

Asphalt Binder Market Assessment

February 2021

Commissioned by



Prepared by



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ADI Analytics is a boutique-consulting firm serving the oil & gas, energy, and chemical industries. Founded in 2009, ADI Analytics has completed 450+ projects for 150+ clients including Fortune 500 and mid-sized companies, start-ups, investors, and government agencies. The company's offerings include consulting services, subscription research, data analytics, and executive forums. ADI Analytics' consulting services include market research, competitive intelligence, economic analysis, strategic planning, and technology assessments. ADI Analytics conducts its work through the disciplined use of content, data, and analytics, reliance on field-based energy industry expertise, and a relentless focus on creating value for clients. For more information, please visit the company's web site at www.adi-analytics.com.

Table of contents

Acknowledgement, disclaimer, and terms of use	2
About the authors	3
List of exhibits	5
List of abbreviations and definitions	7
1.0 Executive summary	8
2.0 Background	10
2.1. Introduction	10
2.2. Objectives and scope	10
2.3. Methodology	11
2.4. Introduction to asphalt binder grades	13
3.0 Asphalt binder market drivers	16
4.0 Asphalt binder demand assessment	21
4.1. Global demand overview	21
4.2. Asian demand assessment	23
4.3. North American demand assessment	31
5.0 Asphalt binder customer behavior and insights	39
5.1. Asian customer preferences	39
5.2. North American customer preferences	42
5.3. Customer and end-user needs and pain points	44
5.4. Key differences in Asian and North American markets	45
6.0 Asphalt binder pricing trends	47
7.0 Supply chain and logistics	50
7.1. Asphalt binder supply chain overview	50
7.2. Transportation costs and logistics	52
7.3. Innovation and technology advances	55
8.0 Strategic implications	57
9.0 Findings and conclusions	59
Notes	61

List of exhibits

Exhibit 1. Asphalt binder industry value chain and areas of focus for this report.	11
Exhibit 2. List of interviewees from primary research.	12
Exhibit 3. Interviewee demographics from primary research.	12
Exhibit 4. Interview guide used for primary research.	13
Exhibit 5. Applications of asphalt grades by segment.	15
Exhibit 6. Growth drivers for the global asphalt binder market.	16
Exhibit 7. Average historical and forecasted infrastructure spending as a percentage of GDP.	17
Exhibit 8. Annual vehicle sales growth percentage over 2010-20 by country in Asia.	18
Exhibit 9. Annual urbanization growth percentage over 2015-20 by country.	18
Exhibit 10. Annual construction growth percentage over 2015-20 by country.	19
Exhibit 11. Infrastructure spending in USD Bn versus GDP growth percentage through 2025.	20
Exhibit 12. Total global asphalt demand in million metric tons per year over 2015-25.	21
Exhibit 13. Demand breakdown for asphalt in 2020 by region and application.	22
Exhibit 14. Asphalt binder market regions of focus for this study.	23
Exhibit 15. Asphalt binder demand in Asia in million metric tons per year.	24
Exhibit 16. Near- and long-term impact of COVID-19 on the Asian asphalt industry.	25
Exhibit 17. Asphalt demand scenarios due to COVID-19 in Asia.	26
Exhibit 18. Asphalt demand in million metric tons per year by application in Asia.	27
Exhibit 19. Asphalt grades use across key countries in Asia.	28
Exhibit 20. Asphalt grades distribution across key countries in Asia.	29
Exhibit 21. Asphalt demand in million metric tons per year by binder grade in Asia.	30
Exhibit 22. Total asphalt binders demand in million metric tons per year in the U.S.	31
Exhibit 23. Asphalt grades distribution by region in North America.	32
Exhibit 24. Asphalt binder demand by region in million metric tons per year in North America.	33
Exhibit 25. Asphalt binder demand outlook by application in North America.	34
Exhibit 26. Asphalt demand in million metric tons per year by application in North America.	35
Exhibit 27. Relative preference of asphalt binder grades by region.	36
Exhibit 28. Asphalt binder grades distribution by region in North America.	37
Exhibit 29. Average recycled asphalt pavement usage in percentage by sector.	37
Exhibit 30. Asphalt demand in million metric tons per year by grade in North America.	38
Exhibit 31. Importance of relationship and quality for Asian asphalt end-users.	40
Exhibit 32. Importance of binder pricing for Asian asphalt end-users.	41
Exhibit 33. Selection criteria for Asian asphalt binder end-users.	42
Exhibit 34. Importance of binder pricing and quality for North American end-users.	43
Exhibit 35. Selection criteria for North American asphalt binder end-users.	44
Exhibit 36. Key pain points for asphalt binder end-users.	45
Exhibit 37. Relative prices of asphalt binder grades in Asia.	47
Exhibit 38. Average asphalt prices by grade in Asia.	48
Exhibit 39. Average asphalt binder prices in U.S. dollars in North America.	49
Exhibit 40. Average asphalt grade PG 64-22 prices in U.S. dollars by region.	49

Exhibit 41. An illustrative view of the asphalt binder supply chain.	50
Exhibit 42. An illustrative list of asphalt binder end-users in Asia.	51
Exhibit 43. An illustrative list of asphalt binder end-users in North America.	52
Exhibit 44. Average costs of road transportation in U.S. dollars per mile per ton by country.	53
Exhibit 45. Preferred mode of transport to asphalt end-users.	54
Exhibit 46. Various modes of transporting asphalt binders.	55
Exhibit 47. Potential markets for Canadian asphalt in Asia.	57
Exhibit 48. Potential markets for Canadian asphalt in North America.	58

List of abbreviations and definitions

MMTPA	Million metric tons per annum
AC	Asphalt cement
BPD	Barrels per day
C	Celsius (temperature scale)
CAGR	Compound annual growth rate
CRMB	Crumb rubber modified bitumen
GDP	Gross domestic product
IRCON	Indian Railways Construction Company
NHAI	National Highway Authority of India
PG	Performance grade
PMB	Polymer modified bitumen
RAP	Reclaimed asphalt pavement
U.S. DOT	United States Department of Transportation
UEM Group	United Engineers Malaysia Berhad
USD	United States dollar
VG	Viscosity grade

1.0 Executive summary

Alberta Innovates commissioned ADI to conduct a voice-of-customer study and assess the market for asphalt in North America and Asia and identify opportunities for Canadian asphalt binders. ADI conducted 40+ productive interviews with asphalt end-users, construction companies, and distributors in Asia and North America covering a broad range of market, commercial, end-use, pricing, and other issues.

A deep dive of the asphalt market in Asia covering China, India, Vietnam, Thailand, Singapore, Malaysia, and Indonesia was completed. We also covered U.S., Canada, and Mexico as part of the study. These countries were selected based on growth drivers, demand, infrastructure spending, and investment outlook for the next 20 years. The asphalt markets in Asia and North America are driven by rapid urbanization, growing infrastructure investments, increasing mobility, and residential and other construction growth.

The global demand for asphalt is estimated at ~143 million metric tons per year (MMTPA) in 2020 and is expected to grow at 3.6% annually to reach ~174 million metric tons per year by 2025. In 2020, the total demand for key countries in Asia was ~39 MMTPA which is expected to grow at 3.0% annually to 45 MMTPA by 2025, mainly in China, followed by India and Thailand. Asphalt demand in U.S. and Mexico was ~26.6 and ~1.7 MMTPA, respectively, in 2020 which is expected to grow annually at 3.1% and 3.2%, respectively, through 2025.

Nearly ~75% of the Asian asphalt demand is for conventional grades such as VG-30 and AC-60/70 followed by emulsions and polymer-modified grades. Viscosity grades VG-30 and VG-10 are the most widely used grades in India. Other countries such as Vietnam, Thailand, Singapore, Malaysia, and Indonesia use pavement grades with AC-60/70 being the most popular and widely used grade. North America uses the superpave grading system with PG 64-22 and PG 64-28 being the most popular grades. In North America, demand is a function of climatic conditions and local needs with greater preference for higher temperature grades in the south and lower temperature grades for colder climates.

Conventional grades can be used for applications such as construction of highway roads, expressways, city roads, airport runways, and waterproofing jobs. Emulsions are used in city and rural roads whereas polymer grades are mostly used for expressways and airport roads. Supplier selection is based on prices, relationships, sector experience, supplier creditworthiness, quality, logistics, offering breadth, and scale of the asphalt supplier. Asphalt prices, relationships, and quality are important criteria for supplier selection in Asia. North American end-users value prices, offering breadth, and quality as important factors for supplier selection.

End-users have several pain-points such as price fluctuations, quality issues, and logistical concerns. Contractors look for pricing stability during demand fluctuations and consistent supply of required grades during project execution without compromising quality.

Polymer-modified grades such as PMB-30 are priced at a ~35% premium over the VG-10 grade. Widely used grades such as VG-30 and AC-60/70 also sell at a ~25% premium over VG-10. In North America, asphalt prices range from U.S. \$450 to U.S. \$600 per ton and U.S. \$650 to U.S. \$700 in Canada.

Most of the asphalt is transported via tank trucks although a few end-users procure small volumes via bitumen drums. Transportation costs range from U.S. \$0.07 to U.S. \$0.15 per metric ton per mile of distance with transportation costs higher in developed nations such as U.S. and Singapore.

In Asia, Canadian asphalt has the best application opportunities in expressways, highways, and some airports and North American application opportunities for Canadian asphalt are led by interstate highways, city roads, and airports. Finally, Canadian producers of asphalt binders will have to invest in educating end-users and the broader market around the value of selecting suppliers based on performance outcomes in order to identify new opportunities and differentiate themselves against growing competition.

2.0 Background

2.1. Introduction

Alberta Innovates (AI) has launched the Bitumen Beyond Combustion program to help diversify applications and end-uses for Alberta's extensive oilsands resources. Specifically, the Bitumen Beyond Combustion program seeks to develop large-scale applications that will consume at least 100,000 barrels of bitumen per day (bpd) by 2030. Asphalt binder is one application of interest where AI is interested in developing a detailed assessment of the current and future asphalt binder markets in North America and Asia. Such an assessment will help asphalt binder suppliers in Alberta understand and target some of the larger and fast-growing markets.

To that end, AI commissioned ADI Analytics to develop this report assessing the asphalt binder markets in Asia and North America. This report reviews asphalt binder market drivers, demand in Asia and North America, customer preferences and insights, market structure and pricing, and logistics and supply chain practices. The findings in these areas were also analyzed to identify strategic implications for the consideration of asphalt binder suppliers in Alberta. Initiated in September 2020, this report was developed using a mix of primary and secondary research and market size modeling, and input from the AI team over interim reviews, and completed in December 2020.

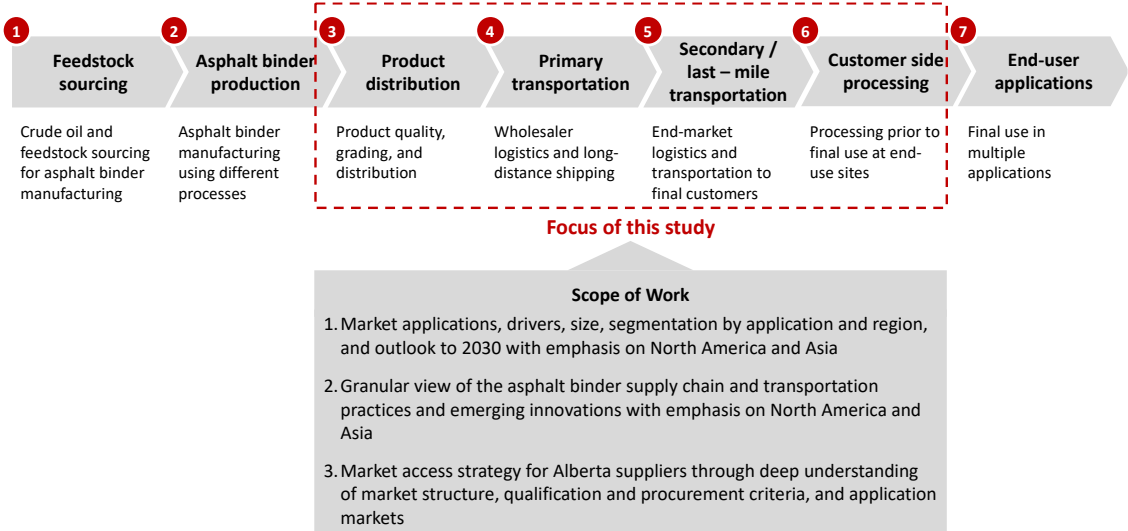
2.2. Objectives and scope

Building on the high-level understanding of the asphalt binder market that AI's prior and on-going work has facilitated, this project and report seeks to build deeper and granular insight in the following key areas of interest:

1. Market applications, drivers, size, segmentation by application and region, and outlook to 2030 with emphasis on North America and Asia
2. Granular view of the asphalt binder supply chain and transportation practices and emerging innovations with emphasis on North America and Asia
3. Market access strategy for Alberta suppliers through deep understanding of market structure, qualification and procurement criteria, and application markets

At AI's request, asphalt binder production feedstocks and technologies or a listing of buyers were considered out of scope. Instead, AI has commissioned ADI Analytics to develop insights on the supply chain including product distribution and transportation, customer practices and market access, and market applications and opportunity as shown in Exhibit 1.

