Assessment of pipelines as the preferred mode for transporting crude/oil products within SAARC member states

SAARC Energy Centre
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- Identification of attractive sectors/sub-segments
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  - Sector/Company financial health
  - Policy and regulatory view
- Opportunity mapping for planning
  - Market dynamics, capacity utilization, economics
  - Policies and regulations
- Demand dashboards across locations and sectors
- Commodity price tracking
  - Short term/long term, regional markets, brand-wise assessments

**Fund raising & valuations**
- Feasibility/Viability studies/Credit Assessment
- Valuations including structured instrument valuation
- Exit diligence

**Strategic initiatives**
- Pre-investment commercial due-diligence
  - Market assessment
  - Channel feedback
  - Financial assessment
  - Management assessment
- Post investment monitoring
  - Market feedback, end-user and growth outlook
  - Exit strategy
- Assessment of partners and tie-ups
- Market entry strategy

**Competitor Benchmarking**
- Competitor strategy – expansion, value addition, supply chain assessment, channel feedback, market intelligence
- Cost Benchmarking
Flow of the Presentation

In this presentation we will cover the following topics:

1. Introduction to Pipelines: Global and SAARC Member Countries
2. Demand – Supply Scenario of POL products in SAARC Member Countries
3. Designing and Construction of Crude Oil and POL Pipelines
4. Implementation and Operation POL Pipelines
Section 1: Introduction to Pipelines
Brief about 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 that were assessed and analyzed in this study include:

- Crude/petroleum product supply chains
- Generic framework prevalent
- Suitability of the pipeline options of crude/ POL products
- Economic and non-economic issues
- Cost of implementation of pipelines
- Funding options of large pipeline
Pipelines across the world

- Crude, natural gas and POL products are transported by various mediums including Pipelines, Marine Vessels, Tank Trucks, and Railways

- 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 with 1/3rd of global operational infrastructure

- According to Petroleum Planning & Analysis Cell (Ministry of Petroleum & Natural Gas, India), in February 2019, ~11,216 km of pipelines were under construction

- 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.

- India-Bangladesh Friendship pipeline was flagged off by the governments in September 2018. The oil pipeline will supply high speed diesel (HSD) to Bangladesh
Modes of transportation for crude oil and petroleum products

- **Marine**
  - Mostly preferred for crude oil and natural gas from producing countries to the demand centers
  - Most of the trade is done from the ports near the producing fields to the ports near the refineries
  - POL products are transported in cases when other options are not viable, especially in case of islands

- **Railway**
  - Crude or POL products are transported through special rail tankers
  - Transportation over long distances
  - Areas/region with high consumption but limited or no pipeline infrastructure

- **Roadway**
  - Most versatile or customizable form of transportation for areas with high demand as well as low demand
  - Same kind of tankers as in rail but mounted on individual vehicles
  - Preferred more for transportation in remote areas where the connectivity is limited

- **Pipelines**
  - There are three basic types of petroleum pipeline transport systems:
    - Gathering pipeline systems
    - Crude-oil trunk pipeline systems
    - Refined-products pipeline systems
  - Preferred more for high and regular demand of products
## Comparison between alternative modes of transportation

