findings reveal that Crude/Oil pipeline network can lead to significant cost savings to Member States and will pave way for improving the trade scenario within the SAARC Region. The study has also suggested an avenue to meet the forecasted demand deficit of each country by 2030. The study recommends the implementation and operation modality of oil pipeline networks in the SAARC region. The study has also recommended that political will, harmonized institutional, legal and regulatory framework, and offering bigger opportunities for private sector participation can accelerate the pace of POL trade within the Region.

**Dr. Nawaz Ahmad**  
Director,  
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# Contents

<b>Acknowledgements</b> .....	<b>I</b>
<b>Foreword</b> .....	<b>II</b>
<b>Contents</b> .....	<b>III</b>
<b>Abbreviations</b> .....	<b>VI</b>
<b>Conversion Factors</b> .....	<b>XII</b>
<b>List of Figures</b> .....	<b>XIII</b>
<b>List of Tables</b> .....	<b>XIV</b>
<b>Executive Summary</b> .....	<b>XVI</b>
<b>1 Introduction</b> .....	<b>1</b>
1.1 Purpose of the Study .....	2
1.2 Objectives of the Study.....	3
1.3 Scope of the Study .....	3
1.4 Methodology of the Study .....	3
1.5 Country-wise Demand-Supply Outlook for Crude Oil and Petroleum Products .....	4
1.5.1 Technical Aspects of Cross-country Pipeline.....	6
1.5.2 Assessment of Economic Feasibility of Alternate Modes of Transportation for Crude Oil and POL Products.....	6
1.6 Limitations of the Study.....	6
<b>2 Transportation of Crude Oil and Petroleum Products</b> .....	<b>8</b>
2.1 Modes of Transportation.....	8
2.1.1 Marine Oil Tankers and Barges.....	8
2.1.2 Rail Transport .....	8
2.1.3 Road Transportation via Trucks.....	8
2.1.4 Pipelines .....	9
2.2 Comparison Between Alternative Modes of Transportation .....	10
2.3 Effective Service Delivery.....	11
2.4 Issues with Landlocked Member States .....	12
2.5 Advantages of Cross-country Pipelines over Roads, Railways, Waterways .....	13
<b>3 Designing, Construction and Operation of Crude Oil and POL Pipelines</b> .....	<b>15</b>
3.1 Pipeline Planning and Design .....	15
3.2 Material and Dimensional Requirement for Cross-country Pipelines .....	22
3.3 Cross-country Pipeline Construction and Installation.....	23
3.3.1 Construction Staging Areas and Storage Yards .....	25
3.3.2 Clearing and Grading of RoW .....	25
3.3.3 Excavating the Trench.....	25

3.3.4	Pipe Transport, Stringing and Assembly .....	26
3.3.5	Obstacles: Roads & Streams.....	27
3.3.6	Testing and Restoration .....	27
3.3.7	Additional Infrastructure.....	28
3.3.8	Transporting LPG through Cross-border Pipelines .....	28
3.3.9	Pipeline System and Component Design Requirements .....	28
3.3.10	LPG Pipeline Installation and Station Construction .....	29
3.3.11	Design of LPG Safety System .....	30
3.3.12	Emergency Plan and Preparedness .....	31
3.4	Transportation of Multi-Petroleum Products Via Cross-country Pipelines.....	33
3.5	Costing of Cross-border Crude Oil and POL Pipelines .....	38
<b>4</b>	<b>Crude Oil/ Petroleum Products Transportation in the SAARC Region .....</b>	<b>41</b>
4.1	Afghanistan .....	41
4.2	Bangladesh.....	41
4.3	Bhutan.....	42
4.4	India .....	42
4.5	Maldives.....	43
4.6	Nepal.....	44
4.7	Pakistan.....	44
4.8	Sri Lanka .....	46
4.9	Existing Policies and Regulations Pertaining to Energy Trade within the SAARC Region .....	48
<b>5</b>	<b>Scope of Oil Pipeline Networks in South Asia .....</b>	<b>50</b>
5.1	Afghanistan .....	50
5.2	Bangladesh.....	53
5.3	Bhutan.....	58
5.4	India .....	62
5.5	Maldives.....	67
5.6	Nepal.....	70
5.7	Pakistan.....	73
5.8	Sri Lanka .....	77
5.9	POL Trade Balance of SAARC Member States till 2030 .....	82
5.10	Avenues to Meet Demand Deficit across SAARC Member States .....	83
5.11	Alternative Modes of Transportation to Promote Cross-Border Trade for Petroleum Products .....	85
<b>6</b>	<b>Implementation and Operation of Oil Pipeline Networks.....</b>	<b>88</b>
6.1	Barriers and Constraints for Setting-up Intra-regional Oil Pipeline Network.....	88
6.2	Financial Modalities and Tariff Design for Cross-Border Pipelines .....	89

6.3	Study of Contractual Terms of Existing SAARC Cross-Border POL Trade via Pipelines and Roadways	92
6.4	Role of Private Sector Participation in Building Cross-Border Oil Pipeline Network .....	93
6.5	Policies & Regulations of SAARC Member States .....	93
6.5.1	Arbitration Laws.....	94
6.5.2	SAFTA - Agreement on South Asian Free Trade Area .....	94
6.5.3	SAPTA - Agreement on SAARC Preferential Trading Arrangement .....	95
6.5.4	SDF – SAARC Development Fund.....	95
6.5.5	SAARC Agreement on Trade in Services .....	95
6.5.6	SAARC Agreement on Mutual Administrative Assistance in Customs Matters .....	96
6.5.7	Agreement to Avoid Double Taxation and Mutual Administrative Assistance in Tax Matters.....	96
6.6	Global Best Practices and Case Studies .....	96
6.6.1	Baku-Supsa Oil Pipeline.....	96
6.6.2	The Express Pipeline between Canada and the US .....	98
6.7	Development of Framework for Crude Oil and POL Pipelines.....	99
<b>7</b>	<b>Conclusion.....</b>	<b>103</b>
	<b>Annexure.....</b>	<b>106</b>
	<b>Bibliography.....</b>	<b>114</b>

## Abbreviations

ACRONYM	Meaning
ADNOC	Abu Dhabi National Oil Company
AEC	Alberta Energy Company
AEDB	Alternative Energy Development Board
AFRA	Average Freight Rate Assessment
AIOC	Azerbaijan International Operating Company
ANDS	Afghanistan National Development Strategy
ANSA	Afghanistan National Standard Authority
ANSI	American National Standards Institute
AOX	Halogenated Solvents- Absorbable Organic Halogens
APA	Afghanistan Petroleum Authority
API	American Petroleum Institute
APL	Attock Petroleum Ltd
APPI	Asia Pacific Petroleum Price Index
ARE	Alternative and Renewable Energy
ARL	Attock Refinery Ltd
ASKM	Available Seat Kilometers
ASME	American Society of Mechanical Engineers
ASTM	ASTM International (Formerly American Society for Testing and Materials)
ATF	Aviation Turbine Fuel
BAPEX	Bangladesh Petroleum Exploration and Production Company Ltd
bbbl	Barrel
BERC	Bangladesh Electricity Regulatory Commission
BGFCL	Bangladesh Gas Fields Company Ltd
BIG	Bhutan Industrial Gas
BOC	Bhutan Oil Corporation
BOGMC	Bangladesh Oil, Gas and Mineral Corporation
BOOT	Build Own Operate Transfer
BORL	Bina Oil Refinery Ltd
BPC	Bangladesh Petroleum Corporation
BPCL	Bharat Petroleum Corporation
bpd	Barrels per day
BPL	Below Poverty Line
BRPL	Bongaigaon Refinery & Petrochemicals Ltd

<b>ACRONYM</b>	<b>Meaning</b>
<b>BTCPL</b>	Bakri Trading Company Private Ltd
<b>BTU</b>	British thermal unit
<b>C&amp;F</b>	Cost including Freight
<b>CAD</b>	Current Account Deficit
<b>CAGR</b>	Compound Annual Growth Rate
<b>CAPEX</b>	Capital Expenditure
<b>CGD</b>	City Gas Distribution
<b>CNG</b>	Compressed Natural Gas
<b>COPHC</b>	China Overseas Port Holding Company
<b>CPC</b>	Ceylon Petroleum Corporation
<b>CPCL</b>	Chennai Petroleum Corporation Ltd
<b>CPEC</b>	China Pakistan Economic Corridor
<b>CSO</b>	Central Statistics Office
<b>DGH</b>	Directorate General of Hydrocarbons
<b>DGPC</b>	Director General of Petroleum Concessions
<b>DME</b>	Dimethyl Ether
<b>DPRD</b>	Downstream Petroleum Regulation Department
<b>DWT</b>	Deadweight Tonnage
<b>E&amp;P</b>	Exploration and Production
<b>ELBL</b>	Eastern Lubricants Blenders Ltd
<b>EMRD</b>	Energy and Mineral Resource Division, Bangladesh
<b>EOL</b>	Essar Oil Ltd
<b>EPP</b>	Export Parity Price
<b>ERL</b>	Eastern Refinery Ltd
<b>Euratom</b>	European Atomic Energy Community
<b>EV</b>	Electric Vehicle
<b>FAME</b>	Faster Adoption and Manufacturing of Hybrid and Electric vehicles
<b>FBE</b>	Fusion Bonded Epoxy
<b>FBP</b>	Final Boiling Point
<b>FENEKA</b>	FENEKA Corporation Ltd
<b>FLGE</b>	Fuel and Liquid Gas Enterprise
<b>FO</b>	Furnace Oil
<b>FOB</b>	Free on Board
<b>FOTCO</b>	Fauji Oil Terminal & Distribution Company
<b>FSM</b>	Fuel Supply Maldives



<b>ACRONYM</b>	<b>Meaning</b>
<b>FY</b>	Financial Year
<b>GDP</b>	Gross Domestic Product
<b>GMS</b>	Greater-Mekong Sub-Region
<b>GO</b>	Gas and Oil Pakistan Private Ltd
<b>GPC</b>	Georgian Pipeline Company
<b>GRM</b>	Gross Refining Margin
<b>GST</b>	Goods and Services Tax
<b>GW</b>	Gigawatt
<b>HAZOP</b>	Hazard and Operability Study
<b>HDIP</b>	Hydrocarbon Development Institute of Pakistan
<b>HELP</b>	Hydrocarbon and Exploration Licensing Policy
<b>HGA</b>	Host Government Agreement
<b>HMEL</b>	HPCL Mittal Energy Ltd
<b>HOBC</b>	High octane blending component
<b>HOEC</b>	Hindustan Oil Exploration Company
<b>HPCL</b>	Hindustan Petroleum Corporation Ltd
<b>HSD</b>	High speed diesel
<b>HSFO</b>	High Sulphur Furnace Oil
<b>IGA</b>	Inter-Governmental Agreement
<b>IMF</b>	International Monetary Fund
<b>IOCL</b>	Indian Oil Corporation Ltd
<b>IPP</b>	Import Parity Price
<b>IRR</b>	Internal Rate of Return
<b>ISO</b>	International Organization for Standardization
<b>ISPRL</b>	Indian Strategic Petroleum Reserves Ltd
<b>JICA</b>	Japan International Cooperation Agency
<b>JOCL</b>	Jamuna Oil Company Ltd
<b>JV</b>	Joint Venture
<b>KL</b>	Kiloliters
<b>KP</b>	Khyber-Pakhtunkhwa
<b>kPA</b>	Kilopascal
<b>KPC</b>	Kuwait Petroleum Corporation
<b>ktoe</b>	Kilo Tonnes of Oil Equivalent
<b>Lanka IOC</b>	Lanka Indian Oil Company
<b>LCV</b>	Light Commercial Vehicle

ACRONYM	Meaning
LDO	Light Diesel Oil
LPG	Liquefied Petroleum Gas
LPGL	LP Gas Ltd
LSFO	Low Sulphur Furnace Oil
M&HCV	Medium and Heavy Commercial Vehicle
MEA	Maldives Energy Authority
MEE	Ministry of Energy and Environment
MFN	Most Favored Nation
MoEA, Bhutan	Ministry of Economic Affairs, Bhutan
MOMP	Ministry of Mines and Petroleum, Afghanistan
MoPEMR	Ministry of Power, Energy and Mineral Resources, Bangladesh
MoPNG	Ministry of Petroleum and Natural Gas, India
MOPNR	Ministry of Petroleum and Natural Resources, Pakistan
MoU	Memorandum of Understanding
MOV	Metal Oxide Varistor
MPL	Meghna Petroleum Ltd
MPRD, Sri Lanka	Ministry of Petroleum Resources Development
MRMR Port	Magampura Mahinda Rajapaksa Port
MRPL	Mangalore Refinery and Petrochemicals Ltd
MS	Motor Spirit (petrol)
MSS	Manufacturers Standardization Society
MSW	Municipal Solid Waste
MT	Metric Tonne
Mtpa	Million Tones per Annum
MU	Million Units
MVR	Maldivian Rufiyaa
MW	Megawatt
MWSC	Male Water and Sewerage Company
NACE	NACE International (Formerly National Association of Corrosion Engineers)
NAFTA	North American Free Trade Agreement
NDC	Nationally Determined Contributions
NDR	National Data Repository
NEL	Nayara Energy Ltd (formerly Essar Oil)
NELP	New Exploration Licensing Policy
NEMMP	National Electric Mobility Mission Plan

<b>ACRONYM</b>	<b>Meaning</b>
<b>NOCL</b>	Nepal Oil Corporation Limited
<b>NR</b>	Nepalese rupee
<b>NREP</b>	National Renewable Energy Policy
<b>NRL</b>	Numaligarh Refinery Ltd
<b>OALP</b>	Open Acreage Licensing Policy
<b>OCAC</b>	Oil Companies Advisory Committee
<b>OGDCL</b>	Oil and Gas Development Corporation
<b>OIDB</b>	Oil Industry Development Board
<b>OIL</b>	Oil India Ltd
<b>OISD</b>	Oil Industry Safety Directorate
<b>OMCs</b>	Oil Marketing Companies
<b>ONGC</b>	Oil and Natural Gas Corporation
<b>OPEX</b>	Operational Expenditure
<b>OVL</b>	ONGC Videsh Ltd
<b>PARCO</b>	Pak Arab Refinery Ltd
<b>PCA</b>	Petroleum Concession Agreement
<b>PCOA</b>	Pipeline Construction and Operating Agreement
<b>PE</b>	Layered Coating with Polyethylene
<b>PEPP</b>	Petroleum Exploration Promotion Project
<b>PKR</b>	Pakistani Rupee
<b>PLF</b>	Plant Load Factor
<b>PMMC</b>	Power cum Motor Control Centre
<b>PMUY</b>	Pradhan Mantri Ujjwala Yojana
<b>PNG</b>	Piped Natural Gas
<b>POCL</b>	Padma Oil Company Ltd
<b>POL</b>	Petroleum, Oil and Lubricants
<b>POL</b>	Pakistan Oil Ltd
<b>PPAC</b>	Petroleum Planning and Analysis Cell
<b>PPL</b>	Pakistan Petroleum Ltd
<b>PSA</b>	Production Sharing Agreement
<b>PSF</b>	Price Stabilisation Fund
<b>PSMP</b>	Power Sector Master Plan
<b>PSO</b>	Pakistan State Oil
<b>PSUs</b>	Public Sector Enterprises
<b>RDB</b>	Regional Development Bank

<b>ACRONYM</b>	<b>Meaning</b>
<b>RE</b>	Renewable Energy
<b>REDF</b>	Renewable Energy Development Fund
<b>RIL</b>	Reliance Industries Ltd
<b>ROV</b>	Remotely Operated Vehicle
<b>RoW</b>	Right of Way
<b>RPL</b>	Reliance Petroleum Ltd
<b>RTO</b>	Regional Transport Office
<b>SAARC</b>	South Asian Association for Regional Cooperation
<b>SADF</b>	South Asian Development Fund
<b>SAFTA</b>	South Asian Free Trade Agreement
<b>SAOCL</b>	Standard Asiatic Oil Company Ltd
<b>SAPTA</b>	SAARC Preferential Trading Arrangement
<b>SBPS</b>	Special Boiling Point Solvents
<b>SDF</b>	SAARC Development Fund
<b>SEC</b>	SAARC Energy Centre
<b>SEZ</b>	Special Economic Zone
<b>SGFL</b>	Sylhet Gas Fields Ltd
<b>SKO</b>	Superior Kerosene Oil
<b>SLPA</b>	Sri Lanka Port Authority
<b>SMSs</b>	SAARC Member States
<b>SOCAR</b>	State Oil Company of the Azerbaijan Republic
<b>SPR</b>	Strategic Petroleum Reserves
<b>SRN</b>	Straight Run Naphtha
<b>STELCO</b>	State Electric Company Ltd
<b>STO</b>	State Trading Organization
<b>SV</b>	Sectionalizing Valve
<b>TPML</b>	Total PARCO Marketing Ltd
<b>TPP</b>	Trade Parity Price
<b>TPPL</b>	Total PARCO Pakistan Ltd
<b>TRV</b>	Thermal Relief Valve
<b>UAE</b>	United Arab Emirates
<b>UNFCCC</b>	United Nations Framework Convention on Climate Change
<b>VGf</b>	Viability Gap Funding
<b>WLO</b>	Wholesale Lending Online

## Conversion Factors

Currency	Conversion Factor for 1 USD
Bangladeshi Taka (BDT)	85
Indian Rupee (INR)	70
Pakistani Rupee (PKR)	154

# List of Figures

Figure 1: Petroleum Product Supply Chain .....	2
Figure 2: Methodology to Estimate Petroleum Product Demand and Supply .....	5
Figure 3: Methodology to Estimate Crude Oil Demand and Supply .....	5
Figure 4: Tanker Categories .....	8
Figure 5 : Batching Schedule Logic .....	34
Figure 6: Typical Fuel Batching Procedure.....	34
Figure 7: Multi Product Transfer .....	35
Figure 8: Interface Formation in Multi-Product Pipelines .....	36
Figure 9: Feasibility and Costing Study of Cross-Border Pipelines .....	38
Figure 10: Sri Lanka Ports.....	47
Figure 11: Consumption of Major POL Products: Afghanistan .....	50
Figure 12 Overall POL Demand Outlook 2030: Afghanistan .....	52
Figure 13: Consumption of Major POL Products: Bangladesh.....	54
Figure 14: Import Payment for Oil Products in FY18: Bangladesh .....	55
Figure 15: Overall POL Demand Outlook 2030: Bangladesh .....	57
Figure 16: Consumption of Major POL Products: Bhutan .....	59
Figure 17: Overall POL Demand Outlook 2030: Bhutan .....	61
Figure 18: Consumption of POL Products: India (Source: PPAC) .....	62
Figure 19: Overall POL Demand Outlook 2030: India.....	65
Figure 20: Import of POL Products (Demand) for the Maldives .....	68
Figure 21: Overall POL Demand Outlook 2030: Maldives .....	70
Figure 22: Imports of POL Products Demand: Nepal.....	71
Figure 23: Overall POL Demand Outlook 2030: Nepal .....	72
Figure 24: Consumption of POL Products: Pakistan .....	74
Figure 25: Overall POL Demand Outlook 2030: Pakistan .....	76
Figure 26: Consumption of Major POL Products: Sri Lanka .....	78
Figure 27: Overall POL Demand Outlook 2030: Sri Lanka .....	80
Figure 28: POL Production at Refinery - Sri Lanka (2016).....	81

## List of Tables

Table 1: Petroleum Product Demand and Deficit Scenario for SMSs by 2030 .....	XVIII
Table 2: Optimal Trade Route and Country-level Savings on Freight Cost.....	XIX
Table 3: Advantages of Cross-country Pipelines over Transport by Roads, Railways and Waterways .....	10
Table 4: Performance Characteristics of Various Modes of Transportation .....	11
Table 5: Critical Activities for Petroleum and Petroleum Products Pipelines.....	16
Table 6: Fluid Categories.....	17
Table 7: Location Categories for Pipeline Route .....	17
Table 8: Design Factor ‘F’ for Pipeline Thickness Calculation Designed for Steel.....	20
Table 9: A Typical Leak Detection System.....	27
Table 10: Parameters to Decide Compatible Fluids .....	35
Table 11: Product Sequencing.....	37
Table 12: Capex Cost Components Compared on Basis of Terrain .....	40
Table 13: Port-wise Total Traffic and POL Traffic Handled in India in FY18 .....	43
Table 14: POL Supply Sources: Nepal .....	44
Table 15: Pipelines Owned and Operated by PARCO.....	45
Table 16: Berthing Specification at the Karachi Port in Pakistan.....	45
Table 17: Berthing Specifications at Qasim Port.....	46
Table 18: MRMR Port, Sri Lanka (Specification).....	47
Table 19: Consumption of Major POL Products: Afghanistan .....	51
Table 20: Overall POL demand Outlook 2030: Afghanistan .....	52
Table 21: POL Trade Balance: Afghanistan .....	53
Table 22: Consumption of Major POL Products: Bangladesh.....	54
Table 23: Petroleum Product Imports: Bangladesh .....	55
Table 24: Overall POL Demand Outlook 2030: Bangladesh.....	57
Table 25: POL Trade Balance: Bangladesh.....	58
Table 26: Consumption of Major POL Products: Bhutan.....	60
Table 27: Overall POL Demand Outlook 2030: Bhutan .....	61
Table 28: Consumption of POL Products: India.....	63
Table 29: POL Product-wise Imports and Exports: India .....	63
Table 30: Overall POL Demand Outlook 2030: India.....	65
Table 31: Upcoming Refineries in India .....	66
Table 32: POL Trade Balance: India .....	66
Table 33: Import of POL Products (Demand) for the Maldives.....	68
Table 34: Overall POL Demand Outlook 2030: Maldives.....	70
Table 35: Imports of POL Products Demand: Nepal.....	71
Table 36: Overall POL Demand Outlook 2030: Nepal.....	72
Table 37: Consumption of POL Products: Pakistan .....	74
Table 38: Overall POL Demand Outlook 2030: Pakistan .....	76
Table 39: POL Trade Balance: Pakistan.....	77

Table 40: Consumption of Major POL Products: Sri Lanka .....	78
Table 41: Overall POL Demand Outlook 2030: Sri Lanka .....	80
Table 42: POL Trade Balance: Sri Lanka .....	82
Table 43: Petroleum Product Demand and Deficit Scenario for SMSs by 2030 .....	82
Table 44: Diesel Demand-Supply Scenario for SMSs by 2030.....	83
Table 45: Crude Oil Slate of West Coast Refinery in India.....	83
Table 46: Estimated Petroleum Product Slates and Prices.....	84
Table 47: Optimal Trade Route and Country-level Savings on Freight Cost.....	87
Table 48: Sample Tariff Model for India-Bangladesh Product Pipeline.....	91
Table 49: Refining Capacities in India (as of March 2019).....	106
Table 50: Crude Oil Pipelines in India (as of March 2019).....	107
Table 51: Details of Petroleum Product Pipelines in India (as of March 2019) .....	108
Table 52: Calculation of each Member State’s Savings in Freight Cost .....	110



# Executive Summary

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## Transportation of Crude Oil and Petroleum Products

Crude oil and POL products are transported via various modes, each having their own advantages and disadvantages. These include:

- 1) Marine Oil Tankers and Barges
- 2) Rail Transport
- 3) Road Transport via Trucks
- 4) Pipelines

Even though pipelines involve significant capital expenditure, these typically are the most suitable, the most cost effective and safest mode of transport. Pipeline systems incur the lowest operational cost, cause least ecological damage, and have the smallest carbon footprint of all modes of transport. Also, high reliability lowers the need for safety stock at the receiving end, while the need of storage is minimized as long as the product is in transit.

## Crude Oil/ Petroleum Products Transportation in the SAARC Region

Most SAARC Member States (except India) are dependent on imports for their requirements of petroleum products. Additionally, crude oil reserves are limited and relatively less explored in the region. Hence, huge volumes of crude oil and petroleum products are transported each year to meet the fuel requirements of the Member States at great cost and inconvenience due to the lack of adequate infrastructure for Inter-country movement. Thus, there is need for development of adequate infrastructure to facilitate trade. At present, the SAARC Member States lack proper transport systems for both Inter-country and Intra-country transits. As such, most petroleum products are transported by road in tankers. This is both hazardous and expensive in terms of transit time and cost of transit. Country-wise infrastructure for transport of oil and petroleum products has been detailed below:

### Afghanistan

Currently, the majority of petroleum, oil and Lubricants (POL) products are distributed by road, which is taken care of by the Government (with support from private players) and coalition forces separately. Afghanistan, being a landlocked country, imports POL products via road from neighboring countries mainly Iran, Turkmenistan, Uzbekistan and Russia.

### Bangladesh

The transport of POL products in Bangladesh is presently undertaken by coastal tankers, railways and tank lorries from the Chittagong port to the refinery and, subsequently, to demand centers. The Private players also use small barges to carry POL products on river routes mostly for captive consumption. The Bangladesh Petroleum Corporation (BPC) estimates that ~Tk 1.4 billion (US\$ 17.5 million) is spent annually to transport fuel across the country. The construction of a Cross-country Pipeline from India's Numaligarh refinery to Parbatipur in northern Bangladesh is underway.

## **Bhutan**

In Bhutan, POL products are directly imported from India and distributed via road tankers. The Small and medium-sized tankers with a carrying capacity of 9-12 kiloliter are utilized due to the country's mountainous terrain and narrow roads. The distributors use these tankers to transport fuel from their regional depots, where the imported products are stored, to retail outlets across the country.

## **India**

India has a crude oil pipeline network of 10,419 km connecting production regions and ports to refineries. These pipelines had a total capacity of 145.6 million ton of crude oil per annum as of June 2019. In addition, there are petroleum product and LPG pipelines connecting refineries and ports to demand centers. Presently, there are 44 POL product pipelines of a total length 14,061 km, with a product-carrying capacity of 94 million ton, and six LPG pipelines covering a length of 3,369 km, with a total capacity of 8.5 million ton. Since the POL pipelines are inadequate to cater to the strong demand, large amounts of petroleum products are transported via roads in India, despite this being more expensive. However, a significant investment is being undertaken in this area with four POL product and four LPG pipelines in various stages of construction.

## **Maldives**

The Maldives, being a 100% POL product import-based economy with no proven crude oil reserves, has no refining infrastructure. The dispersed nature of the islands makes pipeline distribution unfeasible. The downstream infrastructure is thus limited to import, storage and distribution facilities. The petroleum products are transported by the sea route through ships and barges.

## **Nepal**

Nepal is a land-locked country with no proven reserves of petroleum. Thus, it relies on import of POL products to meet its domestic demand. Nepal does not have any POL-based mid-stream infrastructure such as refineries but has an operational Cross-border pipeline from India. The POL products are directly imported from India and distributed via road tankers and the recently commissioned pipeline. Nepal Oil Corporation (NOC) and Indian Oil Corporation (IOCL) have jointly constructed a 70 km long, 2 million-ton, cross-country POL product pipeline from Motihari in Bihar to Amlekhgunj in Nepal. Of the total length, 32.7 km of pipeline has been laid in Indian territory and the remaining in Nepalese territory. The construction of the pipeline has already been completed and has also commenced operations in September 2019.

## **Pakistan**

The oil and petroleum products in Pakistan are primarily transported via road in trucks and tanks, and pipelines. Pipeline infrastructure is inadequate despite it being the cheapest mode. The POL transport in the country via road is 61%, pipeline accounts for only 37% and Rail accounts for the balance 2%. PARCO currently has the largest pipeline network for the transportation of crude oil and POL products. In addition, a 2,000 km long White Oil Pipeline (WOP) is under implementation by PARCO for the transport of POL products to the central regions that account for ~60% of the country's total petroleum consumption. Presently, over 50% of the POL requirement in Pakistan is met through imports with the remaining being supplied through refineries.

## Sri Lanka

The crude oil movement in Sri Lanka from port to refinery is through a 5.8 km long pipeline that is more than 40 years old and suffers occasional ruptures and, hence, requires replacement. The Petroleum Resources Development Secretariat under Ministry of Energy, Sri Lanka, plans to lay a Cross-country pipeline to carry crude oil from Colombo Port to Kolonnawa Oil Terminal on a Government-to-Government Agreement and 100% financing on EPC (Engineering, Procurement and Construction) turnkey basis.

In addition to this, there are three product pipelines that transport petrol, diesel, ATF and FO from the port to the Kolonnawa storage terminal. Only one of these three pipelines is currently operational as all these three pipelines are past their useful life and need replacement.

## Scope of Oil Pipeline Networks in South Asia

Crude oil and derivative POL products are widely consumed energy resources within the SAARC Region. The Member States are some of the fast-growing economies in the world with GDP growth rates ranging from 5%-8% year-on-years. The significant momentum in the economies has led to strong demand for POL products primarily from Transportation and Power sector. However, lack of adequate crude oil reserves has led to crude oil requirements in the region being met through imports. As far as petroleum products are concerned, all Member States except India depend on imports to meet their respective demand for POL products.

Going forward, demand for petroleum products in the region is expected to grow at a pace of 4-6% CAGR<sup>1</sup> in each of the SAARC Member States, with refining infrastructure not keeping up pace with the growing demand. A detailed analysis of crude oil and POL products business across all SAARC Member States, including developing a demand and supply outlook till 2030 suggests that other than India rising demand for petroleum products is expected to keep all the SAARC Member States dependent on imports for key POL products (including petrol and Diesel).

**Table 1: Petroleum Product Demand and Deficit Scenario for SMSs by 2030**

('000 MT)	Petroleum Product Demand	Domestic Production of Petroleum Products	Surplus/Deficit
Afghanistan	5,287	4,132	-1,155
Bangladesh (excludes LPG)	14,306	5,540	-8,766
Bhutan	381	0	-381
India	297,250	328,660	31,410
Maldives	1,214	0	-1,214
Nepal	5,982	0	-5,982
Pakistan (excludes LPG)	47,458	24,618	-22,840
Sri Lanka	7,974	1,867	-6,107
Net deficit in the Region			<b>-15,035</b>

<sup>1</sup> Compound Annual Growth Rate (CAGR) is the rate of return that would be required for an investment to grow from its beginning balance to its ending balance, assuming the profits were reinvested at the end of each year of the investment's lifespan. calculated based on the final value and the current value using

$$\text{CAGR} = ((\text{Final Value} / \text{Current Value}) ^ {1/\text{number of years}}) - 1$$

Considering the outlook on demand-supply scenario in 2030, refinery capacity addition planned in the region will be sufficient to cater to the demand for POL products within the region. One of the most important developments that is expected to result in this scenario is India’s plan to add a 60-million-ton refinery on its western coast. However, considering the demand scenario, we believe that only 20 million ton of the refinery will be commissioned by 2030. The 31-million-ton capacity for exports includes 20 million tone of west coast refinery capacity and tepid increase in petroleum product demand in India. This refinery can serve as a plausible option for balancing the SMS’s demand with other SAARC Member States increasing their stake in terms of investment, crude sourcing or purchase requisition. This will lead to an overall savings for importing nations in terms of freight cost. Construction of pipelines will be economically the most feasible option to facilitate trade in most of the routes.

**Table 2: Optimal Trade Route and Country-level Savings on Freight Cost**

Country	Current Source of Import	Route/Mode of Transport	Optimal Source of Import	Route/Mode of Transport	Savings on Freight Cost (\$ per ton)
<b>Afghanistan</b>	Iran	Road tankers	Iran	Road	NA
<b>Bangladesh</b>	Singapore, India	Rail, Sea, Roads	India	Pipeline from Siliguri to Parbatipur	2.0
<b>Bhutan</b>	India	Road tankers	India	Pipeline from Bongaigaon to Gelephu	0.7
<b>Maldives</b>	UAE	Sea	India	Sea (Mumbai port to Male)	6.3
<b>Nepal</b>	India	Road tankers	India	Pipeline from Motihari to Amlekhgunj	25.8
<b>Pakistan</b>	Kuwait	Sea	India	Pipeline from Bhatinda to Lahore	8.2
<b>Sri Lanka</b>	India	Sea	India	Sea (Chennai to Colombo)	NA

## Development of Framework for Crude Oil and POL Pipelines

While economic feasibility is one aspect, there are several other aspects which need to be considered in the construction of a cross-border pipeline. A detailed framework is necessary to understand the various considerations like funding, physical constraints, regulatory aspect, and operation of these pipelines to ensure smooth implementation of such projects. A framework was developed for implementing a crude oil/POL pipeline network within the SAARC region.

## **Conclusion**

The SAARC Region comprises some of the fast-growing economies in the world which would result in strong growth in energy demand and, subsequently POL demand in future. While the existing trade in the region is taking place through sea or by road transport, it is essential to identify and create awareness of the benefits of developing cross-border pipeline networks for the transportation of crude oil and petroleum products. Pipelines are the cheapest, fastest and safest mode of transport and thus can help in improving POL trade within the region. Hence, pipelines can lead to significant cost savings for importing Member States. India has already built a pipeline network to Nepal and is planning to build another one to Bangladesh. Such initiatives need to be taken by other Member States as well. Political will, improved harmonized institutional, legal and regulatory framework, and offering bigger opportunities for private sector participation can accelerate the pace of trade within the region. Such an integrated infrastructure will pave way for improving the trade scenario within the region.

# 1 Introduction

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The eight-nation SAARC region is on a growth trajectory. Labelled as some of the fastest growing economies in the world, the Member States gross domestic product (GDP) growth rates range from 5% to 8%.<sup>2</sup> Significant momentum in the economies has led to strong demand for crude oil and derivative POL (Petroleum, Oil and Lubricants) products, primarily from the transportation and power sectors. However, lack of adequate crude oil reserves has made the region import-dependent. All Member States, except India, depend on imports to meet their demand for POL products.

The rapid economic growth in the region, led by rise in investments, is expected to improve the demand for petroleum products, boosting intra-regional and inter-regional trade. At present, intra-regional trade of crude oil and petroleum products is limited to export of POL products from India to Bhutan, Nepal and to some extent to Bangladesh and Sri Lanka.

Promotion of trade would require considerable movement of Crude/POL products across SAARC Member States. Therefore, the logistics of petroleum product supply chain should be arranged as safely, efficiently and effectively as possible.

Pipelines, Marine Vessels, Tank Trucks, and Railways are typically used to transport crude oil and petroleum products from the point of origin to pipeline terminals, refineries, distributors, and consumers. Each mode of transport has its pros and cons.

The pipeline network for transportation of crude oil, natural gas and POL liquids has evolved as the most efficient and reliable mode. Globally, 1.9 million km of oil and gas pipelines are operational with more than 200,000 km of trunk line and POL product lines expected to be added by 2022. North America relies heavily on pipeline infrastructure for the transportation of oil and gas across the continent due to high exploration and production of conventional and unconventional fossils. Resultantly, the continent is expected to have around one-third of global additions, followed by India with ~30,000 km of pipelines expected to be added by 2022 as per Petroleum & Natural Gas Regulatory Board. These include national and cross-border crude oil, natural gas and POL pipelines. According to Petroleum Planning & Analysis Cell (Ministry of Petroleum & Natural Gas, India), in February 2019, ~11,216 km of pipelines were under construction.

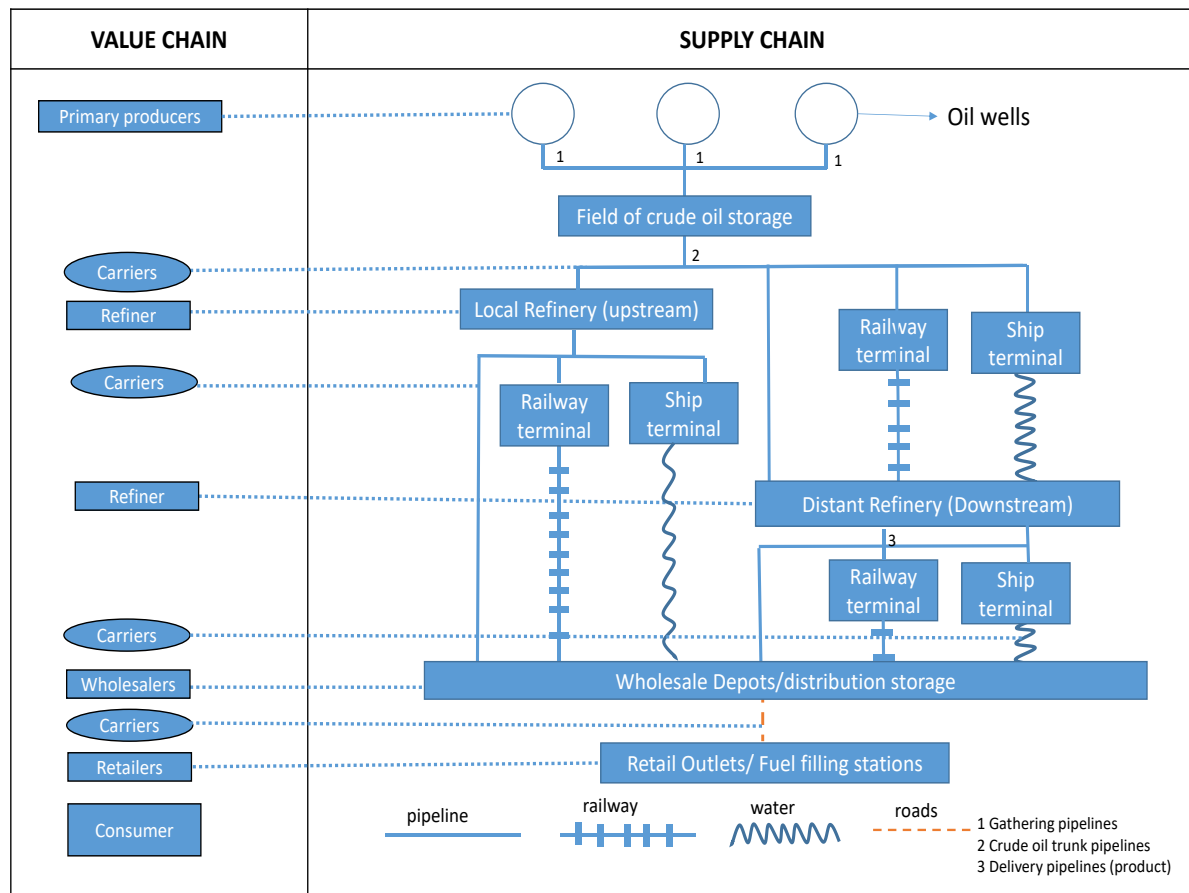
Cross-border pipelines are more complex from a construction and operational perspective. Engineering and installation of cross-border pipelines form a special branch of pipe design and engineering, as it involves many aspects and parameters that are typically faced in the plant piping system within the boundaries of refinery or a chemical / petrochemical plant. Special techniques have to be adopted for design, laying, welding/jointing, corrosion protection, testing, commissioning, etc. India recently commissioned a 70 km pipeline to Nepal. This pipeline has commenced operations in August 2019, supplying High Speed Diesel (HSD), gasoline, aviation turbine fuel (ATF) and superior kerosene oil (SKO) from Motihari, India to Amlekhgunj, Nepal. The pipeline is capable of transporting 20,000 liters of POL

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<sup>2</sup> <https://www.macrotrends.net/countries/SAS/south-asia/gdp-growth-rate>

products in an hour. Moreover, the India-Bangladesh Friendship pipeline was flagged off by the governments in September 2018. The oil pipeline will supply high speed diesel (HSD) to Bangladesh, which is currently transported through cross-border train from Numaligarh refinery. The estimated length of the pipeline is ~130 km, out of which 6 km falls in Indian Territory and the remaining in Bangladesh.