Exhibit 1. Asphalt binder industry value chain and areas of focus for this report.



2.3. Methodology

ADI Analytics’ approach and methodology to complete this project included a mix of primary and secondary research, proprietary analytics, and spreadsheet modeling. Specific initiatives included the following to address different parts of the scope and needs of the project:

- i. Collection and analysis of published information covering investor disclosures, academic and trade journals, conference, and trade show presentations, published and filed patents, and marketing collateral.
- ii. Use of ADI Analytics’ proprietary research and databases on supply and capacity, demand, pricing, and company profiles.
- iii. Primary research with emphasis on interviews was conducted with key stakeholders drawn from ADI- and CMR-proprietary expert databases. Overall, more than 40 asphalt industry participants and experts were interviewed over the course of the project.

Interviewee demographics are summarized in Exhibit 3 and reflect the primary research program’s broad coverage of companies, industry and value chain segments, regions, seniority, and expertise. Per AI’s guidance in the request for proposals, ADI has emphasized interviews with industry participants with experience and expertise in Asia followed by North America. As shown in Exhibit 3, 60% of the interviews conducted during this project were in Asia led by

industry experts from India and China and followed by Vietnam, Thailand, Malaysia, Singapore, and Indonesia. Experts from the U.S. accounted for most of the interviews in North America followed by Canada and Mexico.

ADI Analytics emphasized interviews with industry participants who brought expertise in commercial, supply chain, and sales and marketing functions followed by those in engineering and technical roles. In addition, all interviews were conducted using structured interview guides (see Exhibit 4 for an example) developed in consultation with AI, documented using uniform transcript templates, and with utmost regard to client and expert confidentiality.

Exhibit 2. List of interviewees from primary research.

Exhibit 3. Interviewee demographics from primary research.

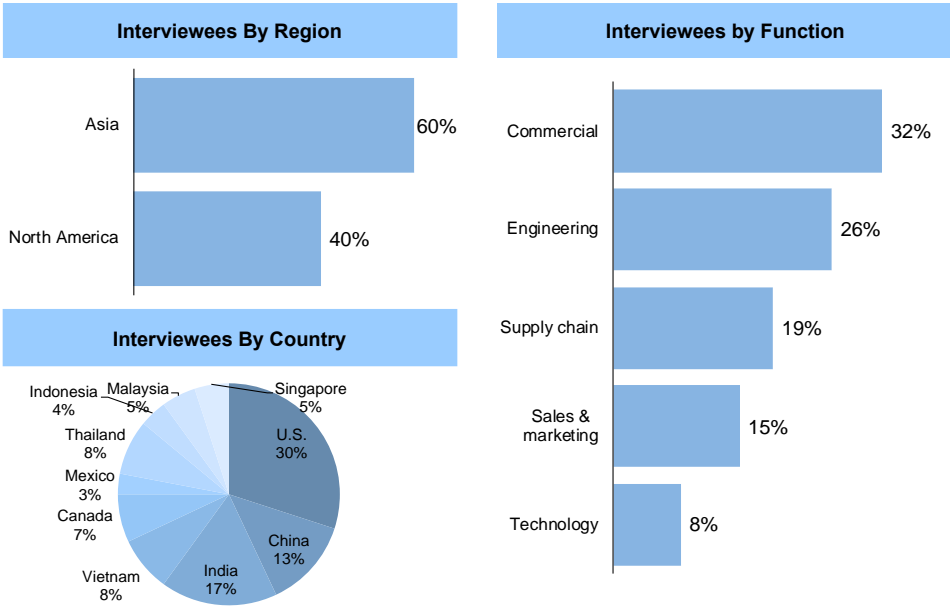


Exhibit 4. Interview guide used for primary research.

Expert	Background
Senior Executive	<ul style="list-style-type: none"> Over 34 years of experience in the construction sector Involved in managing large national highway projects
Market drivers	Commercial insights and economics
<ul style="list-style-type: none"> We see a very good market for asphalt binder in India with several new projects in the pipeline in coming years There is a recent infrastructure boom as government plans to connect new highways and village roads Seasonality also drives the demand with more construction activities happening during summers 	<ul style="list-style-type: none"> Total cost of asphalt to the end-user is a function of distance, mode of transport, and asphalt binder grade Bulk buyers of asphalt pay ~\$350-\$400 per ton depending on the grade and adds transportation costs, storage fees, and margins Typically, truck transport costs ~\$0.05 per ton per mile for asphalt which can vary based on the location and quality of asphalt grade For remote locations and hilly terrains these costs can go up to \$0.07 per ton per mile of distance travelled
Demand assessment	Supply chain and logistics
<ul style="list-style-type: none"> The asphalt binder market in India WILL grow at around ~4% annually for the next ten years Most of the asphalt is used for road construction and only ~2-3% of the total asphalt is used for waterproofing and other applications Most of the asphalt is supplied by big contractors which in turn buy large volumes ranging from 20,000 to 30,000 metric tons per year from local refiners We see a very good market for a quality product, but cost-competitiveness is also a major factor to consider End-users prefer local suppliers for asphalt as long as they meet grade specifications and can provide supply guarantees for the entire duration of the project 	<ul style="list-style-type: none"> Suppliers should meet the essential quality criteria (EQC) which includes meeting grade specifications, Financial capability to meet the end-user needs for big highway projects, and Prior experience of working on similar projects with at least 65% of the current project cost or two projects totaling to 70% of the current project cost Suppliers prefer transportation of asphalt via tankers where it is loaded in liquid form in bitumen tankers and heated later during unloading

iv. Finally, ADI Analytics' proprietary models and analytics on asphalt applications, demand, and supply were used to estimate, forecast, and segment market size by application, grade, and region.

2.4. Introduction to asphalt binder grades

Asphalt binder is available in several grades around the world. Although there is considerable overlap in properties across some of these grades, they may have different names based on traditional test practices, end-uses, and nomenclatures developed over time in various countries. Asphalt binder grades are introduced briefly here since the report has multiple references to several of them.

- Penetration grade bitumen** is refinery bitumen of different viscosities. It is a standard product typically used road paving and construction and to produce asphalt pavements with superior properties. It is characterized based on hardness measured using the penetration test. Major penetration grade bitumens are AC-60/70 that is generally used in most markets while other grades such as AC-80/100 and AC-40/50 also widely used for paving applications.
- Viscosity-grade bitumen:** Although paving bitumens have traditionally been specified in terms of their penetration, the measurement of viscosity provides a more accurate method of specifying binder consistency and a more effective method of determining the bitumen's temperature susceptibility. According to viscosity (degree of fluidity) grading, the higher

the grade, the stiffer the bitumen. Tests are typically conducted at 60 °C and 135 °C, which represent road surface temperatures in the summer and during asphalt binder mixing, respectively. A brief description of the key viscosity-grade bitumens follows:

- **VG-10 bitumen** is widely used in spraying applications such as surface dressing and paving in very cold climates in lieu of the old 80/100 penetration grade bitumen. It is also used to manufacture bitumen emulsion and modified bitumen products.
 - **VG-20 bitumen** is used for paving in cold climate and high-altitude regions.
 - **VG-30 bitumen** is primarily used to construct extra heavy-duty bitumen pavements that need to endure substantial traffic loads. Also, VG-30 is used for applications such as road construction, waterproofing, building construction and in cutback bitumen production. It can be used in lieu of the 60/70 penetration grade. It is the most suitable grade for use in hot and rainy weather conditions as well as in regions with mild climatic conditions.
 - **VG-40 bitumen** is used in highly stressed areas such as intersections, near toll booths, and truck parking lots in lieu of the old 30/40 penetration grade.
- **Superpave grading system** classifies binders based on their performance in extreme cold and hot temperatures. For example, a PG 64-16 binder is for use at a project site where the average seven-day maximum pavement temperature is 64 °C, and the expected minimum pavement temperature is -16 °C.
 - **Bitumen emulsions** are a mixture of fine bitumen droplets and emulsifiers dispersed in water where the latter is used to make the emulsions stable to transport, store, and break during use.
 - **Polymer-modified grades** are specially designed and engineered bitumen grades that are used in making pavements, roads for heavy-duty traffic, and home-roofing solutions to withstand extreme weather conditions.
 - **Cutback asphalt** is a combination of asphalt cement and petroleum solvent.
 - **Oxidized asphalt** is also known as blown bitumen and is produced by passing air through penetration grades to give the bitumen rubber-like properties making it relatively harder.
 - **Reclaimed asphalt pavement (RAP)** is removed and/or reprocessed pavement materials containing asphalt and aggregates. These materials are generated when asphalt pavements are removed for reconstruction, resurfacing, or to obtain access to buried utilities.

Exhibit 5 shows asphalt grades by various application segments. Traditional bitumen grades can be used in all the applications whereas polymer-modified grades are mostly used for the construction of expressways, highways, and airport roads. Recycled asphalt or RAP is widely used in city and rural road projects but occasionally for expressway and highway projects which have higher traffic-load intensities and need premium grades.

Exhibit 5. Applications of asphalt grades by segment.

	Expressways	Highways	City roads	Rural roads	Airports	Waterproofing
Bitumen grades						
Bitumen emulsions						
Polymer modified grades						
Reclaimed asphalt pavement						

Rarely used
 Moderately used
 Widely used

3.0 Asphalt binder market drivers

Asphalt binder, also known simply as asphalt or bitumen, has a number of applications in modern society led primarily by its use in infrastructure of various kind from roads to airports and residential and commercial buildings. As a result, the global asphalt binder market and its growth depends on a few fairly obvious market drivers. Four major drivers for the asphalt binder market include (i) growing infrastructure investments, (ii) increasing mobility, (iii) rapid urbanization, and (iv) residential construction growth. Exhibit 6 lists and details these growth drivers along with identifying the regions where these growth drivers have manifested most explicitly in recent years.

Exhibit 6. Growth drivers for the global asphalt binder market.

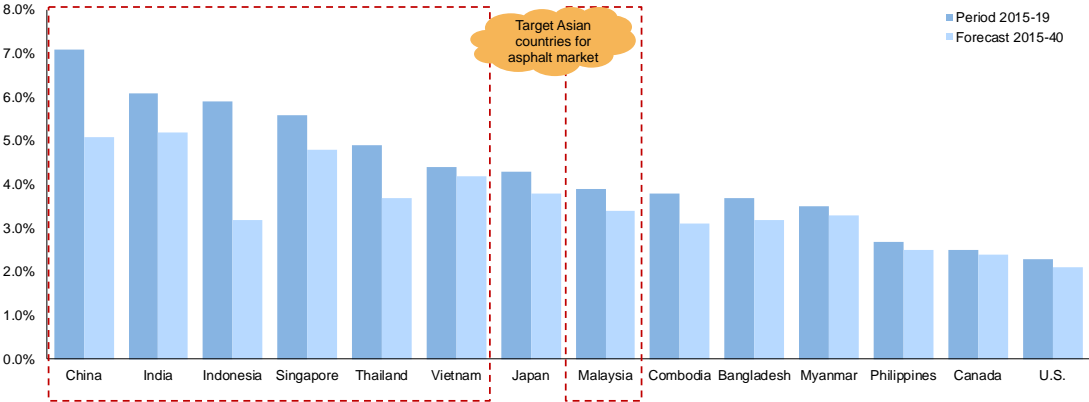
Driver	Region	Discussion
1 Growing infrastructure investments	North America and Asia	<ul style="list-style-type: none"> Investments in roads, airports, ports, and rail infrastructure For example, Vietnam is expected to increase its spending on airport infrastructure from 0.02% to 0.04% of total GDP in the next five years
2 Increasing mobility	Asia	<ul style="list-style-type: none"> Increasing connectivity across large and small cities For example, Policy initiatives in India such as expeditious land acquisition, revival of languishing projects, and timely resolution of disputes is ensuring last-mile connectivity
3 Rapid urbanization	Asia	<ul style="list-style-type: none"> Growth of population density in urban centers driving mass transit and other investments Bridging of existing infrastructure gaps and creating additional facilities to cater to the growing population migrating to urban areas will drive need for infrastructure investments
4 Residential construction growth	North America and Asia	<ul style="list-style-type: none"> Growing population, middle-class incomes, and standards of living are driving residential investment We expect a boom in construction in residential buildings in North America and most of the nations in Southeast Asia

Asphalt binder finds use in a number of infrastructure projects and their growth is, therefore, an obvious and likely the most important growth driver for the global asphalt market. Infrastructure investments in roads, airports, ports, and rail infrastructure are growing globally. Infrastructure development is seen as vital a link to economic growth and, therefore, the stated goal for a number of governments across the world and particularly so in emerging economies.