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Road</th>
<th>Rail</th>
<th>River</th>
<th>Pipeline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investment</td>
<td>Low by unit, high overall</td>
<td>Moderate by unit, high overall</td>
<td>High</td>
<td>Very high and made within a small time horizon</td>
</tr>
<tr>
<td>Infrastructure Costs</td>
<td>Low by unit</td>
<td>Mainly borne by state</td>
<td>Toll duties</td>
<td>High and borne entirely by the company</td>
</tr>
<tr>
<td>Personnel Cost</td>
<td>Very high</td>
<td>Fairly high</td>
<td>High for self-propelled barges, low for push boats</td>
<td>Low (requires skilled personnel but low in number)</td>
</tr>
<tr>
<td>Maintenance Cost</td>
<td>Very high</td>
<td>High except when volume justify collective installments and automation</td>
<td>Very low</td>
<td></td>
</tr>
<tr>
<td>Return Cost</td>
<td>Empty return</td>
<td>Empty return</td>
<td>Return in ballast</td>
<td>Nil</td>
</tr>
<tr>
<td>Length of the route</td>
<td>Outward practically everywhere, natural obstacles lead to significant detours</td>
<td>Fairly dense and limited by natural obstacles</td>
<td>Most circuitous route, where it exists</td>
<td>Most direct</td>
</tr>
<tr>
<td>Climatic condition during transit</td>
<td>Very sensitive</td>
<td>Not very sensitive</td>
<td>Sensitive</td>
<td>Not affected</td>
</tr>
<tr>
<td>Flexibility of transit</td>
<td>Very high</td>
<td>Very limited</td>
<td>Very limited</td>
<td>Nil</td>
</tr>
</tbody>
</table>

Research
Why Pipelines?

Landlocked Countries

Land locked countries do not have ports
Countries lower the dependencies on roads and railways
No hindrances because of geography, terrain, or weather

Land-locked countries include Afghanistan, Nepal, and Bhutan

Research
Why Pipelines?

**Limited Operational Expenses**
- Limited manpower required
- The pipeline system can be automated for continued operations
- Lowered cost of transportation per unit

**Low Environment Impact**
- No pollution during transportation
- Comparatively less hazardous than surface transportation
- Limited land requirement for transportation route compared to roadway and railway

- Train tankers derailed
- Trucks are more prone to accidents
- Fleet setup involves high CAPEX and result in higher pollution

Research
Efficiency of Service Delivery

Efficient service delivery of petroleum products are judged based on how easily the products reach the destination. 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.

<table>
<thead>
<tr>
<th>Service Characteristics</th>
<th>Highest</th>
<th>Rail</th>
<th>Road</th>
<th>Lowest</th>
</tr>
</thead>
<tbody>
<tr>
<td>suitability</td>
<td>Pipe</td>
<td></td>
<td></td>
<td>Rail</td>
</tr>
<tr>
<td>accessibility</td>
<td>Road</td>
<td>Rail</td>
<td>Pipe</td>
<td></td>
</tr>
<tr>
<td>goods security</td>
<td>Pipe</td>
<td>Rail</td>
<td>Road</td>
<td></td>
</tr>
<tr>
<td>journey speed</td>
<td>Pipe</td>
<td>Rail</td>
<td>Road</td>
<td></td>
</tr>
<tr>
<td>reliability</td>
<td>Pipe</td>
<td>Rail</td>
<td>Road</td>
<td></td>
</tr>
<tr>
<td>flexibility</td>
<td>Road</td>
<td>Rail</td>
<td>Pipe</td>
<td></td>
</tr>
</tbody>
</table>
Conclusion

● Pipelines prove to be better alternative to transport crude and POL products due to easy operation and fast delivery

● Pipelines despite of some disadvantages such as requirement of advanced systems to construct and monitor, have multi-fold benefits such as
  ■ Un-interrupted transportation
  ■ No disruption due to natural factors including rains, storms, earthquakes, thundering, mist, etc
  ■ Safe and secure transportation without damaging or theft of goods

● Pipelines have proved to be the most efficient mode of transportation with lowest per unit cost of transportation of products (not considering initial CAPEX)
SECTION 2: Demand Supply Scenario in SAARC Member States
Demand and Supply Scenario

- 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.

- At present, the countries lack proper transport systems for both inter-country and intra-country transits. As such, most petroleum products are transported by road in tankers.

- Afghanistan, Bhutan and Nepal being completely landlocked, have limited refining capacities and rely heavily on imported POL products.

- The 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.
Demand-Supply Review: Afghanistan

- 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 Andkhoi being the major ones.
- Afghanistan has a current refining capacity of 32,500 barrels per day (1,643 thousand tonne per annum). However, these refineries are currently non-operational, due to the ban on crude imports.