The petroleum product supply chain plays a vital role in the planning of a cross-country pipeline. Abundant supply and demand for petroleum products govern the feasibility of a POL pipeline. The supply chain is described below:



**Figure 1: Petroleum Product Supply Chain**

### 1.1 Purpose of the Study

The most preferable mode of transportation of mass commercial crude/oil products is a pipeline because it is safe, cost effective, and reduces traffic and pollution to a great extent. Pipeline systems can serve large regions of the country or move petroleum from one region to another. For pipelines, the type, layout, location, number, and capacity of facilities are of strategic importance. The planning of a pipeline necessitates the investigation of several alternatives in order to determine whether the project is justified. Comparisons may have to be made with alternative locations for the pipeline, and the shortest and most direct alignment between origin and destination. However, deviations may be necessary because of topographic and other environmental considerations, land use, right of way, and the need to pass near certain supply or delivery points or to skirt heavily population areas.

Bangladesh and Pakistan meet part of their petroleum products requirement indigenously, but rely heavily on imports. In contrast, the remaining five SAARC member states except India meet their entire requirement via imports. Hence, transportation of crude/oil products is a major activity throughout SAARC Member States. Therefore, to reiterate, the logistics of petroleum product supply chain should be arranged as safely, efficiently and effectively as possible. In view of these factors, the purpose of the study is to identify, assess and describe the potential, strategies and logistic aspects of the commercial operation of crude/oil pipeline within and among the SAARC Member States.

## **1.2 Objectives of the Study**

The main objectives of this study are as follows:

- 1) To describe the prevailing logistics activities involved in the flow of crude/oil products and indicate the relative efficiency of pipeline as a mode of transportation among the SAARC Member States (SMSs).
- 2) To explore all associated economic and non-economic issues and the cost of implementation of these options for each Member State.
- 3) To analyze the cost structure of large commercial pipeline operations along with the various funding options for large pipeline projects.

## **1.3 Scope of the Study**

This study was conducted to assess pipelines as a preferred mode of movement of crude oil and POL products detailing the various associated issues in terms of cross-border trade and co-operation amongst SMSs, technical and other aspects involved and possible funding options. The broad areas proposed to be assessed and analyzed in this study shall include:

- 1) Crude/petroleum-product supply chains and prevailing logistics activities that are involved in the flow of crude/oil products;
- 2) Generic framework to assess the suitability of pipeline options in SAARC;
- 3) Suitability of the pipeline options of crude/oil products within the country and among SAARC Member States;
- 4) Associated economic and non-economic issues and cost of implementation of pipelines for each country;
- 5) Funding options of large pipeline operations/projects.

## **1.4 Methodology of the Study**

The report has been prepared primarily by using inputs from secondary sources such as government websites, petroleum and natural gas ministry publications of respective Member States, annual reports of major companies, news articles and other reliable sources. The following methodology has been used to assess various aspects of the study:



## 1.5 Country-wise Demand-Supply Outlook for Crude Oil and Petroleum Products

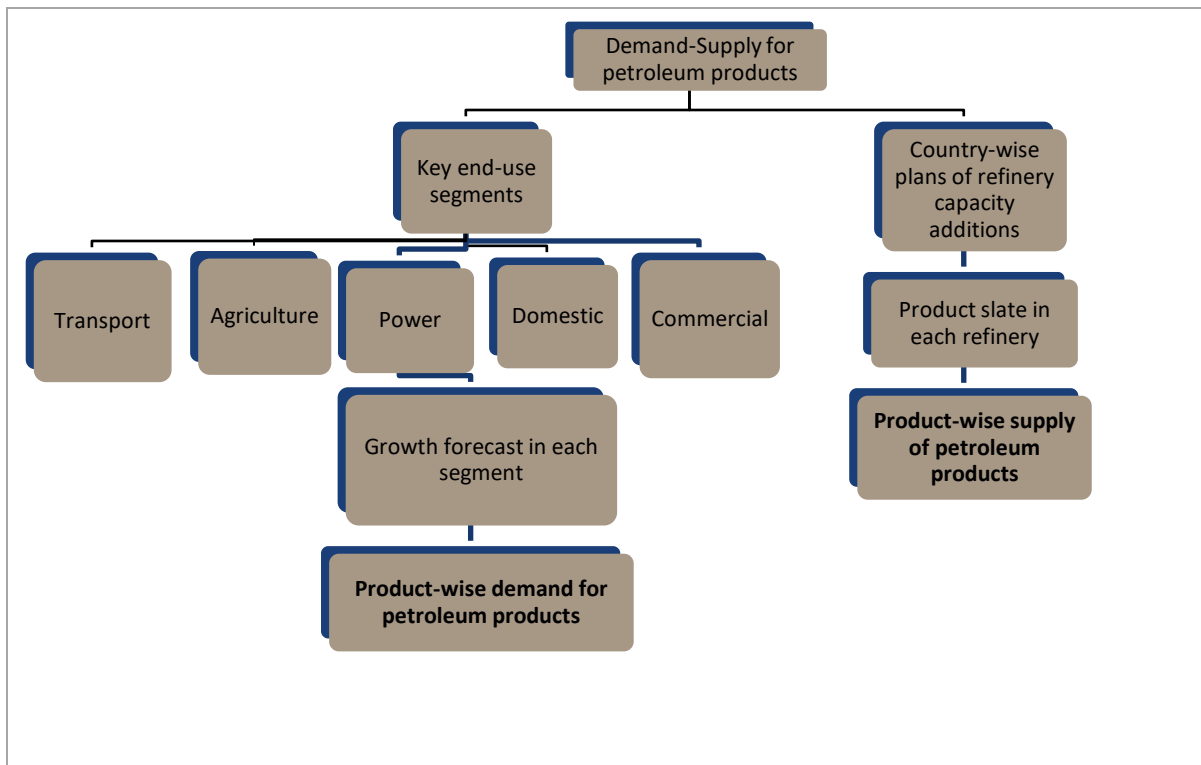
The demand scenario for crude oil and petroleum products has been analyzed for each member state by examining the following aspects:

- 1) **Macro-economic Factors:** The economic growth pattern in a particular country and its potential linkages with petroleum products, as well as the investment outlook in each member state in terms of long-term infrastructure tie-ups with other SAARC and non-SAARC nations have been considered
- 2) **End-use Industries:** For each product, all possible end-use sectors contributing to demand have been considered. POL product-wise, the end-use industries considered include:
  - **Diesel:** Transportation, agriculture, railways, power and industries
  - **Petrol:** Transportation (land and sea (in the case of the Maldives))
  - **LPG:** Residential and commercial cooking needs and transportation
  - **Fuel Oil:** Industrial consumption

Subsequently, for each of these end-use industries, individual factors were analyzed to assess the impact on demand for POL products.

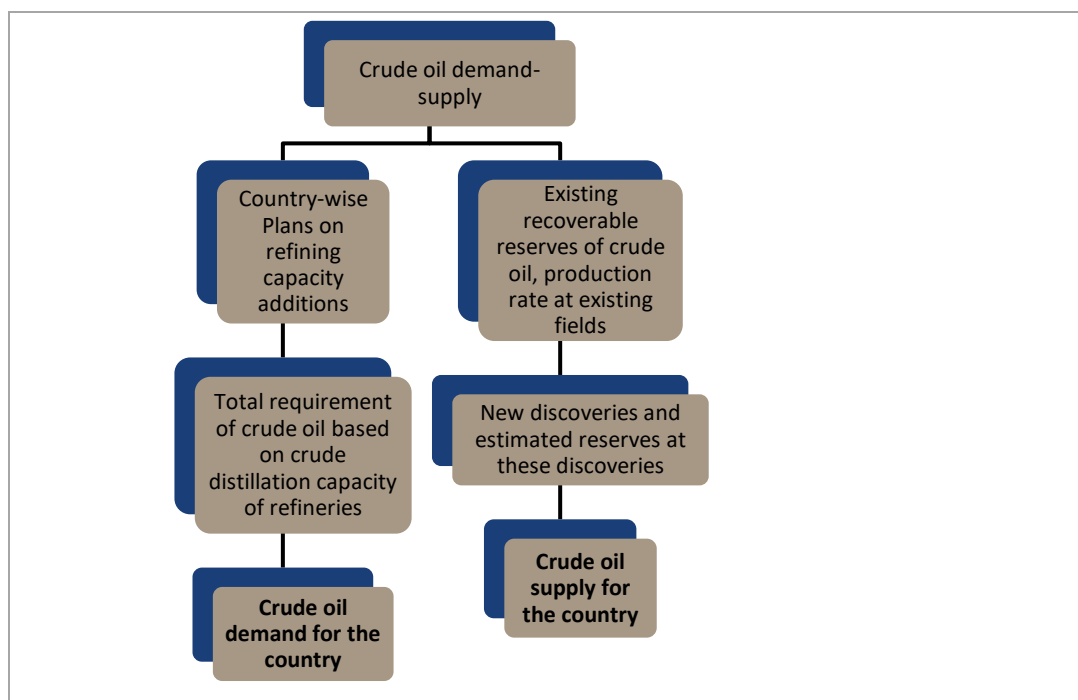
- **Transport sector:** Demand for petroleum products has been correlated to growth in vehicular traffic, (particularly commercial vehicles for diesel and passenger vehicles and two-wheelers for petrol). Vehicular traffic growth has been analyzed by linking it with overall economic activity and growth in personal incomes, coupled with the penetration of vehicles in each country. Further, policies on promotion of alternate fuels like Compressed Natural Gas (CNG), Liquefied Natural Gas (LNG), Biofuels, and Electricity have been studied in-depth to identify factors that could inhibit growth in demand for conventional vehicles.
- **Power sector:** The fuel demand is estimated by planned capacity additions and retirements as stated by the Government. Since power generation from POL products is expensive than other sources, the impact of alternative fuels on POL demand has also been considered.
- **Industrial sector:** Growth in the industrial sector has been linked with the prospects of industrial activity in each Member State for which industrial GDP has been considered. A large part of POL demand in the industrial segment originates from petrochemicals, which are produced by further cracking of petroleum products (naphtha). Industrial solvents such as benzene, toluene and xylene are extensively utilized in cleaning of machine parts.

The demand for each of these sectors has been assessed individually and subsequently added up to determine the POL demand outlook till 2030.



**Figure 2: Methodology to Estimate Petroleum Product Demand and Supply**

On the supply side, each Member State recoverable hydrocarbon reserves have been analyzed to identify the crude oil production potential. Further, maturity of existing fields has been considered and recently bid out fields are taken into account to arrive at an estimate of domestic crude oil production. Post this, each country's plan to add refining capacities has been considered by looking at company annual reports and government announcements. Based on this data, the domestic petroleum production outlook till 2030 has been estimated.



**Figure 3: Methodology to Estimate Crude Oil Demand and Supply**

The deficit/surplus in crude oil and POL products has been assessed to improve imports/exports and trade between the respective nations.

### **1.5.1 Technical Aspects of Cross-country Pipeline**

The sources utilized during secondary research are cited in the bibliography section of the study. The relevant rules and standards applicable in case of cross border pipelines were referred for analysis on the same.

### **1.5.2 Assessment of Economic Feasibility of Alternate Modes of Transportation for Crude Oil and POL Products**

Feasibility of pipelines with other alternate modes of transport was assessed by looking at road, rail as well as sea trade routes and calculation of freight rates for various routes.

- 1) For sea routes, freight was assessed by looking at the sea distance between the origin port and destination port and calculating the total freight cost inclusive of port charges by looking at charter rates for crude oil and POL tankers and taking an average charter rate over the past year. Port charges were taken from respective port websites and average transport cost was calculated.
- 2) For road routes, distance between the origin and destination was calculated and multiplied with the per round trip km freight rate (collected from industry sources) for oil tankers.
- 3) For rail routes, published railway freight data has been collected from government websites. If the same is not available, benchmarks have been taken and proportionate freight has been estimated.
- 4) Finally, for pipelines, a detailed tariff estimation was done for proposed routes by estimating CAPEX as per benchmarks as detailed in later sections of the report.

Each alternative mode of transport was assessed in terms of cost and economic viability and the most feasible mode of transport was arrived at by comparing costs for each alternative route.

## **1.6 Limitations of the Study**

This study has been undertaken through a detailed secondary research exercise. As such the detailing, assumptions and the outlook are entirely dependent on the information available in the public domain. While undertaking this study special care has been taken to cover all aspects of the terms of references. This study however has certain limitations including:

- 1) The data utilized in this study has been sourced majorly from government documents of the respective Member States. However, in case of data constraints, especially in Member States like Afghanistan, reasonable assumptions have been taken based on further secondary reading and information available from reports of other multilateral funding agencies.
- 2) The economic outlook for the country has been developed in line with IMF projections till 2023 beyond which they have been assumed on similar lines.
- 3) While developing the outlook, all the possible developments in terms of infrastructure, policy

change, investment and technology have been incorporated based on the information present in the public domain. These developments have been considered as the business-as-usual scenario. No specific disruptive scenarios or changes have been considered while developing this report which do not find mention in any policy or strategy documents.

- 4) While the outlook has been developed for demand, supply and trade, the pricing outlook is limited to transportation of petroleum products, since SAARC region is inherently a crude oil deficit region so overall pricing outlook is dependent on the international prices for imports and trade.
- 5) Detailed feasibility study for various cross-border pipeline routes was beyond our scope. Hence, reasonable assumptions have been taken to understand CAPEX and develop a tariff model for alternate pipeline routes.

## 2 Transportation of Crude Oil and Petroleum Products

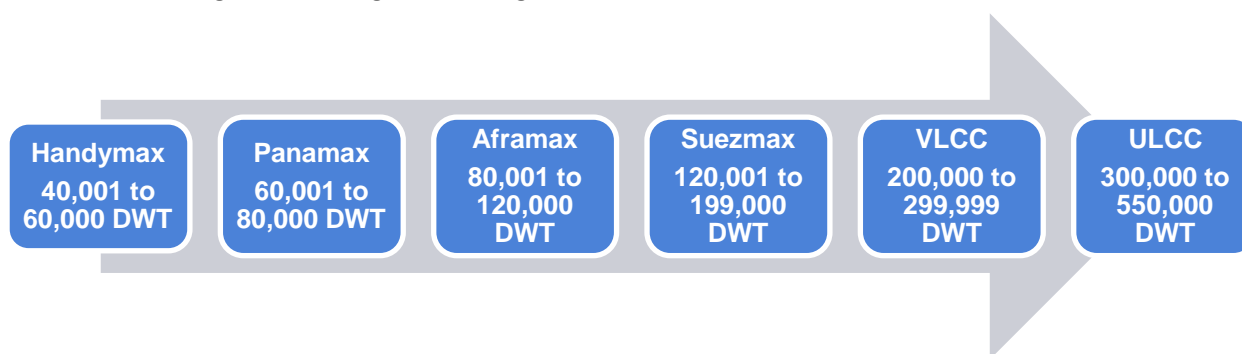
### 2.1 Modes of Transportation

There are several alternative modes of transporting crude oil and POL products from one place to another. These include Marine Oil Tankers and Barges, Road via Trucks, Railways and Pipelines. Each mode of transport has its own advantages and disadvantages. These alternative modes have been discussed below.

#### 2.1.1 Marine Oil Tankers and Barges

##### Types of Tankers

Tankers range in size from small vessels used to transport refined products to huge crude oil carriers. Tanker sizes are expressed in terms of deadweight (dwt) or cargo tons. Ships are manufactured in six sizes, with the larger ones designed for longer hauls.



**Figure 4: Tanker Categories**

Source: Clarkson<sup>3</sup>

#### 2.1.2 Rail Transport

Crude oil and petroleum products can be transported on long cargo trains equipped with special tankers. Rail is a widely used mode of transport, especially in areas lacking pipeline infrastructure. Following the receipt at terminals from marine vessels or pipelines, bulk liquid petroleum products are delivered by non-pressure rail tank cars directly to service stations and consumers or to smaller terminals, called bulk plants, for redistribution. LPG is transported in pressure tanks. In contrast to marine oil tankers, which can hold a significant amount of crude oil in a small number of holding tanks, rail cars can only transport the required quantities of oil in multiple cars. After extraction, oil is loaded on to these railcars and moved across pre-existing tracks to the refinery. Rail is also used to transport refined petroleum products to distribution locations.

#### 2.1.3 Road Transportation via Trucks

Tanker trucks are also used to transport oil, but they are functionally the same as rail transportation, i.e., several large trucks with equipped oil storage tanks are needed to move significant quantities of oil. Generally, trucks are used to carry small capacities of oil over short distances; they are more commonly

<sup>3</sup> www.clarkson.com

used to move refined petroleum products (gasoline) to distribution locations such as gas stations. Instead of relying on established railways, however, trucks can operate more freely as they only require roadways to travel.

#### **2.1.4 Pipelines**

There are three basic types of petroleum pipeline transport systems:

- 1) Gathering pipeline systems
- 2) Crude-oil trunk pipeline systems
- 3) Refined-products pipeline systems

Collectively, these systems provide a continuous link between extraction, processing, distribution, and wholesalers' depots in areas of consumption.

##### **Gathering Pipeline Systems**

As crude oil is extracted in production fields, gathering systems collect and carry it from the wells to central locations by means of a network of small-diameter, low-pressure pipelines. Gathering involves a short-haul collection function, usually consolidating many streams into field storage tanks for later transfer to trunk lines. Gathering pipelines form a part of the materials management or inbound logistics portion of the petroleum product supply chain.

##### **Crude Oil Trunk Pipeline Systems**

Crude oil is transported in trunk lines. These pipelines receive crude oil from storage tanks, gathering systems, ships, barges or other trunk pipelines. As is the case with gathering pipelines, these pipelines form a part of the inbound logistics portion of the petroleum product supply chain.

A trunk line has relatively larger volumes going to relatively fewer delivery points. While the delivery lines carry lesser quantity to a greater number of delivery points. Generally, the trunk system operates in a 'fungible' mode: the shipper receives the same quality of product that it tendered for transport, but not the same molecules, whereas the delivering line operates in a 'batch' mode: the shipper receives the same molecules that it tendered for shipment.

##### **Refined Product Pipeline Systems**

Product pipelines transport refined petroleum products from refineries and seaports to wholesale depots, from where the products are usually transported by trucks to retail outlets and large consumers. Refined product delivery systems are the converse of crude oil gathering systems. Instead of small streams flowing into high-volume trunk pipelines via tank farms, product pipelines are large-capacity systems connecting tank farms at refineries, which branch into small-capacity pipelines to service dispersed delivery points – usually wholesale depots. Product pipelines form part of the distribution or outbound logistics of the petroleum-product supply chain.

## 2.2 Comparison Between Alternative Modes of Transportation

Crude oil is a liquid commodity and its vapors are combustible. Hence, it presents challenges during transportation. Sea transport of crude oil requires special ships. Crude oil pipelines can eliminate the need for sea transport, but the amount of investment and durability required mean that these are only economically-viable for large, long-term volumes.

Each mode of transport (tanker and pipeline) has its advantages and drawbacks. Transportation via railways, roads and sea require specialized equipment along with several regulatory compliances. For instance, trucks carrying POL products across borders require permits and licenses, need to pay octroi, toll, as well as require RTO permission, etc. for every batch of the product transported.

Pipelines, on the other hand, are a cost-effective mode of transportation despite the high capital expenditure (CAPEX). The major challenges in pipeline construction are right-of-way (RoW) and construction cost, which varies with terrain/topography, and at times with the type of product to be transported. Once these challenges are addressed, pipeline systems incur the lowest operational cost, cause least ecological damage, and have the smallest carbon footprint of all modes of transport. Also, high reliability lowers the need for safety stock at the receiving end, while the need of storage is minimized as long as the product is in transit.

Safety and environmental concerns are of increasing importance, and are among the principal criteria by which pros and cons are measured. Pipeline transport is safer, even though pipelines can rupture or be sabotaged. Much progress has been made in sea transport safety in recent years; despite such progress, the fact remains that it takes only one tanker accident and the resulting pollution to give an extremely negative image for sea transportation of hydrocarbons. Fortunately, such accidents are extremely rare in proportion to the volume of traffic.

Refined products are generally transported over shorter distances, but the dispersal of end-consumers and the diversity of the products transported pose specific challenges. For example, the holds of transport ships (tankers) must be cleaned between each product batch. Furthermore, pipelines carrying refined products are relatively rare.

**Table 3: Advantages of Cross-country Pipelines over Transport by Roads, Railways and Waterways**

Parameter	Road	Rail	River	Pipeline
Investment	Low by unit, high overall	Moderate by unit, high overall	High	Very high and made within a small-time horizon
Infrastructure Costs	-	Mainly borne by state	Toll duties	High and borne entirely by the company
Personnel Cost	Very high	Fairly high	High for self-propelled barges, low for push boats	Low (requires skilled personnel but low in number)
Maintenance Cost	Very high	High except when volume justify collective installments and automation		Very low
Return Cost	Empty return	Empty return	Return in ballast	Nil
Length of the Route	Outward practically everywhere, natural obstacles lead to significant detours	Fairly dense and limited by natural obstacles	Most circuitous route, where it exists	Most direct

Parameter	Road	Rail	River	Pipeline
Climatic Condition during Transit	Very sensitive	Not very sensitive	Sensitive	Not affected
Flexibility of Transit	Very high	Very limited	Very limited	Nil

### 2.3 Effective Service Delivery

Pipelines are preferred over other modes of transportation based on performance, which is determined by the factors such as suitability, accessibility, goods security, transit time, reliability and flexibility. We have detailed these factors below:

- 1) **Suitability:** The factor refers to the ability of a carrier to provide required facility and equipment for a continuous supply of fuel. This also takes into consideration the demand of transported liquid at the destination, i.e., if the demand of the fuel or POL liquid is high and regular, pipelines are the most suitable mode of transportation.
- 2) **Accessibility:** The factor refers to the ability to serve a particular destination with specified mode of transportation factoring in the presence or cost of development of the mode compared to others.
- 3) **Goods security:** The factor refers to the arrival of fuel or POL liquids at destination without any loss and in the same quantity as tendered to the carrier. For instance, roads are more prone to loss of goods compared to pipelines.
- 4) **Journey speed:** The factor refers to the time elapsed between placement order and delivery of the product. This depends on the batch of the product carried out. In case of pipeline, due to continuous pumping cycle and no return journey indicates economic and faster transportation.
- 5) **Reliability:** This factor refers to the continuity of supply of the product and depends on the performance of the mode of transportation in achieving timely delivery. Moreover, the automation of operation leads to faster fault detection and limited effect of events such as workforce unavailability, weather disruptions or any calamity.
- 6) **Flexibility:** This factor refers to the adaptability of the mode of transportation to change/variation in parameter of service. The parameters include volumes, collection and delivery times and locations, while flexibility involves no loss in efficiency in case of such variations. Moreover, the ability of the transportation mode to accommodate supply disruptions, schedule deviations, expedite the progress of a consignment and alter collections/deliveries determines its flexibility.

**Table 4: Performance Characteristics of Various Modes of Transportation**



Service Characteristics	Relative Performance in General Terms		
	Highest	←————→	
Suitability	Pipe	Rail	Road
Accessibility	Road	Rail	Pipe
Goods security	Pipe	Rail	Road
Journey speed	Pipe	Rail	Road
Reliability	Pipe	Rail	Road
Flexibility	Road	Rail	Pipe

## 2.4 Issues with Landlocked Member States

SAARC Member States such as Afghanistan, Bhutan and Nepal are landlocked, whereas Bangladesh and Pakistan have small coastlines. This poses a challenge for the development of the economies, owing to restrictions on transportation of traded goods. Because of the lack of ports, these Member States depend on transportation via rail, road, and often through neighboring Member States. Moreover, majority of these Member States depend on imports to meet their energy demands.

The major challenges of landlocked Member States are:

- 1) Over-dependency on neighboring Member State (transit Member States) for trade. This is one of the major challenges for landlocked countries as it requires cordial relations with the countries and there is limited power to drive trade regulations and policies. The policies and the regulations are governed by the transit countries handling the trade while the dependent country can barely amend or modify these regulations and policies. Therefore, landlocked Member States have to adhere to policies or regulations set by the transit countries. Landlocked Member States also depend on these countries to scale up trade despite developing good trade relations with other economies.
- 2) Inefficient border crossings, where oil and POL products can be held up for days or weeks. This can result in products being damaged, stolen or spoilt, along with sufficient addition inventory to be maintained by the traders, thus directly driving up costs to consumers. In addition, landlocked countries usually have to bear high cost of trade as the transit countries levy charges for the trade corridor provided. This further increases the cost of goods, resulting in high inflation in the importing countries.
- 3) Landlocked Member States often have under-developed trade infrastructure owing to dependence on one or two transit countries and thus trade in these countries is restricted. Moreover, due to lack of international trade, the Member States are unable to scale up manufacturing facilities which require imported raw materials.

Owing to high demand of POL products in the SAARC region, pipelines are suitable as these allow transportation of high volumes, resulting in high utilization of the pipeline infrastructure. This translates into economic and efficient transportation of POL liquids compared with other modes. For example, according to DOT vision 2050, between Durban and Gauteng in South Africa, pipeline tariffs per liter of fuel are approximately half of rail tariffs, and one-fifth of road transport tariffs. Also, the throughput capacity of pipelines cannot be matched by other modes of land transport.

The only factors limiting the adoption of pipelines is their fixed RoW leading to high initial investment for land acquisition and leasing. Therefore, in case of intermittent or unstable demand, pipelines are not the preferred mode of transportation. However, in the case of cross-border pipelines, the delivery point is dependent on large demand of the particular facility, area or country.

## **2.5 Advantages of Cross-country Pipelines over Roads, Railways, Waterways**

The most common modes of transport are roads, railways and waterways. However, these modes have limitations which are mentioned below:

- 1) Availability of adequate road length, rail tracks and harbor facilities.
- 2) Condition of the tracks/ roads.
- 3) Condition of the vehicles.
- 4) Procedures and controls involved in transportation (permits, licenses, octroi, toll, RTO, etc.).
- 5) Manpower to operate and maintain the system.
- 6) Availability of fuel and power to run the system.
- 7) Effect of nature on the system, such as rains, storms, earthquakes, thundering, mist, etc.
- 8) Pollution generated by the transporting vehicles.
- 9) Safety, insurance and security of the transported goods and materials.
- 10) Time taken for transportation and delays.

These limitations restrict continuous transportation of bulk commodities, such as crude oil, petroleum products, liquefied petroleum products, natural gas, and even chemicals. Hence, reliability and efficiency are the domain of only cross-country pipelines. The advantages are mentioned below:

- 1) Un-interrupted transportation.
- 2) No dependence on roads, railways, bridges, etc.
- 3) Least manpower requirement to operate (only for inspection and maintenance).
- 4) No hindrances because of geography, terrain, weather, etc.
  - Safety and purity of the product is ensured, there is minimal loss of quality or quantity of the product from source to supply point.
  - Once laid, the pipeline system is entirely automated with modern instrumentation, safety devices, interlocks, communication system, and remote-control devices.
  - Cost of transportation per unit of the product is considerably lower than transportation via trucks, railways and water.
  - Fastest mode of transport even between two Member States or across continents.
  - Comparatively less hazardous than surface transportation.

There are certain disadvantages, which are mentioned below:

- 1) Acquiring land for RoW, especially through private and agricultural land, and habited areas.
- 2) High potential for fire and explosion.

- 3) Issues related to corrosion and leakages.
- 4) Requires daily on-route inspection and testing with quick arrangements for attending to repairs and rectification works.
- 5) Damage caused because of laying of pipeline of other services along the route (due to ignorance of its existence among other agencies).
- 6) Specialized techniques and agencies are required to design, engineer, install and operate the pipeline system.
- 7) Requires expensive cathodic protection for the protection of underground lines running in proximity of overhead High-tension Transmission lines.

Modern techniques are well-developed to offset the effects of these challenges. In fact, storage facilities at the users' end can take care of stoppages even for 15 days to one month in case of any operational challenge leading to pipeline shutdown.

## 3 Designing, Construction and Operation of Crude Oil and POL Pipelines

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### 3.1 Pipeline Planning and Design

Before a pipeline project is awarded/approved, there are several steps to be followed which are given below:

- 1) Product-level data gathering and associated details such as risks and hazards, facility for loading and unloading, and supplied quantity requirement.
- 2) Route survey and analysis, and techno-commercial evaluation of alternatives routes. This includes spot-level surveys, evaluation of soil condition, route mapping, cadastral survey, and availability of material and labor.
- 3) Selection of the route and development of a detailed engineering plan. Estimating CAPEX and OPEX of the pipelines for various routes and then shortlisting the most profitable route. Along with this, a detailed engineering plan is prepared comprising material requirement and other costs associated with the construction of the pipeline.
- 4) Project scheduling is the final step wherein a detailed plan is formulated along with timeline for phase or project completion.

#### Designing of Intra-country Pipeline

SAARC Member States have various policies and regulations governing the trade of POL products. These include trade via pipelines as well as other modes. Of all the Member States, the most detailed and stringent policies are by Petroleum and Natural Gas Regulatory Board, India (PNGRB). Furthermore, India is the only Member State capable of exporting refined products to neighboring countries because of surplus refining capacity available. Therefore, emphasis has been given to Indian Pipeline Regulations and Policies. The policy has been briefly described in the subsequent section. The policies refer to code ASME B31.4-2002<sup>4</sup> published by American Society of Mechanical Engineers (ASME) designed for pipeline transportation systems for liquid hydrocarbons and other liquids. The policy along with the technical specifications outlines the critical activities for POL pipeline designing, construction, commissioning and maintenance. These critical activities are listed in the following table.

According to the design guidelines published in *Oil and Gas Pipelines and Piping Systems Handbook*; Design, Construction, Management, and Inspection of pipeline design is based on the POL product that is to be transported. For a multi-product pipeline system, the characteristics of Heavy Diesel Oil are taken as the reference point, whereas for specific product lines, such as LPG, Naphtha or ATF, the

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<sup>4</sup> Standards for pipeline construction:

- ANSI/ASME Standard B31.1: Power Piping - Applies to steam piping systems
- ANSI/ASME Standard B31.3: Chemical Plant and Petroleum Refinery Piping - Applies to major onshore and offshore facilities worldwide
- ANSI/ASME Standard B31.4: Liquid Transportation Systems for Hydrocarbons, Liquid Petroleum Gas, Anhydrous Ammonia, and Alcohols - Applies to onshore oil pipeline facilities
- ANSI/ASME Standard B31.8: Gas Transmission and Distribution Piping Systems - Applies to onshore gas transmission, gathering, and distribution pipelines

characteristics of the respective products are considered.

**Table 5: Critical Activities for Petroleum and Petroleum Products Pipelines**

Sr. No.	Critical Infrastructure or Activities or Processes	Time Period for Implementation and Compliance	Implementation Plan
1	Test record for radiography, ultrasonic test or other applicable NDT methods (as carried out before commissioning)	6 months	To be complied within 6 months
2	Hydrostatic test (as carried out before commissioning) report as per compliance regulations specified by PNGRB <sup>5</sup>	6 months	To be complied within 6 months
3	Pipeline cathodic protection record	6 months	To be complied within 6 months
4	Pipeline as-built records	6 months	To be complied within 6 months
5	Intelligent pigging to be carried out to detect metal loss for pipelines of size 6 inch (168.3 mm) and above and length of 10 km and above	2 years	If pigging has not been done for more than 5 years for sour liquid petroleum and petroleum products pipelines and 10 years for other liquid petroleum and petroleum products pipelines, intelligent pigging should be carried out within two years. Otherwise, relevant records should be submitted
6	HSE management system (including fire protection system)	6 months to 12 months	To be implemented
7	Environment friendly fire extinguishing system for closed space	1 Year	For control room, switch gear and battery room, etc. (CO <sub>2</sub> is acceptable only for unmanned station)
8	HAZOP <sup>6</sup> to be undertaken for all pipeline facilities		HAZOP to be carried out and mitigation plan to be implemented

Source: PNGRB

While there are alternatives for designing and constructing a pipeline, an economic analysis needs to be carried out to determine the optimum design specification to meet the specified operating requirements with the highest technical integrity at the lowest cost. The following parameters along with other factors should be covered in the analysis:

- 1) Pipe diameters, operating pressures, flow velocities, materials, etc.
- 2) Distance between booster stations, with facilities required for operation and maintenance of booster stations.
- 3) Alternative routes with their problems, peculiarities, impacts and risks with due consideration to the interaction between the pipeline and the environment during each stage of the pipeline life cycle.
- 4) Construction methods particularly at crossings in challenging terrains and marshy areas etc.

<sup>5</sup> PNGRB - Petroleum and Natural Gas Regulatory Board

<sup>6</sup> HAZOP - Hazard and Operability Study

Based on the hazard potential of a fluid transported in the pipeline, it should be segregated as per following categories. These categories govern the standards and directives for site selection, material section, safety regulations/ requirements, operating guidelines/ parameters and maintenance.

**Table 6: Fluid Categories**

Category	Description	Example
<b>A</b>	Non-flammable, stable and non-toxic fluids that are in liquid form at ambient temperature and 50 kPA (0.5 bar) above atmospheric pressure, i.e., having vapor pressure lower than 150 kPA (1.5 bar; abs) at ambient temperature	Water, slurries
<b>B</b>	Flammable or unstable or toxic fluids, which are in liquid form at ambient temperature and 50 kPA (0.5 bar) above atmospheric pressure, i.e., having vapor pressure lower than 150 kPA (1.5 bar; abs) at ambient temperature	Stabilized crude, gas oils
<b>C</b>	Non-flammable, stable and non-toxic fluids, which are in gaseous form or mixture of gas and liquid at ambient temperature and 50 kPA (0.5 bar) above atmospheric pressure, i.e., having vapor pressure lower than 150 kPA (1.5 bar; abs) at ambient temperature	Nitrogen, carbon dioxide
<b>D</b>	Flammable or unstable or toxic fluids, which are in gaseous form or mixture of gas and liquid at ambient temperature and 50 kPA (0.5 bar) above atmospheric pressure, i.e., having vapor pressure lower than 150 kPA (1.5 bar; abs) at ambient temperature	Natural gas, LPG, ammonia

*Source: Oil and Gas Pipelines and Piping Systems Handbook*

Pipeline construction requires site selection and land acquisition (RoW) which is dependent on the location class of the land. These categories are then referred for the calculation of the wall thickness of the pipeline as the design factor of a pipeline is dependent on the location class (a typical example for a steel pipeline is shown in the below table). The following table describes the location categories for pipeline construction.

**Table 7: Location Categories for Pipeline Route**

Location Categories	Criteria
<b>1</b>	1-mile section of pipeline that has 10 or fewer buildings intended for human occupancy. This includes areas such as: <ul style="list-style-type: none"> <li>• Wastelands</li> <li>• Deserts</li> <li>• Rugged mountains</li> <li>• Grazing land</li> <li>• Farmland</li> <li>• Sparsely populated areas</li> </ul>
<b>2</b>	1-mile section of pipeline that has more than 10 but fewer than 46 buildings intended for human occupancy. This includes: <ul style="list-style-type: none"> <li>• Fringe areas around cities and towns</li> <li>• Industrial areas</li> <li>• Ranch or country estates</li> </ul>

Location Categories	Criteria
3	1-mile section of pipeline that has 46 or more buildings intended for human occupancy except when a Class 4 location prevails. This includes: <ul style="list-style-type: none"> <li>• Suburban housing developments</li> <li>• Shopping centers</li> <li>• Residential areas</li> <li>• Industrial areas</li> <li>• Other populated areas not meeting Class 4 location requirements</li> </ul>
4	1-mile section of pipeline where multi-story (more than 4 stories) buildings are prevalent, traffic is heavy or dense, and where there may be numerous other utilities underground.

*Source: American Petroleum Institute, ANSI and ASME standards*

For fluid categories B and C in location classes 3 and 4, and for category D in all location classes, risk assessment should be carried out to confirm that the selected design factors and proximity distances are adequate. Consideration will be given to the potential causes of failure, such as internal corrosion, hydrogen induced cracking, internal erosion, external corrosion, bicarbonate and sulfide stress corrosion and cracking, mechanical impacts and external interferences, fatigue, hydrodynamic forces, geotechnical forces, material defects, thermal expansion forces, etc., and their frequencies, and the factors critical to public safety.

The following design parameters should be considered while preparing a pipeline design report:

- 1) **Flow Rate:** For a given pipe size, fluid characteristics and flow rate, a hydraulic analysis should be carried out to establish the possible range of operational parameters, i.e., pressure and temperature profiles along the pipeline for steady state and transient conditions, by taking into account possible changes in flow rates and operational modes over the lifespan of the pipeline. For liquid lines, the normal average flow velocities should be selected between 1 to 2 m/s. Operations above 4 m/s should be avoided and lines containing a separate water phase and should not operate at velocities below 1 m/s to prevent water dropout which may create corrosive situations. Pressure drops should be calculated for the pipeline fluid, especially if the pipeline passes through hilly terrain or elevation that can build back-pressure. The pressure drop should be compensated with pumping stations based on these calculations.
- 2) **Mechanical Design:** As per the categories applicable for various liquids or gaseous commodities, the mechanical designs of pipes are selected and the codes are followed. For instance, pipelines carrying category B fluids should be designed and constructed in accordance with ANSI/ASME B31.4, while pipelines carrying category C or D fluids should be designed and constructed in accordance with ANSI/ASME B31.8. Although LPG and anhydrous ammonia are covered by ANSI/ASME B31.4, these fluids fall under category D and therefore, pipelines carrying these products should be designed to ANSI/ASME B31.8.

The pipeline mechanical design should also consider pigging capabilities, and should be designed to allow passing of pigs through the pipeline when required. Pigging typically is a maintenance and pipeline

health assessment process that involves a physical pig being run into the pipeline. The main purpose of pipeline pigs is to make sure that the pipe is clean and free from blockades. The pig is usually cylindrical or spherical to aid movement and efficient cleaning. It can remove and detect any obstacle within the pipe, which can often lead to reduced performance, increased energy costs, and corrosion, or could also lead to leaks and cracks in the pipe. In the post commissioning of the pipeline, its integrity is of utmost importance i.e., the pipeline including its piping and support systems should function properly without compromising safe operations. For this, the design must consider the placement of valves, over-pressurization protection systems and de-pressurization facilities.

- **Valves:** These controls and maintain the pressure in the pipeline. In the event of leakage or disconnection of a certain branch line, valves play a key role. Some of the major types of valves are block valves, check valves, thermal relief valves, and safety valves. All valves should comply with ASME Spec 5L<sup>7</sup>. The valve inlet and outlet passages should match the pipe’s internal diameter while the check valves should preferably be swing type to API-6D<sup>8</sup>.
- **Pipeline thickness:** The nominal pipe wall thickness should be calculated according to ANSI B31.4 for category B service and ANSI B31.8 for category C and D services. Special attention should be paid to these standards when the ratio of the pipe’s nominal diameter to wall thickness exceeds 96. The thickness of the pipeline is also dependent on the terrain.
- **Wall thickness:** Wall Thickness ‘t’ for straight steel pipe under internal pressure shall be calculated by the following equation:

$$t = \frac{P_i D}{2 S}$$

Where, D= outside diameter of pipe.

Pi = Internal Pressure

S = F x E x Specified minimum yield strength of pipe.

F is the design factor and explained in detail for the various location classes in the Table 8 and E is 1 for seamless ERW<sup>9</sup> and SAW<sup>10</sup> pipe.