As a result, a number of countries have identified explicit targets for infrastructure development. For example, Vietnam is anticipated to double its spending on airport infrastructure going from 0.02% to 0.04% of its total GDP in the next five years. Collectively, a number of countries in Asia and North America are anticipated to make significant investments in infrastructure as shown in Exhibit 7. Exhibit 7 shows both historical and forecasted infrastructure spending as a percentage of GDP across a number of countries. Asian countries

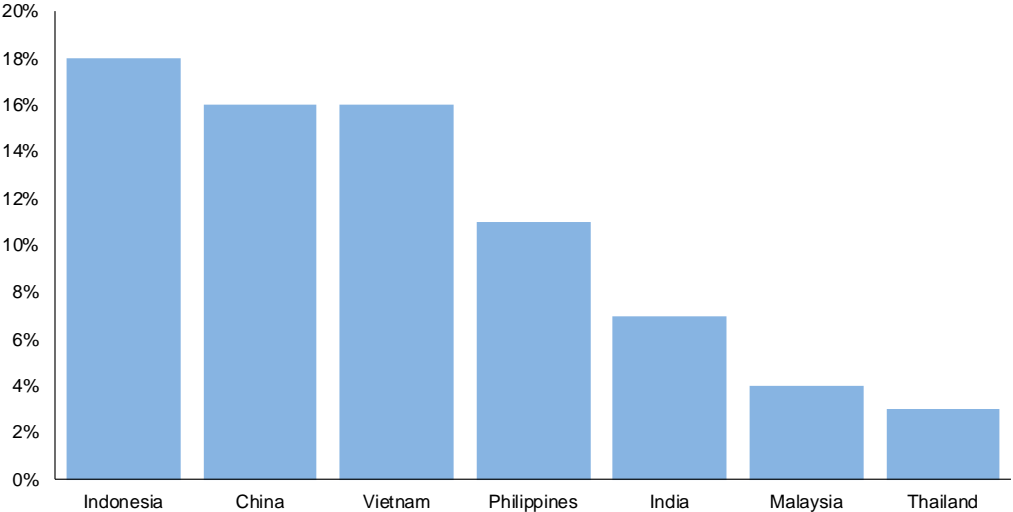
lead the list with China and India although forecasted spend is lower for all countries compared to that in the past five years. Even so, such rapid infrastructure growth will play a critical role in driving demand for asphalt binders.

Exhibit 7. Average historical and forecasted infrastructure spending as a percentage of GDP.ⁱ



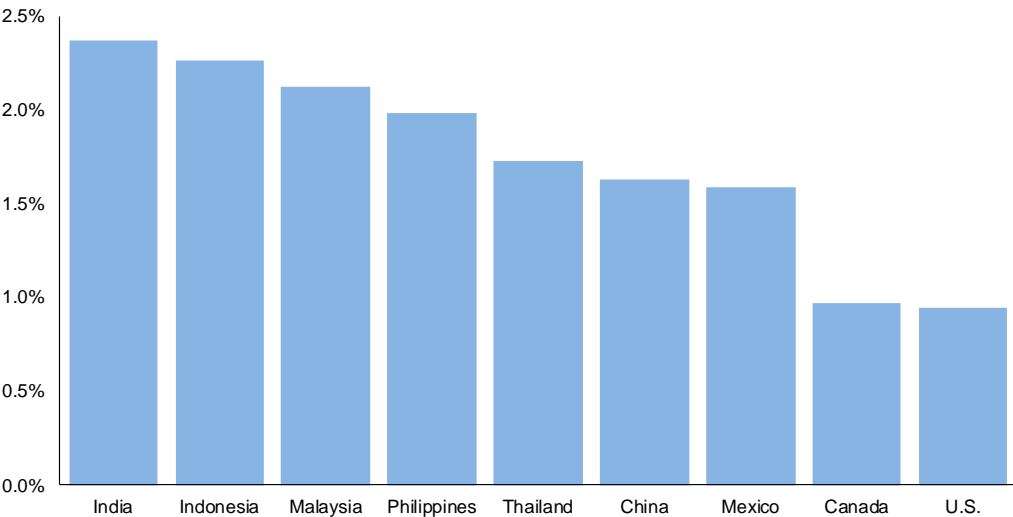
Rising mobility across the population on both global and regional bases will drive investments in road and related infrastructure driving demand for asphalt binders. Exhibit 8 highlights the robust growth in vehicle sales over the past decade including growth in double digits for Indonesia, China, Vietnam, and Philippines. Given this rapid rise in vehicle ownership, several Asian economies are particularly focused on expanding their road infrastructure. For example, the slow pace of road infrastructure development is seen as a major bottleneck to economic growth in India. As a result, policy initiatives such as expedited land acquisition, revival of delayed projects, and timely dispute resolution have been proposed over the years to accelerate infrastructure development and investments in last-mile connectivity. Such efforts that support the rapid growth of mobility will accelerate asphalt binder demand and market growth.

Exhibit 8. Annual vehicle sales growth percentage over 2010-20 by country in Asia.ⁱⁱ



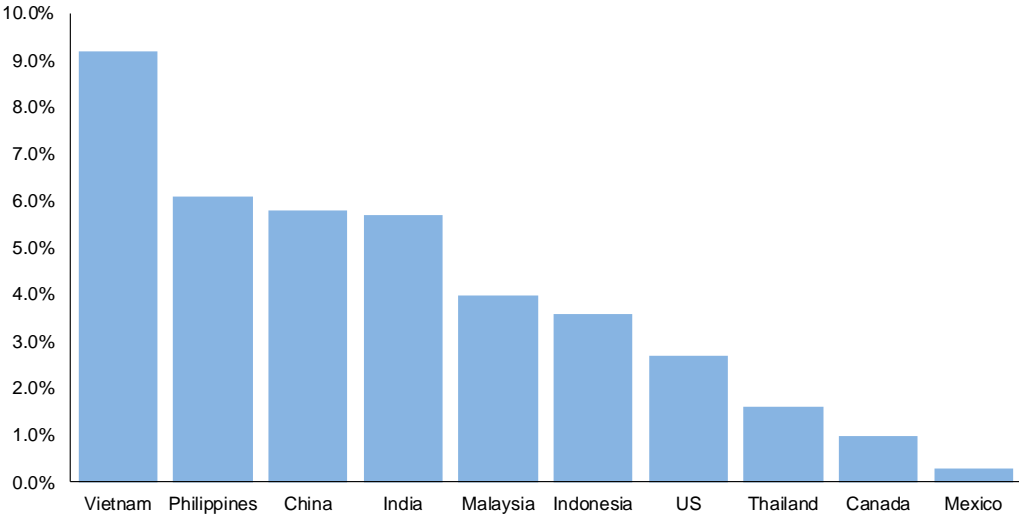
A third driver supporting asphalt binder market demand growth is rapid urbanization. Exhibit 9 illustrates the growth rates of urbanization across a number of countries in Asia and North America. India leads the pack followed closely by Indonesia, Malaysia, and Philippines. As a result, population density is growing rapidly in urban cities globally driving mass transit and related infrastructure investments. Climate change policies and growing traffic congestion will further accelerate such investments requiring new infrastructure and, consequently, higher asphalt binder demand.

Exhibit 9. Annual urbanization growth percentage over 2015-20 by country.ⁱⁱⁱ



Finally, residential construction growth led by expanding populations, rising middle-class incomes, and improving standards of living around the world is manifest in a construction boom in not only emerging economies such as Asia but also mature markets such as the U.S. Exhibit 10 shows residential construction growth in key regions around the world. Such expansion of the residential sector will contribute towards additional growth of the asphalt binder market.

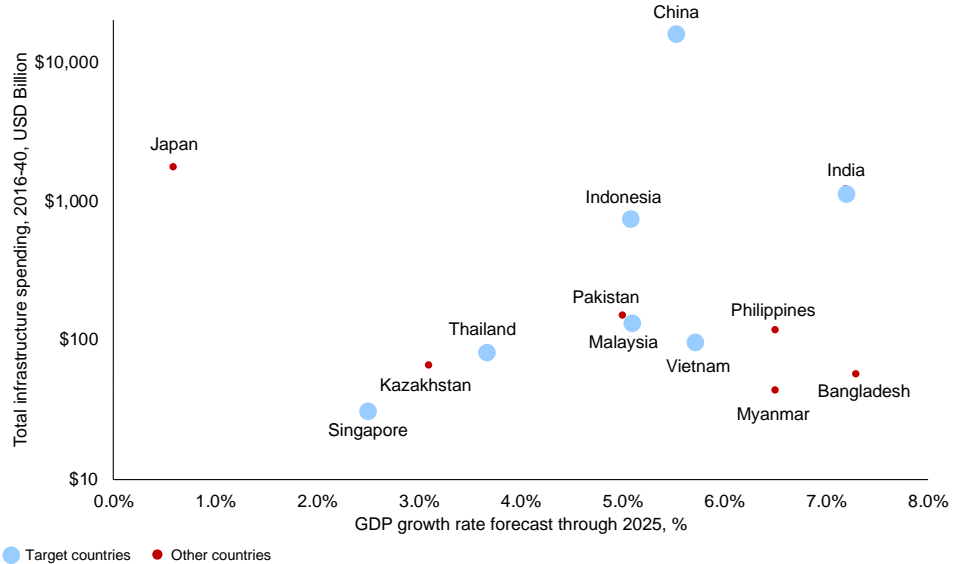
Exhibit 10. Annual construction growth percentage over 2015-20 by country.^{iv}



In summary, significant infrastructure spending is underway and is expected to continue driving demand for asphalt binders globally. Although growth rates for asphalt binders may vary by region – depending on the regional strength of the market drivers discussed above – continued growth in GDP will continue to have a positive impact on infrastructure spending. Exhibit 11 shows the scale of infrastructure spending in key countries in Asia around the world as a function of GDP growth rate anticipated through 2025.

Several countries such as India, China, Indonesia, Malaysia, Vietnam, Thailand, and Singapore all are anticipated to have attractive GDP growth rates driving robust infrastructure spending in those countries. As a result, these countries were selected for deep dives during the course of this project to improve AI’s understanding of asphalt binder markets in the most promising regional markets.

Exhibit 11. Infrastructure spending in USD Bn versus GDP growth percentage through 2025.^v



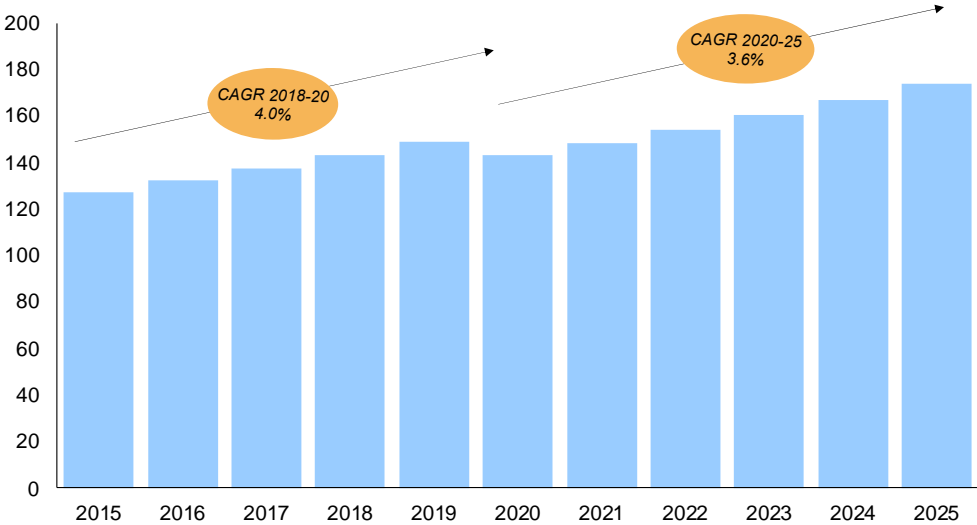
4.0 Asphalt binder demand assessment

Alberta Innovates identified estimating asphalt binder demand and forecasting its growth outlook as a key objective of this report and is discussed in this section. In addition to understanding the size and growth rates of the asphalt binder market globally and across key regions, ADI Analytics has segmented the market by application and binder grades. Finally, this section also includes a discussion of several qualitative insights on the asphalt binder markets gathered through primary and secondary research.