Research
Demand-Supply Outlook: Afghanistan

- Cars and two wheelers are expected to grow rapidly during the period, boosting the demand for petrol, while LPG demand to grow the slowest.
- There is a plan to add 50,000 barrels per day (2,489 thousand tonne per annum) of refining capacity to be fully operational by fiscal 2027.
- In addition, the country has a strategic goal to increase its crude oil production to 100 thousand barrels per day (4.9 mtpa) over the long term, therefore meeting its entire crude requirement.

Source: Central Statistics Organization, CRISIL Research

<table>
<thead>
<tr>
<th>('000 MT)</th>
<th>FY13</th>
<th>FY17</th>
<th>FY18E</th>
<th>FY24F</th>
<th>FY30F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Refining capacity</td>
<td>1,643</td>
<td>1,643</td>
<td>1,643</td>
<td>1,643</td>
<td>4,132</td>
</tr>
<tr>
<td>Crude oil condensates production</td>
<td>1.1</td>
<td>1.1</td>
<td>1.1</td>
<td>498</td>
<td>4,979</td>
</tr>
<tr>
<td>Crude oil imports</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>-847</td>
</tr>
<tr>
<td>Petroleum products, demand</td>
<td>2,082</td>
<td>1,757</td>
<td>2,064</td>
<td>3,252</td>
<td>4,673</td>
</tr>
<tr>
<td>Petroleum products, production</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>400</td>
<td>4,132</td>
</tr>
<tr>
<td>Petroleum products, net imports</td>
<td>2,082</td>
<td>1,757</td>
<td>2,064</td>
<td>2,852</td>
<td>541</td>
</tr>
</tbody>
</table>
Demand- Supply Review: Bangladesh

- 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.
- 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.
- In overall terms, petrol and HOBC consumption in Bangladesh rose steeply between fiscals 2013 and 2018 at 11% and 15.7% CAGR, respectively, mainly driven by the transportation segment.
- Singapore, the global POL trading hub, forms the single largest supplier of POL products, followed by the Middle East.

Research
Demand-Supply Outlook: Bangladesh

- Diesel demand is expected to grow at 6.7% CAGR between fiscals 2018 and 2030, driven by higher demand from the transport segment and industrial growth.
- Due to significant policy push, LPG demand in Bangladesh is expected to grow sharply at a 35% CAGR with restriction of domestic gas only for existing customers and rising transport demand.
Demand- Supply Review: Bhutan

- 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.
- Owing to its landlocked nature, Bhutan is unlikely to undertake indigenous refining and face issues in transportation of crude oil. Therefore, it is expected to continue meeting its POL demand from imports.
**Demand- Supply Outlook: Bhutan**

- 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 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.
- 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.
### Demand-Supply Review: India

#### Port-wise Total Traffic and POL Traffic Handled in India in FY18

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

- Petroleum product consumption in India is expected to log a CAGR of 3% between fiscals 2018 and 2030, with demand crimped by reduction in growth of petrol demand on account of rising substitution by CNG, ethanol blending and greater focus on electric vehicles (EVs).

- Oil players in the refining segment have significant capacity addition plans going forward, taking India’s total crude oil demand to 350 million tonnes by fiscal 2030 from 251 million tonnes at present, clocking a CAGR of 2.7%.