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<sup>7</sup> ASME Spec 5L: Covers the grade specifications for steel and carbon concentration to be used

<sup>8</sup> API 6D specifies requirements and provides recommendations for the design, manufacturing, testing and documentation of ball, check, gate and plug valves for application in pipeline systems

<sup>9</sup> ERW - Electric Resistance Welded

<sup>10</sup> SAW - Submerged Arc Welded



**Table 8: Design Factor 'F' for Pipeline Thickness Calculation Designed for Steel**

Fluid Category		B	C and D			
Applicable ANSI/ ASME code		B 31.4 (Note i)	B 31.8			
Location class		1,2,3, and 4	1	2	3	4
Pipeline		0.72	0.72	0.60	0.50	0.40
Crossing (Note ii)	Private roads	0.72	0.72	0.60	0.50	0.40
	Unimproved public roads	0.60	0.60	0.60	0.50	0.40
	Roads, Highways, Streets and Railways	0.60	0.60	0.60	0.50	0.40
	Rivers, dunes and beaches	0.60	0.60	0.60	0.50	0.40
Parallel encroachments (Note iii)	Private roads	0.72	0.72	0.60	0.50	0.40
	Unimproved public roads	0.72	0.60	0.60	0.50	0.40
	Roads, highways, streets and railways	0.72	0.60	0.60	0.50	0.40
Fabricated Assemblies (Note iv)		0.60	0.60	0.60	0.50	0.40
Pipeline on bridges		0.60	0.60	0.60	0.50	0.40
Near concentration of people		0.72	0.50 (Note v)	0.50 (Note v)	0.50	0.40
Pipelines, block valve stations, and pig trap stations		0.60	0.60	0.60	0.50	0.40
Compressor station piping		-	0.50	0.50	0.50	0.40

**Notes:**

- i. ANSI/ASME B31.4 does not use design factors other than 0.72, which is considered inappropriate at critical locations (e.g., crossings, within plant fences), and for fabricated assemblies. In these situations, design factors in line with ANSI/ASME B31.8 location Class 1 are recommended.
- ii. ANSI/ASME B31.8 differentiates crossings with casings and without casings. Because of the poor experience of cased crossings (i.e., annular corrosion), the same design factor is recommended, whether a casing is used or not. Design factors for crossings of rivers, dunes and beaches not included in ANSI/ASME B31.8 are provided.
- iii. Parallel encroachments are defined as those sections of a pipeline running parallel to existing roads or railways, at a distance less than 50 meters.
- iv. Fabricated assemblies include pig traps, valve stations, headers, and finger type slug catchers.
- v. Concentrations of people are defined in ANSI/ASME B31.8 Article 840.3.
- vi. This category, not specifically covered in ANSI/ASME B31.8, is added for increased safety.

Source: ANSI, ASME standards

**1. Material Selection:** Selection of the pipeline material depends on the type of fluid to be

transported, especially its corrosiveness, flow regime, temperature, and pressure. This should be decided at the conceptual design stage. The most commonly used material is carbon steel, while there are other alternatives depending on the material requirement. These include stainless steel, high alloy steel, and copper tubing in the metallic piping materials.

All materials should comply with relevant codes, standards, specifications and technical requirements set and/or approved by the company, and should be procured from company-approved vendors/ manufacturers/ suppliers. Depending on criticality of the pipeline, the type of material, past performance and quality control system of the manufacturer, the company will specify the level of inspection that needs to be performed (if any). For each pipe size, sufficient spare material for possible route deviations, transportation and construction damages, testing, and set-up of contingency stock should be estimated.

**2. Pipeline Route Selection:** In selecting the route, all associated risks such as safety and environmental risks based on location, fluid categories, and expected frequency of failure should be accounted. Moreover, accessibility for maintenance and inspection, as well as economic factors should be taken into consideration in order to shortlist the most feasible route. Site checks for alternative routes should also be carried out. The pipeline route should be selected to minimize the number of high and low spots along the line. The optimal selection of route depends on:

- **Route Surveys:** This includes acquisition of detailed survey data for the entire route with information related to elevation, gradient, terrain, access roads, restricted areas, construction camps, staging facility, cathodic protection, and mainline valve sites. Computation of population density is also a major part of route surveys as it results in evaluation of RoW costs. Additional plan and profile drawings at enlarged scales need to be provided for challenging sections such as crossings at rivers, roads, railways, and for areas where major excavation or elevated pipeline supports may be required.
- **RoW:** Every pipeline should have a permanent RoW with sufficient width to enable the line to be constructed (including possible future additions) and to allow access for pipeline inspection and maintenance. Land acquisition for RoW is decided based on:
  - Pipeline constructed on the ground or underground.
  - Proposed diameter of the pipeline.
  - Method of construction.
  - Zig-zag configuration of above ground pipeline.
  - Topography - flat, mountainous or hilly areas.
  - Future pipelines along the same route (particularly in hilly and mountainous areas, where blasting and/or excavation for widening of the existing RoW could create issues).
  - Population density in proximity to the pipeline and related infrastructure.
  - Type of fluid, pressure of the pipeline and consequential risks of pipeline failure.

**3. Crossings:** Crossing play a key role in the selection of a pipeline route, as it requires additional

infrastructure or surveys/studies to ensure safety of the pipeline during operations. Crossings are broadly categorized into river crossings, road and railway crossings, other pipeline crossings, and land fault crossings. All of these warrants detailed study of the type of crossing, backed up by cost estimation surveys, and surveys for the alternative routes. Moreover, if the proposed route has a history of landslides, preference should be given to the alternative route that excludes such zones.

### **3.2 Material and Dimensional Requirement for Cross-country Pipelines**

As oil pipelines are subject to various stresses during operations, the pipeline material is selected based on the stresses that the pipeline is likely to undergo. This has to adhere to the codes and associated guidelines for material selection. Some of the most followed codes are:

- 1) ASME B31.4 – Pipeline transportation systems for liquid hydrocarbons and other liquids
- 2) ASME B31.8 – Gas transmission and distribution piping systems
- 3) ISO – 13623 – Petroleum and natural gas industries pipeline transportation systems
- 4) DNV –F-101 – Offshore standard for submarine pipeline systems

For Sulphide-rich fuel/liquids, some additional codes are followed:

- 1) NACE MR-01-75 – Sulphide stress cracking resistant materials for oilfield equipment
- 2) ISO 15156 – Materials for use in H<sub>2</sub>S containing environments in oil and gas production

Apart from this, there are separate codes for pipefittings and valves.

- 1) ISO – 15590 – 1 Pipeline induction bends
- 2) ISO – 15590 – 2 Pipeline fittings
- 3) ISO – 15590 – 3 Pipeline flanges
- 4) MSS – SP 75 – Specification for high test wrought butt-welding fittings
- 5) MSS – SP 44 – Steel pipeline flanges
- 6) ASTM A 694 – Steel forgings for high-pressure transmission service
- 7) API 6D – Pipeline valves
- 8) API 594 – Check valves
- 9) API 608 – Metal ball valves
- 10) API 609 – Butterfly valves
- 11) ISO 14313 – Pipeline valves in petroleum & natural gas industries

#### **Corrosion Control**

Pipes, valves, fittings, flange bolting and other equipment exposed to sour multiphase fluids may be susceptible to stress corrosion cracking and hydrogen-induced stepwise cracking. Therefore, due consideration has to be given to material selection in design. Materials for sour multiphase service should conform to the requirements of NACE Standard MR-0175: Sulfide Stress Corrosion Cracking Resistant Metallic Material for Oil Field Equipment. Depending upon the service and materials involved, sulfide stress corrosion cracking and hydrogen induced cracking tests should be conducted as per NACE standards. The acceptance criteria should be based on current established industry practices.

Both internal and external corrosion must be monitored at regular intervals and controlled using techniques such as paintings and coatings, cathodic protection or sacrificial anode methods. Hydro testing is performed by mixing corrosion inhibitors with the water. The details for each are given below:

## **Protective Coating**

- 1) Coatings should electrically isolate the external surface of the piping system from the environment.
- 2) All joints, fittings, repairs and tie-ins should be coated with a material compatible with the existing coating.

## **Cathodic Protection System**

- 1) Existing bare pipeline system investigation should be employed to determine the extent or effect of corrosion on existing bare pipeline systems. If these investigations indicate that continuing corrosion will create a hazard, corrosion control measures or other remedial action should be undertaken.
- 2) Temporarily out of service cathodically protected pipeline systems shall be maintained immediately.
- 3) Electrical isolation: Whereas such insulating devices are installed, they shall be properly rated for temperature, pressure, electrical properties, and shall be resistant to the commodity carried in the pipeline systems.
- 4) Temporary cathodic protection system: When considered necessary, a temporary cathodic protection system with sacrificial anodes should be installed to ensure adequate protection of pipelines from external till a permanent cathodic protection system is commissioned. The temporary system should preferably be installed during the pipeline laying / installation and monitored periodically.

Safety appliances should be provided against lightning and stray current interference from foreign objects at HT pipeline crossings.

Checking of leak detection system: If any leak detection system is installed on the pipeline system, it shall be checked for effectiveness of operation once in three months.

## **3.3 Cross-country Pipeline Construction and Installation**

Pipeline construction is mostly taken up in phases based on the expertise and availability of skilled labor. The phases include:

- 1) Construction staging areas and storage yards.
- 2) Clearing and grading of RoW.
- 3) Excavating the trench.
- 4) Pipe transport, stringing, & assembly.
- 5) Obstacles: Roads & streams.
- 6) Testing & restoration.
- 7) Additional infrastructure.

A single pipeline may be built using several spreads. This reduces the overall construction period, but increases the labor and secondary resource requirement. A large pipeline project may be divided into two or more segments, and each segment may be assigned to different construction contractors. Various construction activities in a number of segments may be undertaken simultaneously. Each of

these contractors may field several spreads to build a segment.

Before beginning various stages of pipeline construction and installation, a detailed surveying of the RoW is carried out. Surveying and mapping operations are essential not only for pipeline construction, but also to support various engineering decisions including calculation of desired flow capacity of the completed system, foundation designs, pump sizing, and pump station spacing along the route. Surveying also helps identify unique circumstantial factors that must be taken into consideration during the construction (e.g., sensitive environmental areas, archeological or cultural resources) and possible interferences to construction and/or operation (e.g., nearby utilities, buried or otherwise).

In addition to the surveys dictated by regulations, several other surveys are also routinely conducted as a prudent industry practice. Various types of surveys are employed each satisfying a specific purpose or need. Surveys typically associated with long-distance, land-based pipeline installation and operation are itemized below:

- 1) Geodetic surveying takes into account the Earth curvature. Applicable for large areas, long lines, and used to precisely locate basic reference points for controlling other surveys.
- 2) Land, boundary, and cadastral surveys are usually closed surveys that establish property lines and corners. Cadastral surveys are typically conducted only for public lands.
- 3) Topographic surveys provide the location of natural and artificial features and the elevations used in mapmaking. Information on elevation (more precisely, elevation changes) is critical to the design and location of pump stations.
- 4) Route surveys typically connect control or reference points by the most direct routes possible given field conditions. Route surveys may need to be amended when the most direct route encounters obstacles (severe grade changes, environmentally sensitive areas, etc.). Nevertheless, route surveys are conducted to establish the most direct paths between control points which are then amended based on field conditions.
- 5) Construction surveys are conducted during the construction phase to ensure design specifications are met.
- 6) As-built surveys are conducted after the completion of construction, to verify that design specifications were met or to capture the changes to original design specifications that were required to be made to adjust to field conditions.
- 7) Hydrographic surveys are required for all water crossings of pipelines to determine the shoreline and depth of water bodies being crossed.
- 8) Satellite surveying provides positioning data and imagery captured by satellites. Doppler and global positioning are used as a standard practice in remote regions and on subdivided lands where other ground-based reference points may not exist.
- 9) Global Positioning System data is collected simultaneously by as many as 24 or a minimum of six high-altitude navigational satellites positioned in three orbital planes to precisely locate a point on the surface of the Earth.
- 10) Inertial surveying systems are installed on helicopters or ground vehicles to acquire and coordinate data which are then used to control precision of geodetic and cadastral surveys.

- 11) Photogrammetric data acquired from aerial photographs, unique terrestrial data, or data from other sensors that can be used to support any of the surveys described above.

Post surveying and after obtaining all the necessary permits and approvals, the construction phases/stages begin. Various teams take up various phases as per the planned timeline and construction schedule.

### **3.3.1 Construction Staging Areas and Storage Yards**

Staging areas and yards are constructed along the planned RoW to stockpile equipment, pipes and fuel. Some staging areas also have temporary shelters or offices built for workers. The area to be utilized for staging depends largely on the terrain and availability of land near the RoW. Often roads or paved paths need to be developed in the staging area for better inventory movement. These areas could be 15-30 acres in size. In addition, another 10-30 acres may be required for a construction support yard that will serve as an assembly point for construction crew to meet prior to proceeding onto the RoW and for offices, storage trailers, and fuel tanks. The staging area is different from the laydown areas along the RoW, which are used during construction for equipment placement or for debris during excavation.

Although the primary purpose of the construction staging areas is temporary storage of pipeline materials, staging areas are also sometimes used for double joining of two pipe segments before their delivery to the RoW, bending of pipes, and pre-coating. These areas are mostly used for 12-13 weeks and then moved as the construction of the pipeline progresses ahead.

### **3.3.2 Clearing and Grading of RoW**

After the construction of the staging area, the pre-approved RoW is cleared for vegetation along with demarcation and fencing of unapproved areas. Usually, the clearing and grading stage involves following activities:

- 1) Cutting, removal and burning of trees, branches and other debris from the RoW.
- 2) Temporary storage of timber or other wood obtained from clearing of RoW. The wood can be sold by either the landowner (properly stated in agreement) or the constructor.
- 3) Usage of non-saleable timber/wood for construction of pathways or paved roads and burning or dumping the rejected timber.
- 4) Proper areas are marked and cleared for stocking the excavated soil, which is then utilized for making pipeline bedding and final grading after laying of pipelines.

During this phase, it is mandatory to take precautions to not disturb already constructed infrastructure such as railway tracks, irrigation canals, roads/highways and cultivated land. Soil conditions may require additional materials such as stone and sand to create a temporary work road adjacent to the pipeline or create a bedding for pipeline laying.

### **3.3.3 Excavating the Trench**

After clearing and grading the RoW, trenches are dug for housing pipelines. The ditch or trench is usually made to one side of the center of the RoW rather than in the middle to provide adequate room for construction equipment and operations alongside the pipe as well as room for future installations. During excavation, soft soil is excavated easily with minimum efforts and is located along the RoW for

easy restoration processes. The depth of the ditch is based on the minimum cover specifications or the distance from the top of the buried pipe to the ground surface. For the same minimum cover requirements, a pipe with a larger diameter requires a deeper ditch. The minimum cover varies according to requirements of regulatory agencies, standard industry practice guidance, type of area through which the pipeline passes, and features along the pipeline route. A minimum of 3 ft of cover is typical, but it may be less in open, unpopulated areas and more when the pipe passes under roads, rivers and highway borrow ditches.

### **3.3.4 Pipe Transport, Stringing and Assembly**

When excavation and trenching are complete, the RoW is ready for the installation of pipes. These pipes are coated, bent and sometimes welded in the staging area itself, before they are transported to the installation site at the RoW. As welding proceeds along the pipeline, a slight change in direction or a significant change in elevation may require a bend in the pipeline. Pipes are bent to the required curvature by using a bending machine at the job site. Even large-diameter pipes can be accommodated in modern bending machines, but it may also be necessary to make some bends in a shop on a special machine. Depending on the diameter and wall thickness of pipes, slight changes in elevation may be accommodated by flexing the pipes without the bending machine. Very small changes in direction may sometimes be made by letting the pipe lie to one side of the ditch. But changes in direction or elevation without bending must be small, especially when large-diameter, heavy-wall pipes are being used. Similarly, pre-coating or welding is done at the shop or the staging area before pipes are lowered into the ditch.

Once pipes are ready at the shop, these are transported to the excavation site. With the ditch ready and the pipe delivered, welding can begin. The pipe joints are placed over the ditch for welding. As welding proceeds, a section of pipeline steadily increasing in length is in place above or alongside the ditch. Under some circumstances, pipe segments are lowered into their trench before welding together. Welding is done using electric welding equipment (manual or automatic). It is important that the two ends of pipe to be welded are properly aligned so that the weld is uniform around the circumference of the pipe. Line-up clamps are used for this purpose at each joint before welding. After all weld passes have been made, the alignment clamps can be moved to the next welding station. Weld passes are critical for pipeline integrity; therefore, welders work systematically to ensure uniform and strong weld passes. Most of the welding techniques employed for joining pipelines involve melting of a filler material by using a heat source, which then solidifies to form the joint/weld/bend. Then, the welds are thoroughly examined to ensure safety of the pipeline. Common inspection methods are radiographic, X-ray, and ultrasonic testing. Construction plans specify the type of inspection to be employed and the portion of welds to be examined by each method. For instance, in case of a pipeline traversing open areas, 10% of the welds must be X-rayed. However, in case of pipelines crossing railroads, highways, or rivers, all welds must be examined using radiography. Once the welding process is complete, the pipe is pre-coated to prevent corrosion, damage from sand, gravel, etc. This completes the assembly of pipe, which is then lowered into the ditch using harnesses and cranes. Pipes sometimes require a bed in case the terrain is rocky that can affect the integrity and operation of the pipeline.

### 3.3.5 Obstacles: Roads & Streams

Pipelines cross a number of obstacles such as roads, highways, canals, rivers, wetlands, other pipelines or utility lines. These obstacles are typically crossed by passing the pipeline through a bore underneath. There are specific techniques to cross each obstacle:

- 1) **Roads, highways and railway tracks** – Crossing roadways or railroads can be done by either trenching or boring along with reinstallation of the portion disturbed. The techniques and depth of the trench depend on the maximum dynamic loading on the pipe from traffic or trains.
- 2) **Rivers and canals** – Crossing waterbodies depend on site-specific factors such as size and nature of the waterbody and the existing ecosystems. Methods for pipeline installation across such crossings include open cut method, dam and pump and fume.
- 3) **Wetlands** – Wetlands pose a great challenge for laying pipeline as the essential laying equipment are subjectively allowed to cross or work in the wet land. Despite similar laying procedure as followed on ordinary land, wetlands require additional surveying, testing and waste disposal.
- 4) **Other pipelines and utility lines** – When a pipeline is laid in the vicinity of an existing pipeline, due care is required in terms of minimum clearance of RoW, excavation and burial techniques.

### 3.3.6 Testing and Restoration

Once the pipeline is constructed, it undergoes rigorous testing in order to plug any leakages or remove structural errors. Hydrostatic testing is one of the most widely used testing methods to detect leakages. In this method, a section of pipeline is isolated, filled with water and then pressurized to determine leakages. Then, water is removed and pumped to a treatment plant or to a pre-approved disposal site. In addition, pigging is undertaken to test the integrity of the pipeline. For this, a pig (usually cylindrical) is forced through the pipeline to check the integrity of the line and remove debris.

**Table 9: A Typical Leak Detection System**

Non-continuous	Continuous	
	External	Internal
Inspection by helicopter	Fiber-optic cable	Pressure point analysis
Smart pigging	Acoustic system	Mass/volume balance method
Tracking dogs	Sensor hose	Statistical system
	Video monitoring	RTTM-based systems
		E-RTTM <sup>11</sup>

Source: MDPI

Once tested and approved, the trenches are filled with the graded soil obtained during excavation. The soil is free from gravel, large rocks and other unwanted materials. Once the backfilling is complete, the topsoil is returned to its original location, and final grading and contouring are performed. Thereafter, depending on the reclamation plan approved, reclamation of the disturbed area above the pipeline can

<sup>11</sup> E-RTTM - Extended Real-Time Transient Model



begin. Construction equipment is also removed and the construction RoW is reclaimed. However, depending on access constraints, the construction road may remain in place until adjacent spreads are completed, if it is the only access road to those spreads.

### 3.3.7 Additional Infrastructure

Supporting infrastructure is required to maintain the operating conditions in pipelines for optimal functioning and is constructed above the ground, despite the entire pipeline being underground. The infrastructure includes compressor stations, pump stations, valve stations, metering stations, monitoring and surveillance equipment, protection equipment and maintenance/repair equipment.

### 3.3.8 Transporting LPG through Cross-border Pipelines

Liquefied Petroleum Gas (LPG), due to its inherent properties, is susceptible to fire, explosion and other hazards. Such hazards pose a risk to property, equipment, plant personnel and public. Transportation of LPG through pipelines has become a preferred mode over conventional modes such as road/rail, being safer and environment friendly. LPG pipeline systems are designed in accordance with ANSI / ASME B31.4 and API 2510 or equivalent. Also, the design engineer is supposed to provide reasonable protection to prevent damage to the pipeline from unexpected external conditions.

Transporting LPG also requires some pre-requisite factors to be considered in order to plan a pipeline. This includes pipeline installation to be located in the same direction of LPG bulk storage facilities allowing better transporting capability. Additionally, the following factors are carefully included in the construction plans.

### 3.3.9 Pipeline System and Component Design Requirements

- 1) **Piping:** Piping should be specifically designed to handle LPG transportation. Piping that can be isolated and needs thermal safety valves should have a minimum design pressure of 24 kg/cm<sup>2</sup> or maximum pressure that can be exerted by transfer equipment or any other source, whichever is higher and conforms to the provisions of ANSI B31.4 or equivalent.
- 2) **LPG pumps:** LPG pumps should be provided with suction and discharge pressure gauges, a high point vent to a safe height of minimum 3 m above the pump in case of no pump shed or 1.5 m above the pump house rooftop or connected to a cold flare with a flame arrestor. It should also conform to API 610<sup>12</sup>. Additionally, the following alarm and warning system must be provided to ensure safe operations:
  - Low suction pressure of booster and main pump.
  - High discharge pressure at the main pump.
  - Low discharge pressure trip on pump against pipe rupture to avoid liquid vaporization.
  - High casing temperature.
  - High bearing temperature.
  - Tripping of main/ booster pump in case of closure of suction / discharge MOVs.

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<sup>12</sup> API 610: Pump standard for centrifugal pumps in the petroleum, petrochemical, and natural gas industries

- 3) **Pump Drivers:** Electric motors with fixed speed drive or variable frequency drive should meet the requirements of API Standard 54013 and are the major pump drivers. In case of the combustion engine, drives must meet the API Standard 7C - 11F14.
- 4) **Valves:** Following valves are essential for an LPG network:
- Sectionalizing/block valves with remote shut off provision from the control room should be provided at the boundary of station pipeline inlet and outlet locations to isolate the station facility.
  - Check valves should be installed for automatic blockage of reverse flow in the piping system within the station, wherever required.
  - Remotely operated sectionalizing / mainline block valve(s) with blowdown connection to isolate the pipeline section and evacuate the pipeline section in case of emergency and repair. All blowdown piping should have double valve segregation. Mainline sectionalizing/ block valves should be installed at a maximum spacing of 12 km in industrial, commercial and residential areas. Block valves also should be installed on the upstream and downstream of river crossings and public water supply reservoirs.
- 5) **Pipe Support:** If a pipeline is designed to operate at a stress level of more than 50% of the specified minimum yield strength of the pipe, all connections welded to the pipe should be made to a separate cylindrical member which completely encircles the pipe and this encircling member should be welded to the pipe by continuous circumferential welds at both ends. Wherever non-integral attachments such as pipe clamps and ring girders are used, adequate precautions should be taken to prevent corrosion at or near the contact points.
- 6) **Pressure Relief Valves:** These valves should meet the requirements of API 520 Sizing, Selection and Installation of Pressure Relieving Devices in Refineries / OISD-STD-106<sup>15</sup> or equivalent.
- 7) **Communications System:** A reliable and dedicated communications system for interaction between all stations including sectionalizing valve stations across the entire pipeline should be designed, installed and maintained to ensure safe operations under both normal and emergency situations.
- 8) **Electrical Installations of Pipeline Station:** The specifications of electrical equipment should be in line with IS 5571. All electrical equipment, systems, structures and fencing should be earthed conforming to IS 3043. The earthing system should have an earthing network grid with the required number of electrodes.

### 3.3.10 LPG Pipeline Installation and Station Construction

LPG pipelines and stations are constructed based on specific procedures and instructions.

#### 1) Location

Following information is required for finalizing the location of pipeline station:

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<sup>13</sup> API Standard 540: Electrical Installations in Petroleum Processing Plants

<sup>14</sup> API Standard 7C-11F: Recommendation on practice for installation, maintenance, and operation of internal-combustion engines

<sup>15</sup> OISD-STD-106: Pressure Relief & Disposal System, Oct, 2010

- Location of storage facilities to hook up with the LPG pipeline system at upstream and downstream side.
- Findings of risk analysis study for pipeline stations including plan for emergency measures.
- Adequate availability of water from a reliable source or alternative arrangement available / proposed for construction activities.
- Availability of space for future augmentation of facilities keeping in view of complying safety norms.

## 2) Layout

Following points should be considered while establishing the station layout:

- Pipeline installation should be located upwind of LPG bulk storage facilities.
- Main power receiving station comprising HT pole structure, transformers, breaker and PMCC rooms, etc., should be located in a non-hazardous area. Overhead power lines shall not pass over the licensed area.
- Accessibility of mobile firefighting equipment to LPG pumps and other station equipment.
- Due care should be taken to avoid accumulation of LPG vapor in low-lying areas/pits.
- Station equipment and their specifications.
- Piping and Instrumentation diagram for the station.
- Utility requirement.
- Flares.
- Operation and maintenance philosophy of station equipment.
- Fire station and allied facilities.

### 3.3.11 Design of LPG Safety System

The LPG safety system requires additional security and equipment apart from the regular safety systems. Following are the major components specific to the LPG pipeline safety system:

#### 1) Thermal Relief Valve (TRV)

Any equipment or section of the pipeline containing liquid LPG in the form of trapped volume should be protected against excessive pressure developed due to a rise in surrounding temperature by installing TRVs. The discharge of TRVs should be connected to a flare system wherever available. These TRVs should have lock open type isolation valves on both sides of the safety valve.

#### 2) Delivery and Storage Area Protection

High-level alarm and high-high level alarm indication of the storage vessel should be set at 80% and 85% level of volumetric capacity, respectively. The audiovisual indication should be provided at a local panel and the pipeline control room. Pipeline delivery Remotely Operated Valves (ROVs) (supplier's and consumer's premises) should close on actuation of the high-high level alarm.

### 3) Facility Protection

Properly laid out roads should be constructed around facilities within the installation area for smooth access for fire tenders in case of emergency. Proper industry-type boundary wall at least 3 m high with 0.6 m barbed wire on top, should be provided all around the installation, i.e., pump station / intermediate station / delivery station / terminal station should be provided unless the installation is protected as part of refinery / bulk delivery / LPG installation.

The LPG pipeline system should be equipped with the following:

- Supervisory Control and Data Acquisition (SCADA).
- Leak detection system with provision for identification / location of leak and isolation of affected section.
- Facilities for controlled flaring.
- Accessories and kit for arresting leak.

#### 3.3.12 Emergency Plan and Preparedness

The emergency plan should be based on maximum credible risk scenarios as specified in the OISD-GDN-168<sup>16</sup>. It includes the following:

- 1) Geographical area covered, number and size of the pipeline systems involved, and normal operating conditions including pressure and rate flow.
- 2) Written instructions and procedures to be adhered to in case of an emergency. Understanding of the same by the operational staff.
- 3) Instrumentation, control equipment and communication to enable the controller to direct all operations related to emergency.
- 4) Warning on delay of abnormal operating conditions.
- 5) Roles of all organizations involved and periodic meetings to be conducted to ensure integration in terms of resource mobilization, response and resolving issues during emergency.

#### Basis of Emergency Plan

The emergency plan should be prepared based on the following and approved by the factory inspector and district authorities under their jurisdiction:

- 1) Risk analysis and HAZOP study: Detailed HAZOP and operability study should be conducted involving the design, operation and maintenance group to identify the likely deviations in operating parameters from the designed level and corrective measures incorporated.
- 2) Risk analysis and HAZOP study should be reviewed and updated at regular intervals. Such studies should be carried out for the pipeline section under each station and merged with the overall plan.

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<sup>16</sup>OISD-GDN-168: Emergency Preparedness Plan for Marketing Locations of Oil Industry, Jul, 1997

- 3) Risk scenarios Release of LPG leading to spillage, vapor cloud formation, fire & explosion shall be considered for various scenarios along with their method of containing.
- 4) Flow balance record should be maintained preferably automatically to assist detection of leakage.
- 5) Organizational emergency structure should be drawn encompassing individual sections, i.e., pumping, pipeline & receipt and dovetailed to form an integrated organization structure having chain, communication and control system so that action can be initiated as fast as possible.
- 6) Responsibility of all concerned should be clearly defined particularly where there is an interface between the supply and the receiving company. The transferring and receiving organizations should make mutual agreements for this purpose. Such plans should be updated on yearly basis to manage the change in rules, equipment, process, technology, procedures, manpower, etc.

## **Emergency Control Centers**

- 1) Designated emergency control centers should be constituted at the main terminal, booster stations and receiving terminals with round the clock communication link among them. Emergency organization structure with actions to be taken in case of an emergency, should be displayed in the control centers and documented. Each SV station should be attached with the nearest emergency control centers.
- 2) Emergency contact numbers and the action in case of emergency should be displayed in SV stations and along the pipeline route.
- 3) Emergency control centers will be established at the following stations:
  - Main pipeline terminal
  - Pump stations
  - LPG receipt terminal
- 4) Names of contact personnel should be declared for the following stations:
  - Main pumping station
  - Booster station
  - SV station
  - Receipt terminal
- 5) List of fire stations with the contact person, telephone numbers along the pipeline route should be prepared and maintained at each station.
- 6) Periodic meetings, at least once in a quarter should be organized between the supply and receiving organizations to deliberate and resolve issues related to safety, operation and emergency systems, and corrective measures initiated.
- 7) In addition, for efficient and safe operation of the pipeline, a comprehensive operating manual should be developed, which should include the following:

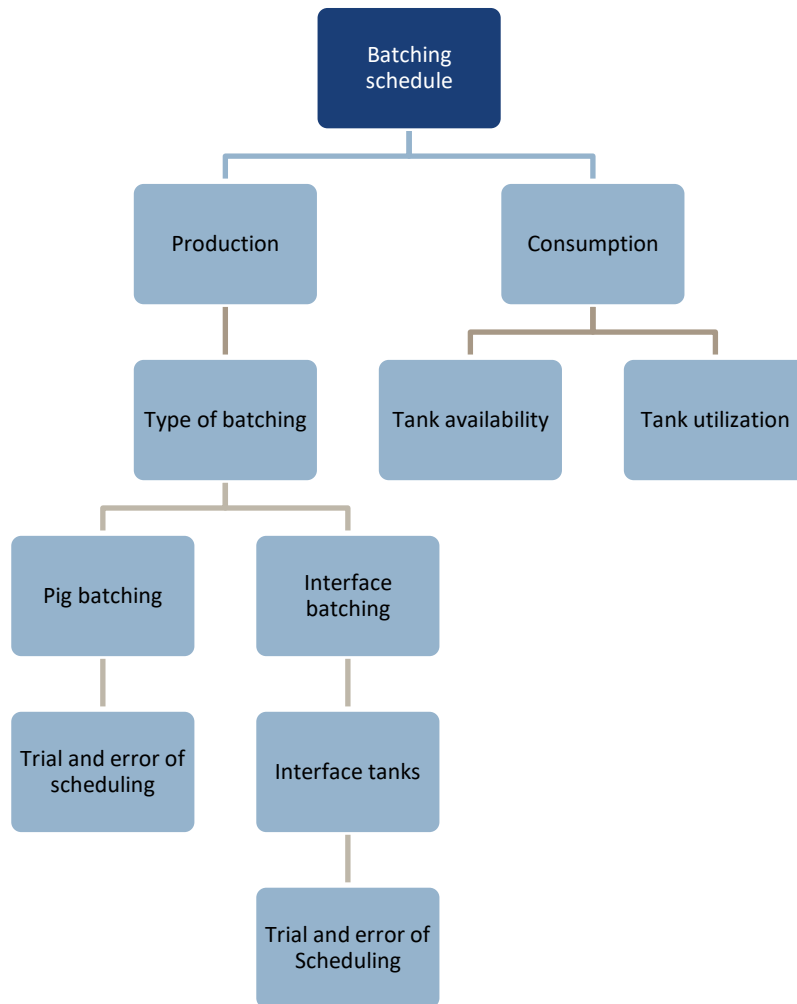
- System description
- Operation set points
- Initial start up
- Normal operations
- Normal shut down procedure
- Temporary operations
- Execution of emergency shutdown in a safe and timely manner
- Emergency shut down
- Conditions under which emergency shutdown is required
- Emergency operations

### **3.4 Transportation of Multi-Petroleum Products Via Cross-country Pipelines**

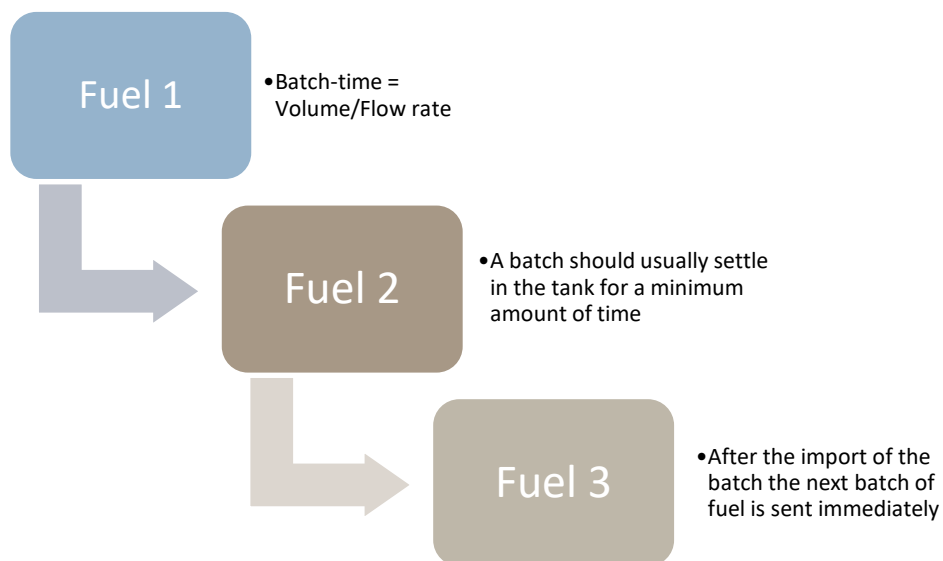
Many liquid petroleum pipelines transport different types of liquid petroleum in the same pipeline. To do so, the pipeline operator sends different products in batches. For example, an operator might send gasoline for several hours, and then switch to jet fuels, before switching to diesel fuel. Product batching means transportation of different products in a sequence down the same pipeline. The goal is to schedule the volumes of each product transported by pipelines and to ensure delivery to the customer.

Batches are often referred to as slugs. A slug is a batch of a specific product being transported in a pipeline. Often a pipeline is utilized for the transport of more than one product (i.e., a multi-product pipeline). Hydrocarbons, for instance, are transported in batches in order to minimize mixing of different types of hydrocarbons. Batching can further be utilized in cases where fuels are received from more than one source and transported to more than one destination, or have multiple intermediate take-off points. It is, therefore, important to establish a batching schedule with regard to the various products being transported while considering the following key influences:

- 1) Fuel destination depot/facility fuel requirements
- 2) Possible pipeline throughput
- 3) Possible fuel import/production rates
- 4) Tank capacities at destination facilities

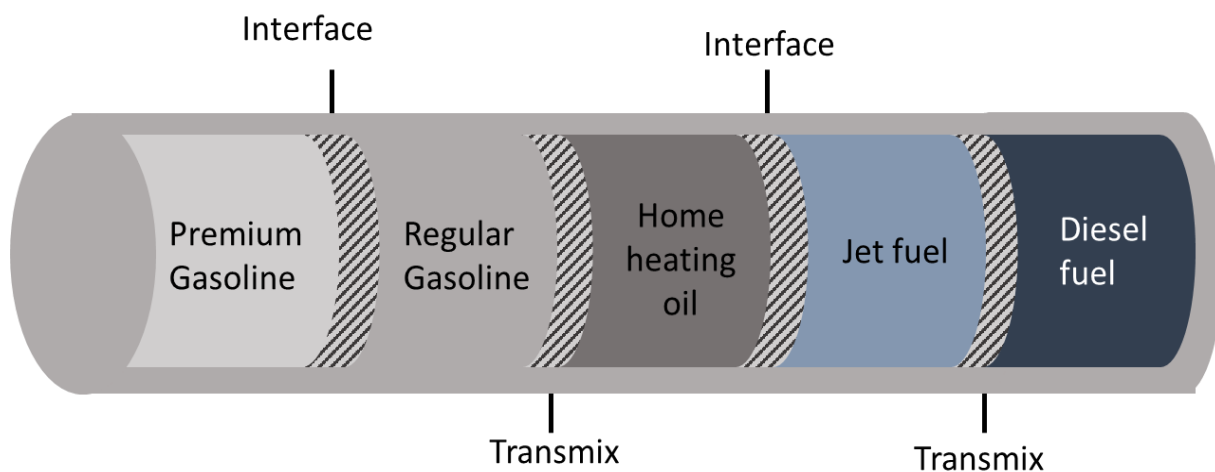


**Figure 5 : Batching Schedule Logic**



**Figure 6: Typical Fuel Batching Procedure**

When consecutive products are batched in the pipeline with differing qualities, they create a mixture known as 'transmix'. Transmix is disposed of from end point locations in multiple ways, often times being trucked out to be re-refined.



**Figure 7: Multi Product Transfer**

The following fuel parameters must be considered to decide on the most compatible fluids for batching:

**Table 10: Parameters to Decide Compatible Fluids**

S. No.	Production	Critical Parameters
1	Motor spirit (MS)	Color, density, FBP, Sulphur, octane number
2	Kerosene (SKO)	Color, density, FBP, flash point, smoke point
3	High speed diesel (HSD)	Color, density, Sulphur, flash point, cetane number, lubricity
4	Aviation turbine fuel (ATF)	Color, density, silver strip corrosion, copper strip corrosion, conductivity, freezing point
5	Mineral turpentine oil (MTO)	Color, density, FBP, flash point
6	SRN	Color, density, FBP

### Common Compatibility Multi-Product Pipelines

- 1) MS – SKO
- 2) HSD – SKO
- 3) ATF - SKO
- 4) Naphtha - SKO
- 5) SKO is the universal plug for all white oils

As mentioned earlier, when different products are dispatched through a pipeline in continuous succession, with no medium to separate them, there is always a mixing at the boundary of two adjacent products, known as 'interface' or transmix.

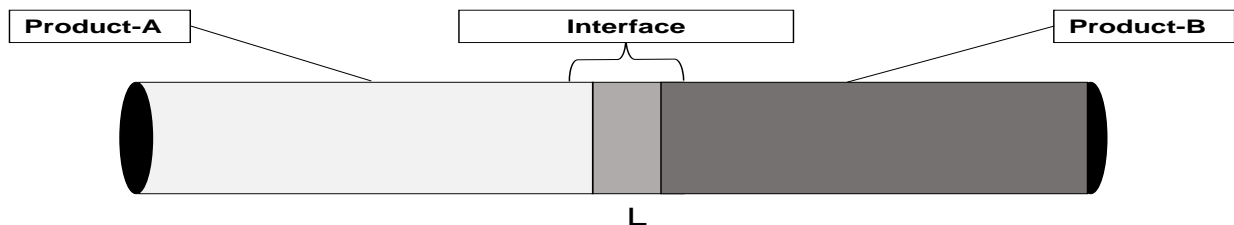
This interface or transmix (a contaminated product) gradually increases in length as one move towards the receiving point (refer to **Error! Reference source not found.** below for interface formation in multi-product pipelines).

The length of this interface needs to be kept to a minimum to reduce the amount of contaminated product.



This can be done with the use of 'pigs' (or liquid plugs that act as physical separators). When pigs are not used, an interface forms between two adjacent products (batches), resulting in mixing, and ultimately, contamination of the adjacent products.