4.1. Global demand overview

In 2020, annual worldwide asphalt binder demand was estimated to be 143 million metric tons and forecasted to grow at 3.6% every year through 2025. At this growth rate, global asphalt binder market is expected to reach almost 174 million metric tons by 2025. Exhibit 12 shows the total global demand for asphalt binder and its historical and forecasted growth over 2010-15 and 2020-25, respectively.

Exhibit 12. Total global asphalt demand in million metric tons per year over 2015-25.

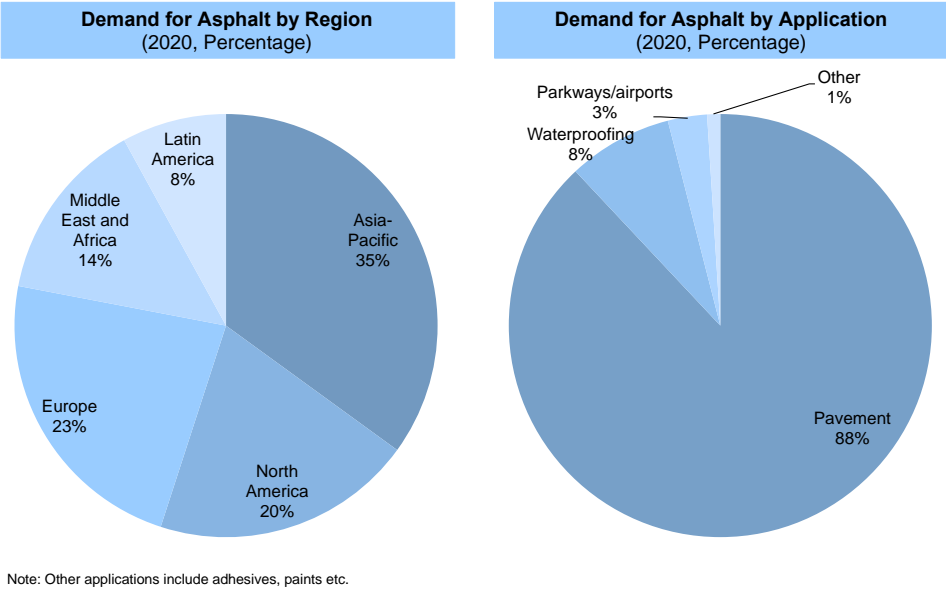


The global asphalt market is growing at a robust pace but slightly slower than the 4.0% observed over the past few years. This slight moderation of the growth outlook is attributed to multiple reasons including potential cuts to infrastructure budgets from COVID-19 and completion of major infrastructure investments from the past decade. In addition, the next tier of infrastructure investment needs has higher complexity because they are in regions with

greater economic and political uncertainty or are in segments such as last-mile transportation that are subject to higher permitting and regulatory oversight.

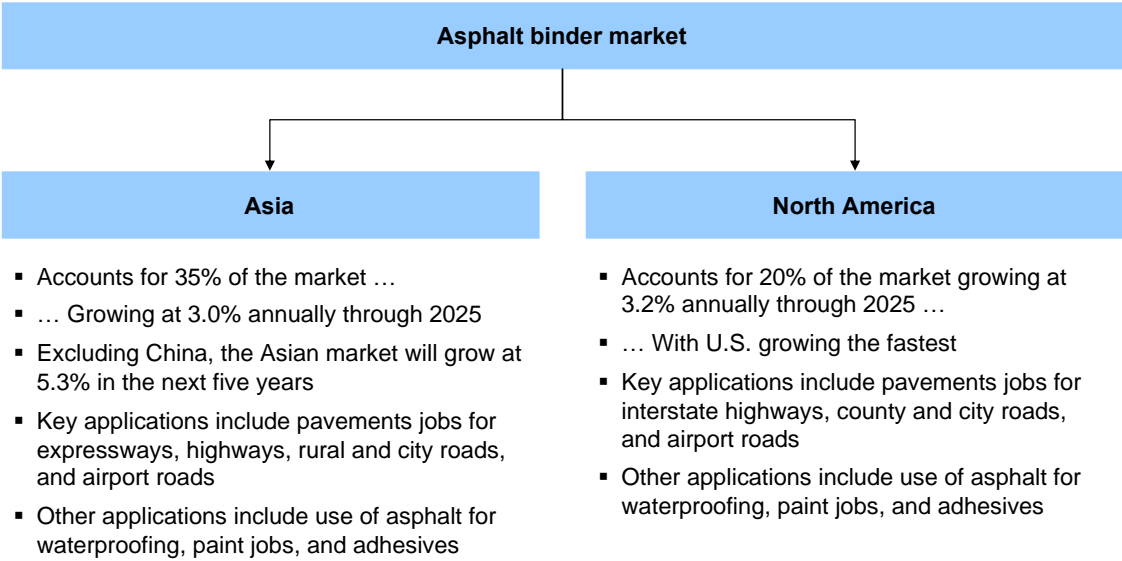
Global asphalt binder markets are dominated by Asia-Pacific, Europe, and North America that collectively accounted for more than three-fourths of total demand in 2020. Middle East and Africa accounts for another 14% of global demand followed by Latin America that consumed only 8% of total asphalt binder globally as shown in Exhibit 13. Exhibit 13 also describes estimates for asphalt applications with pavements consuming as much as 88% of total global demand in 2020. Waterproofing in residential and commercial buildings and parkways and airports accounted for 8% and 3% of asphalt demand in 2020.

Exhibit 13. Demand breakdown for asphalt in 2020 by region and application.



This report has conducted deeper dives into the Asian and North American asphalt binder markets. Exhibit 14 summarizes the highlights for each of these market segments. Briefly, Asia accounts for 35% of total asphalt demand while North America is a fifth of the market. Although North America is growing at a slightly higher pace than Asia, several countries in the latter are actually growing at a far higher pace. For example, if one excluded China from the mix, Asia is likely to grow at 5.3% over the next five years. Both regions have similar applications dominating asphalt use with Asia investing a little more in rural and city road infrastructure as compared to North America. A deeper dive of each region follows in this section of the report.

Exhibit 14. Asphalt binder market regions of focus for this study.

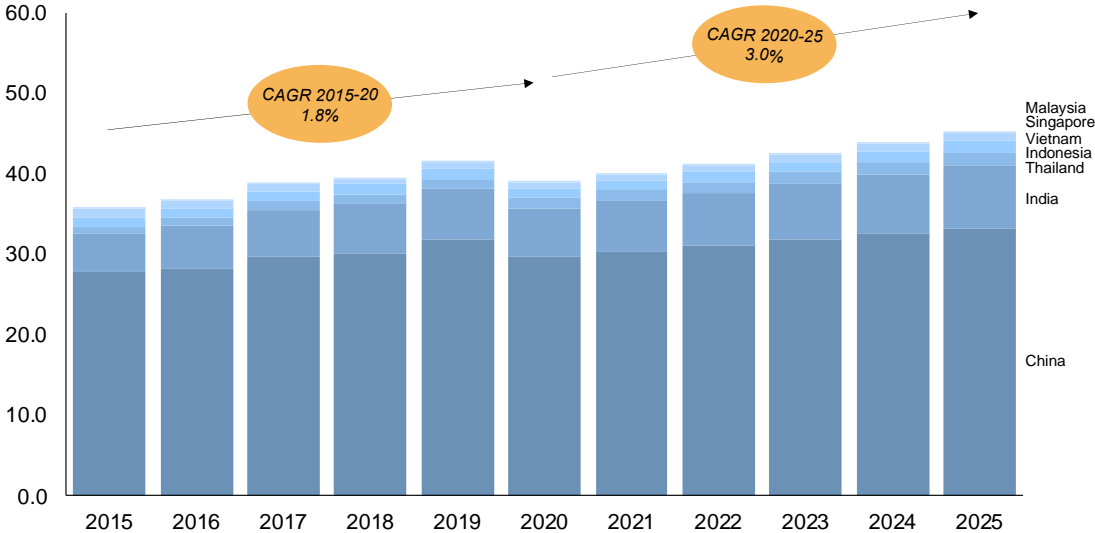


4.2. Asian demand assessment

Asian asphalt binder demand is estimated to be 39 million metric tons per year in 2020. The regional market is forecasted to grow at a robust 3.0% over the next five years through 2025. This is a significant acceleration in growth for the Asia market which, in comparison, grew at 1.8% over 2015-20. Collectively, annual Asian asphalt binder demand is expected to grow to a little more than 45 million metric tons by 2025 as shown in Exhibit 15.

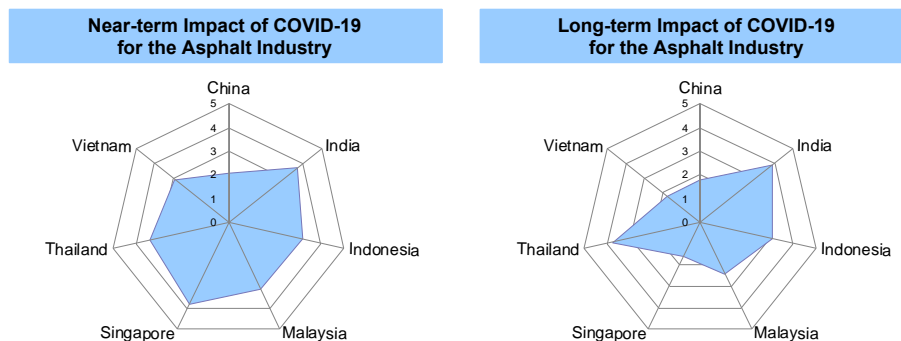
Exhibit 15 also segments Asian demand across the key countries in the region. As expected, China dominates the market accounting for more than three-fourths of demand followed by India, which took 15% of demand in 2020. These two dominant countries are followed by Thailand, Indonesia, Vietnam, Malaysia, and Singapore in decreasing order of asphalt binder demand.

Exhibit 15. Asphalt binder demand in Asia in million metric tons per year.



In 2020, the Asian asphalt binder market declined a little from that in 2019 due to COVID-19 but the impact of the pandemic has varied by country with its effects over time also varying by country. Exhibit 16 shows the pandemic’s impact across key countries in Asia based on qualitative insights gathered through primary research. The exhibit also includes a few quotes from interviews conducted as part of the primary research program.

Exhibit 16. Near- and long-term impact of COVID-19 on the Asian asphalt industry.



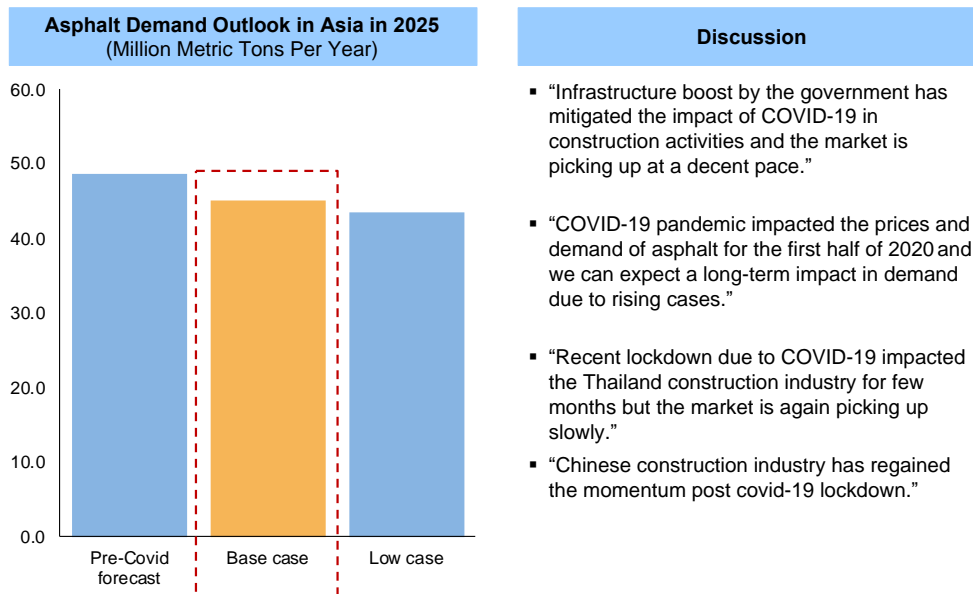
- “The demand for bitumen fell after COVID-19 lockdown but has picked up again in the last few months.”
- “COVID-19 pandemic impacted the prices and demand of asphalt for the first half of 2020 and we can expect a long-term impact in demand due to rising cases.”
- “Construction activities has started picking up post COVID-19 and will be back to normal by year-end.”
- “Demand due to COVID-19 did weaken for 2Q2020 but supplies were also getting tighter, so the overall prices of asphalt grades did not change much.”