### Refining capacity ('000 MT)

<table>
<thead>
<tr>
<th>Year</th>
<th>2012-13</th>
<th>2016-17</th>
<th>2017-18</th>
<th>2018-19</th>
<th>2023-24F</th>
<th>2029-30F</th>
</tr>
</thead>
<tbody>
<tr>
<td>(‘000 MT)</td>
<td>215,066</td>
<td>233,966</td>
<td>247,516</td>
<td>249,366</td>
<td>281,016</td>
<td>322,216</td>
</tr>
<tr>
<td>Crude Oil production</td>
<td>37,919</td>
<td>36,008</td>
<td>35,700</td>
<td>34,200</td>
<td>36,000</td>
<td>36,000</td>
</tr>
<tr>
<td>Crude Oil Imports</td>
<td>184,795</td>
<td>213,932</td>
<td>220,434</td>
<td>220,434</td>
<td>245,016</td>
<td>306,216</td>
</tr>
<tr>
<td>Petroleum Products Demand</td>
<td>157,057</td>
<td>194,598</td>
<td>206,166</td>
<td>213,216</td>
<td>254,332</td>
<td>297,250</td>
</tr>
<tr>
<td>Petroleum product production</td>
<td>219,212</td>
<td>245,360</td>
<td>252,839</td>
<td>262,361</td>
<td>281,233</td>
<td>328,660</td>
</tr>
<tr>
<td>Petroleum product net surplus</td>
<td>62,155</td>
<td>50,763</td>
<td>47,918</td>
<td>49,145</td>
<td>26,901</td>
<td>31,410</td>
</tr>
</tbody>
</table>
Demand-Supply Review: Maldives

- Demand for POL products in the Maldives rose at 5.1% CAGR to 644 thousand tons in 2018 from 502 thousand tons in 2013.
- 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.
- Demand for petrol has risen significantly over the last five years to account for 11% of total POL imports in the country in 2018, led by rising number of motorcycles and passenger cars whose population has doubled during the same time.
Demand-Supply Outlook: Maldives

- Maldives will be entirely import dependent to meet its POL requirements going forward.
- 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.
- 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.
Demand- Supply Review: Nepal

Transportation of petroleum products is available via roadways and recently commissioned pipeline from India

- Shift towards cleaner fuels for residential cooking pushed up LPG demand by 12% CAGR over fiscals 2013-2018. Kerosene, in turn, saw a fall in demand.
- Petrol, diesel and LPG cumulatively accounted for 92% of the total POL products imports in fiscal 2017. Petrol and diesel are mainly consumed by the transport sector, which accounted for 82% of the total key POL products consumption.
- The demand for aviation fuel grew strong at 11% CAGR over the period backed by robust tourism and transport of foreign aid to support the country after the devastating earthquake.
• The consumption of the POL products in Nepal is expected to grow at a CAGR of 8.3% over fiscals 2018-2030 mainly driven by a strong growth in the transport and industrial sectors led by a GDP growth of 4.5%-5%.

• Petrol vehicles are expected to grow over fiscals 2018-2030 due to rising per capita income, leading to a petrol demand growth while the consumption of diesel is expected to grow at 8.2% CAGR over the period, driven by demand from the transport and industrial sectors.

• Mostly used by the residential, commercial and institutional segments for cooking, LPG is estimated to grow at around 8.4% CAGR driven by a rising per capita LPG consumption as consumers increasingly replace biomass with cleaner fuels.
Demand - Supply Review: Pakistan

Demand for petroleum products de-grew to 24.9 million tons in fiscal 2018 as compared with ~25.8 million tons in fiscal 2017. This was primarily on account of a decline in FO consumption in the power sector, where it is being substituted by LNG.

Diesel demand grew on account of higher utilization by the transport sector, led by increased economic activity in the country. Consumption growth was muted until fiscal 2014, declining annually from fiscal 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 fiscal 2015.
Demand-Supply Outlook: Pakistan

- 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, boosting overall demand for petrol.
- 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 going forward.

### Refining capacity

<table>
<thead>
<tr>
<th>('000 MT)</th>
<th>2016-17</th>
<th>2017-18</th>
<th>2023-24F</th>
<th>2029-30F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crude oil condensates production</td>
<td>4,390</td>
<td>4,460</td>
<td>4,627</td>
<td>4,755</td>
</tr>
<tr>
<td>Crude oil Imports</td>
<td>6,084</td>
<td>6,281</td>
<td>18,073</td>
<td>19,862</td>
</tr>
<tr>
<td>Petroleum product demand</td>
<td>25,894</td>
<td>22,948</td>
<td>32,367</td>
<td>47,458</td>
</tr>
<tr>
<td>Petroleum product production</td>
<td>10,475</td>
<td>11,718</td>
<td>22,700</td>
<td>24,618</td>
</tr>
<tr>
<td>Petroleum product net import (Excluding LPG)</td>
<td>15,381</td>
<td>13,272</td>
<td>9,667</td>
<td>22,840</td>
</tr>
</tbody>
</table>
Demand for petroleum products decreased to 24.9 million tons in fiscal 2018 as compared with ~25.8 million tons in fiscal 2017. This was primarily on account of a decline in FO consumption in the power sector, where it is being substituted by LNG.