This is important, as transportation of multiple hydrocarbon products such as diesel, kerosene, and gasoline in a single pipeline is usually more cost effective compared with using separate pipelines for each product.



**Figure 8: Interface Formation in Multi-Product Pipelines**

Length (L) increases as interface moves towards receiving point.

### **Factors to be Considered for Interface Minimization**

#### **Uncontrollable Factors:**

- Differences in densities of the products
- Viscosity of interface
- Ground profile
- Length of the pipeline
- Pipe friction
- Diameter of the pipeline

#### **Controllable Factors:**

- Product change over time at starting point
- Flow in the pipeline
- Change in flow
- Interruptions in flow
- Start-up /shut-down of the pipeline

### **Minimizing the Interface Generation**

- Using mechanical separator between two products
- Using quick closing valves
- Avoiding frequent shutdowns of pipeline operations, which usually result in more usage of interfaces
- Following correct shutdown/start-up procedure
- Accuracy in cutting the interface

- Avoiding laminar below the minimum flow

### Volume of Interface

The volume of interface can be calculated by the formula:

$$V = 2 * CD^2 * \sqrt{L}$$

Where,

V = Volume of interface (m<sup>3</sup>)

C = Co-efficient of sensitivity of measuring instrument (here, it is considered =1)

D = Internal diameter of pipe (m)

L = Length of pipeline (m)

### Length of Interface

The pipeline cannot be operated precisely unless the length or the volume of the interface and its location can be known at any given time. Once the length of interface is determined, it is easy to calculate its volume from line fill.

### Multi-product Pipelines Operation

- Transport two or more different products in the same pipeline
- Sequence is determined in line with compatibility
- No physical separation between the different products
- Product pipeline operation is similar to crude oil pipeline operation
- Interface management is also an aspect of multiproduct pipelines operation, that is different from crude oil pipelines

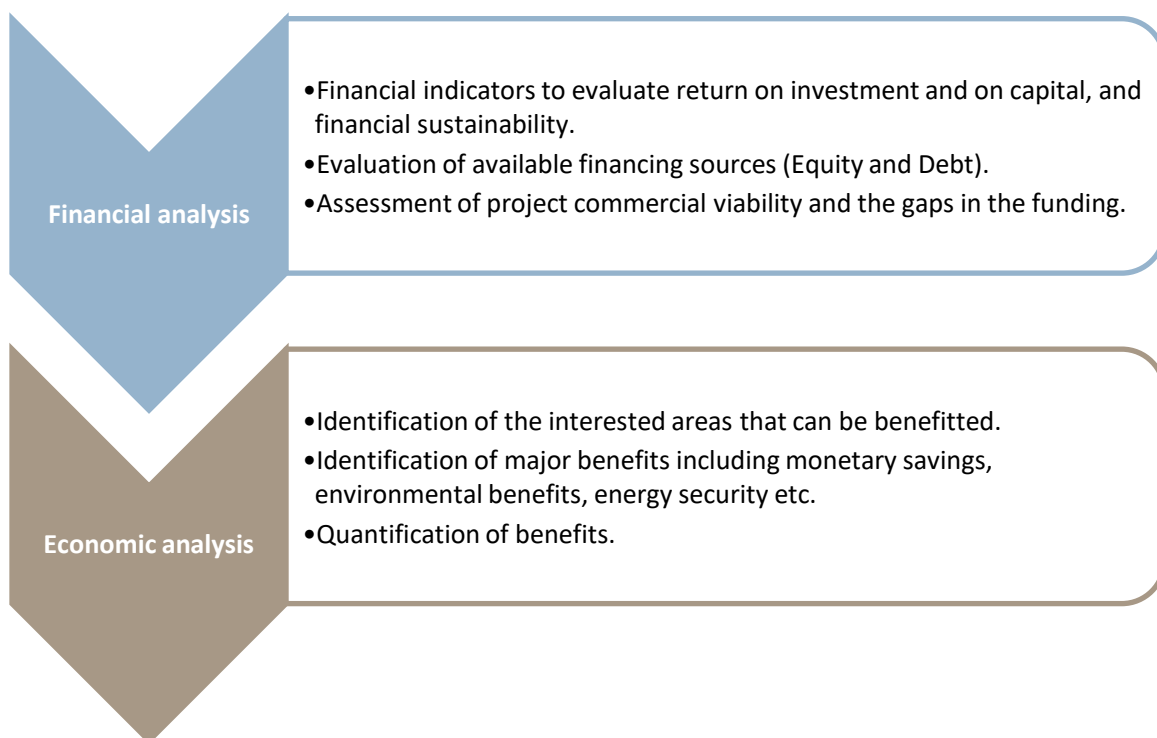
**Table 11: Product Sequencing**

Products	Sequence of Pumping	Interface (I/F) between	Base product in which I/F is taken
<b>SM, MS, SRM, and MRN</b>	SKO-MS-SKO	SKO and MS	MS
	SKO-SRN/MRN-SKO	SKO and SRN/MRN	SRN / MRN
	SKO-SRN-MRN-MS-MRN-SKO	MRN and MS	MS
	SKO-SRN-MS-SKO	SRN and MS	MS
<b>SKO and ATF</b>	SKO-ATF-SKO	SKO and ATF	SKO
<b>HSD and MTO</b>	HSD-MTO-HSD	HSD and MTO	HSD
<b>SKO, HSD and LDO</b>	SKO-HSD-SKO	SKO and HSD	HSD
	HSD-LDO-HSD	HSD and LDO	LDO
<b>AOX and HSD</b>	HSD-AOX-HSD	AOX and HSD	HSD

### 3.5 Costing of Cross-border Crude Oil and POL Pipelines

Cross-border pipelines warrant an order-of-magnitude cost study, even before the designing of the pipeline has begun. This study outlines feasibility of continuing to invest time and capital in the design phase of the project, along with its economic performance. It is carried out in various steps depending upon the phase of the construction of the pipeline.

The first step is the economic evaluation of the entire project, which includes evaluation based on the plant performance, costs, the market, government policy, and the world economic situation. For a smaller piping system, the feasibility decisions are based on comparison of capital and operating costs. However, for more complex systems, other factors govern the practicability of the pipeline system.



**Figure 9: Feasibility and Costing Study of Cross-Border Pipelines**

The financial analysis further includes various components, as given below:

#### **Capital Expenditure (CAPEX, or Initial Investment)**

##### **Major Cost Components (on-shore construction)**

- Pipeline
- Freight (ocean and overland)
- Miscellaneous Materials (valves, fittings, etc.)
- Cathodic Protection
- Coatings (FBE, three-layer PE)
- Compressor/Pump stations
- Metering Station
- Communication Infrastructure/equipment
- Insurance

- Construction (survey & inspection, RoW, hauling & stringing, laying, special crossings, etc.)
- Project Management
- Engineering and Design
- Expected Completion time

### **Major Cost Components (off-shore construction)**

- Pipeline
- Freight (ocean and overland)
- Miscellaneous (buckle arrestors, tie-ins, anodes, valves, etc.)
- Insurance
- Construction (survey, trenching, installation, shore crossings, etc.)
- Coating (concrete, corrosion)
- Project Management
- Cathodic Protection
- Engineering and Design
- Expected Completion Time

### **Operational Expenditure (OPEX and Maintenance Cost)**

#### **OPEX**

- Fuel Cost (for compressor/pump and metering stations) and other consumables
- Other Utility Costs
- Operating Staff Cost
- Land Lease Cost, if applicable
- Insurance and Taxes

#### **Maintenance Cost**

- Inspection Cost
- Labor Cost
- Equipment/Material Replacement and Repair Cost

For a project, cost estimates are improved upon and updated as the project moves from feasibility study to detailed engineering/ design stage (additional details are presented in the section 8).

### **Cost Determination**

#### **Piping Cost Estimation**

Piping always represents a sizable part of the total installed cost of any process plant. It may comprise 20% or more of the entire cost of the plant, including land and buildings, and range between ~10% to as high as two-thirds of the cost of the equipment. Various methods to estimate piping cost include: finagling-factor, piece-by-piece method, and N-system. The N-system is newer than the others and yields accurate results. Hence, it is preferred over other methods.

Piping cost may vary between 20% and 66% of the overall CAPEX, depending upon material requirement, availability, etc. Therefore, the estimator needs to convert the preliminary flow sheet into a fair approximation of an actual design. Furthermore, the estimator needs to draw quick and rather accurate free-hand isometric sketches, so as to back up the analysis in the pre-feasibility study.

Terrain is one the major factors that impacts the construction cost of a pipeline. The following table shows the variation in construction cost due to a change in terrain, as a factor multiple of the flat terrain cost. The red cells in the table highlight increase in cost.

**Table 12: Capex Cost Components Compared on Basis of Terrain**

Sr. No.	Components	Flat Terrain cost/km	Hilly Terrain cost/km : Flat Terrain cost/km	Offshore cost/km : Flat Terrain cost/km
1	Survey and field engineering	1	1	20-25
2	Land acquisition, RoW, and crop compensation	1	1	0
3	Mainline pipes	1	1	20 – 30
4	Mainline material	1	1	20 – 30
5	Mainline construction	1	5-8	30 – 40
6	Pump station and terminal	1	5-8	20 – 25
7	Cathodic protection	1	1	1
8	Telecommunication and tele-supervisory	1	5-8	15 – 20
9	Contingencies	1	1	20 – 30
10	Project management and engineering, insurance	1	5-8	20 – 25
11	Interest during construction	1	1	1
12	Additional refinery facilities	1	1	1
13	Additional marketing facilities	1	1	1

*Note: Red cells denote higher CAPEX cost compared to flat terrain cost components.*

*Source: Detailed Feasibility Reports of existing pipelines, Industry.*

## 4 Crude Oil/ Petroleum Products Transportation in the SAARC Region

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This section details the existing transportation infrastructure for crude oil and petroleum products in each of the SAARC Member States. At present, these countries lack proper transport systems for both inter-country and intra-country transits. As such, most petroleum products are transported by road in tankers. This is both hazardous and expensive in terms of transit time and cost of transit. Country-wise infrastructure for transport of oil and petroleum products has been detailed below:

### 4.1 Afghanistan

POL distribution in Afghanistan can be broadly classified across three categories based on end consumers, private consumers (bulk and retail), government and coalition forces. Currently, the majority of POL products is distributed by road, which is taken care of by the Government (with support from private players) and coalition forces separately.

Afghanistan, being a landlocked country, imports POL products via road from neighboring countries, mainly Iran, Turkmenistan, Uzbekistan and Russia. It has seven major land ports that facilitate import and storage of petroleum products, with Herat, Nimrooz and Andkhai being the major ones.

### 4.2 Bangladesh

Transport of POL products in Bangladesh is presently undertaken by coastal tankers, railways and tank lorries from the Chittagong port to the refinery and, subsequently to demand centers. The Private players also use small barges to carry POL products on river routes mostly for captive consumption. Bangladesh Petroleum Corporation (BPC) estimates that ~Tk 1.4 billion (US\$ 17.5 million) is spent annually to transport fuel across the country.

Bangladesh does not have a POL product pipeline network. However, the government plans to build five major pipelines in three years, with a total length exceeding 600 km across the country at a cost of ~Tk 81.21 billion (US\$ 955 million). This will comprise four intra-country pipelines and a cross-country pipeline with India.

- 1) 237 km pipeline to transport diesel fuel from Chittagong to Dhaka.
- 2) 17 km pipeline to carry jet fuel from Pitloganj of Narayanganj to Kurmitola aviation depot.
- 3) Two 110 km pipelines to be constructed under a single-point mooring (SPM) system to transport crude oil and diesel fuel from offshore vessels to an onshore terminal in Chittagong.
- 4) 136 km pipeline to transport Diesel fuel from India's Numaligarh refinery to Parbatipur in northern Bangladesh.

The 136 km cross-country pipeline from India to Bangladesh will facilitate the import of petroleum products currently transported by rail. NRL currently distributes 10,000-12,000 kiloliter of diesel every month across districts in northern Bangladesh.

The 6 km Indian leg of the 1-million-ton capacity pipeline will be financed by the Numaligarh refinery.

The remaining 130 km of pipeline will be in Bangladesh and is financed by India's ongoing development co-operation program. The total cost of the pipeline is pegged at ₹360 crore (\$51.4 million). The project construction is underway with the groundbreaking ceremony held in September 2018. The project will replace the existing practice of sending diesel by rail, covering a distance of 510 km.

To facilitate oil and POL imports, Bangladesh also has two major seaports connecting the country with the rest of the world i.e., the ports of Chittagong and Mongla. The Chittagong port is considered the heart of the Bangladeshi economy. Its geographic location enables easy and cost-effective foreign trade with all the SAARC Member States, as well as other Asian countries. POL products are mainly imported through the Chittagong port. Regarding LPG, there are four import storage units and several LPG private operators in Bangladesh that deal with LPG imports, shipping and distribution.

Mongla, Bangladesh's second largest port, has faced developmental difficulties that have led to its operations declining significantly over the past few years. The Government of Bangladesh is undertaking a development project to construct an economic zone near the port and build railway lines from Mongla to Kolkata in India, as well as necessary link roads to enhance regional connectivity.

In addition to the above two ports, the under-construction Payra port, with a draft of 16m, is situated in Meghna estuary at Rabnabad channel in Patuakhali district. It has been partially operational since August 2016 and, once completed in 2021, will have rail, road, and waterway links with the capital city of Dhaka.

### **4.3 Bhutan**

Bhutan is entirely dependent on imports to meet domestic demand for petroleum oil products. The key petroleum products, including Diesel, petrol, ATF, LPG and furnace oil, are entirely imported from India. Other POL products such as lubricating oils and bitumen are imported not only from India but also from Singapore and Thailand.

POL products are directly imported from India and distributed via road tankers. Small and medium-sized tankers with a carrying capacity of 9-12 kiloliter are utilized due to the country's mountainous terrain and narrow roads. Distributors use these tankers to transport fuel from their regional depots, where the imported products are stored, to retail outlets across the country.

Indian Oil Corporation Limited (IOCL) and Bharat Petroleum Corporation Limited (BPCL) operate through three private distributors in the country, namely Bhutan Oil Corporation (BOC), Druk Petroleum, and Damchen Petroleum. LPG is imported directly in cylinders of 14.2 - 19 kg from India. There is a monthly quota of 700 MT subsidized LPG import to Bhutan from India under a grant assistance program.

### **4.4 India**

India has a crude oil pipeline network of 10,419 km connecting production regions and ports to refineries. These pipelines had a total capacity of 145.6 million ton of crude oil per annum as of June 2019. In addition, there are petroleum product and LPG pipelines connecting refineries and ports to demand centers. Presently, there are 44 POL product pipelines of a total length 14,061 km, with a product-carrying capacity of 94 million ton, and six LPG pipelines covering a length of 3,369 km, with a

total capacity of 8.5 million ton. Since the POL pipelines are inadequate to cater to the strong demand, a large amount of petroleum products is transported via road in India, despite this being more expensive. However, a significant investment is being undertaken in this area with four POL product and four LPG pipelines in various stages of construction. Player-wise details of crude and POL product pipelines (existing and upcoming) have been provided as a part of the annexures (Table 34 and 35).

India has 12 major and 200 minor and intermediate notified ports. Further, under the National Perspective Plan for Sagarmala, six new mega ports are proposed to be developed in the country. 13 ports in India handle trade of crude oil and petroleum products, including imports and exports. The table below summarizes information on port-wise data on trade of petroleum products as of fiscal 2018.

**Table 13: Port-wise Total Traffic and POL Traffic Handled in India in FY18**

Name of Port	Total Traffic (million ton)	POL Traffic (million ton)	POL Traffic as Percentage of Total Traffic
<b>Kolkata/Haldia</b>	57.89	8.92	15.4%
<b>Mumbai</b>	62.83	37.68	60.0%
<b>Chennai</b>	51.88	13.5	26.0%
<b>Cochin</b>	29.14	19.57	67.2%
<b>Kandla</b>	110.10	62.20	56.5%
<b>Vishakhapatnam</b>	63.54	16.05	25.3%
<b>Mormugao</b>	26.9	0.63	2.3%
<b>JNPT</b>	66.0	4.64	7.0%
<b>Paradip</b>	102.01	33.78	33.1%
<b>Tuticorin</b>	36.58	0.64	1.8%
<b>New Mangalore</b>	42.06	24.72	58.8%
<b>Ennore</b>	30.45	4.34	14.3%
<b>Total</b>	<b>679.38</b>	<b>226.66</b>	<b>33.4%</b>

Source: MoPNG<sup>17</sup>

## 4.5 Maldives

The Maldives, being a 100% POL product import-based economy with no proven crude oil reserves, has no refining infrastructure. The dispersed nature of the islands makes pipeline distribution unfeasible. The downstream infrastructure is thus limited to import, storage and distribution facilities.

Male is the major sea port of the Maldives with an internal and outer harbor. Male outer commercial harbor handles all types of cargo vessels including container traffic at berth except for dry bulk and POL products. A tanker terminal for handling POL products is available at Funadhoo and Thilafushi ports. LPG and LNG are exclusively handled at Thilafushi port. STO acquired a 25,000 MT oil tanker in 2017 to

<sup>17</sup> MoPNG - Ministry of Petroleum and Natural Gas



facilitate oil import and reduce freight cost. Ship-to-ship transfer facility is available at both these ports to ensure seamless distribution of POL products to other islands.

The Maldives, being an import-dependent economy, needs to maintain strong import infrastructure. The current commercial port in Male has already reached its maximum physical capacity. Therefore, the Maldivian government plans to further develop Thilafushi port to facilitate additional future POL product imports.

## 4.6 Nepal

Nepal is a land-locked country with no proven reserves of petroleum. Thus, it relies on import of POL products to meet its domestic demand. Indian Oil Corporation (IOCL) is the single largest supplier of POL products, accounting for more than 98% of POL imports to Nepal under a five-year contract that was last signed in March 2017. Key petroleum products imported includes Motor Spirit (MS), Superior Kerosene Oil (SKO), High Speed Diesel (HSD), LPG and Aviation Turbine Fuel (ATF). A miniscule quantum of other POL products is reported to have been imported from Japan, Thailand and South Korea.

Nepal doesn't have any POL-based mid-stream infrastructure such as refineries but has an operational cross-border pipeline from India. The POL products are directly imported from India and distributed via road tankers and the recently commissioned pipeline. The region-wise segregation of supply sources to meet Nepal's POL demand is detailed as follows:

**Table 14: POL Supply Sources: Nepal**

Regions in Nepal	Supply Sources (IOCL Refinery/Depots)
Eastern	Barauni refinery
Central	Raxual depot
Western	Betalpur depot, Mugalsari terminal
Mid-Western	Allahabad terminal, Gonda depot
Far-Western	Banthara depot

Source: NOC

Nearly 60% of all POL products are consumed in the central region alone. It is estimated that there are 494 transporters in Nepal engaging 1,893 tankers to transport these products. Nepal Oil Corporation (NOC) and Indian Oil Corporation (IOCL) have jointly constructed a 70 km long, 2-million-ton, cross-country POL product pipeline from Motihari in Bihar to Amlekhgunj in Nepal. Of the total length, 32.7 km of pipeline has been laid in Indian Territory and the remainder in Nepal. The construction of the pipeline has already been completed and has also commenced operations in September 2019. The pipeline enables a trade of 2 million tons of POL every year between India and Nepal.

## 4.7 Pakistan

Oil and petroleum products in Pakistan are primarily transported via road in trucks and tanks, and pipelines. Pipeline infrastructure is inadequate despite it being the cheapest mode. As per OCAC, transporting oil by road costs PKR 2,628 (\$17.1) per ton compared with PKR 792 (\$5.14) per ton via

pipeline. However, 61% of the POL transport in the country is via road; pipeline accounts for only 37%, Rail accounts for the balance 2%. PARCO currently has the largest pipeline network for the transportation of crude oil and POL products.

**Table 15: Pipelines Owned and Operated by PARCO**

Pipeline	Type	Length (km)	Capacity (mtpa)
<b>Karachi- Mahmoodkot pipeline</b>	Crude	870	2.9
<b>Mahmoodkot-Faisalabad-Machike Pipeline</b>	Diesel, kerosene	362	3.7
<b>Korangi Port Qasim Link Pipeline</b>	Imported crude/product	22	NA

Source: PARCO

Other than those mentioned above, a 2,000 km long White Oil Pipeline (WOP) is under implementation by PARCO for the transport of POL products to the central regions that account for ~60% of the country's total petroleum consumption.

- 1) Portion 1: Karachi to Mahmoodkot
- 2) Portion 2: Mahmoodkot to Machike near Lahore

This pipeline is proposed to have a capacity of 8 mtpa, expandable to 12 mtpa, including excess storage facilities. Some of the other pipeline projects in various stages of progress are:

- 1) Connection between the Port Qasim and Karachi Port and then to the interiors of the country
- 2) Oil transportation pipeline from the Gwadar Port in Baluchistan to Kashgar, China as part of the China-Pakistan Economic Corridor (CPEC)

Imports of oil and petroleum products in Pakistan are undertaken at three major seaports – Karachi Port, Port Muhammad Bin Qasim and Gwadar Port. The Karachi Port is the largest of the three ports in Pakistan, handling over 11.7 million ton of liquid cargo and 25.5 million ton of dry cargo that constitute ~60% of the country's trade. The port has three oil pier berths dedicated to the petroleum products trade, with specifications as below:

**Table 16: Berthing Specification at the Karachi Port in Pakistan**

Berth	Max Length Overall	Max Draft	Product
<b>OP-1</b>	259 m	13 m	Crude oil & HSD
<b>OP-2</b>	259 m	11.88 m for imports and 12.88 m for exports	Chemical, ethanol, molasses, crude oil, palm oil, HSD, aviation gas, motor gas, naphtha, HSFO and LSFO
<b>OP-3</b>	259 m	12.5 m for imports and 12.25 m for exports	Chemical, ethanol, molasses, crude oil, vegetable oil, naphtha, base LSFO, HSFO, aviation gas, motor gas

Source: The Karachi Port Trust, Logistics Capacity Assessment

The Port Qasim is located at a distance of 50 km from Karachi. It has a specialized oil terminal named

FOTCO offering state-of-the-art facilities to tankers up to 80,000 DWT (dead weight tonnage). The terminal handled 7,817 thousand ton of crude oil and POL imports in fFY 2014. This port has three dedicated berths for the trade of crude oil, petroleum products, chemicals and LPG.

**Table 17: Berthing Specifications at Qasim Port**

Berth	Max length overall	Max draft	Product
EVTL-13	255 m	11 m	HSDO, crude oil and fuel oil
MW-1	185 m	10 m	Liquid chemicals
SSGC/LPG	163 m	10 m	LPG

*Source: The Port Qasim Authority, Logistics Capacity Assessment*

The Gwadar Port was constructed and started functioning in 2007, as the capacity expansion programs at the Karachi and Qasim ports were not expected to keep pace with the expected growth in demand. In particular, the Karachi Port has significant limitations mainly due to its location within densely populated Karachi. The development of the Port Qasim, despite the substantial space for expansion is hampered by its upstream location which is more than 40 km from the open sea. This results in a long turnaround time for incoming ships. The Gwadar Port currently has three 200 m long conventional berths with a turning basin of 45 m diameter and a 4.5 km approach channel that is dragged to 12.5 m.

Under the CPEC plan, China Overseas Port Holding Company (COPHC) plans to expand the Gwadar Port with the construction of nine new multi-purpose berths. It is estimated that till date, the port has handled over 1 million ton of cargo mainly construction material for other CPEC projects. COPHC plans to expand the port's capacity to up to 400 million ton of cargo per year. By 2045, the port will have a total of 100 berths.

#### **4.8 Sri Lanka**

Crude oil movement in Sri Lanka from port to refinery is through a 5.8 km long pipeline that is more than 40 years old and suffers occasional ruptures and, hence, requires replacement. The Petroleum Resources Development Ministry, Sri Lanka, plans to lay a cross-country pipeline to carry crude oil from Colombo Port to Kolonnawa Oil Terminal on a Government-to-Government Agreement and 100% financing on EPC (Engineering, Procurement and Construction) turnkey basis, with either China, India, Malaysia or the US.

In addition to this, there are three product pipelines that transport petrol, Diesel, ATF and FO from the port to the Kolonnawa storage terminal. Only one of these three pipelines are currently operational as all of them are past their useful life and need replacement. Sri Lanka has seven ports managed and operated by the Sri Lanka Ports Authority.



**Figure 10: Sri Lanka Ports**

Source: CPC Annual Report 2015

The Port of Colombo lets out into the Gulf of Mannar and is considered Sri Lanka’s international hub for containers. Four terminals are in operation at the port, through which a large portion of Sri Lanka’s crude oil and POL trade takes place. The Government of Sri Lanka has planned to expand the port to cater to the increasing demand for services from the international shipping industry. The new harbor will have three terminals each having facilities to accommodate three berths alongside.

Trincomalee Harbor is the second-best natural harbor in the world and the available water and land area is ~10 times as much as the Port of Colombo. Trincomalee was tentatively identified to cater to bulk and break-bulk cargo and port-related industrial activity including heavy industries, tourism and agriculture. At present, SLPA is in the process of redeveloping Trincomalee as a metropolis growth center. The port currently has a dedicated oil berth with an overall length of 200 m and a draft of 9.75 m.

The Government of Sri Lanka has begun constructing a port in Hambantota (MRMR Port) in January 2008, given its proximity to one of the busiest sea lanes in Asia. Phase one of the project has been completed. The MRMR Port has two operational terminals handling oil cargos, each with a length of 300 m and depth of 17 m. In addition, the port has a bunkering and tank farm facility and is connected to the oil terminals through a pipeline. The facility consists of 14 storage tanks with a capacity of 80,000 m<sup>3</sup>.

**Table 18: MRMR Port, Sri Lanka (Specification)**

Description	Tank Capacity	No of Tanks
<b>Bunkering fuel</b>	51,000	8
<b>Aviation fuel</b>	23,000	3
<b>LPG tanks</b>	6,000	3

Source: SLPA

## **4.9 Existing Policies and Regulations Pertaining to Energy Trade within the SAARC Region**

The existing regional energy trade among SAARC Member States is limited to the trade of electricity between Bangladesh-India, Bhutan-India, India-Nepal and the trade of petroleum products from India to Bangladesh, Bhutan, Nepal, and Sri Lanka. The trade of electricity is based on indigenous resources while POL products import is due to the excess refining capacity available in India which makes it export excess crude oil to meet the needs of Bangladesh, Bhutan and Nepal. In addition, India is also partially meeting the POL demand in Sri Lanka. In terms of overall trade, the first initiative, the first was taken in 1993, with the signing of SAPTA (South Asian Preferential Trade Agreement) which came into effect in December 1995. To achieve the objectives of economic cooperation in greater form the framework agreement of SAFTA (South Asian Free Trade Agreement) was established in April 1993. The vision was setup for 2015 to establish South Asian Custom Union (SACU) and in 2020 to drive the final stage of economic union. The establishment of free trade agreement and a trading block has not improved trade within the region. The concept of 'sensitive list' exists in SAFTA, wherein trade of commodities on these lists can be regulated by the countries. The countries continue to maintain long sensitive lists. Though there is a commitment on reducing tariff barriers, non-tariff barriers still remain high. In 2014, the SMSs signed the SAARC Framework Agreement for Energy Cooperation (Electricity). This broad-based agreement for cooperation in the energy sector primarily lays emphasis on electricity cooperation in the region. The framework has the following provisions:

- 1) Joint development and protection of grid systems incidental to cross-border interconnection ensuring reliability and security of grids of participating member states
- 2) Grid operators to jointly develop coordinated procedures for secure and reliable operations of interconnected grids, including scheduling, dispatch, energy accounting, and settlement procedures
- 3) Members to enable non-discriminatory access to transmission grids as per laws, rules, regulations, and applicable intergovernmental bilateral trade agreements
- 4) Members to enable authorized entities to engage in cross-border electricity trade subject to local or domestic laws
- 5) Enabling knowledge sharing and joint research and exchanges between experts and professionals related to, among other things, power generation, transmission, distribution, energy efficiency, reduction of transmission and distribution losses, and development and grid integration of renewable energy resources
- 6) Development of structural, functional, and institutional mechanisms to resolve regulatory issues related to electricity exchange and trade
- 7) Development of a dispute-resolution mechanism
- 8) The ability or the right of member states to withdraw from the agreement subject to ongoing projects at the time of withdrawal; and
- 9) Scope of review of the agreement after 5 years of signing.

However, no such agreement has been developed in for promotion of hydrocarbon trade in the region. The implementation of the above framework also has significant challenges in, due to lack of collaboration between Member States in terms of their legal and regulatory frameworks.

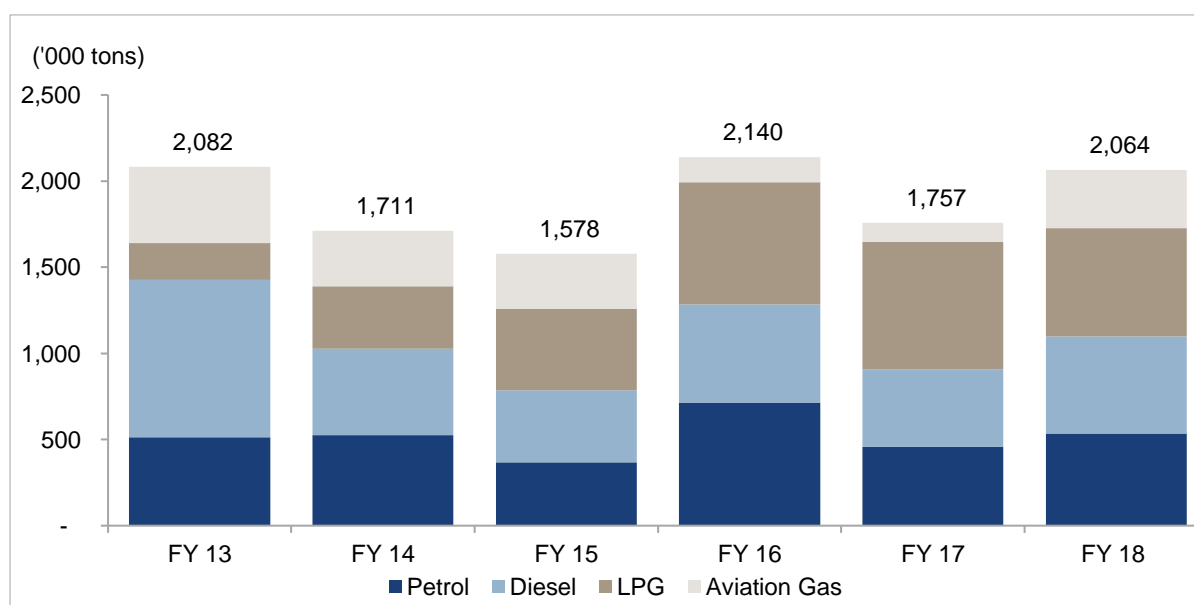
## 5 Scope of Oil Pipeline Networks in South Asia

Most SAARC Member States (except India) are dependent on imports for their requirements of petroleum products and few of these Member States have limited crude oil reserves. Hence, huge volumes of crude oil and petroleum products are transported each year to meet the fuel requirements of these Member States at great cost and inconvenience due to the lack of adequate infrastructure for inter-country movement. The section below details the existing demand-supply scenario for crude oil and petroleum products in each of the SAARC Member States and the outlook on consumption until the year 2030. This will help in understanding the import requirements of each of these Member State and the need for the building of cross-country pipelines to facilitate trade.

### 5.1 Afghanistan

#### Prevalent Demand-Supply Scenario for POL Products

Afghanistan's overall demand for POL products is estimated to have remained stable between fiscals 2013 and 2018. While demand for petrol and LPG clocked 1% and 24% CAGR, respectively, during the period, this was offset by a decline in diesel demand (de-growth of 9.2% CAGR) and ATF, which saw a decline of 5.2% CAGR during the period. This is based on the data available from Central Statistic Organization (CSO) to review POL product demand, which includes only private import data. Additionally, POL products have been imported and consumed by foreign vehicles of coalition forces, data for which is unavailable. There is also a strong possibility of consumption of unreported POL products that have been imported illegally into the country.



**Figure 11: Consumption of Major POL Products: Afghanistan**

Source: Central Statistics Organization

Diesel and petrol together comprise 52% of the total POL demand in the country. More than 95% of demand comes from the transportation segment which saw decent growth over the past five years. Both diesel and petrol-based vehicles clocked 3% CAGR from fiscal 2013 to 2018. LPG is the second-

largest POL component, accounting for ~30% of the total demand share. Its demand seems to have risen with the replacement of biomass with domestic cooking fuel in both rural and urban households

**Table 19: Consumption of Major POL Products: Afghanistan**

('000 MT)	FY 13	FY 14	FY 15	FY 16	FY 17	FY 18
<b>Petrol</b>	512	526	369	713	459	535
<b>Diesel</b>	915	502	416	571	447	564
<b>LPG</b>	214	361	475	710	741	627
<b>Aviation Gas</b>	442	322	319	146	111	338
<b>Total</b>	<b>2,082</b>	<b>1,711</b>	<b>1,578</b>	<b>2,140</b>	<b>1,757</b>	<b>2,064</b>

Source: Central Statistics Organization

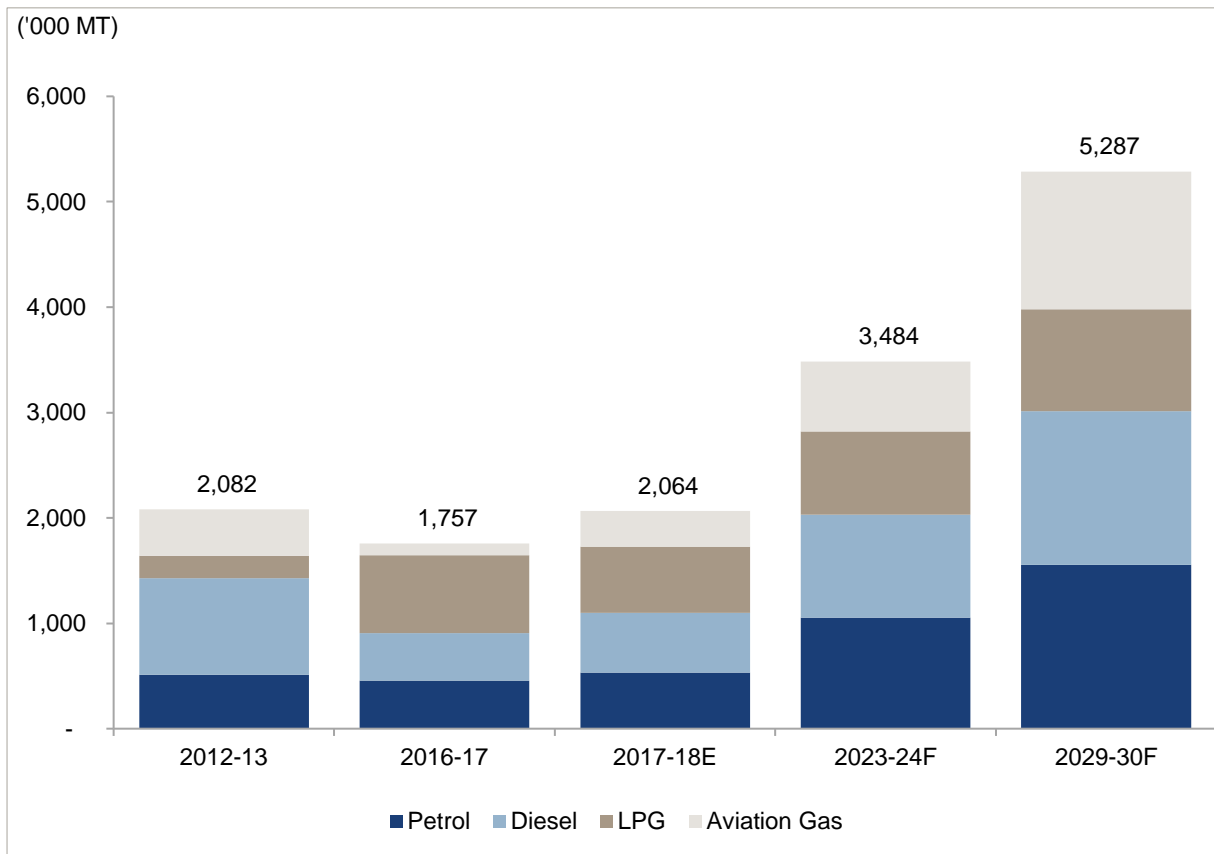
### Outlook on the Demand Scenario for POL Products

Petroleum product consumption in Afghanistan is expected to clock 8.2% CAGR between FYs 2018 and 2030, as against no growth over the past five years. Overall economic activity is expected to remain strong, with GDP growth between 4% and 5% (based on IMF estimates), resulting in strong demand for the transportation segment.

POL product-wise factors resulting in demand growth:

- 1) **Petrol:** Strong GDP growth and resultant increase in per capita income is expected to boost overall vehicle sales (particularly cars and two-wheelers) in the upcoming years. Cars and two-wheelers are expected to grow rapidly during the period, boosting overall demand for petrol, which is expected to clock 9.3% CAGR
- 2) **Diesel:** Diesel demand is expected to clock 8.2% CAGR between fiscals 2018 and 2030, driven by higher demand from the transport segment. Demand from the power sector is expected to effectively decline to zero, due to the availability of cheaper power from imports and increase in renewable energy supply
- 3) **LPG:** LPG consumption is primarily meant for household cooking purposes in both rural and urban households. Afghanistan is expected to clock 3% CAGR in demand for liquid gas due to the region's rising population. Demand growth will remain tepid compared with growth seen over the past five years, as per capita consumption of LPG is already significant at 27 kg per capita and is not expected to grow much





**Figure 12 Overall POL Demand Outlook 2030: Afghanistan**

**Table 20: Overall POL demand Outlook 2030: Afghanistan**

('000 MT)	2012-13	2016-17	2017-18E	2023-24F	2029-30F
<b>Petrol</b>	512	459	535	1,055	1,553
<b>Diesel</b>	915	447	564	977	1,459
<b>LPG</b>	214	741	627	790	968
<b>Aviation Gas</b>	442	111	338	662	1,306
<b>Total</b>	<b>2,082</b>	<b>1,757</b>	<b>2,064</b>	<b>3,484</b>	<b>5,287</b>

*E-Estimated, F-Forecasted*

### Outlook on Supply Scenario and Trade for POL Products

Afghanistan has a current refining capacity of 32,500 barrels per day (1,643 thousand ton per annum). However, these refineries are currently not producing any POL products due to technical issues. For the sake of this assessment, it has been assumed that since the economy has started to grow and political turmoil is over, these refineries will be operational by FY 2020. Additionally, there is a plan to add 50,000 barrels per day (2,489 thousand ton per annum) of refining capacity over the next ten years, entailing a total investment of \$700 million. This refinery is expected to be fully operational by FY 2027. As a result

of this expansion, Afghanistan is expected to produce petroleum products of 4.1 million ton against demand of 5.2 million ton, leaving an import requirement of only 1.1 million ton.

In addition, the country has a strategic goal of increasing its crude oil production to 100 thousand barrels per day (4.9 mtpa) over the long term. We expect this production to come on stream by fiscal 2030 completely. Thus, the country would not require any import of crude oil by FY 2030 if the production target is achieved.

The following table showcases the balance of POL trade for Afghanistan until FY 2030.