Note: The scale and significance of impact increase from 1 to 5

As illustrated in exhibit 16, near-term impact of COVID-19 on the asphalt market has been the most pronounced in India and Singapore followed by Thailand, Indonesia, and Vietnam. Expert interviews were conducted well after the pandemic had been controlled in China reflecting a minimal impact in the country. Exhibit 16 also shows that industry experts anticipate the pandemic’s impact to continue lingering on in the longer term i.e., 3-5 years in Indonesia, India, and Thailand while the other countries are best positioned for a quicker recovery.

Even so, there is considerable uncertainty around the actual impact of COVID-19 on the asphalt market, and this is reflected in the estimates shared in Exhibit 17. Prior to the pandemic, Asian asphalt demand was expected to be almost 49 million metric tons per year in 2025 but is now expected to be 45.2 million metric tons per year although continued lockdowns may further suppress demand to as low as 43.6 million metric tons per year in 2025. A few interview excerpts are also included in Exhibit 17 reflecting the outlook to depend heavily on the scale of impacts on infrastructure spending budgets across different countries in Asia.

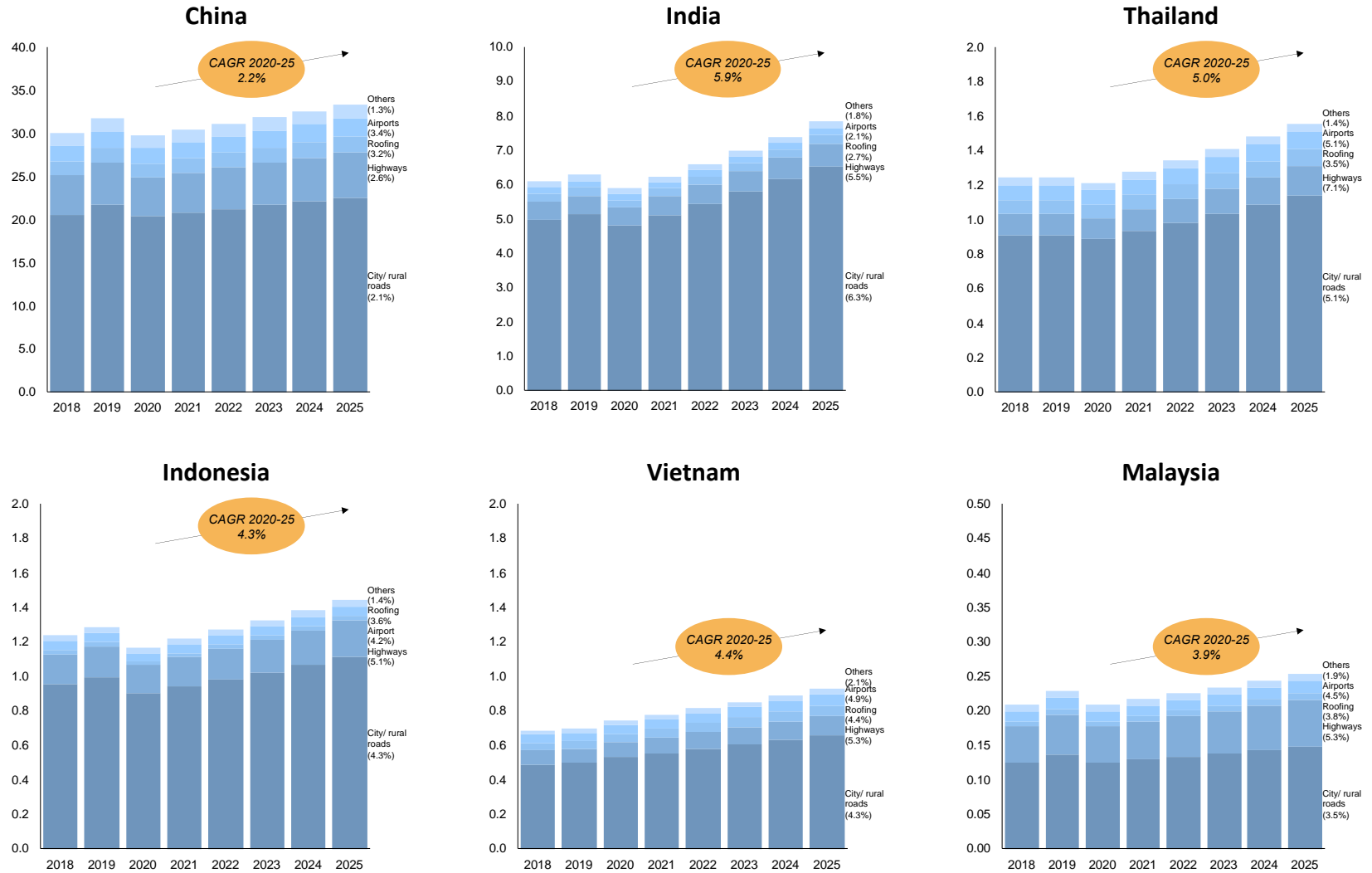
Exhibit 17. Asphalt demand scenarios due to COVID-19 in Asia.



Another key goal of this report is to segment asphalt binder demand by application and binder grades. Asphalt binder demand by application and grade along with growth forecasts for each of the major Asian countries are summarized in Exhibits 18 and 21. Although China dominates the market in terms of volume, India leads the region in growth forecasts over the next five years followed by Thailand, Vietnam, and India. China, in fact, has the slowest growth outlook among the seven countries evaluated in this study.

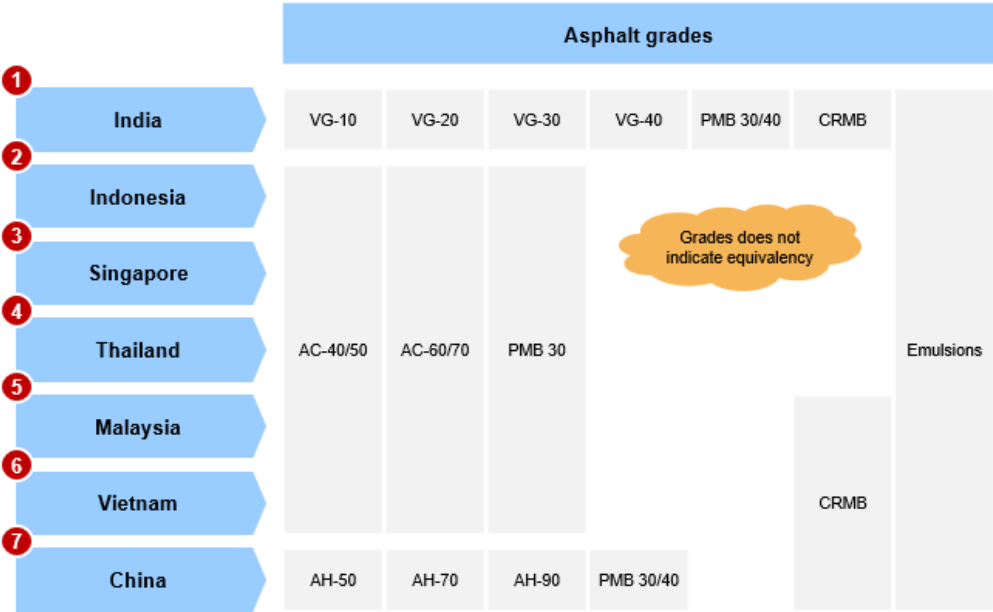
In terms of applications, most countries – Thailand, Indonesia, Vietnam, and Malaysia– are seeing asphalt binder demand growing the fastest for constructing highways and county and rural roads along with airports (see Exhibit 18). In China and Singapore though, airports, roofing applications, and highway construction – in that order – are the fastest growing end-uses reflecting that these countries have already made substantial road infrastructure investments. India, on the other hand, is seeing asphalt binder use growing the fastest in county, rural, and highway road construction followed by roofing and airport projects. In all countries though, county and rural road construction dominates asphalt binder use by volume.

Exhibit 18. Asphalt demand in million metric tons per year by application in Asia.



Most Asian countries use the pavement grading system to define their asphalt binder grades with India being the only exception. India has come to rely on viscosity grades to classify asphalt binders. In addition, there are a few other specialty grades including emulsions and polymer- and rubber-modified grades as detailed in Exhibit 19.

Exhibit 19. Asphalt grades use across key countries in Asia.



At a high level, bitumen grades dominate the distribution of asphalt binder grades in the key Asian countries as shown in Exhibit 20. In most key countries, bitumen grades account for 75% to 80% of the market although they account for a much higher share of 90% in India. The remaining market is distributed between bitumen emulsions and polymer-modified bitumen grades with some variations by country on their relative shares. For example, Malaysia and Thailand rely more on bitumen emulsions while Indonesia and Vietnam use more polymer-modified bitumens. The remaining countries – China, India, and Singapore – have a more or less even split across emulsion and polymer-modified bitumens. Finally, Exhibit 21 provides a deeper dive of the use and growth outlook for various asphalt binder grades in key Asian countries.

Exhibit 20. Asphalt grades distribution across key countries in Asia.