Diesel demand grew on account of higher utilization by the transport sector, led by increased economic activity in the country. Consumption growth was muted until fiscal 2014, declining annually from fiscal 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 fiscal 2015.

Research
Demand-Supply Outlook: Sri Lanka

- 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.
- Demand for furnace oil 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.

<table>
<thead>
<tr>
<th>('000 MT)</th>
<th>2013</th>
<th>2016</th>
<th>2017E</th>
<th>2023F</th>
<th>2029F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Refining capacity</td>
<td>2,490</td>
<td>2,490</td>
<td>2,490</td>
<td>2,490</td>
<td>2,490</td>
</tr>
<tr>
<td>Crude oil imports</td>
<td>1,743</td>
<td>1,685</td>
<td>1,980</td>
<td>1,980</td>
<td>10,524</td>
</tr>
<tr>
<td>Petroleum product demand</td>
<td>3,716</td>
<td>5,096</td>
<td>5,167</td>
<td>6,043</td>
<td>7,974</td>
</tr>
<tr>
<td>Petroleum product production</td>
<td>1,556</td>
<td>1,633</td>
<td>1,867</td>
<td>1,867</td>
<td>1,867</td>
</tr>
<tr>
<td>Petroleum product net import</td>
<td>2,160</td>
<td>3,462</td>
<td>3,300</td>
<td>4,176</td>
<td>6,107</td>
</tr>
</tbody>
</table>
SECTION 3: Designing, Construction and Operation of Crude Oil and POL Pipelines
Stages of pipeline construction and operations

Pipeline construction has the following stages:

1. Planning & Surveying
2. Designing and material selection
3. Obtaining RoW at site
4. Construction of pipeline
5. Transportation of crude or POL liquid
6. Testing and maintenance
Designing of a pipeline

**Product Analysis**
- Analysis of product demand and available supply options
- Assessment of associated details such as risks and hazards
- Facility requirement for loading and unloading

**Route Survey**
- Site survey and analysis
- Techno-commercial evaluation of alternative routes
- This includes spot-level surveys, evaluation of soil condition, route mapping, cadastral survey, and availability of material and labor

**Site Selection**
- Selection of the route and development of a detailed engineering plan
- Estimation of CAPEX and OPEX of the pipelines for various routes capital CAPEX and shortlisting the most profitable route
- Preparation of detailed engineering plan comprising material requirement and other costs associated with the construction of the pipeline

**Project Scheduling**
- Formulation of detailed feasibility plan
- Preparation of timeline for phase or project completion
Material and Dimensional Requirement for Cross-country Pipelines

Material requirement is based on the hazard potential of a fluid transported in the pipeline, it should be segregated as per following categories:

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Non-flammable, stable and non-toxic fluids that are in liquid form at ambient temperature and 50 kPA (0.5 bar) above atmospheric pressure</td>
</tr>
<tr>
<td></td>
<td>Water, slurries</td>
</tr>
<tr>
<td>B</td>
<td>Flammable or unstable or toxic fluids, which are in liquid form at ambient temperature and 50 kPA (0.5 bar) above atmospheric pressure</td>
</tr>
<tr>
<td></td>
<td>Stabilized crude, gas oils</td>
</tr>
<tr>
<td>C</td>
<td>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</td>
</tr>
<tr>
<td></td>
<td>Nitrogen, carbon dioxide</td>
</tr>
<tr>
<td>D</td>
<td>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</td>
</tr>
<tr>
<td></td>
<td>Natural gas, LPG, ammonia</td>
</tr>
</tbody>
</table>

Source: Oil and Gas Pipelines and Piping Systems Handbook
## Material and Dimensional Requirement for Cross-country Pipelines

Material requirement is also based on the land category of the route and type of land.