**Table 21: POL Trade Balance: Afghanistan**

('000 MT)	FY13	FY17	FY18E	FY24F	FY30F
Refining capacity	1,643	1,643	1,643	1,643	4,132
Crude oil condensates production	1.1	1.1	1.1	498	4,979
Crude oil imports	0	0	0	0	-847
Petroleum products demand	2,082	1,757	2,064	3,484	5,287
Petroleum products production	0	0	0	400	4,132
Petroleum products net imports	2,082	1,757	2,064	3,084	1,155

## 5.2 Bangladesh

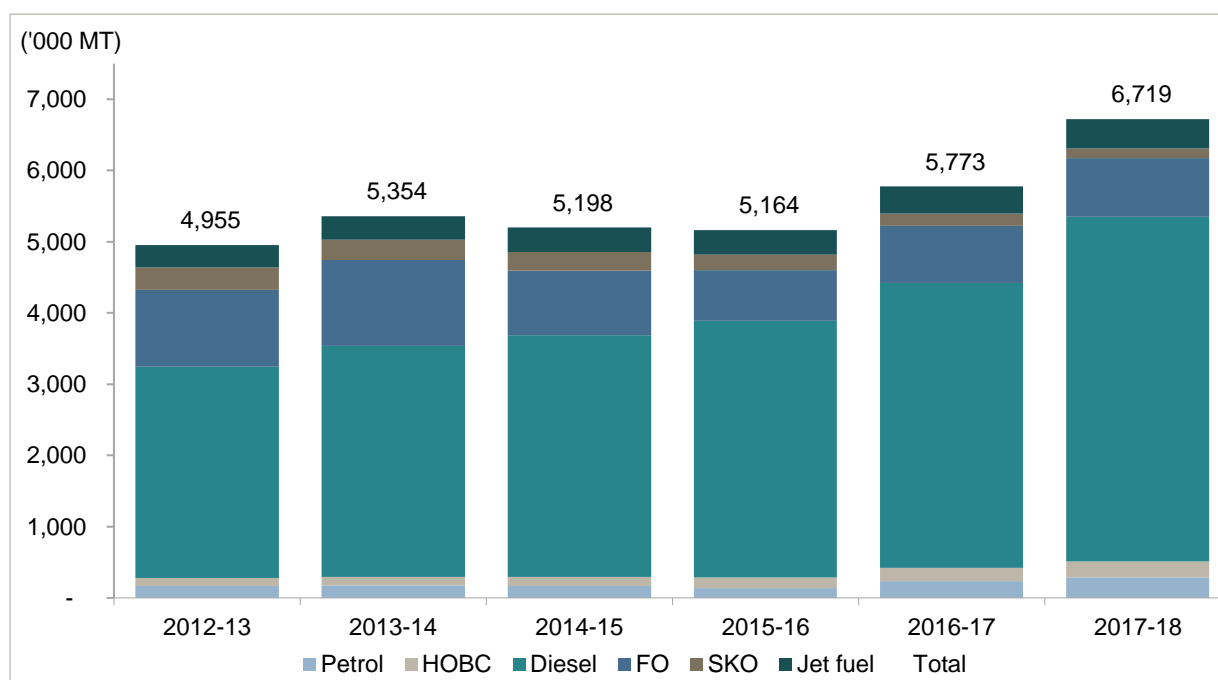
### Prevalent Demand-Supply Scenario for POL Products

Bangladesh's overall demand for POL products has risen at a 6.3% CAGR from FY 2013 to FY 2018 (exclusive of LPG) with specific growth of 16.4% in FY 2018. This was led by rising demand for petrol and Diesel, driven by increased transportation activity.

Low fuel prices and faster vehicular growth – mainly motorcycles and cars (25% CAGR over the past five years) led to an increase in petrol and HOBC consumption by 22.5% and 23.2% respectively in FY 2018. Diesel consumption grew 20.9% in FY 2018, due to higher transportation activity led by a strong 7.1% GDP growth. Commercial vehicles which drive diesel consumption increased 15% in FY 2018, and at a 12.3% CAGR over the past five years. Furnace oil consumption saw a relatively slower growth of 2%, with falling plant load factors leading to a rise in cheap electricity imports from India.

In overall terms, petrol and HOBC consumption in Bangladesh rose steeply between FYs 2013 and 2018 at 11% and 15.7% CAGR, respectively, driven by the transportation segment. Diesel consumption also saw a rapid 10.3% CAGR, because of a rise in demand from the industrial and agricultural segments in addition to the increased offtake from the transport segment. Consumption of Furnace oil (with the power sector accounting for a major share) has declined over years at a 5.3% CAGR between FYs 2012 and 2018, with a shift to electricity imports from India.

JICA estimates that LPG demand<sup>18</sup> in Bangladesh is less than 2% of overall oil demand. While official statistics on LPG are not available for Bangladesh, publicly available information suggests that LPG consumption over the past few years was ~110,000 tons per annum. The private sector accounted for more than 80% of the share in LPG distribution.



**Figure 13: Consumption of Major POL Products: Bangladesh**

Source: BPC

**Table 22: Consumption of Major POL Products: Bangladesh**

('000 MT)	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18
<b>Petrol</b>	170	179	167	137	232	285
<b>HOBC</b>	111	117	126	148	187	230
<b>Diesel</b>	2,965	3,243	3,396	3,606	4,000	4,836
<b>FO</b>	1,076	1,203	907	712	806	822
<b>SKO</b>	315	290	263	214	171	138
<b>Jet fuel</b>	318	323	339	347	377	408
<b>Total</b>	<b>4,955</b>	<b>5,354</b>	<b>5,198</b>	<b>5,164</b>	<b>5,773</b>	<b>6,719</b>

Source: BPC

Bangladesh, with a domestic production of 1.2 million tons, imported more than 80% of its total POL product requirement in FYs 2017 and 2018. The overall trends in POL product imports are detailed as below:

<sup>18</sup> LPG is not reported in POL products in Bangladesh and has been therefore showcased separately.

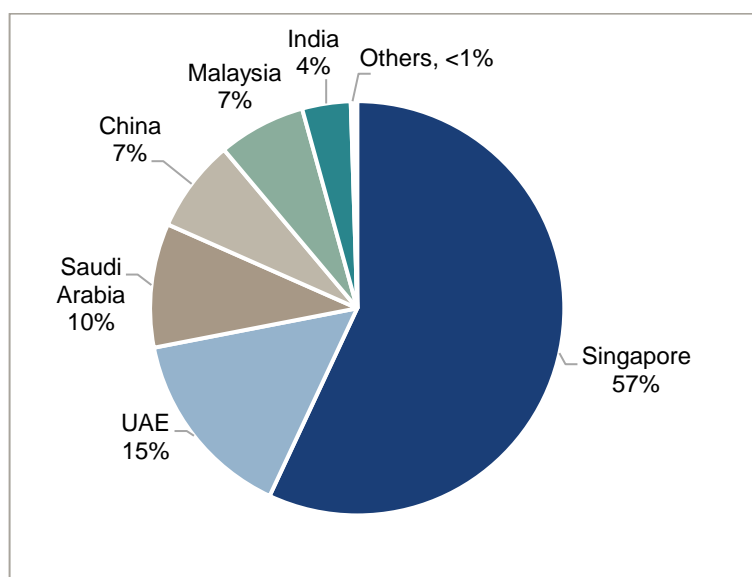
**Table 23: Petroleum Product Imports: Bangladesh**

('000 MT)	2013	2014	2015	2016	2017	2018
<b>Petrol</b>	98	36	34	151	33	33
<b>Diesel</b>	2,609	2,904	2,975	3,130	3,716	3,458
<b>Jet fuel</b>	311	334	338	354	394	306
<b>FO</b>	1,005	869	414	482	564	343

Source: BPC

Diesel, with high demand from the transportation and industrial sectors, is evidently the largest imported POL commodity. Fuel oil imports saw a dip, with a shift in the supply of electricity to cheaper Indian imports.

The Bangladesh Bank, the apex bank, details the country and commodity-wise value of imports. POL products are estimated to have been categorized under '*Mineral fuels, mineral oils and products of their distillation bituminous substances*'. Overall, country-wise POL product imports, as interpreted from import value, is showcased below:



**Figure 14: Import Payment for Oil Products in FY18: Bangladesh**

Source: Bangladesh Bank

It can be inferred from the above that Singapore, the global POL trading hub, forms the single largest supplier of POL products, followed by the Middle East. SAARC Member States (including India and Pakistan) cumulatively accounted for less than 5% of imports value in FY 2018.

### Outlook on the Demand Scenario for POL Products

Petroleum product consumption in Bangladesh is expected to grow at 6.2% CAGR (excluding LPG) between FYs 2018 and 2030, as against 6.3% growth over the past five years. Strong overall economic activity is expected to continue, with GDP growth between 6.5% and 7%, resulting in healthy demand for diesel from the transportation and industrial segment. Demand for fuel oil is expected to pick up again with rising power demand and limitation in power supply from gas-based capacities and imports.

POL product-wise factors resulting in demand growth are detailed as follows:

**Petrol and HOBC:** Strong GDP growth and resultant increase in per-capita income is expected to boost overall vehicle sales (particularly cars and two-wheelers) in the coming years. Cars and two-wheelers are expected to grow rapidly during the period, boosting overall demand for petrol and HOBC, which is expected to grow at a 10% CAGR. Additionally, the lack of domestic gas availability will limit the use of CNG in the transport segment, boosting overall demand for petrol and HOBC.

**Diesel:** Diesel demand is expected to grow at a 6.7% CAGR between FYs 2018 and 2030, driven by higher demand from the transport segment and industrial growth.

- 1) Transport constituted 55% of diesel demand as of FY 2018. Strong economic activity is expected to keep demand for commercial vehicles high, supporting diesel demand.
- 2) Diesel demand from the power sector, which today contributes to 17% of the overall diesel demand, is also expected to see marginal growth for the next two-three years, and stagnate thereafter. As a result, the overall share of the power sector in diesel demand is expected to decline to 10% in 2030 from 17% currently.

**Furnace Oil:** Furnace oil is consumed primarily in the power sector. Currently, FO-based capacities in Bangladesh stand at 3,597 MW (as of July 2019). The Bangladesh government, as per Bangladesh Power Development Board Annual Report, 2016-17, is planning to add 700-800 MW of FO-based plants over and above the existing capacities by 2021. This is expected to result in demand for FO growing at 3.2% CAGR between FYs 2018 and 2030. Additionally, marginal growth in demand is expected from industries due to improved economic activity.

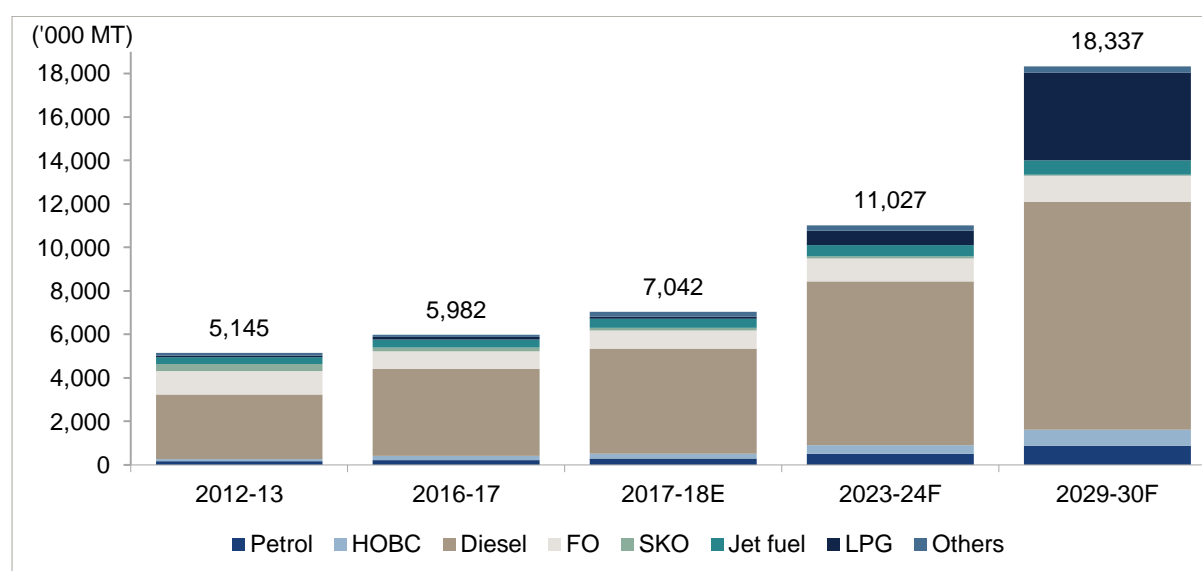
**Other Petroleum Products:** Demand for other petroleum products is expected to witness a healthy growth in the jet fuel segment, which is expected to grow at a 4% CAGR. Kerosene (SKO) demand is expected to decline at an 8% CAGR, as its use in the domestic cooking segment is expected to be substituted by LPG.

**LPG:** LPG is a relatively new entrant in Bangladesh's POL value chain. It is increasingly substituting Piped Natural Gas (PNG) as a household cooking fuel, because of the rising shortage of the domestic natural gas. The Government's pipelined gas access limit policy, with restriction on any new piped-gas connections for households and commercial buildings and a reduction in hours for gas distribution, has encouraged the use of LPG. The energy division of the Government of Bangladesh has come out with the following proposals as a part of 'LPG Strategy Paper', which has obtained the approval of the Prime Minister as an authorized policy:

- 1) Natural gas prices should be raised to an appropriate level
- 2) No further new connections for domestic customers
- 3) LPG prices should be at the international market level
- 4) Natural gas risers at buildings should be utilized for LPG
- 5) Import duty for LPG cylinder material should be lowered
- 6) Land acquisition for LPG business should be promoted
- 7) The government's LPG storage capacity should be secure

- 8) Tax incentives for LPG import facilities (e.g., LPG road tanker) should be introduced
- 9) Conversion from CNG to LPG vehicles should be promoted (should be started from government vehicles)
- 10) LPG business license fee for private enterprises should be lowered
- 11) LPG statistics and database, and preceding survey should be implemented
- 12) Customer awareness raising for LPG usage should be conducted

Assuming the above policy is applied, demand for LPG is expected to grow rapidly in the future. With the restriction on domestic gas only to existing consumers and a rise in demand from the transportation segment, as a result of conversion of CNG vehicles to either gasoline or LPG, LPG demand is expected to surge at a 35% CAGR between FYs 2018 and 2030.



**Figure 15: Overall POL Demand Outlook 2030: Bangladesh**

Overall, demand for POL products (excluding LPG) is expected to rise from 6.7 million tons in FY 2018 to 14 million tons in FY 2030. Additionally, demand for LPG is expected to rise from 0.1 million tons to 4 million tons during the period.

**Table 24: Overall POL Demand Outlook 2030: Bangladesh**

('000 MT)	2012-13	2016-17	2017-18E	2023-24F	2029-30F
<b>Petrol</b>	170	232	285	504	893
<b>HOBC</b>	111	187	230	408	723
<b>Diesel</b>	2,965	4,000	4,836	7,532	10,482
<b>FO</b>	1,076	806	822	1,062	1,199
<b>SKO</b>	315	171	138	84	51
<b>Jet fuel</b>	318	377	408	517	654

('000 MT)	2012-13	2016-17	2017-18E	2023-24F	2029-30F
<b>LPG</b>	78	110	110	666	4,031
<b>Others</b>	112	99	213	255	304
<b>Total</b>	<b>5,145</b>	<b>5,982</b>	<b>7,042</b>	<b>11,027</b>	<b>18,337</b>

E: Estimated; F: Forecast

### Outlook on Supply Scenario and Trade for POL Products

ERL, the only refinery in Bangladesh, had plans to expand its existing capacity from 1.5 million tons to 4.5 million tons. However, there has been no progress on these projects. A private business conglomerate, the Basundhara group, has undertaken the investment in a mega-refinery planned in Bangladesh. Located in Chittagong, the refinery is expected to have a processing capacity of 4.7 million tons. This refinery is expected to come on-stream by FY 2025.

The total refining capacity in Bangladesh is expected to increase at a 12.6% CAGR to 6.2 million tons by 2030. However, even after the capacity expansion, the domestic refining capacity would fall short of domestic demand. While the total domestic production of petroleum products is expected to increase to 5.5 million tons in 2030, overall demand for POL products will outstrip supply by reaching 14.3 million tons (excluding LPG), resulting in an import requirement of 8.7 million tons by 2030. Additionally, crude imports for Bangladesh are expected to rise to feed the incremental refining capacities.

The following table shows the balance of POL trade for Bangladesh until FY 2030, highlighting that it will have an overall deficit of 8.7 million tons by 2030.

**Table 25: POL Trade Balance: Bangladesh**

('000MT)	2012-13	2016-17	2017-18E	2023-24F	2029-30F
<b>Refining capacity</b>	1,500	1,500	1,500	1,500	6,200
<b>Crude oil condensates production</b>	60	26	27	30	40
<b>Crude oil Imports</b>	1,301	1,365	1,139	1,320	5,540
<b>Petroleum products demand (excluding LPG)</b>	5,067	5,872	6,932	10,362	14,306
<b>Petroleum product production (excluding LPG)</b>	1,361	1,392	1,166	1,320	5,540
<b>Petroleum product net import (excluding LPG)</b>	<b>3,706</b>	<b>4,481</b>	<b>5,766</b>	<b>9,012</b>	<b>8,766</b>

E: Estimated; F: Forecast

Note: Here demand data excludes LPG as Bangladesh also produces LPG through fractionators and hence forms a part of natural gas demand.

## 5.3 Bhutan

### Prevalent Demand-Supply Scenario for POL Products

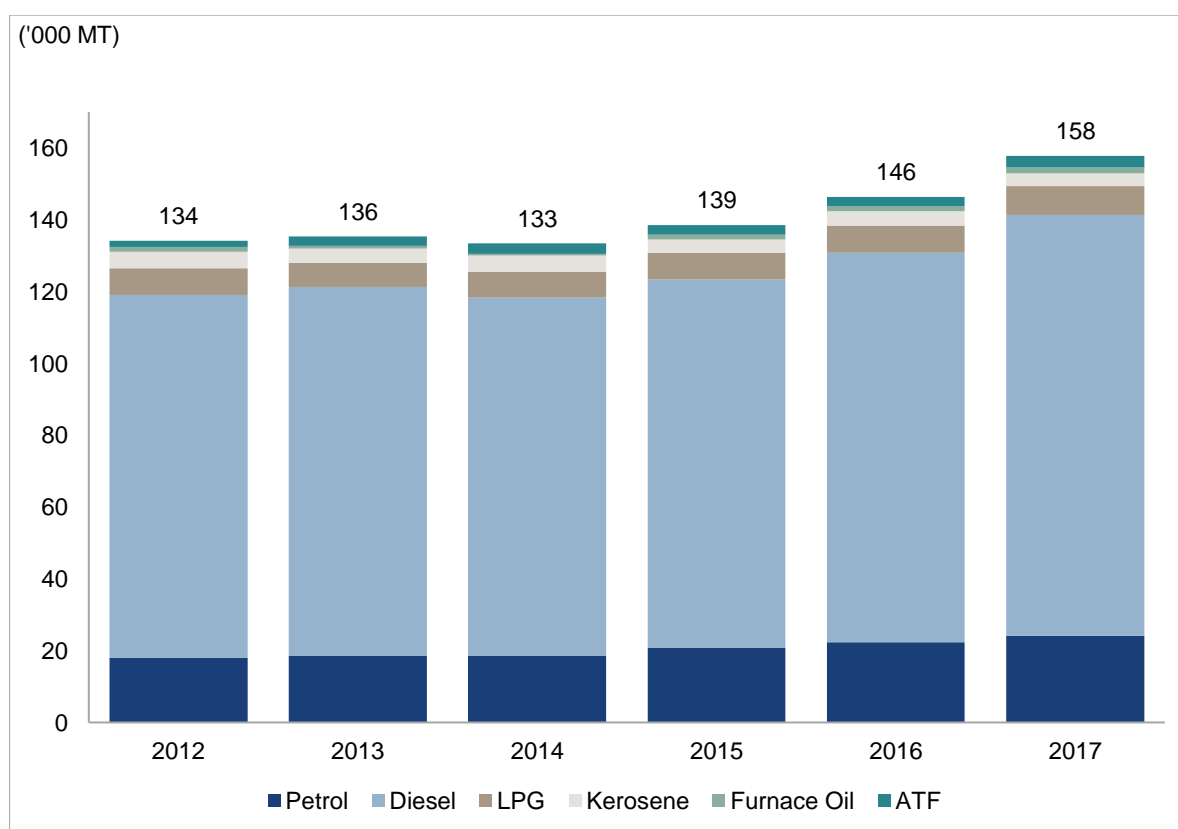
Bhutan saw stagnation in demand growth for POL products from the transportation sector between 2012 and 2014, due to a ban on imports of private and commercial vehicles (except for tourism

purposes) by the government. The ban was lifted in 2014. However, even with the imposition of a stringent tax structure of 100% on imports, vehicular demand grew at a 9% CAGR from 2014 to 2017, leading to demand growth of a strong 6% CAGR for POL products during the period.

Strong vehicular growth at a 6.1% CAGR from 2012 to 2017, even after the ban on imports (particularly passenger cars and utility vehicles), led to a 6% CAGR in petrol consumption during the period. Diesel consumption grew at a 3% CAGR with a pickup in demand for commercial vehicles, subsequent to removal of the ban on vehicle imports. The transport sector accounted for more than 95% of the total diesel demand in the country in 2017. The other diesel-consuming areas include agricultural pump sets and industrial furnaces.

Petrol and Diesel cumulatively accounted for more than 90% of total POL product demand in 2017. Other key petroleum products include kerosene, which has seen a decline in demand at a 5% CAGR from 2012 to 2017 because of replacement with subsidized LPG as cooking fuel. LPG demand grew at a 5% CAGR from 2014 to 2017 to 8,100 MT in 2017.

Some portion of the total imports of petrol and Diesel in Bhutan is consumed by Indian vehicles plying on Bhutanese roads for the transportation of goods and tourist services. Refueling by Indian vehicles is undertaken in the border towns of Samdrup Jongkhar, Gelephu, Phuntsholing and Samtse. As per the data reported in the Bhutan Energy Directory, about 20% of petrol and 6.5% of diesel were re-exported from 2010 to 2014. The aforementioned domestic demand has been accordingly netted off for exports to determine the domestic demand.



**Figure 16: Consumption of Major POL Products: Bhutan**

Source: Statistical Year Book



**Table 26: Consumption of Major POL Products: Bhutan**

('000 MT)	2012	2013	2014	2015	2016	2017
<b>Petrol</b>	18	19	19	21	22	24
<b>Diesel</b>	101	103	100	103	108	117
<b>LPG</b>	7	7	7	7	8	8
<b>Kerosene</b>	5	4	5	4	4	4
<b>Furnace Oil</b>	1	1	0	1	1	2
<b>ATF</b>	2	3	3	3	3	3
<b>Total</b>	<b>134</b>	<b>136</b>	<b>133</b>	<b>139</b>	<b>146</b>	<b>158</b>

Source: Statistical Year Book

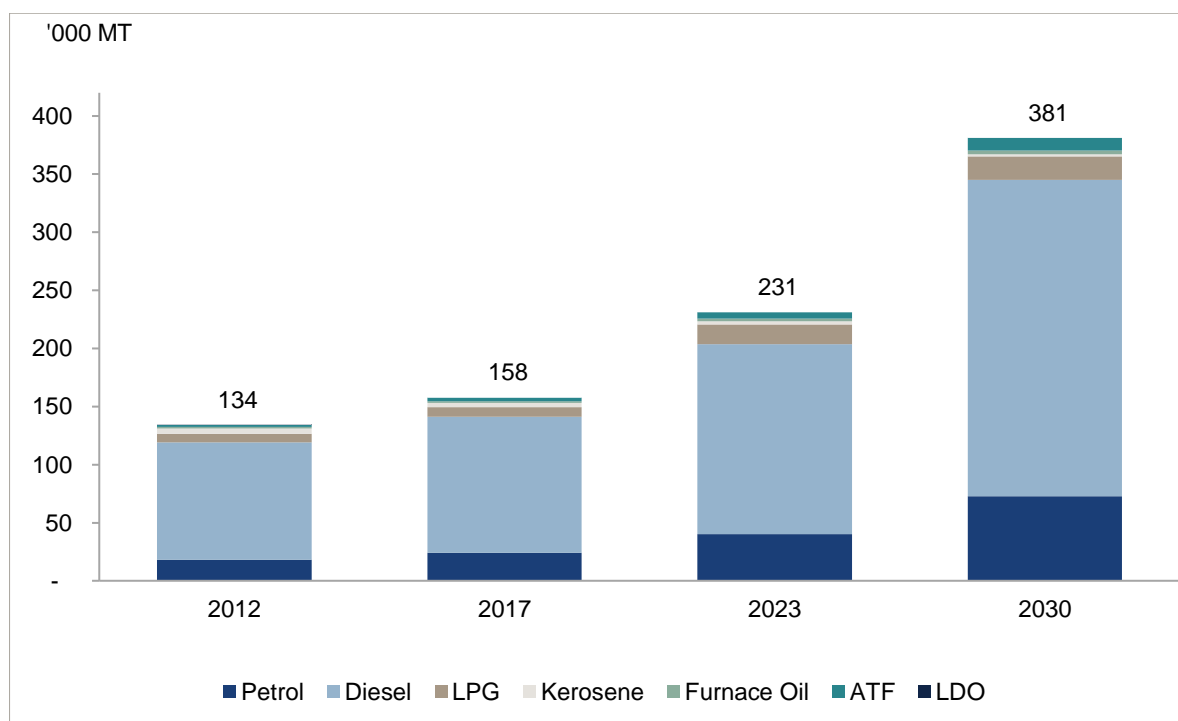
### Outlook on Demand Scenario for POL Products

Consumption of key petroleum products in Bhutan is expected to grow at a 7% CAGR from 2017 to 2030, as against 6.8% growth from 2015 to 2017, subsequent to lifting of the vehicular import ban. Overall economic activity is expected to continue showing strong growth, led by expansion in industries, leading to economic growth, which will result in strong growth in the transportation segment (particularly in the commercial vehicle segment). The POL product-wise factors resulting in demand growth are detailed as follows:

- 1) **Petrol:** Strong GDP growth (more than 8-9%) and a resultant increase in per-capita income is expected to boost overall vehicular sales (particularly cars) in the coming years. Lack of availability of any alternative fuels (CNG) and minuscule penetration of electric vehicles in the overall stock (1%) would boost demand for petrol, which is expected to grow at 8.9% CAGR from 2017 to 2030.
- 2) **Diesel:** Diesel demand is expected to grow at a 6.7% CAGR from 2017 to 2030, driven by higher demand from the transport segment and industrial growth. The transport sector constituted ~95% of diesel demand as of 2017. Strong economic activity is expected to be driven by increasing investment in infrastructure and construction. This will keep demand for commercial vehicles high, supporting diesel demand.
- 3) **LPG:** LPG consumption is expected to grow at a 7.3% CAGR from 2017 to 2030, compared with 4.6% CAGR growth from 2014 to 2017. An increase in LPG availability, subsequent to the launch of the non-subsidized cylinder scheme in February 2018, and focus on shift towards cleaner cooking fuels are expected to be the key factors driving demand. Earlier, the total monthly quota was of 1,200 MT for domestic subsidized LPG (700 MT) and commercial LPG (500 MT). However, Bhutan is now authorized to procure an additional 1000 MT per month of non-subsidized LPG (14.2 kg cylinder) per month from IOCL (Indian Oil Corporation Limited).
- 4) **Other Petroleum Products (Furnace Oil, ATF, Kerosene, LDO):** Demand for other petroleum products is expected to increase at a 5% CAGR from 2017 to 2030. This will be driven by ATF fuel

demand, which is expected to grow at a ~10% CAGR during the period. Kerosene demand is expected decline at a 5.8% CAGR, as its use in the domestic cooking is expected to be substituted by LPG. Light diesel oil (LDO), whose demand has already reduced considerably, is not expected to increase in future.

Overall, demand for POL products is expected to rise from 0.158 million tons in 2017 to 0.381 million tons in 2030.



**Figure 17: Overall POL Demand Outlook 2030: Bhutan**

**Table 27: Overall POL Demand Outlook 2030: Bhutan**

('000 MT)	2012	2017	2023	2030
<b>Petrol</b>	18	24	40	73
<b>Diesel</b>	101	117	163	273
<b>LPG</b>	7	8	17	20
<b>Kerosene</b>	5	4	3	2
<b>Furnace Oil</b>	1	2	2	3
<b>ATF</b>	2	3	6	11
<b>Total</b>	<b>134</b>	<b>158</b>	<b>231</b>	<b>381</b>

### Outlook on Supply Scenario and Trade for POL Products

Bhutan is unlikely to undertake indigenous refining and face issues in transportation of crude oil because of its landlocked nature. Therefore, it is expected to continue meeting its POL demand from imports. Overall deficit of POL products is expected to reach 0.381 million tons by 2030. Considering the strong political relationship and locational constraints, it shall continue to be met by imports from India.

## 5.4 India

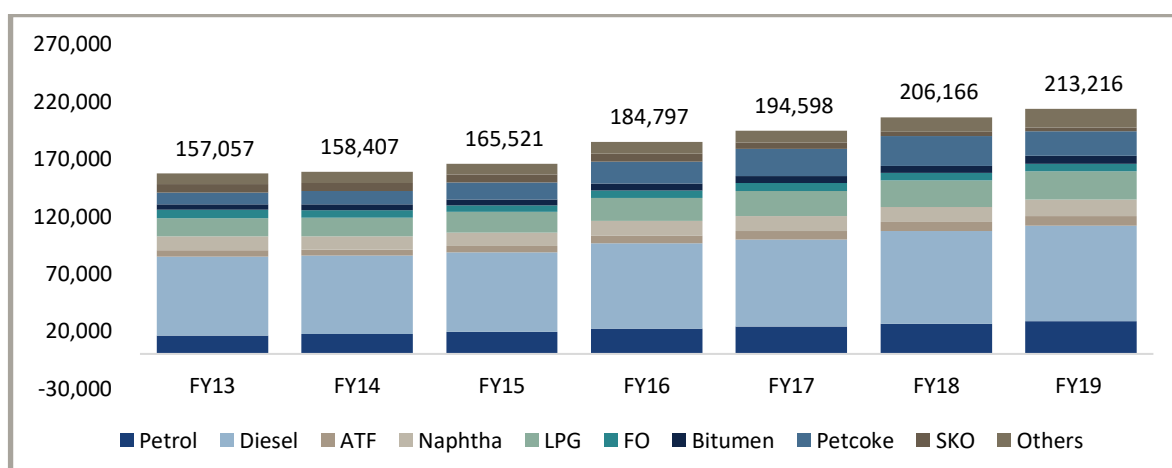
### Prevalent Demand-Supply Scenario for POL Products

India's overall demand for POL products is estimated to have risen at a 6% CAGR from FY 2014 to FY 2019, led by rising demand for petrol and LPG because of increased transportation activity and promotion of clean fuel for cooking in below-poverty line (BPL) households.

Petrol consumption grew at a strong 10.6% CAGR from FY 2014 to FY 2019, led by healthy growth in passenger vehicles. Low fuel prices coupled with new-model launches in the small-car segment also boosted demand. Diesel consumption grew 6.7% in FY 2018, after a recovery in the economic activity; demonetization had led to slowdown in GDP in second half of FY 2017 affecting industrial and transportation sector. Diesel demand growth dipped to 2% in FY 2017. Overall, diesel demand grew at a 4.1% CAGR from FY 2014 to FY 2019 led by commercial-vehicles sales growth.

LPG demand rose at a healthy 8.9% CAGR from 16.3 million tons in FY 2014 to 24.9 million tons in FY 2019, driven by a concerted push from the Government through Pradhan Mantri Ujjwala Yojana (PMUY) to disburse free LPG connections to BPL families. The scheme is aimed to provide 50 million LPG connections to BPL families. More than 72 million LPG connections have already been released under this scheme. Demand for Aviation Turbine Fuel (ATF) grew at an 8.6% CAGR between FYs 2014 and 2019, with increase in passenger-carrying capacity, determined in available seat kilometers, to 156 billion-km in FY 2019 from 81 billion-km in FY 2014.

While the key POL products include petrol, Diesel, LPG, Furnace Oil and Aviation Fuel, 13% of the total POL demand in fiscal 2018 came from Petcoke, because of a strong cement industrial base. Its demand shot up by 21% from FY 2013 to FY 2018, due to a rise in coal prices that made Petcoke more competitive for use in cement plants. However, the Government's thrust on moving from polluting fuel to cleaner fuel, visible in the recent regulatory changes, is expected to have a greater impact on Petcoke consumption. Petcoke consumption fell sharply in the second half of FY 2019, following a ban on imported Petcoke for fuel purpose in August 2018. Overall Petcoke consumption declined ~20% in FY 2019.



**Figure 18: Consumption of POL Products: India (Source: PPAC)**

**Table 28: Consumption of POL Products: India**

('000 MT)	FY13	FY14	FY15	FY16	FY17	FY18	FY19
<b>Petrol</b>	15,744	17,128	19,075	21,846	23,812	26,175	28,284
<b>Diesel</b>	69,080	68,364	69,416	74,647	76,015	81,073	83,528
<b>ATF</b>	5,271	5,505	5,723	6,262	6,998	7,623	8,300
<b>Naphtha</b>	12,289	11,505	11,382	13,271	13,241	12,889	14,131
<b>LPG</b>	15,601	16,294	18,000	19,623	21,608	23,343	24,907
<b>FO</b>	7,656	6,236	5,961	6,673	7,150	6,721	6,564
<b>Bitumen</b>	4,676	5,007	5,073	5,938	5,935	6,086	6,708
<b>Petcoke</b>	10,135	11,756	14,558	19,297	23,964	25,657	21,346
<b>SKO</b>	7,502	7,165	7,087	6,826	5,397	3,845	3,460
<b>Others</b>	9,104	9,448	9,246	10,413	10,478	12,754	15,988
<b>Total</b>	<b>157,057</b>	<b>158,407</b>	<b>165,521</b>	<b>184,797</b>	<b>194,598</b>	<b>206,166</b>	<b>213,216</b>

Source: PPAC

India is a net exporter of petroleum products, with net exportable surplus of 50 million tons as of FY 2019. Currently, petrol and Diesel form over 65% of the net surplus. However, it is private players such as Reliance and Essar (Nyara Energy) that export majority of Petrol and Diesel (more than 95%), as they produce Euro V/VI grade fuel, which is suitable for global markets. These players mainly export refined products to the European Union, Singapore and Japan where they have established markets. Public sector units account for a miniscule proportion of exports; the major destinations are other SAARC Member States including Bangladesh, Bhutan, Nepal and Sri Lanka. India is however deficit in LPG and is dependent on Middle Eastern nations mainly Qatar to meet its domestic demand.

**Table 29: POL Product-wise Imports and Exports: India**

('000 MT)	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19
<b>Imports</b>							
<b>Crude Oil</b>	<b>184,795</b>	<b>189,238</b>	<b>189,435</b>	<b>202,850</b>	<b>213,932</b>	<b>220,433</b>	<b>226,498</b>
<b>LPG</b>	6,301	6,567	8,313	8,959	11,097	11,382	13,235
<b>Naphtha</b>	1,762	1,020	1,034	2,931	2,777	2,212	2,082
<b>Others</b>	8,292	9,109	11,954	17,565	22,413	21,870	118,032
<b>Total Product Import</b>	<b>16,354</b>	<b>16,697</b>	<b>21,301</b>	<b>29,456</b>	<b>36,287</b>	<b>35,461</b>	<b>33,348</b>
<b>Exports</b>							
<b>Petrol</b>	16,657	15,247	16,048	16,817	15,417	14,035	12,885
<b>Naphtha</b>	8,647	8,322	7,008	7,116	8,727	8,951	6,963
<b>Diesel</b>	22,464	26,469	25,559	24,037	27,302	29,676	27,833

('000 MT)	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19
<b>Fuel oil</b>	5,922	6,159	4,762	2,806	2,248	2,492	2,197
<b>Others</b>	9,718	11,667	10,554	9,763	11,821	11,603	11,218
Total Product Export	<b>63,408</b>	<b>67,864</b>	<b>63,932</b>	<b>60,539</b>	<b>65,513</b>	<b>66,757</b>	<b>61,096</b>

Source: PPAC

## Outlook on Demand for POL Products

Petroleum product consumption in India is expected to log a CAGR of 3% between FYs 2018 and 2030, as against 5.5% growth seen over the past five years, with demand crimped by reduction in growth of petrol demand on account of rising substitution by CNG, ethanol blending (currently at 6.2%), and greater focus on electric vehicles (EVs).

The POL product-wise factors boosting demand are as follows:

**Petrol:** Demand for petrol is expected to clock a CAGR of 5% from FYs 2018 to 2030, as against a stronger growth seen over the past five years, driven by increasing passenger vehicle and two-wheeler sales. However, improving efficiencies and substitution with CNG in the medium term and ethanol blending and electric vehicles over the long term are expected to restrict demand growth in petrol. With improvements in vehicle technology, EV charging infrastructure and declining battery costs, EV sales are expected to pick up after 2023, when battery costs in the global market fall to ~\$100 per kWh. EVs are estimated to account for 10% of the total car stock and 12% of the total two-wheeler stock by 2030. The Indian Government aims to increase the blending rate to 20% by 2030 from 2% currently. However, lack of domestic production will restrict blending rate from exceeding 10% by FY 2030.

**Diesel:** Demand is expected to grow at a CAGR of 3.3% from FY 2018 to FY 2030, led up improvement in transportation by commercial vehicles, which constitutes two-thirds of overall demand. Transportation by commercial vehicles is expected to increase with industrial activity gaining momentum and strong focus on infrastructure project execution. CV sales are expected to grow at 4-6% during the period, which will support diesel demand growth. However, slower growth in sales of diesel cars (cars and utility vehicles) will limit demand for diesel.

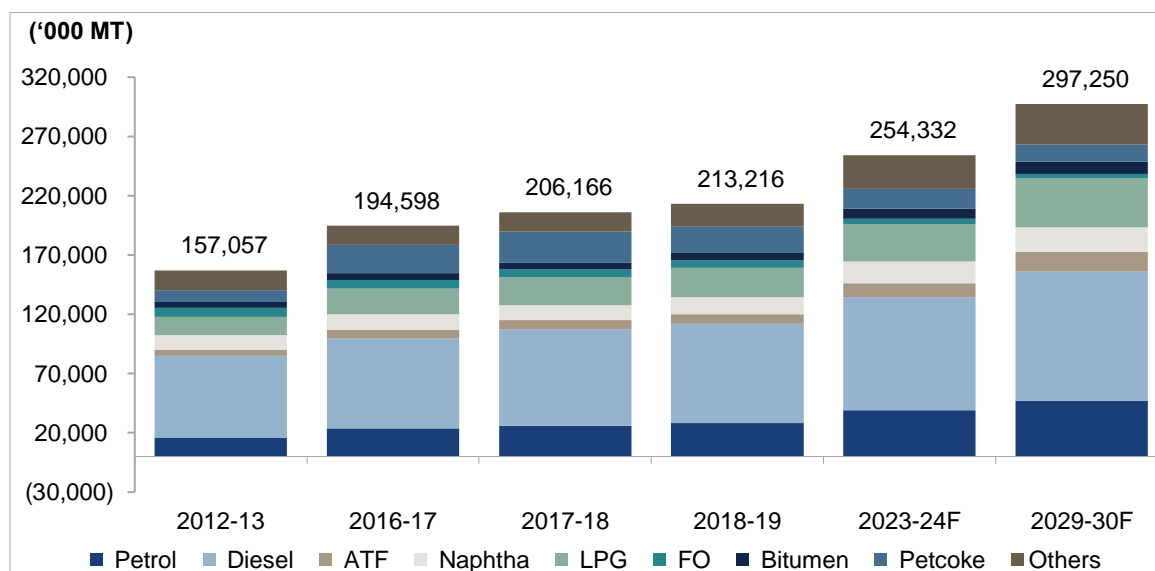
Diesel demand from the non-transport sector is expected to increase only marginally during the period, led by growing demand from the agriculture segment, where it is used to run Agri-pump sets and tractors. Growth in demand from the transport and agriculture sectors will be partially offset by lower offtake of diesel in the railways as the Government of India aims to electrify all diesel-based rail locomotives by 2021.