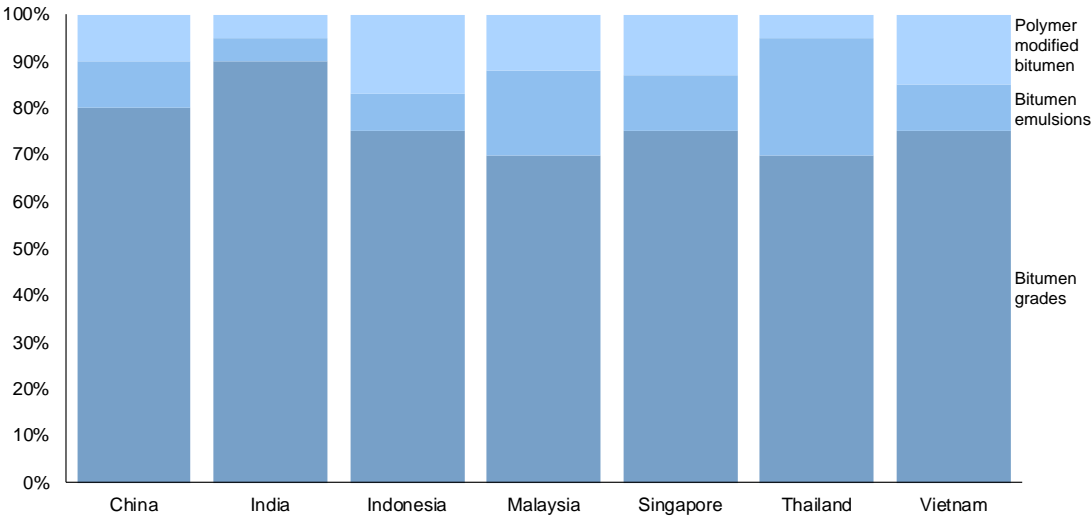
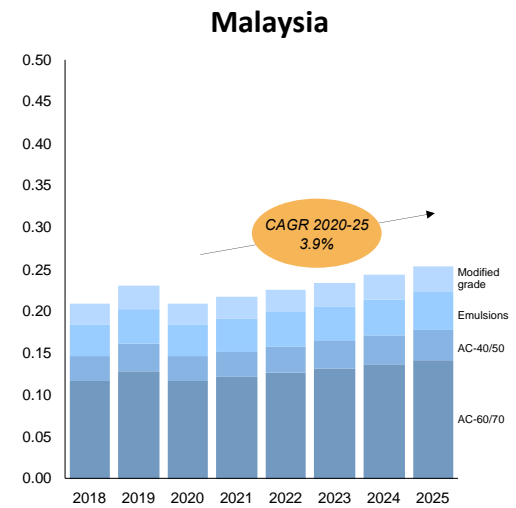
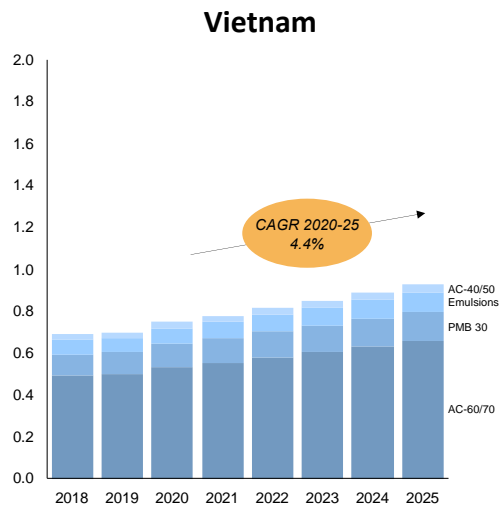
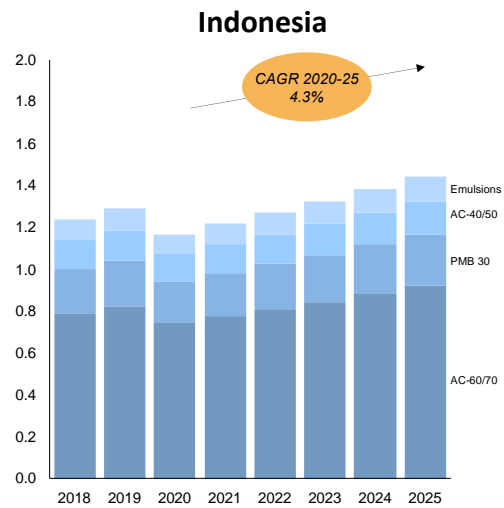
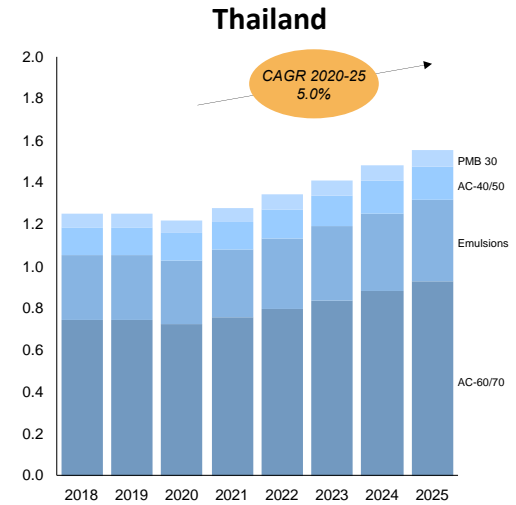
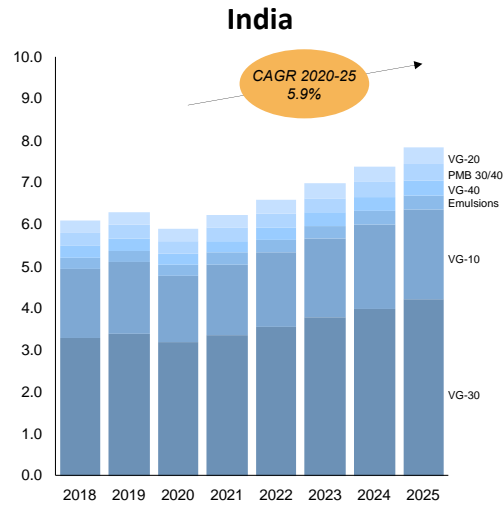
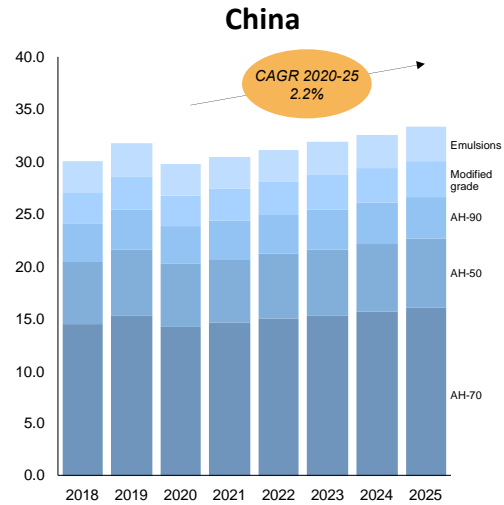


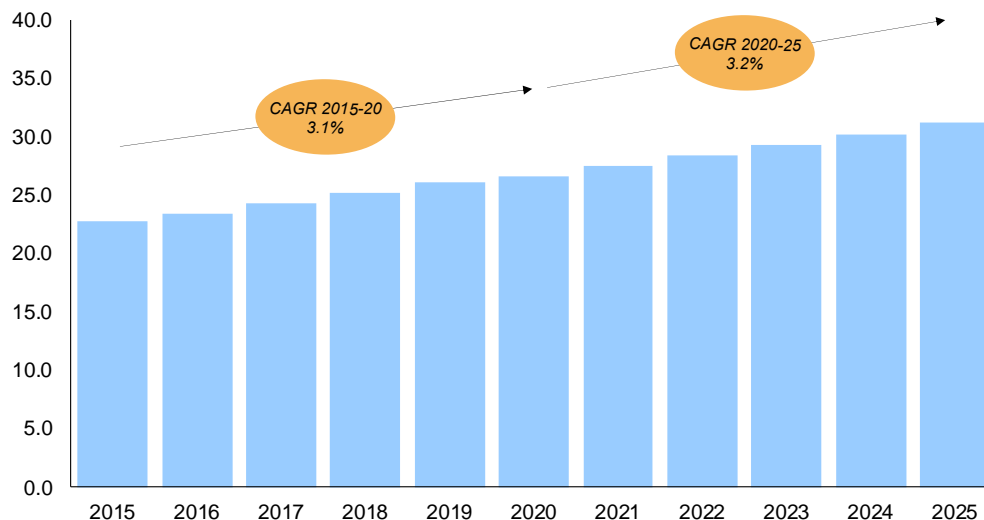
Exhibit 21. Asphalt demand in million metric tons per year by binder grade in Asia.



4.3. North American demand assessment

The North American demand assessment focused on the U.S. and Mexico based on AI guidance. Annual U.S. asphalt binder demand was estimated at 26.6 million metric tons in 2020 and expected to grow at 3.2% – not really different from the 3.1% observed over the past five years – to 31.2 million metric tons per year by 2025. Should there be significant new infrastructure investments as proposed by President Joe Biden during his election campaign, it is likely that the asphalt binder market may grow at a faster pace in the next five years. Exhibit 22 details the total demand for asphalt binder in the U.S., which is growing faster than Asia collectively but much slower than some of the key Asian countries such as India and Thailand.

Exhibit 22. Total asphalt binders demand in million metric tons per year in the U.S.



Unlike Asia, North American asphalt binder demand suffered disruptions due to COVID-19 but actually grew over the course of 2020 because the lockdowns provided federal and state government agencies and contractors an opportunity to complete road work backlogs. This is reflected in Exhibit 22 where asphalt binder demand grew in 2020 by 1.9% from 2019. Although the growth in 2020 was lower than the annual growth rate observed over the past five years, it was remarkable given the circumstances.

Finally, qualitative insights from expert interviews on the pandemic's impact on North American asphalt demand are summarized in Exhibit 23. Interview quotes show that although COVID-19 caused initial disruptions, asphalt binder demand and pricing both quickly recovered. Relative to the U.S. and Canada, expert interviews suggest that the initial disruptions were more severe in Mexico but the long-term implications are very limited across North America.

Exhibit 23. Asphalt grades distribution by region in North America.

Near-term Impact of COVID-19 for the Asphalt Industry in North America

Long-term Impact of COVID-19 for the Asphalt Industry in North America

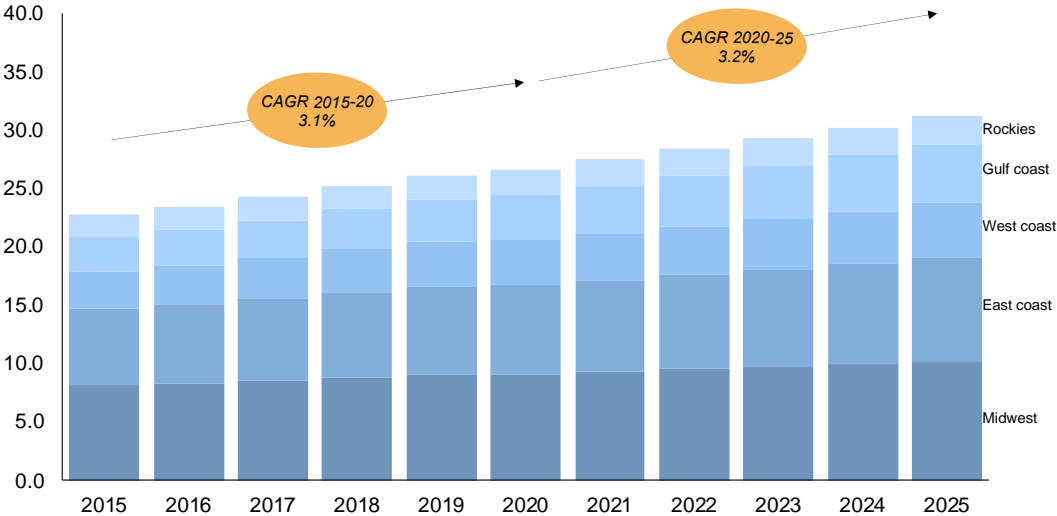


- “We saw a sudden drop in demand during COVID-19 lockdown and the supply of asphalt also slowed due to the oil price crash and refiners reducing their operating rates.”
- “Except for some pockets like in Pennsylvania, New York, and New Jersey area, the rest of the country had road work that was healthy during COVID-19.”
- “Asphalt prices were quite stable even during COVID as demand was robust during the lockdown.”
- “Demand for asphalt increased during COVID-19 as it was a good chance with low traffic to construct and maintain new roads.”

Note: The scale and significance of impact increase from 1 to 5

Exhibit 24 segments the total asphalt demand in the U.S. by region. The Midwest leads the regions accounting for a third of the country’s total demand followed closely by the East coast, which consumes more than 28% of the total demand in the U.S. The remaining demand is dominated by the U.S. Gulf and West costs and Rockies. Each of these regions have varying growth outlooks though as detailed in Exhibit 26 which segments asphalt demand by the various end-use applications. The Gulf coast leads the country with growth forecasted at 5.2% through 2025 followed by the West coast at 3.9% and the East coast and Rockies both of which are growing at rough similar rates. The Midwest is growing the slowest at 2.1% annually through 2025 but off of a large base. Exhibit 24 also includes market size estimates for Mexico where annual asphalt binder demand is estimated to be 1.8 million metric tons in 2020 and growing at 3.2% through the next five years.

Exhibit 24. Asphalt binder demand by region in million metric tons per year in North America.