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
<th>Land Areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1-mile section of pipeline that has 10 or fewer buildings intended for human occupancy.</td>
<td>Wastelands, Deserts, Rugged mountains, Grazing land, Farmland, Sparsely populated areas</td>
</tr>
<tr>
<td>2</td>
<td>1-mile section of pipeline that has more than 10 but fewer than 46 buildings intended for human occupancy.</td>
<td>Fringe areas around cities and towns, Industrial areas, Ranch or country estates</td>
</tr>
<tr>
<td>3</td>
<td>1-mile section of pipeline that has 46 or more buildings intended for human occupancy except when a Class 4 location prevails.</td>
<td>Suburban housing developments, Shopping centers, Residential areas, Industrial areas, Other populated areas not meeting Class 4 location requirements</td>
</tr>
<tr>
<td>4</td>
<td>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.</td>
<td></td>
</tr>
</tbody>
</table>

Research
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.

### Pipeline

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

### Additional Guidelines*

- **NACE MR-01-75** – Sulphide stress cracking resistant materials for oilfield equipment
- **ISO 15156** – Materials for use in H₂S containing environments in oil and gas production

### Pipefittings and valves

- **ISO – 15590 – 1** – Pipeline induction bends
- **ISO – 15590 – 2** – Pipeline fittings
- **ISO – 15590 – 3** – Pipeline flanges
- **MSS – SP 75** – Specification for high test wrought butt-welding fittings
- **MSS – SP 44** – Steel pipeline flanges
- **ASTM A 694** – Steel forgings for high-pressure transmission service
- **API 6D** – Pipeline valves
- **API 594** – Check valves
- **API 608** – Metal ball valves
- **API 609** – Butterfly valves
- **ISO 14313** – Pipeline valves in petroleum & natural gas industries
Cross-country Pipeline Construction and Installation

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.

After the construction of the staging area, the pre-approved RoW is cleared for vegetation along with demarcation and fencing of unapproved areas. During this phase, it is mandatory to take precautions to not disturb already constructed infrastructure.

After clearing and grading the RoW, trenches are dug for housing pipelines. The ditch or trench is usually made to one side of the centre 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.

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.
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.

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.

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.
Transporting LPG through Cross-border Pipelines

- Liquefied Petroleum Gas (LPG), due to its inherent properties, is susceptible to fire, explosion and other hazards
- Transporting LPG also requires some pre-requisite factors to be considered in order to plan a pipeline

<table>
<thead>
<tr>
<th>Pipeline System and Component Design Requirements</th>
<th>Piping, LPG pumps, pump drivers, pipe support, and pressure relief valves</th>
<th>Communications system and electrical installations of pipeline station</th>
</tr>
</thead>
<tbody>
<tr>
<td>LPG Pipeline Installation and Station Construction</td>
<td>Location of storage facilities, and availability of space &amp; other resources</td>
<td>Layout of pipeline installation and location of other infrastructure from the pipeline</td>
</tr>
<tr>
<td>Design of LPG Safety System</td>
<td>Thermal relief valve, and delivery-storage area protection,</td>
<td>Facility Protection including SCADA, leak detection system, and other accessories</td>
</tr>
<tr>
<td>Emergency Plan and Preparedness</td>
<td>Emergency plan approved by the factory inspector and district authorities</td>
<td>Emergency control centers at main terminal, booster &amp; receiving terminals</td>
</tr>
</tbody>
</table>
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). It is, therefore, important to establish a batching schedule with regard to the various products being transported while considering the following key influences:

- Fuel destination depot/facility fuel requirements
- Possible pipeline throughput
- Possible fuel import/production rates
- Tank capacities at destination facilities
Transportation of Multi-Petroleum Products Via Cross-country Pipelines

Typical Fuel Batching Procedure

- **Fuel 1**
  - Batch-time = Volume/Flow rate

- **Fuel 2**
  - A batch should usually settle in the tank for a minimum amount of time