**LPG:** LPG demand is expected to clock a CAGR of 4.9% between FYs 2018 and 2030, because of the Government's continued thrust to promote the use of LPG and target of rolling out 100 million connections in the next 3-4 years. LPG penetration is expected to reach 97% by FY 2022 and 100% by 2030 from 75% in FY 2017. While growth in demand will be higher at 6-7% over the next 4-5 years, once penetration reaches 100%, demand growth in LPG will slow down. Moreover, with the CGD network spreading to the remaining parts of the country, some LPG demand is expected to be substituted by Piped Natural Gas.

**Other Petroleum Products:** Naphtha demand to log a CAGR of 4.1% from FY 2018 to FY 2030, primarily driven by increased utilization of recently commissioned petrochemical capacities, as well as newer capacities expected to be added.

ATF demand is expected to see a growth of 6.7% between FYs 2018 and 2030, due to an increase in ASKM that is expected to clock a CAGR of 10% during the period, following fleet addition by airlines such as Indigo, Go Air and Jet Airways.

Overall, demand for POL products is forecast to rise from 206 million tons in FY 2018 to 297 million tons in FY 2030.



**Figure 19: Overall POL Demand Outlook 2030: India**

**Table 30: Overall POL Demand Outlook 2030: India**

('000 MT)	2012-13	2016-17	2017-18	2018-19	2023-24F	2029-30F
Petrol	15,744	23,812	26,175	28,284	38,888	47,275
Diesel	69,080	76,015	81,073	83,528	95,494	108,724
ATF	5,271	6,998	7,623	8,300	11,801	16,714
Naphtha	12,289	13,241	12,889	14,131	18,351	20,851
LPG	15,601	21,608	23,343	24,907	31,590	41,434
FO	7,656	7,150	6,721	6,564	4,475	3,290
Bitumen	4,676	5,935	6,086	6,708	8,596	10,264
Petcoke	10,135	23,964	25,657	21,346	16,695	14,789
Others	16,606	15,875	16,599	19,448	28,443	33,910
<b>Total</b>	<b>157,057</b>	<b>194,598</b>	<b>206,166</b>	<b>213,216</b>	<b>254,332</b>	<b>297,250</b>

E: Estimated; F: Forecast

### Outlook on Supply and Trade of POL Products

India's current oil production is ~34.2 million tons (crude oil and condensates production as of fiscal 2019) while annual consumption of crude oil by refineries is 249 million tons. Therefore, India depends on imports from Middle Eastern nations for the remaining 226 million tons. Most of India's currently

producing nomination fields are ageing, thus witnessing an annual production decline of ~0.5% to 1%. In March 2019, the Government invited bids for 23 oil and gas blocks in the third bidding round of the Open Acreage Licensing Policy (OALP) covering 31,000 sq. km. The Government had already bid out 14 blocks in OALP-II (covering 30,000 km) and 55 blocks under OALP-I (covering 60,000 sq. km) in FY 2018. With these blocks coming into commercial production, oil production is expected to increase only marginally in the long term with a natural decline in India's mature fields offsetting this rise.

By contrast, oil players in the refining segment have significant capacity addition plans going forward, taking India's total crude oil demand to 322 million tons by FY 2030 from 249 million tons at present, a 2.3% CAGR.

**Table 31: Upcoming Refineries in India**

Refinery	Capacity ('000 MT)	Expected commissioning
<b>BPC, BORL-Bina, MP-Expansion</b>	1,800 (already completed)	-
<b>IOC, Barauni, Bihar</b>	3,000	2022-23
<b>IOC, Panipat, UP</b>	5,000	2023-24
<b>IOC, Panipat, UP - 2</b>	5,000	2027-28
<b>BPC, BORL-Bina, MP-Expansion</b>	7,200	2025-26
<b>HPC, Mumbai</b>	2,000	2020-21
<b>HPC, Visakh</b>	6,700	2021-22
<b>NRL, Numaligarh-(Expansion)</b>	6,000	2022-23
<b>HPCL, Rajasthan</b>	9,000	2023-24
<b>Mega Project, Raigad</b>	20,000	2026-27
<b>CPCL, Narimanam (expansion)</b>	9,000	2025-26

Source: Company Reports

Considering the rise in domestic production of POL products and hence increasing requirement for crude, crude oil imports are expected to increase to 306 million tons from the current 226 million tons. As against the above, petroleum product demand is only expected to reach 297 million tons by FY 2030.

The below table shows the balance of POL trade for India until FY 2030, and indicates an overall surplus of 31 million tons by 2030. Thus, while total production of petroleum products would be ~328 million tons, the balance 31 million tons will be India's exportable surplus of petroleum products.

**Table 32: POL Trade Balance: India**

('000 MT)	2012-13	2016-17	2017-18	2018-19	2023-24F	2029-30F
<b>Refining capacity</b>	215,066	233,966	247,516	249,366	281,016	322,216
<b>Crude Oil production</b>	37,919	36,008	35,700	34,200	36,000	36,000
<b>Crude Oil Imports</b>	184,795	213,932	220,433	226,498	245,016	306,216

('000 MT)	2012-13	2016-17	2017-18	2018-19	2023-24F	2029-30F
<b>Petroleum Products Demand</b>	157,057	194,598	206,166	213,216	254,332	297,250
<b>Petroleum Product Production</b>	219,212	245,360	252,839	262,361	281,233	328,660
Petroleum product Net Surplus	<b>62,155</b>	<b>50,763</b>	<b>47,918</b>	<b>49,145</b>	<b>26,901</b>	<b>31,410</b>

*E: Estimated; F: Forecast*

As a result, despite a 3% rise in demand per annum between FYs 2018 and 2030, India will continue to remain a net exporter of petroleum products by FY 2030 due to the significant refinery capacity additions planned in future.

## 5.5 Maldives

### Prevalent Demand-Supply Scenario for POL Products

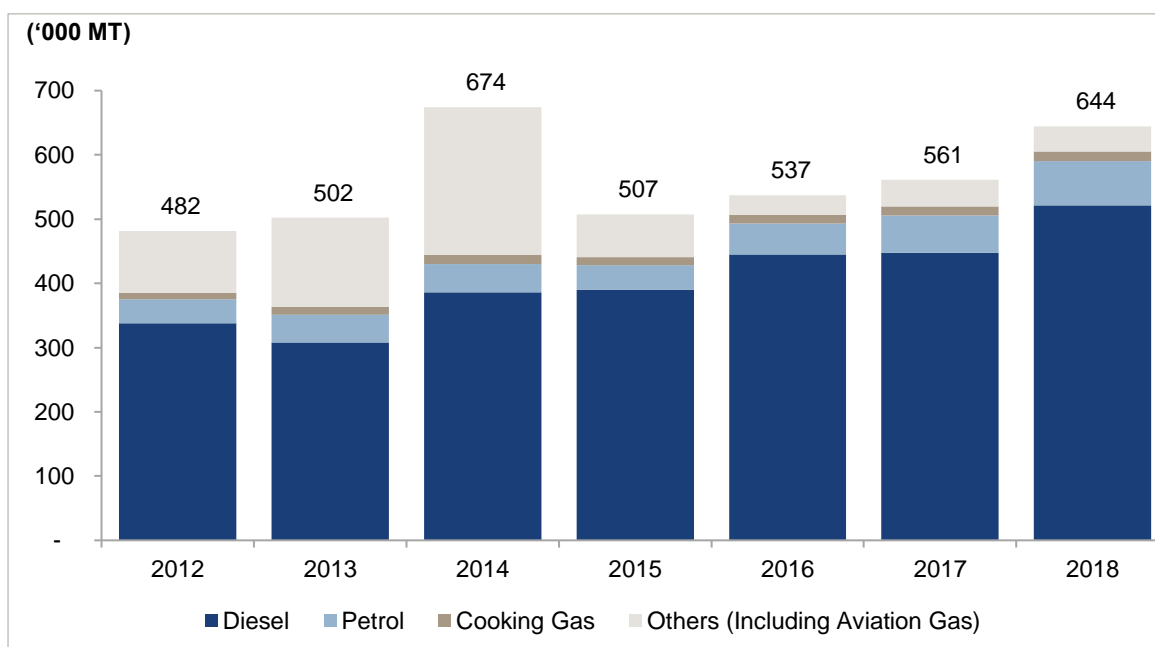
Demand for POL products in the Maldives rose at 5.1% CAGR to 644 thousand tons in 2018 from 502 thousand tons in 2013. The rise was led by strong growth in demand for Diesel and petrol at 11% and 10% CAGR, respectively.

Diesel serves as the major primary energy source fuel, accounting for more than 80% of total POL imports in the country in 2018. The power sector accounted for more than 80% of diesel consumption with power generation led by demand, posting 8% CAGR to reach 1,600 MU from 1,085 MU in 2013. The overall installed diesel-based power capacity in inhabited islands for meeting residential demand is estimated to have risen from 141 MW in 2012 to 240 MW in 2017.

Demand for petrol has risen significantly over the past five years to account for 11% of total POL imports in the Maldives in 2018 led by the rising number of motorcycles and passenger cars whose population has doubled during the period.

Import data suggests the demand for cooking gas in the Maldives has risen from 12,000 MT in 2013 to 15,000 MT in 2018 with residential consumption accounting for more than 60% of the total demand. The remaining demand came from resorts and fishing segments. The focus on clean energy has led to a complete shift from kerosene to LPG as the cooking fuel over the past five years. The demand for aviation gas has been quiet erratic over the years since it is dependent on refueling of international aircrafts and is not used for domestic consumption.





**Figure 20: Import of POL Products (Demand) for the Maldives**

Source: Maldives Customs Service

**Table 33: Import of POL Products (Demand) for the Maldives**

('000 MT)	2012	2013	2014	2015	2016	2017	2018
<b>Diesel</b>	338	308	386	390	445	448	522
<b>Petrol</b>	38	43	44	39	48	58	69
<b>Cooking Gas</b>	10	12	14	12	14	14	15
<b>Others (Including Aviation Gas)</b>	96	139	230	66	31	42	39
<b>Total</b>	482	502	674	507	537	561	644

Source: Maldives Customs Service

### Outlook on Demand for POL Products

The MNOC plans to source crude oil for refining and processing in the refineries of neighboring countries such as India, Sri Lanka and Singapore. However, these plans are at a very nascent stage. No crude oil imports/re-exports are estimated to be undertaken till 2030. We believe the Maldives would continue its dependence on imports for meeting its primary POL demand, including petrol, Diesel and Cooking gas. The outlook on demand for POL products in the Maldives has been estimated by using industry-level benchmarks established in the Maldives Energy Supply and Demand Survey.

POL product-wise factors resulting in demand growth are as follows:

**Diesel:** As part of its efforts to reduce dependence on imported fuel, the Government of the Maldives is pushing for power generation through renewable energy. However, diesel is still expected to remain the primary fuel to meet power demand, with only 10% of total electricity demand estimated to be met from renewable energy sources by 2030. It is estimated in addition to 240 MW of centralized installed

diesel-based power capacity in inhabited islands, there is cumulatively 260 MW of distributed diesel-based power capacity with tourist resorts, used by them to meet their captive power requirements.

The Maldives achieved universal access to electricity in 2008. Electricity demand in the Maldives primarily arises from residential consumers, tourist resorts and other industries, including water purification. Total electricity demand in the Maldives is estimated to have been 1,600 MUs in 2018 and is expected to rise in line with past trends at 6.5% CAGR to reach 3,457 MUs in 2030. Almost 90% of the total power demand is expected to be met by diesel-based capacities that are expected to reach 937 MW by 2030.

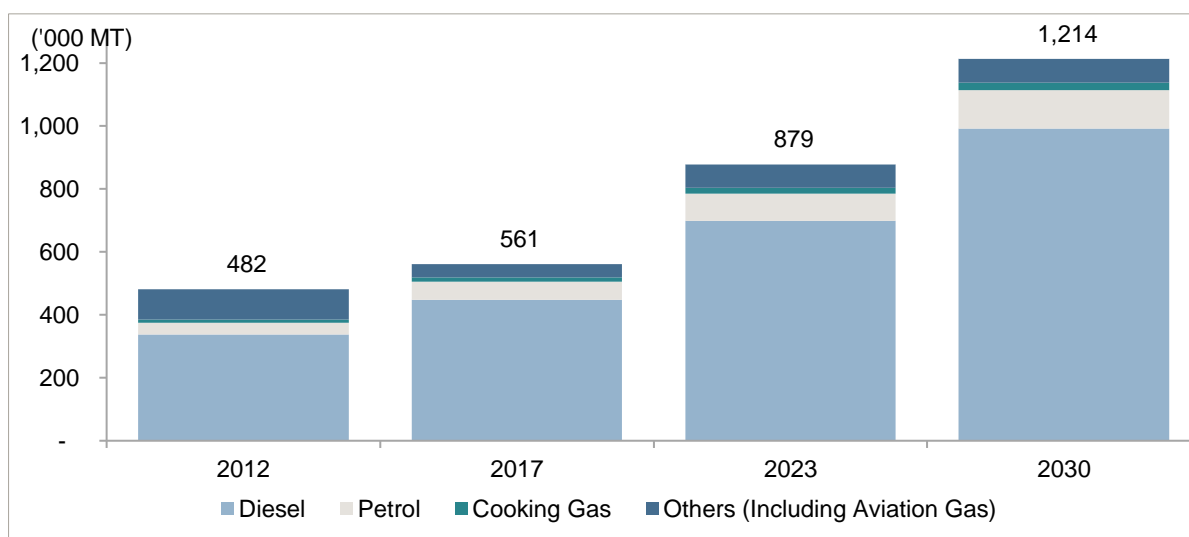
In addition to the power sector, which would likely continue to account for more than 80% of Diesel demand in the country, pick-up in passenger movement across islands through boats, yachts, launches and cargo movement using barges and bahthelis is also expected to contribute towards additional Diesel requirements. Overall, demand for Diesel would increase at 6.3% CAGR, in line with GDP growth, to reach 992,557 MT in 2030.

**Petrol:** Even with the limited land mass, the Maldives has posted significant growth in the number of cars and motorcycles over the past five years at 11-12% CAGR, primarily led by rising per capita income because of 6% GDP growth. Going forward, we expect addition in number of cars and motorcycles to grow at a strong 9% and 11% respectively, till 2022, beyond which it is forecast to slow to 5% on-year. This will boost demand for petrol from the transport segment at 6% CAGR, accounting for 60% of total consumption in 2030.

Additionally, growth in the tourism segment (estimated with increase in tourist arrivals at 7-8% CAGR) is expected to result in higher demand of petrol from speed boats used for tourist transits. Overall, it is expected the demand for petrol would rise at 6% CAGR to reach 123,026 MT in 2030.

**Other Petroleum Products:** Apart from petrol and Diesel, Cooking gas forms another critical POL product for import. The decline in Kerosene demand suggests cooking gas has effectively replaced Kerosene as the primary cooking fuel. While the demand for household cooking has grown significantly over the past five years on account of the low base effect, going forward, we expect the growth to moderate at 4% CAGR. It would primarily be led by rising per capita cooking gas consumption, which is expected to reach 32 kg in 2030 from 26 kg in 2017. Overall cooking gas demand is expected to reach 24,000 MT in 2030 from 14,500 MT in 2017.

Demand for POL products in the Maldives is expected to rise at 6.1% CAGR to 1,214,667 MT in 2030 from 561,433 MT in 2017, led by strong growth in demand for petrol and Cooking gas. Since demand for Aviation gas has shown erratic trends in the past, it has been assumed as the average of the past five years.



**Figure 21: Overall POL Demand Outlook 2030: Maldives**

**Table 34: Overall POL Demand Outlook 2030: Maldives**

('000 MT)	2012	2017	2023	2030
<b>Diesel</b>	338	448	699	992
<b>Petrol</b>	38	58	86	123
<b>Cooking Gas</b>	10	14	19	24
<b>Others (Including Aviation Gas)</b>	96	42	75	75
<b>Total</b>	482	561	879	1,214

## Outlook on Supply and Trade of POL Products

Maldives is expected to continue depending on imports for its POL requirements by 2030.

## 5.6 Nepal

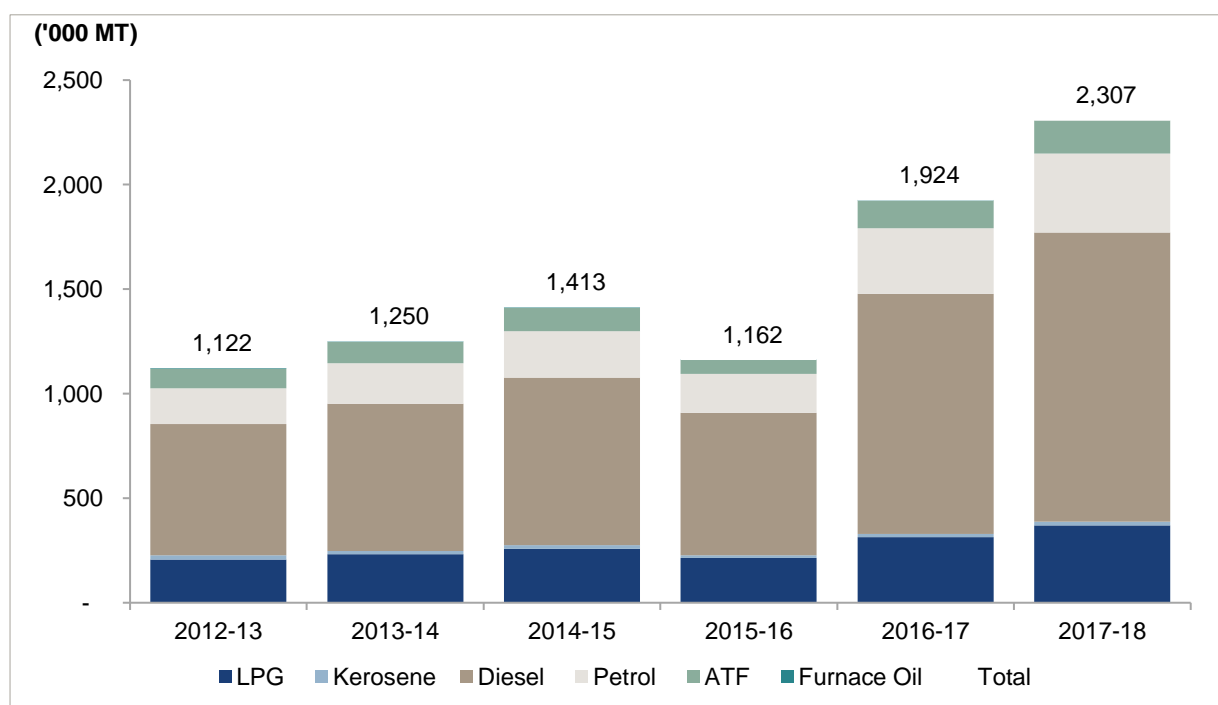
### Prevalent Demand-Supply Scenario for POL Products

Demand for POL products in Nepal grew at a strong 8% CAGR over FYs 2013-15 and subsequently declined ~18% on-year in FY 2016. The decline can be attributed to the political unrest in the country following the introduction of the new constitution in September 2015. This resulted in trade blockade in the Terai region due to which all imports including that of the POL products were hit. The country was also only recovering from the impact of the April 2015 earthquake. Cumulatively, the blockade and earthquake, which resulted in the country's GDP growth slowing to 0.4% from ~3.3% in FY 2015, resulted in a fall in overall POL product demand. After the situation was normalized, the consumption of the POL products witnessed a significant growth on a low base in FY 2017. Overall, the demand grew at around 15% CAGR over FYs 2013-18.

Petrol, Diesel and LPG cumulatively accounted for 92% of the total POL products imports in FY 2017. Petrol and Diesel are mainly consumed by the transport sector which accounted for 82% of the total

key POL products consumption. The industrial sector accounted for 11% of the diesel consumption in FY 2017. The fuel is primarily used for power backup in the sector. Other sectors such as agriculture accounted for the balance.

Shift towards cleaner fuels for residential cooking pushed up LPG demand by 12% CAGR over FYs 2013-18. Kerosene, in turn, saw a fall in demand. The demand for aviation fuel grew at a robust 11% CAGR over the period backed by tourism and transport of foreign aid to support the country after the devastating earthquake.



**Figure 22: Imports of POL Products Demand: Nepal**

Source: Nepal Oil Corporation

**Table 35: Imports of POL Products Demand: Nepal**

('000 MT)	FY 13	FY 14	FY 15	FY 16	FY 17	FY 18
<b>LPG</b>	207	233	258	214	313	371
<b>Kerosene</b>	20	15	16	12	16	18
<b>Diesel</b>	627	703	802	684	1,148	1,382
<b>Petrol</b>	172	195	221	185	314	376
<b>ATF</b>	94	101	114	68	133	159
<b>Furnace Oil</b>	3	2	1	0	0	0
<b>Total</b>	<b>1,122</b>	<b>1,250</b>	<b>1,413</b>	<b>1,162</b>	<b>1,924</b>	<b>2,307</b>

Source: Nepal Oil Corporation

### Outlook on Demand Scenario for POL Products

The consumption of POL products in Nepal is expected to grow at 8.3% CAGR over FYs 2018-30, mainly

driven by strong growth in the transport and industrial sectors led by a 4.5%-5% uptick in GDP. The Product-wise factors that drive demand growth are detailed as follows:

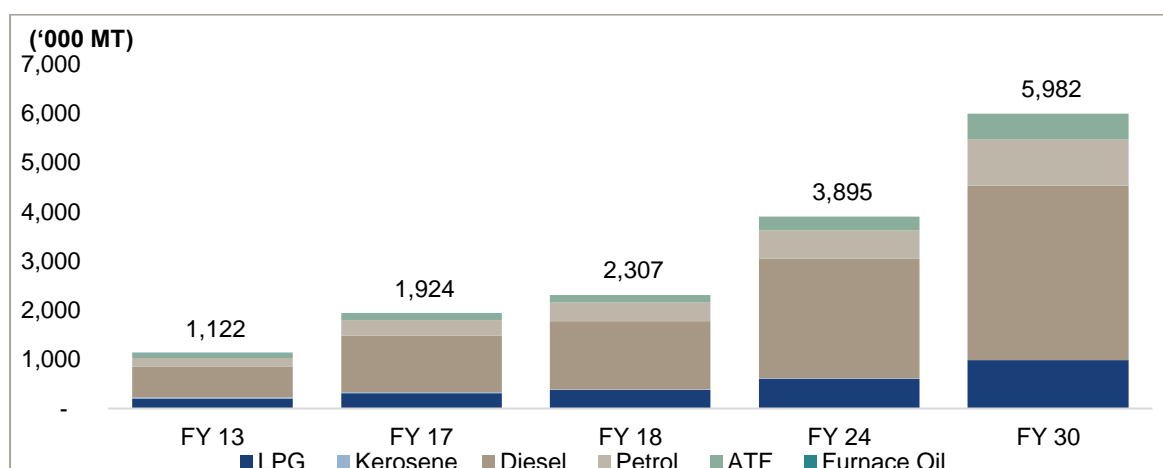
**Petrol:** Petrol vehicles are expected to grow at 7.8% CAGR over FYs 2018-30 owing to rising per capita income. Even though Nepal has a policy to promote electric vehicles, the demand for these has not picked up much in the past. Going forward, even if the number of such vehicles increase, the impact on demand for petrol is expected to remain small. Overall, the petrol demand is expected to grow strongly at 8% CAGR from FY 2017-18 to FY 2029-30.

**Diesel:** The consumption of diesel is expected to grow at 8.2% CAGR over the period, driven by demand from the transport and industrial sectors.

- 1) Diesel consumption from the transport sector, which constitutes ~80% of the total demand for fuel in the country is expected to grow at ~9% CAGR, riding on growth in commercial vehicles.
- 2) Diesel consumption from the industrial sector, which accounts for ~11% of the total consumption is expected to grow at ~5.2% CAGR, supported by improved power supply. However, this is still lower than the historical growth of ~7-7.5% CAGR.
- 3) Demand from other sectors is expected to grow at 4% CAGR in line with historical trends.

**LPG:** Mostly used by the residential, commercial and institutional segments for cooking, LPG is estimated to grow at ~8.4% CAGR, driven by rising per capita LPG consumption as consumers increasingly replace biomass with cleaner fuels.

**Other Petroleum Products (ATF, Kerosene, and Furnace Oil):** These are expected to grow at 9.3% CAGR driven by the demand of ATF, which is seen growing at ~10% CAGR over FYs 2018-30. The demand for Kerosene has already reduced considerably over the past few years and it is expected to hit zero by FY 2030 with clean energy such as Electricity and LPG substituting its consumption in the residential segment. The demand growth for Furnace Oil which has already reduced to zero in FY 2018, is not expected to increase in the future. Overall, Nepal’s import of the POL products is expected to rise from 2.3 million tons in FY 2018 to 6 million tons in 2030.



**Figure 23: Overall POL Demand Outlook 2030: Nepal**

**Table 36: Overall POL Demand Outlook 2030: Nepal**

('000 MT)	FY 13	FY 17	FY 18	FY 24	FY 30
<b>LPG</b>	207	313	371	602	979
<b>Kerosene</b>	20	16	18	13	-
<b>Diesel</b>	627	1,148	1,382	2,429	3,548
<b>Petrol</b>	172	314	376	565	942
<b>ATF</b>	94	133	159	286	513
<b>Furnace Oil</b>	3	0	-	-	-
<b>Total</b>	1,122	1,924	2,307	3,895	5,982

### Outlook on Supply Scenario and Trade for POL Products

Owing to its landlocked nature, Nepal is unlikely to undertake indigenous refining with issues in transportation of crude oil. Therefore, it is expected to continue meeting its POL demand through imports. We expect the overall deficit of POL products to reach 6 million tons by 2030. Considering the strong political relationship and locational constraints, it would continue to be met through the imports from India. However, significant investment will be required for ensuring seamless imports.

## 5.7 Pakistan

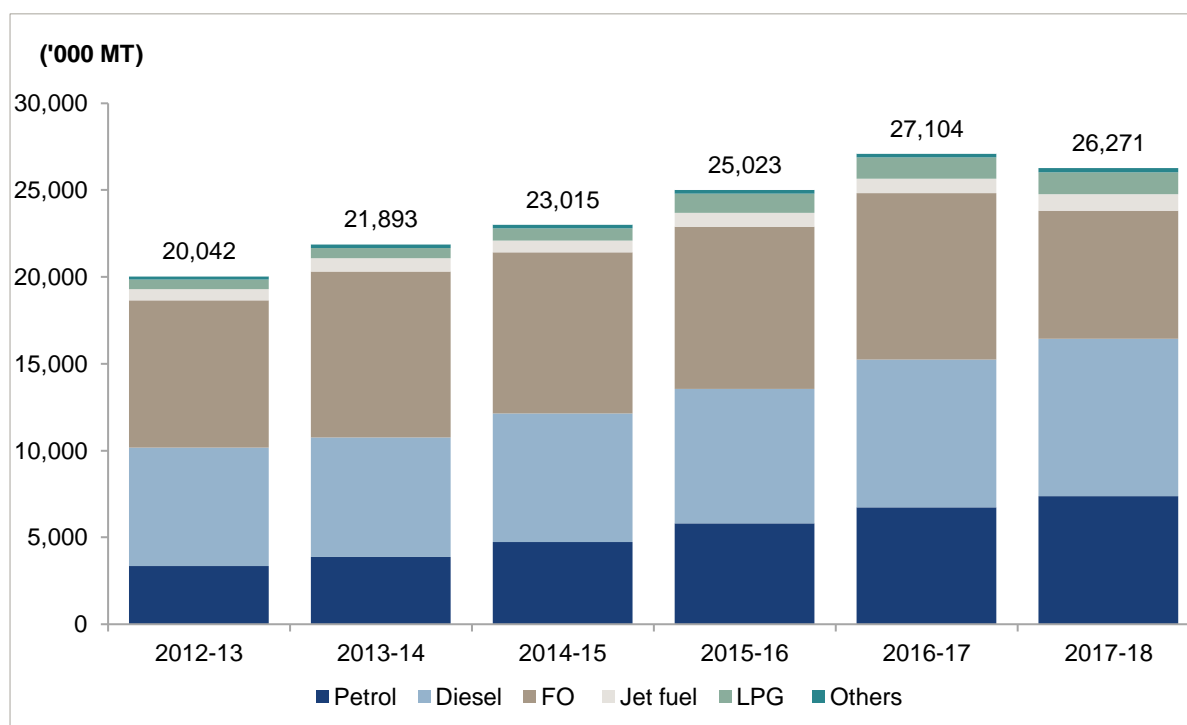
### Prevalent Demand-Supply Scenario for POL Products

Demand for petroleum products de-grew to 26.2 million tons in FY 2018 as compared with ~27.1 million tons in FY 2017. This was primarily on account of a decline in FO consumption in the power sector, where it is being substituted by LNG. Furnace Oil (FO) consumption declined by ~23% on-year in FY 2018. Moreover, there was a minor ~5.5% decrease in kerosene consumption.

On the other hand, the transport sector was a demand driver during the year, leading to a rise in petrol consumption by ~11% on-year in FY 2018. This was primarily owing to the rise in the number of vehicles, particularly in the two-wheeler segment. Further, low crude Oil prices, along with reduced availability of CNG owing to lack of domestic gas availability boosted petrol consumption in recent years. In 2011, the government had banned the import of CNG kits and cylinders to reduce CNG usage.

Diesel demand grew ~6.5% on-year in FY 2018, mainly on account of higher utilization by the transport sector, led by increased economic activity in the country. Consumption growth was muted until FY 2014, declining annually from FY 2008. However, with a pick-up in economic activity and subdued crude Oil prices, along with a ban on CNG usage in public transportation, diesel consumption rose rapidly post FY 2015.

Consumption of FO with the power sector accounting for a major share, has shown mixed trends over the years. Further, as the Government of Pakistan plans to move away from FO in the power sector, FO demand is expected to be subdued going forward.



**Figure 24: Consumption of POL Products: Pakistan**

In overall terms, POL consumption in Pakistan is estimated to have de-grown at 3.5% on-year from FY 2016 to FY 2017, and at a 5.1% cumulative annual rate (including LPG) from FY 2013 to FY 2018.

**Table 37: Consumption of POL Products: Pakistan**

('000 MT)	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18
<b>Petrol</b>	3,341	3,865	4,732	5,801	6,738	7,386
<b>Diesel</b>	6,829	6,898	7,417	7,751	8,493	9,044
<b>FO</b>	8,473	9,553	9,263	9,355	9,599	7,394
<b>Jet fuel</b>	668	765	686	776	833	928
<b>LPG</b>	528	586	699	1,116	1,209	1,281
<b>Others</b>	202	226	218	224	231	238
<b>Total</b>	20,042	21,893	23,015	25,023	27,104	26,271

### Outlook on Demand Scenario for POL Products

Petroleum product consumption in Pakistan is expected to grow at an annual 5.3% between FYs 2018 and 2030. This will primarily be driven by rising demand for petrol in the transportation segment. Diesel demand is also expected to rise owing to improving economic activity. However, increasing demand from petrol and Diesel will be partially offset by a decline in FO consumption. The POL product-wise factors translating into demand growth are:

**Petrol:** Pakistan's vehicle market is under-penetrated with only 20 vehicles per 1,000 people. Rising per capita income is expected to boost vehicle sales (particularly cars and two-wheelers) in the coming years. Cars and two-wheelers are expected to grow rapidly at an 11% CAGR during the period, boosting

overall demand for petrol, which is expected to grow at ~12% CAGR.

Currently, Pakistan is not focusing on shifting towards CNG as a transport fuel owing to limited domestic gas availability. Hence, CNG consumption is expected to grow at a muted 2% per annum till FY 2030. Part of this growth can be attributed to increased availability of LNG, which could divert some of the existing domestic gas to the CNG segment. Electric vehicles (EVs) are not expected to significantly impact Pakistan's car market, as the country has recently launched its electric vehicle policy. The Climate Change Ministry, Pakistan has come up with an EV policy with an aim to convert 30 percent of total number of vehicles mainly cars and rickshaws into EVs during the first phase of 4 years. The lack of adequate infrastructure and higher cost of EVs is expected to keep penetration low over the next 13 years.

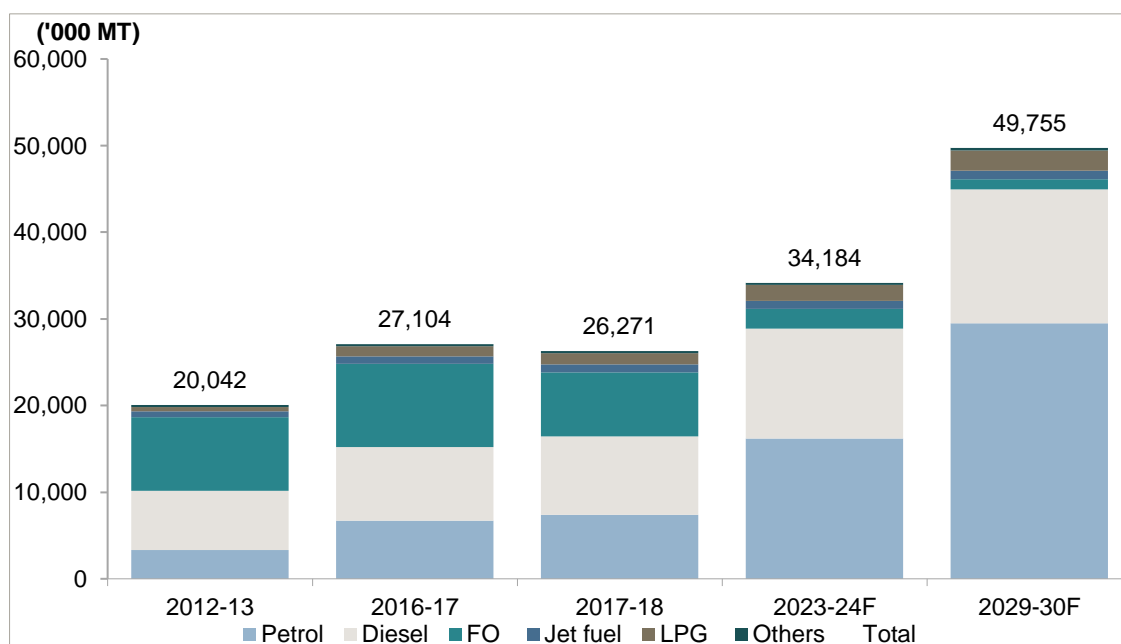
**Diesel:** Diesel demand is expected to grow at 4.6% CAGR between FYs 2018 and 2030, driven by higher demand from the transport segment and industries. Transport constituted 90% of diesel demand in FY 2017. Over the next 13 years, Pakistan's GDP is expected to grow at ~5% CAGR. As a result, the commercial vehicle market is forecast to grow at 7-8% CAGR supporting Diesel demand. In particular, Diesel demand is expected to see a robust growth over the next 2-3 years rising 7% per annum and thereafter moderating over the longer term.

The Diesel demand is expected to grow marginally owing to improved industrial activity. Further in 2014, the Ministry of Railways launched Pakistan Railways Vision 2026 which also includes the China–Pakistan Economic Corridor Rail Upgrade. The plan includes new locomotives, and development and improvement of rail infrastructure. The first phase of the project was completed in 2017, and the second phase is scheduled for completion by 2021. This is expected to improve Diesel demand from the railways. However, Diesel demand from the power sector is expected to decline owing to a lower power deficit and a shift to alternate fuels.

**Furnace Oil:** Furnace Oil (FO) is sourced primarily by the Power sector and Industries. Currently, FO-based capacities in Pakistan are 9,500 MW (as of FY 2018). As the Government of Pakistan is planning a shift from FO-based capacities to Coal and Gas in the power sector, we expect FO-based capacities to reduce to ~1,000 MW by 2030. FO consumption is, therefore, expected to decline at 14% CAGR to 1.2 million tons by FY 2030.

**Other Petroleum Products:** The Jet fuel segment is estimated to grow 3% annually. Since the supply in Pakistan is via its gas fields as well as imports, LPG is not considered as part of petroleum products in Pakistan. LPG consumption in Pakistan is expected to grow at 5% CAGR between FYs 2018 and 2030, driven by rising penetration of LPG in the household cooking segment.





**Figure 25: Overall POL Demand Outlook 2030: Pakistan**

Overall, demand for POL products is expected to rise from 26.3 million tons (including LPG) in FY 2018 to 49.8 million tons in FY 2030.

**Table 38: Overall POL Demand Outlook 2030: Pakistan**

('000 MT)	2012-13	2016-17	2017-18	2023-24F	2029-30F
<b>Petrol</b>	3,341	6,738	7,386	16,187	29,466
<b>Diesel</b>	6,829	8,493	9,044	12,707	15,466
<b>FO</b>	8,473	9,599	7,394	2,262	1,202
<b>Jet fuel</b>	668	833	928	928	985
<b>LPG</b>	528	1,209	1,281	1,816	2,297
<b>Others</b>	202	231	238	284	339
<b>Total</b>	<b>20,042</b>	<b>27,104</b>	<b>26,271</b>	<b>34,184</b>	<b>49,755</b>

F: Forecast

### Outlook on Supply Scenario and Trade for POL Products

Pakistan's sedimentary basin is majorly unexplored. With increased investment in upstream activities, oil production is expected to rise to ~96 thousand barrels per day from the current 87 thousand barrels per day.

Significant new discoveries are being made in the region, with oil production from newer discoveries expected to more than offset the decline in production from mature fields. However, owing to increasing demand for petroleum products, dependence on imports will continue.

The Pakistan Oil Ltd has discovered its largest oil and natural gas reservoir in the Jhandial well located in Ikhlas block, with 23 million barrels of oil expected to be recovered from the block. The provincial Government of Khyber-Pakhtunkhwa aims at increasing the production from its field to four times the

current level by 2025. Khyber-Pakhtunkhwa currently produces ~50,000 bpd of crude oil, which is more than a half of the country's total production of ~91,000 bpd.

Presently, over 50% of the POL requirement in Pakistan is met through imports with the remaining being supplied through refineries. Attock Refinery Limited (ARL), which completed an expansion of its refining capacity by 10.4 thousand bpd in December 2016 is expected to improve its throughput. In addition, PARCO is planning to set up a new refinery with a capacity of 250,000 bpd in a joint venture with Abu Dhabi through Mubadala Investment Company entailing an investment of ~\$6 billion. The project is expected to come on-stream by the year 2023.

ARL also has plans to install a state-of-the-art 50,000 bpd deep conversion greenfield refinery if sustainable enhanced supplies of local crude Oil from the north become available and the Government comes up with an investment-friendly refining policy.

Overall, it is expected the total refining capacity will increase at 4% CAGR till 2030, provided both refineries come online. Total domestic production of POL products is, therefore, expected to increase to 24.6 million tons in FY 2030 from 11.7 million tons in FY 2017 (excluding LPG). However, overall demand for POL products will remain higher, reaching 50 million tons by FY 2030. As a result, Pakistan will remain a net importer of petroleum products.

The following table showcases the balance of POL trade for Pakistan till FY 2030, highlighting that it will have an overall deficit of 22.8 million tons by FY 2030.