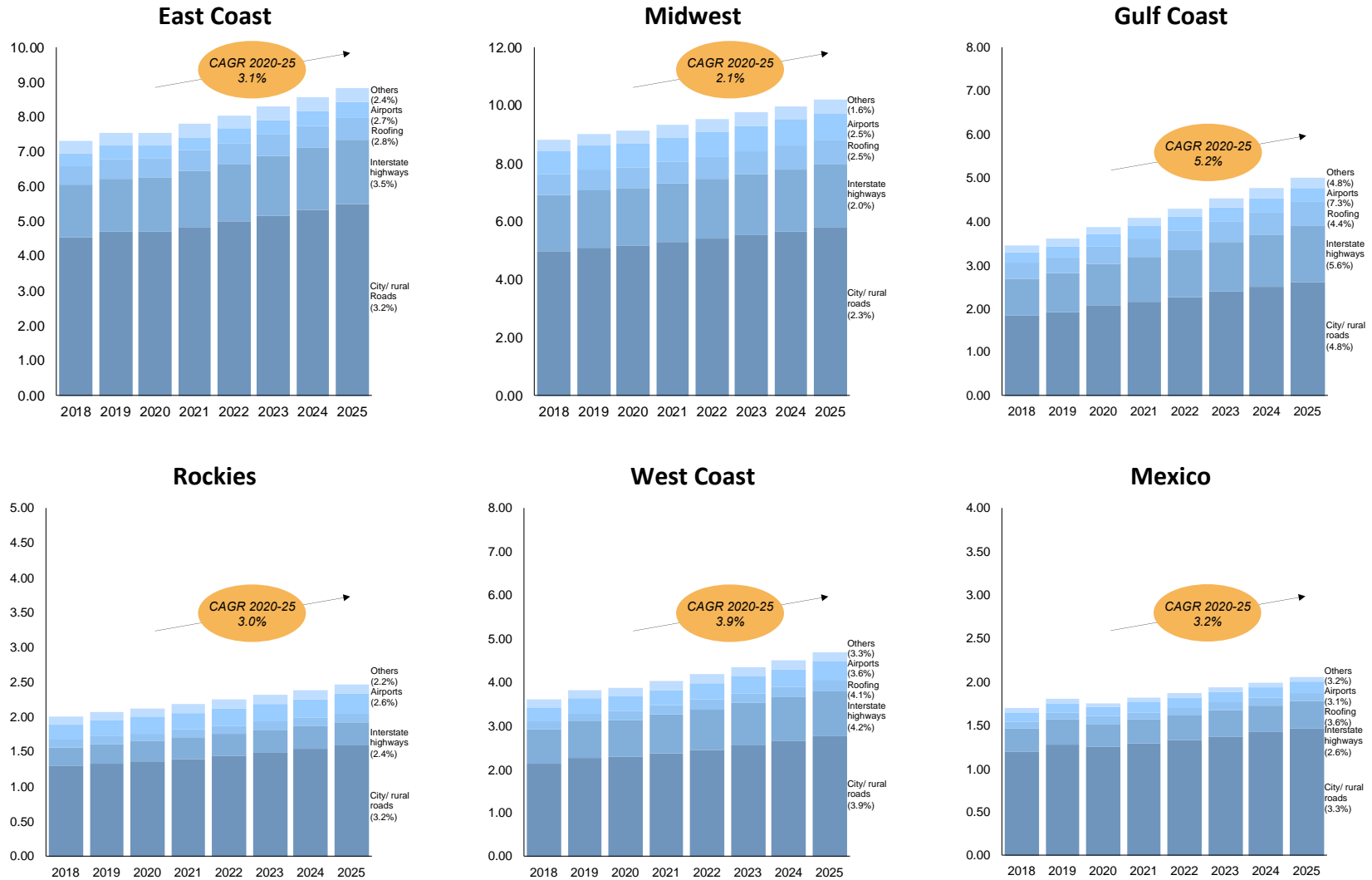
Assessing the outlook for asphalt binder demand in various applications in Exhibit 25 shows that the best opportunities are in interstate highways and roofing. These are followed by similar demand growth opportunities in rural and city roads and airport infrastructure. A qualitative assessment of the demand outlook by application for asphalt binder is illustrated in Exhibit 25. Evaluating the exhibit on a regional basis shows that the Gulf and West coast regions offer the best opportunities for growth in the U.S. followed by Mexico where interstate highways and roofing applications are doing well. Finally, East coast and the Rockies lag the other regions with promising growth opportunities in just one application each.

Exhibit 25. Asphalt binder demand outlook by application in North America.

	Interstate highways	Rural/City roads	Airport roads	Roofing
U.S.	●	●	●	●
East Coast	●	●	●	●
Midwest	●	●	●	●
Gulf Coast	●	●	●	●
Rockies	●	●	●	●
West Coast	●	●	●	●
Mexico	●	●	●	●

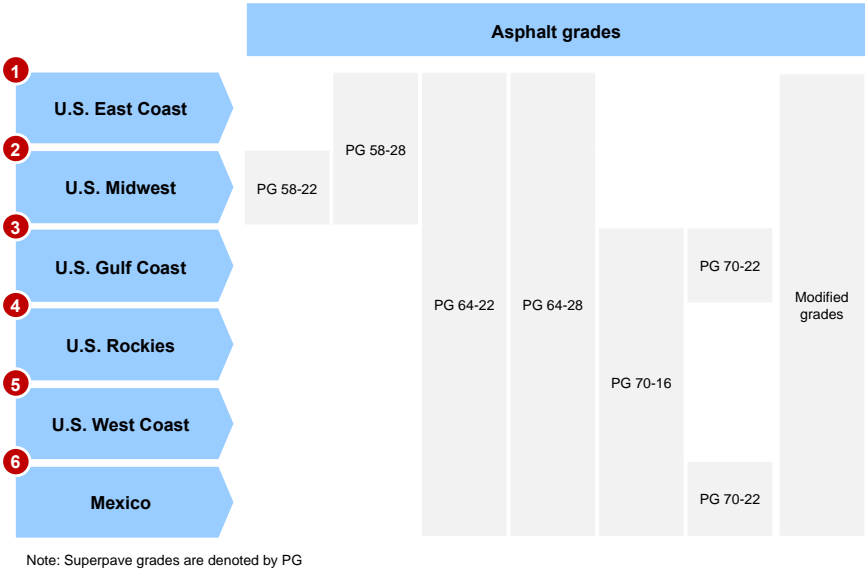
● Low growth ● Moderate growth ● High growth

Exhibit 26. Asphalt demand in million metric tons per year by application in North America.



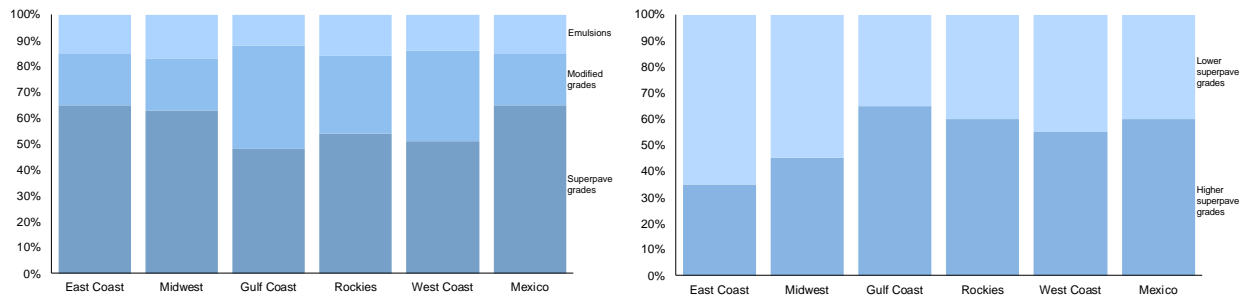
The U.S. classifies asphalt binders using the superpave terminology and Exhibit 27 shows the relative preference for grades by region. Superpave grades PG 64-22 and 64-28 along with polymer-modified bitumen are widely used across the country. There are additional grades that have varying preferences based on climatic conditions in the U.S. colder parts of the East coast and the Midwest rely more on PG 58-22 and 58-28. A warmer climate in the Gulf and West coasts, the Rockies, and Mexico drives a preference for PG 70-16 with PG 70-22 also being preferred on the Gulf coast and in Mexico.

Exhibit 27. Relative preference of asphalt binder grades by region.



Collectively, as shown in Exhibit 28, superpave grades account 48% to 65% of asphalt binder demand across the regions in U.S. and Mexico. The East coast, Midwest, and Mexico are at the higher end of that range in their demand for superpave grades while the other regions are on the lower end of the range and, instead, rely more on modified bitumen grades, which varies between 20% to 40% across the regions. In general, most regions have a more or less similar level of demand for emulsion grades ranging from 12% to 17%. Finally, as also seen in Exhibit 28, climatic conditions drive the preference between lower and higher superpave grades. Colder climates in the East coast and Midwest drive their preference for the lower superpave grades, while higher superpave grades find most use in the Gulf and West coasts, the Rockies, and Mexico. A deeper diver on regional demand for bitumen segmented by grades is provided in Exhibit 30.

Exhibit 28. Asphalt binder grades distribution by region in North America.



Finally, although asphalt binder demand growth is promising in North America, the use of recycled asphalt pavement (RAP) is also growing steadily. Exhibit 29 shows that commercial and residential customer are the largest users of RAP, which accounts for more than 20% of asphalt demand in the sector. Projects funded by the U.S. Department of Transportation are the next largest users of RAP at about 21% of their asphalt binder consumption. State government agency-funded projects lag these users in RAP use which accounts for nearly 19% of the segment’s demand. Collectively, average RAP use across the U.S. is a little over 20% of asphalt demand. The share of RAP is likely to only increase further with growing societal and regulatory pressure around sustainability putting some downward pressure on the overall market’s growth.

Exhibit 29. Average recycled asphalt pavement usage in percentage by sector.^{vi}

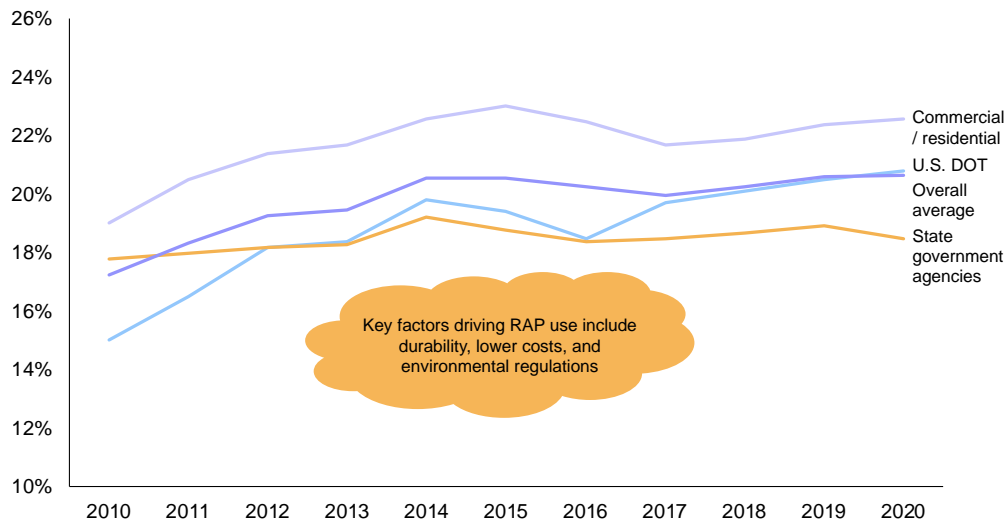
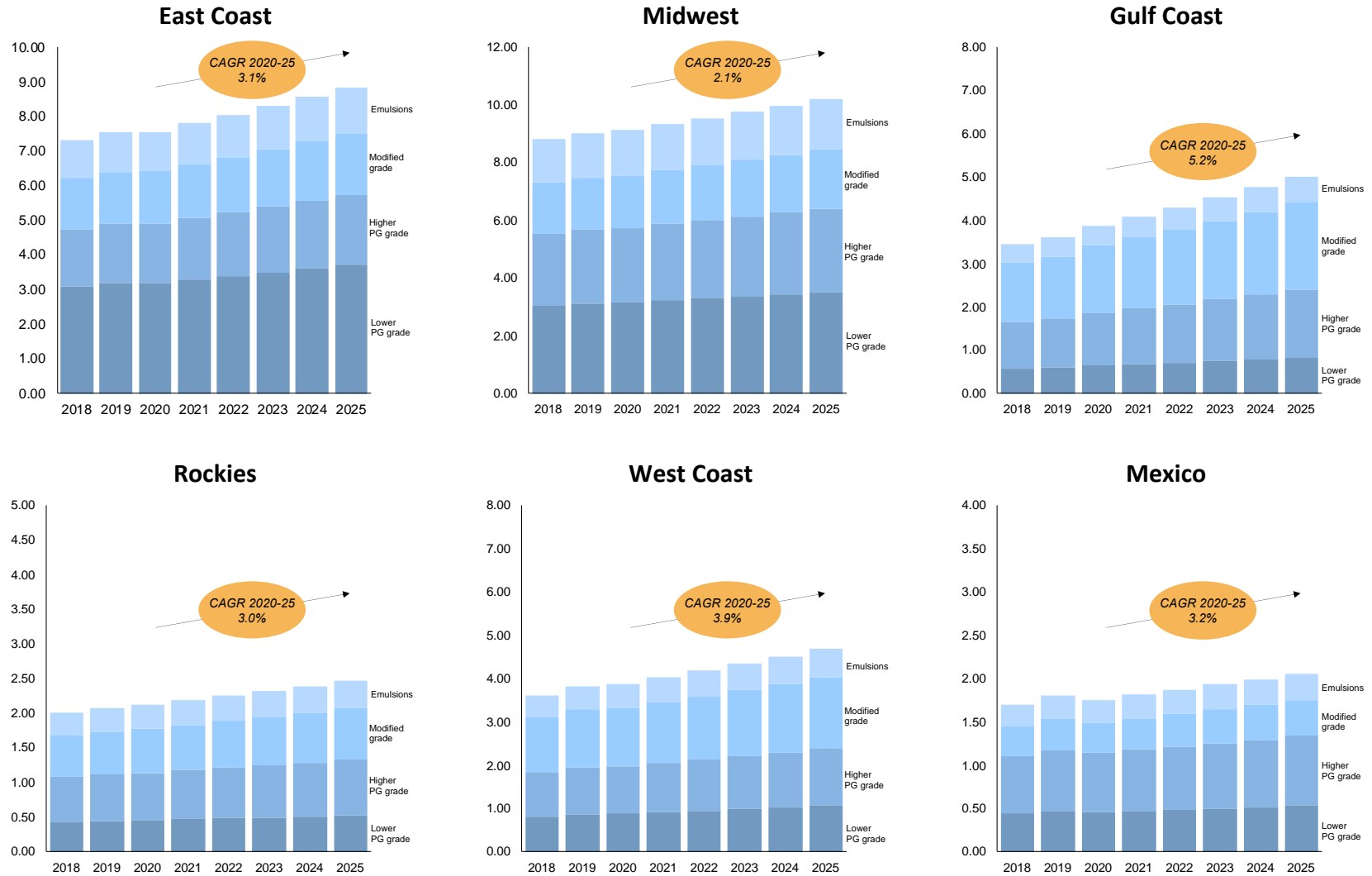


Exhibit 30. Asphalt demand in million metric tons per year by grade in North America.