- **Fuel 3**
  - After the import of the batch the next batch of fuel is sent immediately

Multi Product Transfer

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.
SECTION 4: Implementation and Operation POL Pipelines
## Overall POL Deficit/Surplus scenario in the SMSs

<table>
<thead>
<tr>
<th>Country</th>
<th>Petroleum Product Demand</th>
<th>Domestic Production</th>
<th>Surplus/Deficit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Afghanistan</td>
<td>5,287</td>
<td>4,132</td>
<td>-1,155</td>
</tr>
<tr>
<td>Bangladesh (excludes LPG)</td>
<td>14,306</td>
<td>5,540</td>
<td>-8,766</td>
</tr>
<tr>
<td>Bhutan</td>
<td>381</td>
<td>0</td>
<td>-381</td>
</tr>
<tr>
<td>Pakistan (excludes LPG)</td>
<td>47,458</td>
<td>24,618</td>
<td>-22,840</td>
</tr>
<tr>
<td>Maldives</td>
<td>1,214</td>
<td>0</td>
<td>-1,214</td>
</tr>
<tr>
<td>Maldives</td>
<td>7,974</td>
<td>1,867</td>
<td>-6,107</td>
</tr>
<tr>
<td>Nepal</td>
<td>5,982</td>
<td>0</td>
<td>-5,982</td>
</tr>
</tbody>
</table>

**Net Deficit (POL) of the Region**

- **2030**: -15,035

**Net Deficit (Diesel) of the Region**

- **2030**: 6,461
Avenues to Meet Demand Deficit across SAARC Member States

India’s West Coast Refinery could cater to fuel needs of the SAARC Member States

1. Centrally located, most feasible to serve all SMSs
2. Only country with a surplus of POL products in the region

Refinery level profitability (at crude prices of $60/bbl)

<table>
<thead>
<tr>
<th>Product</th>
<th>Product slate (%)</th>
<th>Price ($/barrel)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LPG</td>
<td>3</td>
<td>45.5</td>
</tr>
<tr>
<td>Naphtha</td>
<td>10</td>
<td>60.0</td>
</tr>
<tr>
<td>Petrol</td>
<td>15</td>
<td>74.3</td>
</tr>
<tr>
<td>ATF</td>
<td>15</td>
<td>78.4</td>
</tr>
<tr>
<td>Diesel</td>
<td>45</td>
<td>80.5</td>
</tr>
<tr>
<td>Furnace oil</td>
<td>5</td>
<td>58.6</td>
</tr>
<tr>
<td>Other by-products</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Overall GRMs</td>
<td></td>
<td>$4.5-5</td>
</tr>
</tbody>
</table>

- Refinery level operating profitability would be around $650-750 million
- Investing in such a refinery could help generate additional returns for the SMSs in addition to meeting their fuel demand
# Pipeline leading to significant cost saving on freight cost

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

- Apart from Afghanistan and Sri Lanka we can have the potential savings while transporting the POL products via pipeline.
- For Sri Lanka the most cost efficient transportation is likely to be sea route while road transportation from neighboring countries is likely to be the efficient way of transporting POL products.
Barriers and Constraints for Setting-up Intra-regional Oil Pipeline Network

- Geopolitical Risks Pertaining to Construction and Operation of the Pipeline
- Lack of a uniform legal and regulatory framework
- Physical constraints pertaining to terrain and locational disadvantages
- Lack of adequate financial modalities
- Lack of clarity in the customs duty regime
- Presence of Multiple Parties and Selection of Commercial Consortium

- The biggest challenge of intra-regional pipeline projects is ensuring safety and security of the pipeline during both the construction phase and operation phase.
- In Intra-regional pipeline projects, the involvement of several sovereign, commercial and regulatory agencies.
- SAARC Member States have significant divergence in Energy Regulatory Framework with no single, uniform body at the regional level.
- Intra-regional pipelines entail huge investments, and given the associated risks and uncertainty particularly relating to the safety of operations.
## Cost Components for POL pipeline