**Table 39: POL Trade Balance: Pakistan**

('000 MT)	2016-17	2017-18	2023-24F	2029-30F
<b>Refining capacity</b>	19,600	19,600	32,400	35,200
<b>Crude oil condensates production</b>	4,390	4,460	4,627	4,755
<b>Crude oil Imports</b>	6,084	6,281	18,073	19,862
<b>Petroleum product demand (Excluding LPG)</b>	25,895	24,990	32,367	47,458
<b>Petroleum product production (Excluding LPG)</b>	10,475	11,718	22,700	24,618
Petroleum product net import (Excluding LPG)	<b>15,420</b>	<b>13,272</b>	<b>9,667</b>	<b>22,840</b>

F: Forecast

Note: Here demand data excludes LPG as Pakistan also produces LPG through fractionators and hence forms a part of natural gas demand.

## 5.8 Sri Lanka

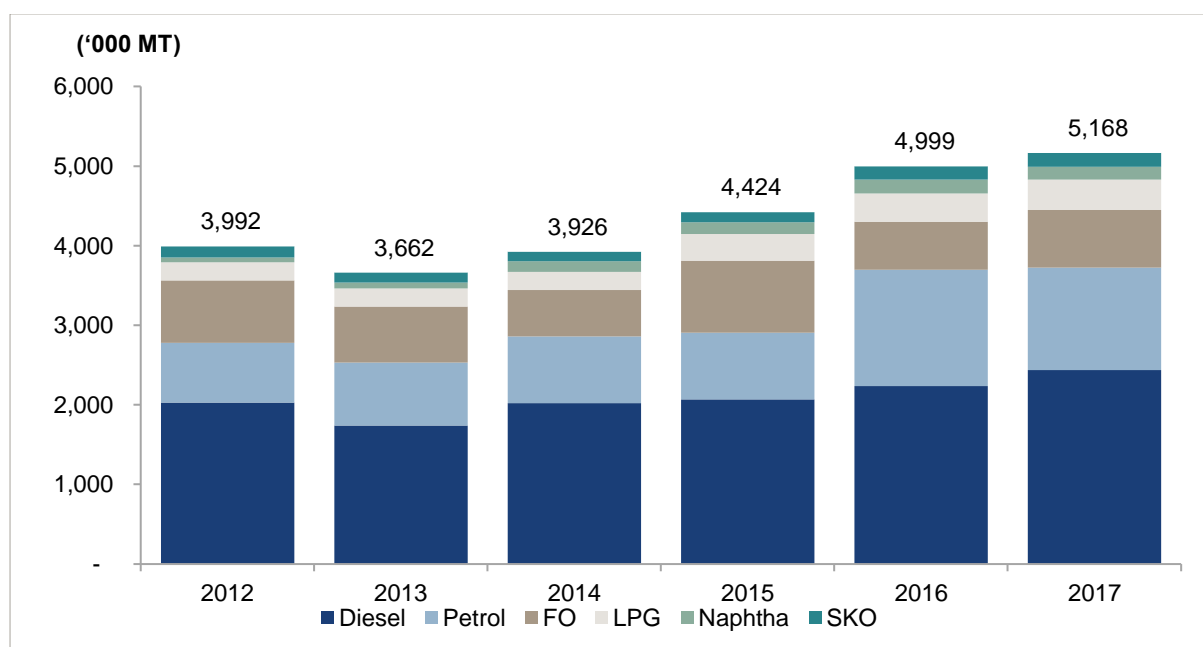
### Prevalent Demand-Supply Scenario for POL Products

The demand for POL products in Sri Lanka is estimated to have risen at 3% CAGR over the past five years till 2017, particularly driven by an 11.5% rise in demand for petrol. Demand for POL products was up 15% on-year in 2016 on account of rising demand for petrol and Diesel, driven by increased transportation activity.

Petrol demand surged by ~75% on-year in 2016, driven by significantly low prices along with increasing

vehicle population. However, such demand growth is expected to be an anomaly, which is estimated to have corrected in 2017 with a rise in fuel prices. Increasing demand from the transport sector was driven by the growing number of cars, two-wheelers and three-wheelers which rose at an annual rate of 9%, 11%, and 9.5%, respectively, from 2011 to 2016.

Diesel consumption grew 16% on-year in 2016 owing to increased transportation activity as a result of GDP growth coupled with a significant rise in demand from the power sector, as the country experienced severe drought leading to reduced generation from its hydropower units. Furnace oil consumption on the other hand, declined 22% on-year despite a rise in power demand on account of lower offtake from industries.



**Figure 26: Consumption of Major POL Products: Sri Lanka**

Source: Sri Lanka Energy Authority

Overall, the demand for POL products in Sri Lanka is estimated to have risen from 4 million tons in 2012 to 5.2 million tons in 2017. Sri Lanka meets more than 60% of its POL product demand through imports. Total production of petroleum products through refineries is estimated to have stood at approximately 1.8 million ton in 2017 against a total demand of 5.2 million ton.

**Table 40: Consumption of Major POL Products: Sri Lanka**

('000 MT)	2012	2013	2014	2015	2016	2017
<b>Diesel</b>	2,027	1,742	2,020	2,070	2,235	2,436
<b>Petrol</b>	751	787	836	836	1,463	1,287
<b>FO</b>	787	704	584	907	599	726
<b>LPG</b>	223	231	232	336	356	378
<b>Naphtha</b>	61	72	133	145	174	165
<b>SKO</b>	143	126	122	130	172	176
<b>Total</b>	3,992	3,662	3,926	4,424	4,999	5,168

Source: Sri Lanka Energy Authority

## Outlook on Demand for POL Products

POL product consumption in Sri Lanka is expected to clock a CAGR of 3.3% between 2017 and 2030 as against 3% growth seen over the past 5 years. This will primarily be driven by rising demand for petrol in the transportation segment. In addition, Diesel demand is expected to rise due to improving economic activity. However, rising demand from petrol and Diesel will be partially offset by a decline in demand for naphtha, thus slowing down overall growth in oil demand. The POL product-wise factors resulting in demand growth are as follows:

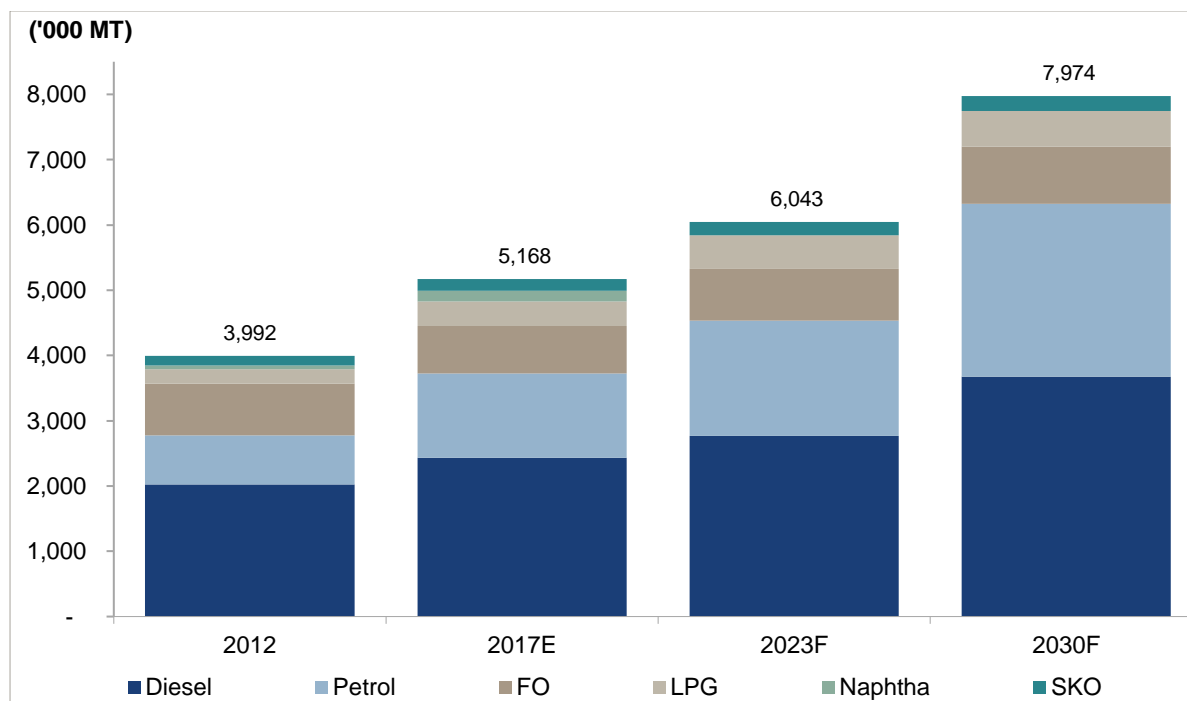
**Petrol:** Sri Lanka's vehicle market is currently underpenetrated with only 24 cars per 1,000 people. Rising per capita income is expected to boost overall vehicle sales (particularly cars and two-wheelers) in the upcoming years. The demand for cars and two-wheelers is projected to grow rapidly from 2017 to 2030, clocking a CAGR of 5% and boosting overall demand for petrol, which is expected to record a CAGR of 5.4%. The demand is likely to remain strong at more than 6% till 2025. However, factors such as rising EV penetration, infrastructure development, and Government support towards purchase of EVs are expected to restrain the growth to 5.5% by 2030.

**Diesel:** Demand for diesel is forecast to witness a CAGR of 3.2% between 2017 and 2030, driven by demand from the Transport segment and Industries. Transport constituted 83% of Diesel demand as of 2016. Sri Lanka's GDP growth is expected to clock a CAGR of ~4.7% over the next 13 years. With a pick-up in economic activity, the commercial vehicles market is forecast to log a CAGR of 4-5% during the period, supporting Diesel demand. In particular, Diesel demand is expected to see a slowdown over the next 2 years, growing at 1-2% per annum due to higher fuel prices, and rising subsequently over the long term. Diesel demand is also expected to see marginal growth coming from improvement in industrial activity. However, diesel demand from power is expected to decline because of the fall in power deficit and shift to alternate fuels.

**Furnace Oil:** Demand is expected to see a rise in 2018 subsequent to commissioning of 320 MW of additional Furnace oil-based capacity, taking the overall capacity to 430 MW. However, we foresee 100 MW of old capacities being retired in the long-term resulting in lower demand from the power sector. Decline in demand from the power sector shall be compensated by demand from Industries which is expected to see a marginal growth of 2%. At an overall level, demand for Furnace oil is expected to post a CAGR of 1.4% between 2017 and 2030.

**Other Petroleum Products:** Demand for LPG in Sri Lanka is forecast to grow at a CAGR of 3% from 2017 to 2030, driven by population growth and increase in per capita consumption of LPG from the household cooking segment. Naphtha on the other hand is expected to see a decline, with its consumption falling to zero by 2030, as no new naphtha-based thermal power capacities are expected going forward and all existing capacities will be retired.

Overall, demand for POL products is projected to increase from 5.2 million ton in 2017 to 7.9 million ton in 2030.



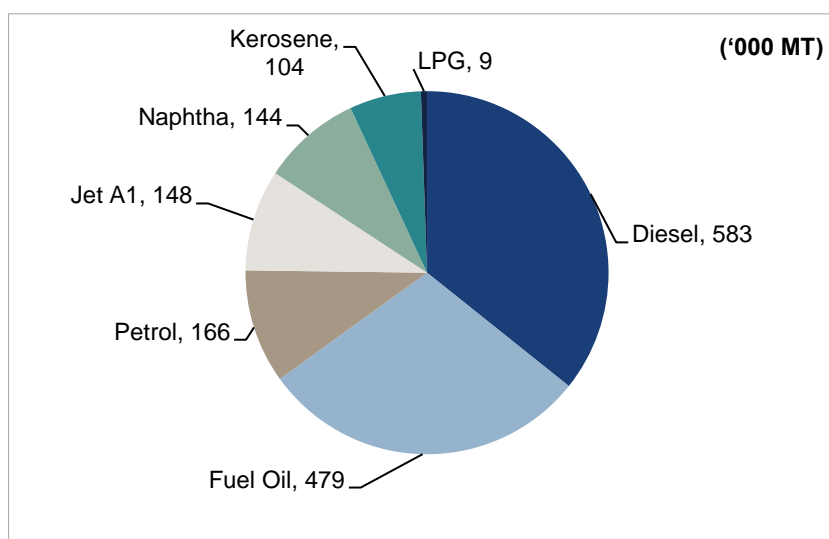
**Figure 27: Overall POL Demand Outlook 2030: Sri Lanka**

**Table 41: Overall POL Demand Outlook 2030: Sri Lanka**

('000 MT)	2012	2017E	2023F	2030F
<b>Diesel</b>	2,027	2,436	2,770	3,674
<b>Petrol</b>	751	1,287	1,767	2,650
<b>FO</b>	787	726	792	875
<b>LPG</b>	223	378	517	547
<b>Naphtha</b>	61	165	-	-
<b>SKO</b>	143	176	198	227
<b>Others</b>	513	-	-	-
<b>Total</b>	<b>4,505</b>	<b>5,168</b>	<b>6,043</b>	<b>7,974</b>

*E: Estimated; F: Forecast*

Sri Lanka meets more than 60% of its POL product demand through imports. Total production of petroleum products through refineries is estimated to have stood at approximately 1.8 million ton in 2017 against a total demand of 5.2 million ton.



**Figure 28: POL Production at Refinery - Sri Lanka (2016)**

Source: Sri Lanka Energy Authority

The rest was met through imports from India, China, Malaysia and Singapore. Data from the Ministry of Commerce, India indicates that 45-50% of Diesel imported in Sri Lanka comes from India for distribution by Lanka IOC.

### Outlook on Supply Scenario and Trade of POL Products

Domestic production was able to meet only 32%-35% of total POL requirement in Sri Lanka in 2017, the remaining was met through imports. Sri Lanka had plans to set up a new refinery in a tie-up with Iran, with a total capacity of 100,000 bpd. However, with recent political developments and trade sanctions on Iran, we do not expect this refinery to commission before 2030. Additionally, in March 2019, Sri Lanka signed an agreement with India's Accord Group to build a new refinery with a total capacity of 200,000 bpd and a total investment of \$3.85 billion. As per plans, this refinery is to be constructed on the Southern Coast near the Hambantota Port. The country plans to export the entire output from this refinery through the port. As a result, we do not expect any substitution of imports by this refinery.

Considering the aforementioned capacity additions, the total domestic production of petroleum products is expected to increase to 9.9 million ton from 1.7-1.8 million ton at present. However, the additional production will be redirected to serve the export demand rather than meet the country's internal demand. Overall demand for petroleum products is expected to reach ~7.9 million ton by 2030. As a result, the country is forecast to import 6-6.2 million ton of POL products. With the new refinery coming online, the country will have to import additional volumes of crude oil for processing, which will be ~10.5 million ton compared with the current import of 1.9 million ton.

The following table presents the balance of POL trade for Sri Lanka till 2030. This highlights that Sri Lanka will have an overall deficit of 6.1 million ton by 2030.

**Table 42: POL Trade Balance: Sri Lanka**

('000 MT)	2013	2016	2017E	2023F	2029F
<b>Refining capacity</b>	2,490	2,490	2,490	2,490	2,490
<b>Crude oil imports</b>	1,743	1,685	1,980	1,980	10,524
<b>Petroleum product demand</b>	3,716	5,096	5,167	6,043	7,974
<b>Petroleum product production</b>	1,556	1,633	1,867	1,867	1,867
Petroleum product net import	<b>2,160</b>	<b>3,462</b>	<b>3,300</b>	<b>4,176</b>	<b>6,107</b>

E: Estimated; F: Forecast

## 5.9 POL Trade Balance of SAARC Member States till 2030

A detailed analysis of crude oil and POL products business across all SAARC Member States, including developing a demand and supply outlook till 2030, suggests that other than India, rising demand for petroleum products is expected to keep all the SAARC nations dependent on imports for key POL products (including petrol and diesel).

**Table 43: Petroleum Product Demand and Deficit Scenario for SMSs by 2030**

('000 MT)	Petroleum Product Demand	Domestic Production of Petroleum Products	Surplus/Deficit
Afghanistan	5,287	4,132	-1,155
Bangladesh (excludes LPG)	14,306	5,540	-8,766
Bhutan	381	0	-381
India	297,250	328,660	31,410
Maldives	1,214	0	-1,214
Nepal	5,982	0	-5,982
Pakistan (excludes LPG)	47,458	24,618	-22,840
Sri Lanka	7,974	1,867	-6,107
Net Deficit in the Region			-15,035

Significant refinery capacity additions planned to be undertaken by most of the SMSs, excluding Bhutan, Maldives and Nepal are expected to limit the overall deficit of POL products in the SAARC region to approximately 15 million ton by 2030.

The trade balance for diesel in 2030, the single-largest POL product based on consumption in SMSs, turns out to be positive with net surplus in India, effectively balancing the deficit in other SMSs.

**Table 44: Diesel Demand-Supply Scenario for SMSs by 2030**

('000 MT)	Diesel demand	Production	Deficit/surplus
<b>Afghanistan</b>	1,459	1,859	400
<b>Bangladesh</b>	10,482	2,232	-8,250
<b>Bhutan</b>	273	0	-273
<b>India</b>	108,724	136,394	27,670
<b>Maldives</b>	992	0	-992
<b>Nepal</b>	3,548	0	-3,548
<b>Pakistan</b>	15,466	9,847	-5,619
<b>Sri Lanka</b>	3,674	747	-2,927
Net Surplus in the Region			<b>6,461</b>

The SAARC Secretariat, in its report on SAARC Regional Energy Trade Study published in 2010, discussed a Petroleum products deficit scenario within the region and recommended construction of a regional refinery of 23 million ton per annum. However, since then, majority of the SAARC Member States including Bangladesh, India and Pakistan have announced plans for significant addition in refining capacities through greenfield and brownfield expansions. Considering the outlook on demand-supply scenario in 2030, these additions will be sufficient to cater to the demand for POL products within the Region. One of the most important developments that is expected to result in this scenario is India's plan to add a 60-million-ton refinery on its western coast. However, considering the demand scenario, we believe that only 20 million ton of the refinery will commission by 2030. The exportable surplus of 31 million ton from India is after considering only 20 million ton of this capacity as India's demand for petroleum products, on the backing of strong focus on alternative fuels, is not expected to rise sharply.

### **5.10 Avenues to Meet Demand Deficit across SAARC Member States**

India's planned west coast refinery can serve as one of the possible options to supply POL products to other SAARC Member States and promote intra-regional POL product trade by 2030. It is planned to be an integrated refinery of 60-million-ton capacity with an associated petrochemical complex to be set up with an overall investment of \$3 trillion. This refinery is planned to be set up by IOCL, HPCL and BPCL in a joint venture in Raigad district of Maharashtra, India. Recently, Saudi Aramco and ADNOC of UAE signed an MoU with the Indian oil companies to jointly hold 50% share of the refinery, while India's IOCL, BPCL and HPCL will hold the remaining 50% stake. Considering India's demand scenario for Petroleum products, only 20 million ton of this refinery is expected to come online until 2030. The refinery plans to source crude oil from the following sources:



**Table 45: Crude Oil Slate of West Coast Refinery in India**

Crude Type	Importing from	% of total
<b>Basrah light</b>	Iraq	32.1
<b>Basrah heavy</b>	Iraq	24.8
<b>Castilla</b>	Columbia	20.2
<b>Oman export</b>	Oman	22.9

Since a large proportion of crude oil is expected to be heavy Crude and primarily sourced from the Middle East, the refinery will have the advantage of higher margins (owing to heavy crude processing) and incur significantly lower freight cost in comparison with crude oil being sourced from other locations such as the US. This is expected to have a significant impact on overall profitability of the refinery. In addition, India being a large demand center is pitching along with other Asian countries to scrap off the “Asia premium” charged on crude oil sourced from the OPEC nations. Assuming that this premium is scrapped off, crude oil sourced from the Middle East will be cheaper by \$2-3 per barrel, hence benefitting the overall economics of the refinery.

The refinery is proposed to be configured for producing 8-9 million ton of diesel (40-45% of the total capacity). Other products proposed to be produced include petrol, Naphtha, ATF, LPG, and by-products for industrial use. This refinery can serve as a plausible option for balancing the SMSs’ demand, with other SAARC Member States increasing their stake in terms of investment, crude sourcing or purchase requisition.

### **Refinery-level Profitability**

The west coast refinery shall incur raw material expenses on procurement of feedstock in the form of crude oil. To assess the profitability, the average Gross Refinery Margins (GRMs) of the refinery can be estimated using current crude prices of ~\$60 per barrel (price of Brent crude as of August 2019) and subsequently calculated major international hub prices for POL products.

**Table 46: Estimated Petroleum Product Slates and Prices**

Product	Product slate (%)	Price (\$/barrel)
<b>LPG</b>	3	45.5
<b>Naphtha</b>	10	60.0
<b>Petrol</b>	15	74.3
<b>ATF</b>	15	78.4
<b>Diesel</b>	45	80.5
<b>Furnace oil</b>	5	58.6
<b>Other by-products</b>	<b>7</b>	

At prevailing levels of crude oil and Petroleum product prices, the refinery is expected to make GRMs of \$4.5-5 per barrel and an overall operating profit of \$650-750 million at current crude oil prices. From

SAARC's perspective, if each Member State contributes towards investing in the refinery or the SAARC Development Fund is utilized to make an investment in the refinery, all Member States could benefit by receiving a share in overall profits.

### **5.11 Alternative Modes of Transportation to Promote Cross-Border Trade for Petroleum Products**

As discussed in the previous section, among the SAARC Member States, India is the only country with a petroleum product surplus and capability to export. All the other Member States are dependent on imports to meet their fuel requirements. Besides, as India is centrally located, it makes most sense even logistically, for all the SAARC Member States to import their fuel requirement from India. Most of these Member States are currently importing petroleum products either from the Middle East or from Singapore. India is much closer in proximity to all of these Member States thus making it economically feasible to import from India. In this section, we have analyzed the feasibility of various alternative modes of transportation for existing and potential trade routes for each of the SAARC Member States and suggested the best possible source and mode of import.

We have not considered Afghanistan which, due to its close proximity with Iran, will continue to meet its demand from Iran. A detailed analysis for the remaining Member States is discussed below:

#### **Bangladesh**

Majority of Bangladesh's Diesel requirement is imported from Singapore. India is also exporting some Diesel to Bangladesh via the rail route with a total distance of 510 km. However, India plans to build a product pipeline of 129.5 km from Siliguri Marketing Terminal to Parbatipur in Bangladesh. Once the pipeline becomes operational, Numaligarh refinery can supply diesel to Bangladesh in a swap arrangement with the west coast refinery. Once the pipeline becomes operational, Bangladesh's freight cost will reduce by ~\$2 per ton when compared with freight on imports from Singapore. Additionally, there is a saving on rail freight (current mode of transport from India to Bangladesh for POL exports) to the extent of ~\$1.5 per ton. With a total petroleum product import requirement of 8.7 million ton by 2030, Bangladesh is expected to save ~\$13 million on freight cost if it imports from India. This saving is calculated by comparing the freight cost of imports via sea tankers from Singapore with a pipeline tariff of Rs 6.9 per km per ton or \$0.098 per km per ton (average tariff for 25 years). Tariff has been computed assuming a pipeline CAPEX of Rs 346 crore or \$49.4 million (funded by a grant-in-aid of Rs 285 crore or \$40.7 million by the Indian Government and Rs 61 crore or \$0.87 million investment to be infused by NRL) and a minimum internal rate of return (IRR) of 12% which needs to be earned on the project to make it feasible.

#### **Bhutan**

Bhutan currently imports all of its petroleum product requirement from India by road through tankers. If instead, a pipeline is constructed between India's Bongaigaon refinery and Gelephu (One of Bhutan's key product storage terminals), this would have an approximate length of 44 km. Considering the hilly terrain, the pipeline would still have high tariff rates in order to make it feasible. Pipeline costs can be lowered if the project is funded through Viability Gap Funding (VGF). If the entire project is funded in a

70:30 debt-equity ratio by the operator, the pipeline entails a tariff of ~Rs 11.2 per km per ton (\$0.16 per km per ton). Even with this high level of tariff, the pipeline still offers a saving of \$0.6-0.7 per ton of logistics cost. Thus, even at high tariff rates, the pipeline turns out to be more feasible than the current mode of transport through road via tankers. Additionally, transportation through pipeline will save significant amount of time and thus is economically more efficient. Note that feasibility of such a pipeline will also depend on whether construction is possible on the kind of terrain, RoW and other such technical considerations. Therefore, a detailed ground survey will be required.

### **Maldives**

Maldives currently imports most of its diesel requirements from the UAE. Instead, if it imports from India's west coast refinery, it would save ~\$7.5 per ton on freight cost. Considering a total import requirement of 0.9 million ton of diesel in 2030, Maldives shall save \$6.7 million on Diesel imports alone at current prices. Since Maldives is an island, if a pipeline between India and the Maldives is constructed, it would have to go through the offshore route. The CAPEX of an offshore pipeline is almost 20-30 times as compared to a regular underground pipeline due to difficulties faced during construction. Hence, a pipeline option does not appear to be economically feasible when compared to imports via ships in case of the Maldives.

### **Nepal**

Currently, Nepal entirely imports its fuel requirement from India by way of road tankers. With the commissioning of the Motihari Amlekhgunj pipeline between India and Nepal, freight costs are expected to come down significantly. Considering a CAPEX of Rs 325 million (\$ 4.56 million), the pipeline tariff comes to Rs 6.1 per km per ton or \$0.085 per km per ton (25-year average tariff). There is significant savings on the freight cost as the road distance between the Barauni refinery in India and Amlekhgunj in Nepal is ~280 km and the truck freight charges are higher than the regular rates due to the hilly terrain. As a result, per ton savings on freight via the pipeline comes to about \$25.8. This will result in a saving of \$51.6 million in terms of transportation costs for Nepal for a 2-million-ton pipeline, if utilized at 100% capacity.

### **Pakistan**

Pakistan buys most of its Diesel from Kuwait. Instead, Pakistan could purchase fuel from India's HMEL (Bhatinda) refinery, which is approximately 150 km away from Lahore by road. Bhatinda refinery could again enter into a swap arrangement with the west coast refinery and meet its fuel requirement. This would lead to a savings of \$3.0 per ton in freight cost for Pakistan (when transported via sea). With a total diesel import requirement of 5.6 million ton by fiscal 2030, Pakistan could save up to ~\$17 million on freight cost, by importing diesel from India. Alternatively, there could be a pipeline constructed from Bhatinda refinery to Lahore, with a total length of ~155km. Considering that the route is a flat terrain, the pipeline could prove to be highly economical, with a tariff of only Rs 1.7 to 1.8 per km per ton or \$0.24 per km per ton (for a 2 mtpa pipeline). Thus, this pipeline could generate savings of \$8-8.5 per ton of POL product imported when compared to current imports via sea from Kuwait.

## Sri Lanka

Similar to the Maldives, Sri Lanka is also surrounded by water on all sides. Currently, most of Sri Lanka's POL requirement is being met through imports from India via the sea route through tankers. We believe that this is the most feasible option for transporting POL products, even going forward. Construction of a pipeline under the sea would entail huge investments, thus making it a rather uneconomical option.

The table below shows the most optimal route for importing POL products for each of the SAARC Member States.

**Table 47: Optimal Trade Route and Country-level Savings on Freight Cost**

Country	Current Source of Import	Route/Mode of Transport	Optimal Source of Import	Route/Mode of Transport	Savings on Freight Cost (\$ per ton)
<b>Afghanistan</b>	Iran	Road tankers	Iran	Road	NA
<b>Bangladesh</b>	Singapore, India	Rail, Sea, Roads	India	Pipeline from Siliguri to Parbatipur	2.0
<b>Bhutan</b>	India	Road tankers	India	Pipeline from Bongaigaon to Gelephu	0.7
<b>Maldives</b>	UAE	Sea	India	Sea (Mumbai port to Male)	6.3
<b>Nepal</b>	India	Road tankers	India	Pipeline from Motihari to Amlekhgunj	25.8
<b>Pakistan</b>	Kuwait	Sea	India	Pipeline from Bhatinda to Lahore	8.2
<b>Sri Lanka</b>	India	Sea	India	Sea (Chennai to Colombo)	NA

*Source: for detailed calculations and assumptions, refer to annexure*

## 6 Implementation and Operation of Oil Pipeline Networks

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### 6.1 Barriers and Constraints for Setting-up Intra-regional Oil Pipeline Network

The major barriers for pipeline construction are mentioned below:

- 1) **Geopolitical Risks Pertaining to Construction and Operation of the Pipeline:** The biggest challenge of intra-regional pipeline projects is ensuring safety and security of the pipeline during both the construction phase and operation phase given the geopolitical situation in host Member States. The physical security of pipelines along the route has the potential of being compromised due to ongoing unrest in conflict-prone areas where revolts are frequent. It takes large number of resources to establish such sites and all the operators have to ensure deep security to prevent theft of equipment, extortion, sabotage and kidnapping of workforce. For key infrastructure such as oil and gas, security is always a major concern world-wide as this sector has high probability and vulnerability to terrorist attacks and sabotage. Offshore platforms are highly vulnerable, high-risk installations having high probability of attacks of terrorists.
- 2) **Presence of Multiple Parties and Selection of Commercial Consortium:** In Intra-regional pipeline projects, the involvement of several sovereign, commercial and regulatory agencies with divergent agenda and geopolitical interests leads to challenges in reaching alignment on issues. A project would typically include the supplier country, procuring country, the transit country, probably an international oil company providing upstream technology expertise, the pipeline construction company (likely to be a consortium with midstream participants from participating countries) and banks/lending bodies (such as ADB/ World Bank). Geopolitical uncertainty and coordination issues among various sovereign, commercial as well as regulatory authorities often discourage participation of players in such projects.
- 3) **Lack of A Uniform Legal and Regulatory Framework:** SAARC Member States have significant divergence in Energy Regulatory Framework with no single, uniform body at the regional level to address the differences pertaining to taxation, pricing, and functions of private players in the POL products domain. Presently, each Member State has a well-defined institutional set-up, with countries such as India and Pakistan having separate sector-wise regulators within the Energy sector. Bangladesh has just one Energy regulator, while Sri Lanka's energy sector is regulated by the Public Utilities Commission, which is not limited to the Energy sector alone. There is no single rule/ governing framework under which all Member States/ companies will fall under and hence limited ability exists to bring things back on track in case of any incident of non-adherence of contract terms.
- 4) **Physical Constraints Pertaining to Terrain and Locational Disadvantages:** Pipeline construction involves significant upfront capital expenditure. The cost goes further up if the pipeline has to be laid in hilly terrains, which require additional pump stations in order to maintain the pressure. Furthermore, the RoW usually crosses small canals, rivers, and have terrain gradient

resulting in additional construction cost. On the other hand, for a Member States like the Maldives, which is surrounded by water, laying a cross border pipeline is tedious as it has to be offshore, resulting in higher construction and operational costs. The routes from India to Bangladesh, Bhutan and Nepal are comparatively less challenging but require extensive planning as all the possible pipeline routes would have a variety of terrains or topographies to cover.

- 5) Lack of Adequate Financial Modalities:** Intra-regional pipelines entail huge investments, and given the associated risks and uncertainty particularly relating to the safety of operations, such projects have difficulty in getting finance. Financial closure for such projects would involve significant support from participating Member States, including equity participation and guarantees for the project debt. This is because the construction and operation of the pipeline, which will pass through difficult and conflict-affected geographies in partner Member States, carry major credit risks. The lack of adequate financing is a major barrier in promoting the construction of intra-regional pipelines in the SAARC region. While there has been emergence of new institutions and agencies in other developing countries, which have facilitated infrastructure development, no significant progress is visible in the SAARC region. In countries with limited access to international markets, regional development banks help finance smaller transactions. There is, therefore, a need for development of regional financing and forming institutions that can facilitate provision of finance and credit to promote intra-regional trade. Another way to generate finance is through increased private participation. Traditionally, infrastructure investments in South Asia have been funded by the public sector. The crude oil and petroleum product sector is largely operated by publicly owned utilities under a subsidized domain which serves as a deterrent for the entry of private players. However, infrastructural development required to promote cross-border trade in term of pipelines, ports and storage terminals, needs significant private capital inflow.
- 6) Lack of Clarity in the Customs Duty Regime:** The movement of oil and petroleum through cross-border pipelines across international borders typically attract duties at several transit points. Federal and state levies in participating Member States (GST/local taxes and entry taxes) under multiple tax laws also stand as a constraint. Taxes and fees, freedom of transit crossing different state borders, interpretation of contract terms, and unilateral termination of contract are main reasons for trans-national pipeline disputes.

## **6.2 Financial Modalities and Tariff Design for Cross-Border Pipelines**

For successful and effective construction and operation of cross-border pipelines, a regulatory framework should be established to determine funding modalities, tariff, and operation rules for the pipeline as several Member States and parties are involved. Such clearly defined rules and regulations enable identification and allocation of various task to various parties and easy resolution in case of conflicts.

## **Financial Modalities**

Once the possible pipeline route is identified and initial survey is done to determine the CAPEX for the pipeline, the next step is to assess the funding options for the pipeline. Pipeline construction usually involves huge CAPEX; the CAPEX is particularly high when the terrain is a hilly, or if the pipeline crosses the sea.

Oil and gas businesses have been traditionally profitable and as such, external investments in such projects can be made possible through large multinationals and state-owned enterprises. A typical financing structure involves a combination of debt and equity for such infrastructure related projects.

International pipeline projects present a high-risk profile for investors and lenders given their complexity and long-time horizon. Political risks are intensified with several countries involved and geopolitical concerns often come into picture. In addition, environmental and social risks are substantial as pipelines usually cover a long distance and cross an array of land uses. Such issues may lead to significant delays. The distance covered by these pipelines also creates difficulties in terms of maintenance and security. This high level of risk may hinder investment options. Pipelines also face competition from shipping as an alternative means of transport. Even with all these issues, many international pipelines have materialized and are running effectively. In projects like these, project funding is usually done by parties involved in buying and selling of the products transported. Such a consortium approach helps distribute the risks and ensures that the interests of different stakeholders are represented.

From a contractual point of view, pipeline projects necessitate different agreements including a transportation agreement ensuring that the project company is paid as long as the pipeline is operational, an Inter-Governmental Agreement (IGA) among the involved Governments to set out the rights and privileges required for building and operating the pipeline and a Host Government Agreement (HGA) to be signed by the project company with each host country. To facilitate these contractual arrangements, the Energy Charter, an intergovernmental process on energy cooperation in Eurasia, has developed models for IGA and HGA.

The India-Nepal pipeline has been constructed and successfully commissioned with a total investment of Indian Rupees 3.2 billion (US\$ 46 million). Construction and funding of the pipeline were undertaken by IOCL of India, in collaboration with Nepal Oil Corporation Ltd (NOCL). NOCL is building additional storage facilities in Nepal for which it has committed a funding of Indian Rupees 750 million (US\$ 10.7 million).

The pipeline envisaged between India and Bangladesh is also being funded by the Indian Government and NRL, which will be operating the pipeline and also supplying fuel to Bangladesh.

## **Tariff Design**

The Tariffs for pipeline projects in India are usually determined for a period of 25 years by way of competitive bidding. A 70% weightage is given to the tariff bid by parties and 30% weightage is given to the bid volume flow within the pipeline. A weighted average score of the lowest tariff and the highest volume is then calculated to determine the winning bid. While lower tariff is usually preferred, players

who are bidding also have to cover their cost of capital and generate a minimum of 12% IRR for the project. They also have to meet their target volume projections; else they are penalized. For cross-border pipelines, we have calculated the tariff in a similar manner. A detailed example has been presented below for the case of India-Bangladesh pipeline.

The pipeline has a total estimated CAPEX of Indian Rupees 3.46 billion (US\$ 49.4 million). OPEX for year 1 has been assumed at 2.5% of the overall CAPEX and escalated at ~7% per annum (these assumptions have been taken by looking at tariff bid documents of existing pipelines and benchmarking OPEX against CAPEX and have been validated through primary data collection by various industry participants). Based on a 12% IRR, the tariff comes to Rs 6.9 per km per ton (US\$ 9.8 cents per km per ton-average tariff for 25 years). The sample tariff model is shown below:

**Table 48: Sample Tariff Model for India-Bangladesh Product Pipeline**

Assumption	Unit	Value
Pipeline Capacity	MMTPA	1
Length of the Pipeline	Km	129.5
Capex of Pipeline	US\$ Million	49.4
OPEX	US\$ Million	1.2
OPEX Escalation	%	7%
Variable tariff for year 1	USD/MMTPA/Km	0.0675
Variable tariff escalation per year	%	3%

Tariff model	Unit	Y1	Y2	Y3	Y4	Y5	Y10	Y15	Y20	Y25
Capacity of pipeline	MMTPA	1	1	1	1	1	1	1	1	1
Length of pipeline	km	129.5	129.5	129.5	129.5	129.5	129.5	129.5	129.5	129.5
Utilization	%	40%	50%	60%	70%	80%	80%	80%	80%	80%
Volume of product transferred	MMTPA	0.40	0.50	0.60	0.70	0.80	0.80	0.80	0.80	0.80
Transportation tariff	USD/MTPA/km	0.07	0.07	0.07	0.07	0.08	0.09	0.10	0.12	0.14
<b>Total capex outflow</b>										
CAPEX	USD Million	49.4	-							
OPEX	USD Million	1.24	1.32	1.41	1.51	1.62	2.27	3.19	4.47	6.27
<b>Total cash inflow</b>										
Revenue	USD Million	3.50	4.51	5.57	6.70	7.88	9.14	10.59	12.28	14.24
<b>Net cash flow</b>	USD Million	-47.1	3.19	4.16	5.18	6.26	6.87	7.41	7.81	7.97
<b>IRR</b>	<b>%</b>	12 %								

Note: Conversion factor considered (1 US\$ = 70 Indian Rupees)



### 6.3 Study of Contractual Terms of Existing SAARC Cross-Border POL Trade via Pipelines and Roadways

Currently, the trade of crude oil and petroleum products is happening through road and sea routes. Apart from the recently commissioned India-Nepal pipeline, no other cross-border pipeline is operational to facilitate trade within the region. For roadways, we studied the tender documents published by oil Public Sector Undertaking (PSUs) for transporting petroleum products from India to Nepal and Bangladesh. The contract terms will be between the supplier of POL product and the transporter. While contract terms vary, we have identified the key terms and conditions that are likely to be applicable for POL products transported via roadways. The terms of contract are listed below:

- 1) **Time period of contract:** Contract between the transporter and the supplier of POL products is usually for a period of two years, extendable by one year. The company can terminate the contract prior to expiration by providing an advance notice.
- 2) **Vehicle for transportation:** POL products are transported in barrels/tankers in ISO certified container trucks having a payload of not less than 16 metric tons with valid permits and licenses. These include national permits, road permits, inter-state permits, etc.
- 3) **Transit loss:** The transporter bears any loss of supplier's products. In the event of any loss to the corporation due to leak / damage of products / packages, the corporation will recover the cost of actual loss of products / packages from the transporter's bill / bank guarantee as under:
  - Amount equivalent to prevailing Maximum Retail Price (MRP).
  - Dealer billing price (Basic listed selling price + Excise duty) for barrels + 20% penal charges on dealer billing price, for non-MRP based products.
  - Amount equivalent to the cost of package damaged.
- 4) **Delay in delivery:** If delivery is delayed beyond the permissible transit time, the transporter would be liable to explain the reason for delay and the company reserves the right to impose suitable penalty in the event of unjustified/unexplained delays.
- 5) **Utilization of trucks:** The supplier of the product usually does not guarantee a minimum number of trucks or minimum mileage of trucks during the period of the contract.
- 6) **Volume to be transported:** Total volume per annum to be transported is specified as an indicative figure in the contract. However, it is not binding on the supplier to transport the quantity. There is no take or pay agreement between the supplier of the product and the transporter.
- 7) **Truck rates:** The supplier usually specifies the minimum and maximum price band it is willing to pay to the transporter (per metric tons of the product to be transported through a specified route).
- 8) **Force majeure clause:** In cases when operations by either party is discontinued or delayed due to war, hostility, act of public enmity, civil commotion, sabotage, fires, floods, explosions epidemics, quarantine restrictions, strikes, lockouts or acts of God, then the party has to provide a notice within 21 days of the data of such an occurrence, and the contract continues to hold with neither party liable to pay for any damage caused due to such an event.

## **6.4 Role of Private Sector Participation in Building Cross-Border Oil Pipeline Network**

Traditionally, infrastructure investments in South Asia have been funded by the public sector. The crude oil and petroleum product sector is largely operated by publicly owned utilities under a subsidized domain, which serves as a deterrent for the entry of private players. However, infrastructural investment required to promote cross-border trade in term of pipelines, ports and storage terminals require significant private capital inflow. This can be brought in either individually or jointly with public utilities provided the markets are open and pricing of POL products is decontrolled by the respective Governments. The deregulation process has already started in a few SMSs which has seen a rise in the share of private players and therefore, improved the efficiency.

As discussed earlier, in case of cross-border pipeline projects, there is increased risk for investors due to the complexity of the project coupled with geopolitical considerations. However, publicly run projects have several issues in terms of operating inefficiencies, lack of funding and management issues. If in the course of a project, a private sector participation is emerging, the Government can play a role by assuming some early risks which because of the regulatory and legal uncertainties, private companies are unwilling to accept until privatization has been completed. Once a clear regulatory framework has been established and the rights and obligations of private investors have been well defined, involvement of the private sector can reap large benefits for the project as seen in case of the express pipeline between Canada and the US (details given in the next section) which was entirely sponsored by the private sector. Cross-border pipelines involve significant capital inflow and hence, private participation can open significant avenues for funding. Besides funding, projects funded by the private sector are driven by profit motives and hence, smooth and efficient functioning of the project is ensured.

Private sector participation can be undertaken in several ways that vary in terms of roles of public and private sectors as they concern ownership, management, risk sharing, and contractual management with users. These options may be classified into two groups: (a) projects that retain public ownership of the assets while contracting out management and operation, and (b) projects that involve partial or temporary private ownership of assets. The first group includes service contracts, management contracts, lease arrangements, etc. The second group includes: build-own-operate-transfer (BOOT), reverse BOOT (whereby the public entity builds the infrastructure and progressively transfers it to the private sector) and joint ownership. Each of these options will have a different degree of economic viability, efficiency in operations, competition and cost recovery. Thus, these options provide flexibility in terms of less risky arrangements without involving private investment.

## **6.5 Policies & Regulations of SAARC Member States**

In order to improve and promote Intra-regional trade, SAARC Member States follow various Policies along with Agreements to facilitate the financial stability and economic cooperation among the Member States. These Policies and Agreements are applicable to most of the product trade except for the products under sensitive list. According to World Bank, each country has many products in this sensitive list, ranging from 6-45 percent of its imports from other South Asian countries. Bangladesh, Nepal and

Sri Lanka have the highest share of sensitive imports from South Asia. Apart from trade agreements among the SAARC Member States, there are also other trade agreements. For instance, ASEAN Free Trade Area (AFTA) with Brunei Darussalam, Indonesia, Malaysia, the Philippines, Singapore, Thailand, Cambodia, Laos, Myanmar and Vietnam. In 2009, India also joined AFTA under ASEAN–India Free Trade Area (AIFTA). Some of the major policies, regulations, directives and agreements followed among the SAARC member states are described below:

### **6.5.1 Arbitration Laws**

SAARC Arbitration Council was established in 2013 with an aim to provide a legal framework within the region for fair and efficient settlement through conciliation and arbitration of commercial, investment, and such other disputes as may be referred to the Council by agreement. It is an Inter-Governmental body mandated to provide a legal framework/forum within the Region for fair and efficient settlement of commercial, industrial, trade, banking, investment, and such other disputes, as may be referred to it by the Member States and their people. The objectives of the Council are briefly described below:

- 1) Promote the growth and effective functioning of national arbitration institutions within the Region;
- 2) Provide fair, inexpensive and expeditious arbitration in the Region;
- 3) Promote international conciliation and arbitration in the Region;
- 4) Provide facilities for conciliation and arbitration;
- 5) Act as a coordinating agency in the SAARC dispute resolution system;
- 6) Coordinate the activities of and assist existing institutions concerned with arbitration, particularly those in the Region;
- 7) Render assistance in the conduct of ad hoc arbitration proceedings;
- 8) Assist in the enforcement of arbitral awards;
- 9) Carry out such other activities as are conducive or incidental to its functions.

The rules have been published by the Council as agreed by the Member States of creating conditions favorable for fostering greater investment by investors of one Member State in the territory of another Member State.

### **6.5.2 SAFTA - Agreement on South Asian Free Trade Area**

Agreement on South Asian Free Trade Area was established in April 1993 to promote and enhance mutual trade and economic cooperation among the Contracting States through exchanging concessions in accordance with this Agreement. However, the Contracting States signed a framework agreement on SAFTA in January 2004, as a progress beyond a preferential trading arrangement and move towards a higher level of trade and economic cooperation in the Region, which came into enforcement in the year 2006. The SAFTA Agreement is implemented through the following instruments:

- 1) Trade Liberalization Program.
- 2) Rules of Origin.
- 3) Institutional Arrangements.

- 4) Consultations and Dispute Settlement Procedures.
- 5) Safeguard Measures.
- 6) Any other instrument that may be agreed upon.

### **6.5.3 SAPTA - Agreement on SAARC Preferential Trading Arrangement**

SAARC Preferential Trading Arrangement (SAPTA) was established to promote and sustain mutual trade and the economic cooperation among the Contracting States through exchanging concessions in accordance with this Agreement. Therefore, SAPTA promoted higher levels of trade and economic co-operation in the Region. The SAPTA Agreement has following principles:

- 1) Overall reciprocity and mutuality of advantages in such a way as to benefit equitably all contracting states.
- 2) Step by step negotiations to improve and develop the agreement in stages.
- 3) Preferential treatment to the Least Developed Contracting States' needs.
- 4) Includes all products, manufactures and commodities in their raw, semi processed and processed forms.

### **6.5.4 SDF – SAARC Development Fund**

In 1996, SAARC Development Fund (SDF) was established to support industrial development, poverty alleviation, protection of environment, institutional/human resource development and promotion of social and infrastructure development projects in the SAARC region. However, due to the limited scope of work and quantum of the fund it was reconstituted in 2005 to form SAARC Development Fund (SDF). SDF was established with an aim to:

- 1) Promote the welfare of the people of SAARC Region,
- 2) Improve their quality of life, and
- 3) Accelerate economic growth, social progress and poverty alleviation in the Region.

The fund operates under three major windows namely Social window, Economic window, and Infrastructure window. In addition to these Social Enterprise Development Program and Micro, Small and Medium Enterprises (MSME) Funding Scheme are also considered under funding windows of SDF.

### **6.5.5 SAARC Agreement on Trade in Services**

The SAARC agreement on Trade in Services was signed in 2010, with an aim to promote and enhance trade in services among the Contracting States in a mutually beneficial and equitable manner by establishing a framework for liberalizing and promoting trade in services within the Region in accordance with Article V of General Agreement on Trade in Services. The agreement excludes the following services:

- 1) Government procurement.
- 2) Services supplied in exercise of Government authorities.
- 3) Transportation and non-transportation air service, including domestic and international service.

Moreover, the agreement has laid out provision for the services that were not technologically feasible at the time of signing of this agreement but can be possible over the years due to advancements.

### 6.5.6 SAARC Agreement on Mutual Administrative Assistance in Customs Matters

The agreement allows the Customs Administrations of the Member States to provide each other either on request or on their own initiative, with information and intelligence which helps to ensure proper application of the Customs law and the prevention, investigation and combating of Customs offences. The assistance shall be performed in accordance with its national legal and administrative provisions and within the limits of its Customs Administration's competence and available resources.

### 6.5.7 Agreement to Avoid Double Taxation and Mutual Administrative Assistance in Tax Matters

The agreement was signed in November 2005, applicable only in the Member States where an adequate direct tax structure is in place. Further, in case of a Member State where such a structure is not in place, this agreement shall become effective from the date on which such a Member State introduces a proper direct tax structure and notifies the SAARC Secretariat to this effect. The agreement applies to the following taxes in the Member States:

Bangladesh	Taxes on income that is direct tax
Bhutan	Income Tax imposed under Income Tax Act 2001 and the rules thereof
India	Income Tax including any surcharge thereon
Maldives	Taxes on income that is direct tax
Nepal	Income Tax imposed under the Income Tax Act, 2058
Pakistan	Taxes on Income
Sri Lanka	Income tax including the income tax based on the turnover of enterprises licensed by the Board of Investment

## 6.6 Global Best Practices and Case Studies

### 6.6.1 Baku-Supsa Oil Pipeline

The Baku-Supsa pipeline (also known as the Western Route Export Pipeline (WREP) and Western Early Oil Pipeline) is a 920 km pipeline that runs from Sangachal Terminal near Baku to Supsa Terminal in Georgia. It transports oil from the Azeri-Chirag-Guneshli field. The pipeline is operated by The British Petroleum Company (BP).

The pipeline was constructed as part of the Baku Early Oil Project, which involved development of the Chirag oilfield in the Caspian Sea. Preparations for the pipeline construction started in 1994. On March 8, 1996, President of Azerbaijan and the President of Georgia agreed on the establishment of the

pipeline. The trilateral contract was signed between Azerbaijan International Operating Company (AIOC), SOCAR and the Government of Georgia. The pipeline was completed in 1998. On April 17, 1999, the pipeline and Supsa Terminal were inaugurated and commissioned. The total cost of the construction of the pipeline and terminal was US\$ 574 million.

### **Case Facts**

- 1) The WREP involved constructing a pipeline in Azerbaijan from the terminal at Sangachal to the Georgian border. It also involved reconstructing and refurbishing an existing pipeline in Georgia to be used exclusively for the transport of AIOC's oil, installing pumping stations, and constructing an export terminal, storage facilities, and offshore loading facilities at Supsa. The pipeline had an initial capacity of 120,000 barrels per day. The cost was initially estimated at US\$ 315 million, but escalated to US\$ 574 million as long stretches of the pipelines in Georgia were replaced instead of being refurbished as originally planned. AIOC financed the project.
- 2) In March 1996, the Government of Georgia and the oil companies forming AIOC signed a HGA for the Baku-Supsa pipeline. Under the agreement, AIOC operates the Azerbaijan section of the pipeline on behalf of the unincorporated joint venture partners. In Georgia, the Georgian Pipeline Company, an operating company owned by the joint venture partners through AIOC operates the pipeline and terminal. AIOC will return ownership of the pipeline to Georgia after 30 years of operation.
- 3) Under the HGA, the foreign oil companies are entitled to full exemption from all taxes related to their pipeline operations or to the petroleum that is transported through the pipeline. They also have the right to import into and re-export from Georgia free of any taxes or restrictions and in their own name, all equipment, materials, machinery, tools, vehicles, spare parts, goods, and supplies necessary for the conduct of pipeline operations. All employees of the foreign oil companies and foreign contractors who are not citizens of Georgia and who are engaged in pipeline operations, were exempt from payment of any form of Georgian personal income tax.
- 4) The Pipeline Construction and Operating Agreement (PCOA) signed by the Georgian International Oil Corporation (GIOC) and the foreign oil companies forming AIOC constituted an appendix to the HGA. Under the agreement, AIOC must pay GIOC an inflation-adjusted transit fee of UD\$ 0.17 per barrel of petroleum transported through the pipeline.
- 5) The PCOA also specifies environmental standards and safety practices for pipeline operations. AIOC is liable for all losses and damages suffered by the Georgian Government or third parties due to the failure of AIOC to comply with the mitigation and monitoring provisions of the approved Environmental Impact Assessment, the technical standards specified in the Agreement, and applicable environmental laws. The operating company must immediately notify GIOC of all emergencies or events. It may request the Georgian Government to assist in repair efforts, in which case it must reimburse the Government for its assistance.
- 6) As long as export routes through Iran and Russia are difficult for political reasons, Georgia will remain the key transit country not only for the Baku-Supsa pipeline but also for all future Caspian oil and gas pipelines. The Georgian Government is responsible for ensuring the security of its segment of the pipeline under the HGA and has agreed to provide at its expense, physical security for the facilities and personnel engaged in pipeline operations.

## **Things to learn from the case**

Effective mechanisms for the resolution of disputes and enforcement of agreements are essential for the successful implementation of any cross-border oil pipeline project. The production sharing agreement HGA and PCOA all contain articles on arbitration that constitute the conflict-resolution structure for the Baku-Supsa Early Oil Pipeline. Additionally, the risk of expropriation in the early oil project is mitigated by several facts. If Georgia were to sabotage the pipeline and cause AIOC to terminate pipeline operations, it would lose transit revenue. Azerbaijan would lose transit and tax revenues and also its share of profit from selling oil. AIOC's losses would correspond to its investment and net revenue from the petroleum that it could not export. The operations of the WREP have been successful, with occasional minor problems. For example, in November 1999, the line was temporarily closed because of flooding, and in May 2002, it was again closed while an 'illegal valve' was removed. The pipeline exported 3.75 million tons of oil in 2018.

### **6.6.2 The Express Pipeline between Canada and the US**

The Express Pipeline is a 1,263 km, 24-inch pipeline connecting Canadian and US Rocky Mountains Crude oil production to various markets in the Rocky Mountains and, through a connecting carrier, to areas of the US Midwest. The pipeline originates at terminal facilities at Hardisty, Alberta runs south across the international border near Wild Horse, Alberta and terminates near Casper, Wyoming. It was designed to deliver 172,000 barrels per day. The capacity of the pipeline has been increased to 280,000 barrels per day.

#### **Case Facts**

- 1) Alberta Energy Company (AEC) originally conceived the Express Pipeline Project in 1992. At the time, production of crude oil in British Columbia, Alberta and Saskatchewan exceeded the then capacity of pipelines for transport to favorable markets. The pipelines were unable to handle heavy and sour crudes. This combination of export pipeline constraints in western Canada and the lack of market diversification resulted in significant discounting in the value the producers received for their crude oil in the markets they served. Western Canadian producers, Governmental authorities and other stakeholders in the region all suffered an opportunity cost from shut-in production. AEC identified the Rocky Mountain States as a logical export destination for expanding western Canadian production.
- 2) The Express Pipeline began as a corporate joint venture, common-carrier oil pipeline. It is classified as an independent pipeline, as the majority of throughput is from non-owners. The project sponsors sought to obtain sufficient support from producers in the form of term throughput contracts, to enable them to attract financing for the project on favorable terms. The project sponsors were willing to proceed with the project only if they could obtain sufficient term service contracts prior to the construction of the pipeline.
- 3) The regulations in both Canada and the US require the Express Pipeline to operate as a common carrier providing service to all parties according to published tariffs. A unique feature of the pipeline is that it provides both long term and spot services to shippers. Any shipper that signed a term pipeline transportation service agreement during the open season (autumn 1995) obtained secure

capacity rights and stable tariff arrangements for the term selected (5, 10, or 15 years). Shippers that chose instead to ship on a spot basis are subject to the published tariff at the time they wish to ship and access is subject to the limits of the capacity available to spot shippers.

- 4) The tariffs offered were based on market considerations reflecting the risks of cost overruns to the extent the market would permit. Any future expansion of transport capacity would again be arranged as a new open season.
- 5) The major share of the throughput or crude supply risk is borne by the shippers that have signed term contracts. The line's throughput risk is limited to the uncommitted portion of the capacity, that is, the spot shipments and the capacity that becomes available at the end of the term agreements. The Express Pipeline assumed significant economic risks with respect to capital cost overruns and financing.
- 6) The pipeline primarily relied on shipper contracts to obtain the collateral necessary to obtain debt finance from financial institutions and the approval of the boards of directors of its respective sponsors.

### **Things to learn from the case**

The Express Pipeline has been entirely sponsored by the private sector. It operates under uniform management and it maintains a balance between committing a part of the capacity under long-term shipping contracts while offering the remaining capacity in the spot market for short-term capacity. The rent sharing is simply based upon contracts drawn up in a competitive market. The interests of the parties thus are aligned by market mechanisms. The pipeline has been operating smoothly since its commissioning and its funding was made easy with private participation.

## **6.7 Development of Framework for Crude Oil and POL Pipelines**

In the previous sections of the report, we have discussed that the SAARC Region has significant demand potential in terms of crude oil and POL products and established the need for Intra-regional trade. We have also assessed the feasibility of various alternative routes to transport POL products and the viability of a pipeline vis-a-vis alternative modes of transport. While economic feasibility is one aspect, there are several other aspects that need to be considered in the construction of a Cross-border pipeline. A detailed Framework is necessary to understand the various considerations like funding, physical constraints, regulatory aspect, and operation of these pipelines to ensure smooth implementation of such projects. A framework was developed for implementing a crude oil/POL pipeline network within the SAARC region as detailed below:

### **Aim of the Framework**

- 1) To establish trade relation between the contracting Member States for POL trade via pipeline and establish an arrangement to enhance the existing trade potential between the SMSs.
- 2) The Framework and any Agreement based on the Framework shall be governed by a separate entity formed under SAARC, with clearly recognizing the needs of the lesser developed country and developing preferential measures for the best interest of both the parties.



## **Components of the Framework**

- 1) Participants
- 2) Governing/Regulatory entity under SAARC
- 3) Construction, Operation and Maintenance of the pipeline network
- 4) Tariff recovery

## **Participants Involved in the Framework for the Agreement**

- 1) Government of the Member State and respective Ministries/Regulatory authority
- 2) Ministry of External/Foreign Affairs
- 3) Ministry of Physical Infrastructure & Transport
- 4) Ministry of Petroleum
- 5) Regulatory Authority for Petroleum trade

## **Development of the Agreement**

An Inter-governmental Trade Agreement needs to be signed between the Member States pertaining to the trade, which defines in detail the terms of trade for every product. Such an Agreement should focus on eliminating all forms of tariff as well as non-tariff barriers to facilitate ease of trade between the Member States. The agreement would focus on the following broad functions:

### **Creation of A Separate Entity to Conceive, Coordinate and Implement Pipeline Projects**

At present, each Member State is operating as a separate entity. Intra-regional projects require significant amount of coordination and planning between nations. We believe that an Inter-governmental committee could be set up that is responsible from the start of conceiving such a project to ensuring proper execution.

Such a committee/entity will consist of representatives from each Member State which will meet at least annually to review the progress made in the implementation of the Inter-governmental Agreement and execution of planned projects. Following are some of the responsibilities of the committee to promote Cross-border pipelines:

- 1) To begin with, this entity will coordinate with each SMS to identify the regions with trade potential and possible routes for construction of crude oil and POL products pipelines.
- 2) Next step is to coordinate with the respective Governments in the identified routes and collect information to run a preliminary survey to assess the viability of such a pipeline project. The body could appoint independent technical consultants to carry out such an assessment.
- 3) The next step is to estimate the cost of such a project and assess the possible funding options for the same. Funding of the project can be carried out through various means, these include:
  - Governments of the contracting SAARC Member States.
  - Multilateral organizations such as SAARC Development Fund.
  - Public Sector Companies or State-owned Companies.
  - Private Investments from multinational oil companies.

In most cases, the majority of the funding is done by the Governments involved in buying and selling of the products or the company responsible for operation of the pipeline. The SAARC Development Fund could also be utilized in funding of such projects. It funds projects in the South Asian region via three windows i.e., Social, Economic, and Infrastructure. Further, the South Asian region does not have a dedicated regional development bank. Therefore, as a long-term strategy, the SDF could assume the role of a multilateral financial institution for the region with active support from Member States. Some of the roles and functions of the SDF may be further fine-tuned with focus on promoting construction of Cross-border pipeline networks to facilitate trade within the Region.

Currently, funding from any public sector company or multinational company for developing Cross-country pipeline has not been witnessed at large among the Member States. However, considering the growth in POL demand, these funding options are likely to aid the development of more cross-country pipelines. Moreover, enabling participation of such entities can bring in global technological expertise and will further increase the competitiveness in terms of efficient operations of pipelines.

### **Construction of a Pipeline**

Once a pipeline route has been conceived and a detailed feasibility study undertaken, the next step is to obtain the RoW and other necessary clearances to construct the pipeline. There could be delays as more than one Member State is involved, and they could have contradicting regulations and laws. Thus, the Inter-governmental committee could play a significant role by defining various regulations applicable for Cross-border projects and coming up with a dispute resolution mechanism. This committee will undertake the responsibility of acquiring RoW in respective Member States.

Moreover, construction of a pipeline involves various stakeholders which are to be considered before construction of the pipeline. These stakeholders are to be managed and coordinated by the entity proposed under this framework. For the project to be successful, alignment of the stakeholders' interests is of utmost importance. The following engagement can be undertaken for better stakeholder management:

- 1) Arranging consultation of affected businesses, communities, NGOs and the general public.
- 2) Creating a website for information and progress of the project.
- 3) Tracking news stories from different media sources.

Typically, pipeline construction work is carried out by an EPC contractor by way of competitive bidding. This could be carried out by entities operating in the Region where the pipeline has to be constructed. Construction work can also be carried out separately by several parties in various locations. Hence, the construction of the pipeline can be tendered to different parties for parts lying in different Member States.

### **Operation and Maintenance of the Pipeline**

The Operation and Maintenance of a POL pipeline is typically carried out by the supplier of the POL product, originating at its refinery or storage terminal. In case of the SAARC Member States, we have identified various possible pipeline routes originating from Indian refineries to other Member States. Most of these refineries are owned by PSU oil marketing companies. For example, the product pipeline

running from India to Nepal is being operated by IOCL, which will also be responsible for supplying products. Similarly, the pipeline planned from India to Bangladesh will be operated by NRL.

### **Tariff Recovery for the Pipeline**

Since cross-border pipelines are not competitively bid, tariffs can be determined on a cost-plus basis by estimating the OPEX and assuming a certain IRR (usually ranging between 12% and 15%). For a regular pipeline, tariff is paid by the supplier of the product to the operator of the pipeline, who has also undertaken the CAPEX of the pipeline which eventually is added to the final price of the product recovered from the end-user. In case of cross-country pipelines, as funding is infused by the Governments of the Member States where the pipeline is being constructed, the tariff might be recovered from the importing country, by adding it to the delivery price of the product being exported.

## 7 Conclusion

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The SAARC Region comprises some of the fast-growing economies in the world, which would result in strong growth in energy demand and, subsequently POL demand in future. While the existing trade in the Region is mostly taking place through sea or by road transport, it is essential to identify and create awareness of the benefits of developing cross-border pipeline networks for the transportation of crude oil and petroleum products. Pipelines are the cheapest, fastest and safest mode of transport and thus can help in improving POL trade within the Region. The pipelines can lead to significant cost savings for importing nations and also help promote harmonious relations between Member States. India has already built a pipeline to Nepal and is planning to build another one to Bangladesh. Such initiatives need to be taken by other Member States as well. Political will, improved harmonized institutional, legal and regulatory framework, and offering bigger opportunities for private sector participation can accelerate the pace of trade within the Region. Such an integrated infrastructure will pave way for improving the trade scenario within the Region. The following are some steps which can accelerate and improve the overall trade scenario in the Region:

**Harmonization of Legal and Regulatory Framework:** A single energy regulatory body needs to be developed at the regional level to facilitate coordination among the Member States involved on pricing, taxation, promotion of private players, etc., and to ensure seamless trade. Further, this body can be instrumental in providing a common legal and regulatory framework for investments in cross-border projects required to promote effective execution. It is, however, important that such a regional regulator ensures cohesiveness between regional and individual state policies and regulations to prevent any concerns and conflicts. As in the case of the Baku-Suspa oil pipeline, there has to be effective mechanisms for the resolution of disputes and enforcement of agreements.

**Governmental Support for Cross-Border Business of Crude Oil & Petroleum Products through Oil Pipeline Networks:** The construction of cross-border pipelines involve a certain degree of government intervention and control at every stage, from funding of the pipeline to its operations. The permanent use of land requires government approval for getting the Right of Way. Oil and gas pipelines are projects of national strategic importance and hence their construction and operation have been historically undertaken by state-owned entities. As a result, enormous amount of government support is essential to ensure smooth execution and functioning of the pipeline. The following are some areas where government support is essential:

- Regulations relating to pipeline construction and operations ranging from health, safety and environment to profitability and returns associated with the pipeline.
- In the case of the Indo-Bangladesh pipeline, majority of the investment is being undertaken by the Indian government to enable smooth execution of the pipeline. Such funding initiatives can lead to cooperation between Member States and promote trade. Similar funding initiatives could be undertaken by various Governments to construct Cross-border pipeline infrastructure and enable an effective trade network for crude oil and petroleum products.
- The interest of various stakeholders is to be aligned with the key aim of the project. Additionally, if,

in the course of a project, the private sector evinces interest in participating, the government can play a role by assuming some early risks which, because of regulatory and legal uncertainties, private companies are unwilling to accept until privatization has been completed.

- Support from the governments of both the exporting and importing Member States in communications is vital to remove any political differences that obstruct trade operations.

In addition to the above-mentioned pipeline routes, subsea routes can also be explored for making petroleum products available to Member States such as the Maldives and Sri Lanka. Though pipelines involve huge CAPEX, they are the fastest, safest and most environment friendly mode of transport.

**Role of Private Participation:** The private sector plays an important role in the development of such projects. Once a clear regulatory framework is established and the rights and obligations of private investor well defined, involvement of the private sector can reap large benefits for the project as seen in case of the Express Pipeline between Canada and the US, which was entirely sponsored by the private sector. Cross-border pipelines involve significant capital spend and hence private participation can open fresh avenues for funding. Besides funding, projects funded by the private sector are driven by profit motives and hence smooth and efficient functioning is ensured.

**Promotion of Effective Trans-Border Cooperation Among SAARC Member States:** While construction of infrastructure plays an important role in promoting trade, it is also essential that there is cooperation between Member States in order to avoid any conflicts. In case of Intra-regional projects, geopolitical issues and lack of cooperation between participating Member States can bring significant barriers towards successful implementation of such projects. Some factors that are essential to promote cooperation among SAARC Member States are:

- ***Building of an Energy Database to Facilitate Information Sharing:*** Lack of information sharing is a major issue in the SAARC region. This is a barrier to transparency and efficiency in trade. Development of a common energy database will help estimate the costs and benefits associated with potential trade and related infrastructure investments, thus enhancing trade
- ***Development of a Regional Energy Trade Agreement:*** The SAFTA Agreement came into force on January 1, 2006, after the seven governments ratified it. However, it has not been able to improve the trade relations of the SAARC Member States significantly. Intra-regional trade is still below 5% of the total trade of the SAARC Member States. The reason for this is the concept of 'sensitive list' in the SAFTA. As per the Agreement, the countries can regulate the trade of commodities in these lists and they all have long such lists. Though there is a commitment to reduce tariff barriers, non-tariff barriers remain high. Hence, Member States need to come together to develop an Inter-governmental agreement defining areas where the governments shall commit to work towards regional energy trade eliminating the trade barriers in true sense.
- ***Development of a Regional Business Treaty Similar to Energy Treaty:*** The Energy Charter Treaty was signed in December 1994 and legally enforced in April 1998. Currently, there are 53 signatories and contracting parties to the treaty. These include both the European Union and Euratom. The treaty provides a multilateral framework for energy cooperation that is unique

under international law. It is designed to promote energy security through the operation of more open and competitive energy markets, while respecting the principles of sustainable development and sovereignty over energy resources. The SAARC Regional Energy Treaty could be structured in a similar way in order to minimize the risks associated with energy-related regional trade and focusing on Inter-governmental cooperation in the sector. For example, The Energy Charter Treaty can also serve as the basis for developing a strong Regional Energy Trade Agreement.

## Annexure

**Table 49: Refining Capacities in India (as of March 2019)**

Refinery	Capacity ('000 MT)
<i>PUBLIC SECTOR (PSU)</i>	
IOC, Digboi	650
IOC, Guwahati	1,000
IOC, Koyali	13,700
IOC, Barauni	6,000
IOC, Haldia	7,500
IOC, Mathura	8,000
IOC, Panipat	15,000
IOC, Bongaigaon	2,350
IOC, Paradip	15,000
IOC, Total	<b>69,200</b>
HPC, Mumbai	7,500
HPC, Visakh	8,300
HPC, Total	<b>1,5800</b>
BPC, Mumbai	1,2000
BPC, Kochi	15,500
BPC, Total	<b>27,500</b>
CPCL, Manali	10,500
CPCL, Cauvery Basin	1,000
CPCL, Total	<b>11,500</b>
NRL, Numaligarh	<b>3,000</b>
ONGC, Tatipaka	66
MRPL, Mangalore	15,000
<i>Total PSU</i>	<b>142,066</b>
<i>JVC/PVT</i>	
BPC, BORL-Bina	7,800
HMEL, GGSR	11,300
MRPL, Mangalore	
RIL, Jamnagar	33,000
RPL (SEZ), Jamnagar	35,200
NEL (Formerly EOL) Vadinar	20,000
<i>Total JVC/PVT</i>	<b>107,300</b>

Refinery	Capacity ('000 MT)
ALL INDIA TOTAL	249,366

Source: PPAC

**Table 50: Crude Oil Pipelines in India (as of March 2019)**

Name of the pipeline	Owner	Length (Km)	Capacity (million tons)
CTF (Central Tank Farm) Kalol to CTF Nawagam - New (New line commissioned in August 2010)	ONGC	63	3.1
Nawagam-Koyali (18" line) New		80	5.4
Nawagam-Koyali (14" line) (Old) (1)		78	3.3
MHN-NGM (Mehsana-Nawagam) trunk line -		77	2.3
CTF (Central Tank Farm), Ankleshwar to Koyali oil pipeline (AKCL-Ankleshwar Koyali Crude Line)		95	2.2
CTF (Central Tank Farm), Ankleshwar to CPF (Central Processing Facility), Gandhar		44	0.4
CPF (Central Processing Facility), Gandhar to Saraswani 'T' point		57	1.8
Akholjuni- Koyali oil pipe line (Commissioned in July 2010). Akholjuni to Laxmipura T' point		66	0.5
Lakwa-Moran oil line (New)		18	1.5
Lakwa-Moran oil line (Old)		15	1.5
Geleki-Jorhat oil line		49	1.5
Geleki-Jorhat oil line (New)		48	1.5
Borholla- Jorhat oil line		43	0.6
Borholla- Jorhat new TPL (New)		43	0.6
NRM (Narimanam) to CPCL (Chennai Petroleum Corporation Limited)		5	0.7
KSP-WGGS to TPK Refinery (Kesnapalli-West-Group Gathering Station to Tatipaka)		14	0.1
GMAA EPT (Gopavaram Early Production Terminal) to S. Yanam Unloading Terminal (3.5 Km long and 4")		4	0.1
Mumbai High - Uran - Trunk (MUT) 30" pipeline		204	15.6
Heera - Uran - Trunk (HUT) 24" pipeline		81	11.5
Bombay-Uran Trunk (BUT) 30" pipeline		203	6.4
	<b>Subtotal ONGC</b>	<b>1,283</b>	<b>60.6</b>



Name of the pipeline	Owner	Length (Km)	Capacity (million tons)
Salaya-Mathura pipeline (SMPL)	IOCL	2,646	25.0
Paradip-Haldia-Barauni pipeline (PHBPL)		1,355	15.2
Mundra-Panipat pipeline		1,194	8.4
Salaya-Mathura Pipeline (Offshore segment)		14	-
Paradip-Haldia-Barauni Pipeline (Offshore segment)		92	-
	<b>Subtotal IOCL</b>	<b>5,301</b>	<b>48.6</b>
Duliajan-Digboi-Bongaigaon-Barauni pipeline	OIL	1,193	8.4
Mangla-Bhogat pipeline	CAIRN	660	8.7
Bhogat Marine	CAIRN	28	2.0
	<b>Subtotal CAIRN</b>	<b>688</b>	<b>10.7</b>
Mundra- Bathinda pipeline	HMPL	1,017	11.3
Vadinar-Bina pipeline	BORL	937	6.0
Total Crude pipelines		<b>10,419</b>	<b>145.6</b>

Source: PPAC

**Table 51: Details of Petroleum Product Pipelines in India (as of March 2019)**

Name of the Pipeline	Owner	Length (km)	Capacity (million tons)
Barauni - Kanpur pipeline (BKPL)	IOCL	857	3.5
Guwahati -Siliguri pipeline		435	1.4
Haldia-Barauni pipeline		526	1.3
Haldia-Mourigram-Rajbandh pipeline		277	1.4
Koyali-Ahmedabad pipeline		79	1.1
Koyali-Sanganer pipeline		1,644	4.6
Koyali-Ratlam pipeline		265	2.0
Koyali-Dahej pipeline		197	2.6
Mathura-Tundla pipeline		56	

Name of the Pipeline	Owner	Length (km)	Capacity (million tons)
	IOCL		1.2
Mathura-Bharatpur pipeline		21	
Mathura-Delhi pipeline		147	3.7
Panipat-Amabala-Jalandhar (Including Kurukshetra-Roorkee-Najibabad branch line)		434	3.5
Panipat-Delhi (Including Sonapat-Meerut branch line) pipeline		189	
			3.0
Panipat Bijwasan ATF pipeline		111	
Panipat-Bathinda pipeline		219	1.5
Panipat-Rewari pipeline		155	2.1
Chennai-Trichy-Madurai pipeline		683	2.3
Chennai - Meenambakkam ATF pipeline		95	0.2
Chennai-Bengaluru pipeline		290	2.5
Digboi - Tinsukia pipeline (DTPL)		0	0.0
Devangonhi - Devanhalli pipeline		36	0.7
Paradip Raipur Ranchi pipeline (PRRPL)		1,073	5.0
Kolkata ATF pipeline		27	0.2
		<b>Subtotal IOCL</b>	<b>7,816</b>
Mumbai-Manmad-Bijwasan pipeline (MMBPL)	BPCL	1,389	6.0
Bina-Kota pipeline (BKPL)		259	4.4
ATF P/L Mumbai Refinery (MR)-Santacruz		15	1.4
ATF P/L Kochi Refinery (KR)-Kochi Airport		34	0.6
Kota - Jobner branch pipeline		211	1.7
Mumbai Refinery- Wadilube Pipeline		12	1.3
Cochin-Coimbatore-Karur (CCK) pipeline		293	3.3
	<b>Subtotal BPCL</b>	<b>2,213</b>	<b>18.7</b>

Name of the Pipeline	Owner	Length (km)	Capacity (million tons)
Mumbai-Pune-Solapur pipeline	HPCL	508	4.3
Vizag-Vijaywada-Secunderabad pipeline		572	5.4
Mundra-Delhi pipeline		1054	5.0
Ramanmandi-Bahadurgarh pipeline		243	4.7
Ramanmandi-Bathinda pipeline		30	2.1
Awa-Salawas pipeline		93	-
Bahadurgarh-Tikrikalan pipeline		14	-
Rewari- Kanpur Pipeline		443	-
ATF pipeline from Mumbai Refinery to Mumbai Airport		20	1.1
Black Oil Pipeline (BOPL)		22	1.5
Lube Oil Pipeline: Trombay to Wadibundar		17	1.0
<b>Subtotal HPCL</b>		<b>3,015</b>	<b>25.1</b>
Mangalore-Hassan-Bengaluru (MHB) pipeline		Petronet MHB	363
Numaligarh-Siliguri pipeline	OIL	654	1.7
<b>Total Petroleum product pipelines (w/o LPG pipelines)</b>		<b>14,061</b>	<b>94.7</b>
Panipat-Jalandhar pipeline (PJPL)	IOCL	280	0.7
Paradip Haldia Durgapur pipeline		673	1.3
Mumbai-Uran pipeline	BPCL	28	0.8
Jamnagar-Loni pipeline	GAIL	1,414	2.5
Vizag-Secunderabad pipeline		618	1.3
Mangalore-Hassan-Mysore-Solur LPG	HPCL	356	1.9
Total LPG pipelines		<b>3,369</b>	<b>8.5</b>
Total POL pipelines		<b>17,430</b>	<b>103</b>

Source: PPAC

**Table 52: Calculation of each Member State's Savings in Freight Cost**

Bangladesh			
Import Source	Singapore	India (pipeline)	

Bangladesh			
		Pipeline length km	136
Distance (nautical miles)	1,866	Pipeline tariff (Rs per ton per km)	6.9
Days at sea	6	Pipeline freight (USD per ton)	<b>13.4</b>
Sailing time round trip (days)	14		
Charter rate (USD per day)	15,000		
Ocean freight (USD)	210,000		
Ocean freight (\$ per ton)	5		
Bunker fuel requirement (ton)	45		
Sailing time fuel consumption (ton)	630		
Load/Unload time Fuel consumption (ton)	45		
Idle time (hours)	23		
Bunker cost (USD per ton)	350		
Total fuel cost (USD)	244,125		
Fuel cost (USD per ton)	6.1		
Total ocean freight (USD per ton)	<b>15.4</b>		
Savings on freight cost (USD per ton)	<b>2.0</b>		

Bhutan			
Import source	India (road tankers)	India (pipeline)	
Road distance from Bongaigaon to Gelephu	60	Pipeline length km	44
Road freight (Rs per round trip km)	5	Pipeline tariff (Rs per km per ton)	11.0
Cost per ton (Rs)	540	Pipeline freight (\$ per ton)	<b>7.0</b>
Road freight (\$ per ton)	7.7		
Savings on freight cost (\$ per ton)	<b>0.7</b>		

Maldives		
Import Source	UAE	India
	Dubai port	Mumbai port

Maldives		
Distance Km	2,329	934
Days at sea	8	3
Parcel Size (tons)	40,000	
Sailing time round trip (days)	17	8
Charter rate (USD per day)	15,000	14,500
Ocean freight (USD)	255,000	116,000
Ocean freight (\$ per ton)	6	3
Bunker fuel requirement (ton)	45	45
Sailing time fuel consumption (ton)	765	360
Load/Unload time Fuel consumption (ton)	45	45
Idle time (hours)	23	23
Bunker cost (USD per ton)	350	420
Total fuel cost (USD)	291,375	179,550
Fuel cost (USD per ton)	7	4.5
Total ocean freight (USD per ton)	17.7	11.4
Savings on freight cost (USD per ton)	6.3	

Nepal			
Import source	India (road tankers)	India (pipeline)	
Road distance from Barauni to Amlekhgunj (km)	279	Pipeline length km	70
Road freight (Rs per round trip km)	4	Pipeline tariff (Rs per km per ton)	6.1
Cost per ton (Rs)	2,234	Pipeline freight (\$ per ton)	6.1
Road freight (\$ per ton)	32		
Savings on freight cost (\$ per ton)	25.8		

Pakistan			
Import Source	Kuwait	India (pipeline)	

Pakistan			
Distance (nautical miles)	1,213	Pipeline length km	160
Days at sea	4	Pipeline tariff (Rs per km per ton)	1.7
Sailing time round trip (days)	10	Pipeline freight (\$ per ton)	<b>3.9</b>
Charter rate (USD per day)	15,000		
Ocean freight (USD)	147,000		
Ocean freight (\$ per ton)	4		
Bunker fuel requirement (ton)	<b>45</b>		
Sailing time fuel consumption (ton)	441		
Load/Unload time Fuel consumption (ton)	45		
Idle time (hours)	23		
Bunker cost (USD per ton)	350		
Total fuel cost (USD)	177,975		
Fuel cost (USD per ton)	4		
Total ocean freight (USD per ton)	12.1		
Savings on freight cost (USD per ton)	<b>8.2</b>		

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