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

- Piping always represents a sizable part of the total installed cost of any process plant.
- Piping cost may vary between 20% and 66% of the overall CAPEX, depending upon material requirement, availability, etc.
- Terrain is one the major factors that impacts the construction cost of a pipeline.
- 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.
Tariff Design

<table>
<thead>
<tr>
<th>Assumption</th>
<th>Unit</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipeline Capacity</td>
<td>MMTPA</td>
<td>1</td>
</tr>
<tr>
<td>Length of the Pipeline</td>
<td>Km</td>
<td>129.5</td>
</tr>
<tr>
<td>Capex of Pipeline</td>
<td>US$ Million</td>
<td>49.4</td>
</tr>
<tr>
<td>OPEX</td>
<td>US$ Million</td>
<td>1.2</td>
</tr>
<tr>
<td>OPEX Escalation</td>
<td>%</td>
<td>7%</td>
</tr>
<tr>
<td>Variable tariff for year 1</td>
<td>USD/MMTPA/Km</td>
<td>0.0675</td>
</tr>
<tr>
<td>Variable tariff escalation per year</td>
<td>%</td>
<td>3%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tariff model</th>
<th>Unit</th>
<th>Y1</th>
<th>Y2</th>
<th>Y3</th>
<th>Y4</th>
<th>Y5</th>
<th>Y10</th>
<th>Y15</th>
<th>Y20</th>
<th>Y25</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity of pipeline</td>
<td>MMTPA</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Length of pipeline</td>
<td>km</td>
<td>129.5</td>
<td>129.5</td>
<td>129.5</td>
<td>129.5</td>
<td>129.5</td>
<td>129.5</td>
<td>129.5</td>
<td>129.5</td>
<td>129.5</td>
</tr>
<tr>
<td>Utilization</td>
<td>%</td>
<td>40%</td>
<td>50%</td>
<td>60%</td>
<td>70%</td>
<td>80%</td>
<td>80%</td>
<td>80%</td>
<td>80%</td>
<td>80%</td>
</tr>
<tr>
<td>Volume of product transferred</td>
<td>MMTPA</td>
<td>0.40</td>
<td>0.50</td>
<td>0.60</td>
<td>0.70</td>
<td>0.80</td>
<td>0.80</td>
<td>0.80</td>
<td>0.80</td>
<td>0.80</td>
</tr>
<tr>
<td>Transportation tariff</td>
<td>USD/MMTPA/km</td>
<td>0.07</td>
<td>0.07</td>
<td>0.07</td>
<td>0.07</td>
<td>0.08</td>
<td>0.09</td>
<td>0.10</td>
<td>0.12</td>
<td>0.14</td>
</tr>
</tbody>
</table>

- 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.
Role of Private Participation

- Traditionally, infrastructure investments in South Asia have been funded by the public sector.
- 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.

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:

- Projects that retain public ownership of the assets while contracting out management and operation,
- 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.
Global Best Practices

Baku-Supsa Oil Pipeline

- The Baku-Supsa pipeline 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 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.

The Express Pipeline b/w 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.
- The capacity of the pipeline has been increased to 280,000 bpd.
- The Express Pipeline has been entirely sponsored by the private sector.
Development of framework for Pipelines

Aim of the framework
- 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.
- The Framework and any Agreement based on the Framework shall be governed by a separate entity formed under SAARC.

Components of the framework
- Participants
- Governing/Regulatory entity under SAARC
- Construction, Operation and Maintenance of the pipeline network
- Tariff recovery

Participants involved in the framework for the agreement
- Government of the Member State and respective Ministries/Regulatory authority
- Ministry of External/Foreign Affairs
- Ministry of Physical Infrastructure & Transport
- Ministry of Petroleum
- Regulatory Authority for Petroleum trade

FRAMEWORK

Development of the agreement

Creation of a separate entity to conceive, coordinate and implement pipeline projects

Tariff recovery for the pipeline

Construction and O&M of a pipeline
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