5.0 Asphalt binder customer behavior and insights

A key part of this project has been primary research with emphasis on interviews with a broad range of market participants and industry experts. ADI interviewed more than 40 experts with experience in multiple regions of the world and across the asphalt binder value and particularly so in sales, marketing, supply chain and logistics, and customer engagement.

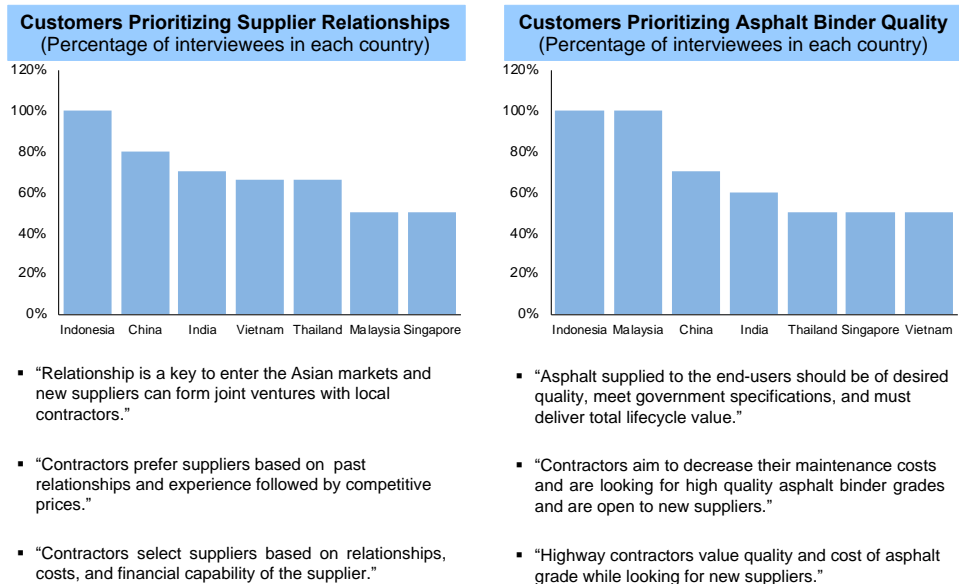
A structured interview guide (see Exhibit 4) was developed in collaboration with AI to ensure that these interviews focus on the key questions of interest to Canadian asphalt binder suppliers. Interview transcripts and notes were analyzed carefully to identify a number of market and commercial insights around customer behavior, vendor selection and decision making, pain points and needs, and supplier positioning. This section summarizes the key findings and insights from this work.

5.1. Asian customer preferences

Relationships with asphalt binder suppliers, asphalt binder pricing, and product quality – in that order – are the top three factors that Asian customers use in selecting suppliers. In most of the key Asian countries, at least two-thirds of the experts interviewed identified relationships with asphalt binder suppliers as an important factor in selecting vendors. Recognizing the importance of this factor, interviewees suggested that partnering with existing, local vendors would be an effective way for new suppliers to enter the Asian market. Exhibit 31 shows that 50% of interviewees in Malaysia and Singapore identified relationships as a key factor in selecting suppliers with that metric being as high as 100% in Indonesia and more than 66% in the other key.

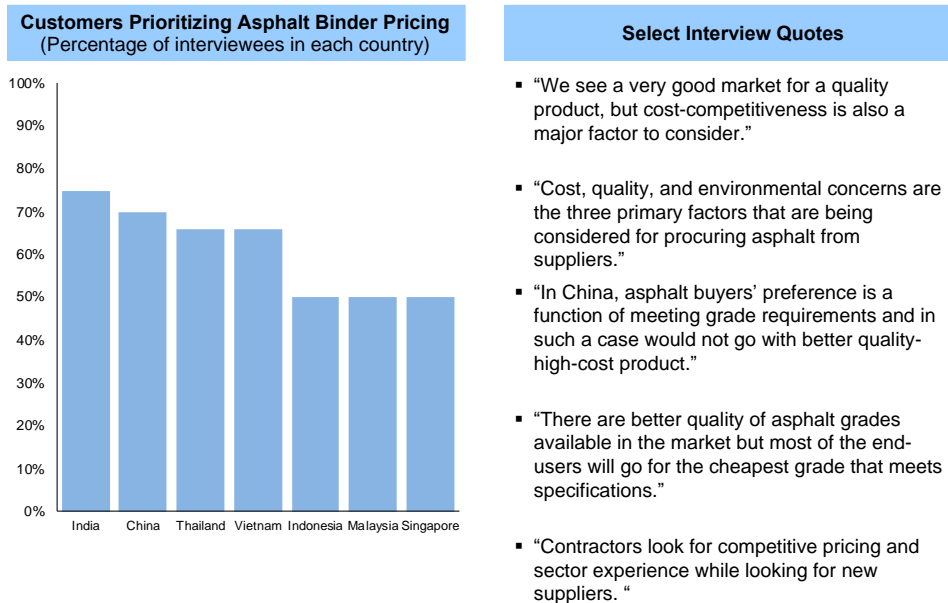
Exhibit 31 also shows the importance interviewees in Asian countries placed on asphalt binder quality. All interviewees in Indonesia and Malaysia followed by 50% to 70% of interviewees in the remaining Asian countries ranked quality as one of the top three criteria for selecting asphalt binder suppliers. Even so, interviews on this topic demonstrated that many customers in Asia viewed asphalt binders that comply with a limited set of specifications set by government or other agencies as a sufficient metric for quality. At best, customers saw a variation in asphalt binder grades as another metric for product quality. In fact, no one mentioned additional tests or property measurements of asphalt binders to assess any performance outcomes.

Exhibit 31. Importance of relationship and quality for Asian asphalt end-users.



Pricing followed by vendor relationships was identified as the most important criteria in selecting asphalt binder suppliers. Exhibit 32 shows that across Asia 50% to 75% of interviewees prioritized asphalt binder pricing as a factor in selecting suppliers. A larger number of interviewees in India and China saw pricing as an important driver while Indonesia, Malaysia, and Singapore had fewer but still half of all interviewees viewing pricing as critical to their decision-making process. Several industry participants mentioned during interviews that new suppliers into this part of the world would have to demonstrate high levels of pricing competitiveness to win customers and gain market share.

Exhibit 32. Importance of binder pricing for Asian asphalt end-users.



Collectively, interviews with Asian customers show that vendor relationships, pricing, and quality are three most important criteria used to select asphalt binder suppliers. However, a few other factors were also identified as inputs into the decision-making process as shown in Exhibit 33. Specifically, the following additional factors were mentioned during interviews in decreasing order of importance after the top three factors: (1) experience in supplying asphalt binder to a particular customer's end-use sector (e.g., airport infrastructure, freeways, etc.), (2) breadth of asphalt binder grade offerings, (3) suppliers' creditworthiness given that a lot of customers are building government-funded and expensive infrastructure projects, (4) scale i.e. the ability to produce large volumes of asphalt binder, and (5) location and logistical capabilities.

Interesting country-specific observations can also be made from Exhibit 33. For example, barring China and India, most countries in Asia rely most on no more than three factors. For example, Indonesia, Malaysia, and Singapore are the three countries that specifically view quality as an important factor in decision-making. Canadian asphalt binder suppliers could begin by first focusing on those three countries to develop business and find new customers. Vietnam, on the other hand, is heavily dependent on supplier relationships, and partnerships will be critical to develop opportunities in that country.

Finally, India and China rely on four and six different factors, respectively, in selecting asphalt binder suppliers indicating their large and complex markets. Canadian asphalt binder suppliers should, therefore, approach by first carefully segmenting these markets into end-use

applications that value quality and performance outcomes and then develop appropriate go-to-market strategies based on price competitiveness, local partnerships, and other features that allow them to win business efficiently.

Exhibit 33. Selection criteria for Asian asphalt binder end-users.

	Price	Relationships	Sector experience	Supplier creditworthiness	Quality	Location/ logistics	Offering breadth	Scale
China	High priority	High priority	High priority	Low priority	Moderate priority	High priority	High priority	High priority
India	High priority	Moderate priority	Moderate priority	High priority	Moderate priority	Moderate priority	High priority	High priority
Indonesia	Moderate priority	High priority	Moderate priority	Low priority	High priority	Moderate priority	Moderate priority	Low priority
Singapore	Low priority	High priority	Moderate priority	High priority	High priority	Moderate priority	Low priority	Low priority
Thailand	High priority	Moderate priority	High priority	Moderate priority	Moderate priority	Moderate priority	Moderate priority	Moderate priority
Vietnam	Moderate priority	High priority	Moderate priority	Moderate priority	Moderate priority	Moderate priority	Moderate priority	Moderate priority
Malaysia	High priority	Moderate priority	Moderate priority	Moderate priority	High priority	Low priority	Moderate priority	Low priority

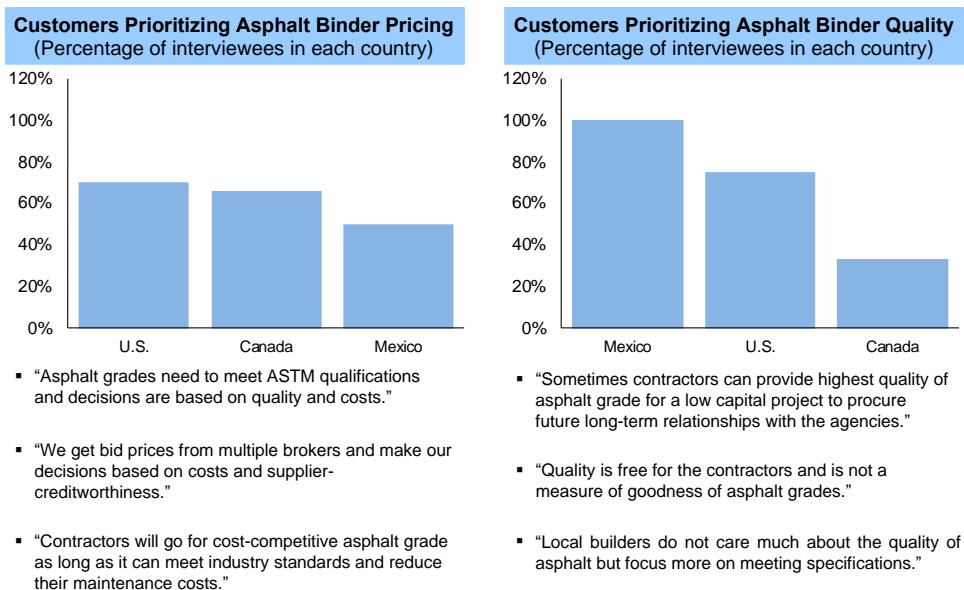
● Low priority
 ● Moderate priority
 ● High priority

5.2. North American customer preferences

Asphalt binder pricing, product quality, and breadth of grade offerings – and all equally weighted – are the top three factors that North American customers use in selecting suppliers. Interviews with industry participants in the region showed that 50% to 70% of customers value pricing highly in their supplier selection process as shown in Exhibit 34. In the case of product quality, 33% to 100% of interviewees saw it as an important factor in supplier selection.

Country-specific factors also play a role in interviewee responses. For example, since a lot of infrastructure projects are focused on road construction in Mexico and local asphalt binder suppliers compete heavily on price, industry participants in our interviews took that as a given and more did not identify price as a key decision-making criterion. U.S. interviewees, on the other hand, came from a much wider range of asphalt applications and, therefore, saw price more important especially since some of them relied on more expensive asphalt binder grades.

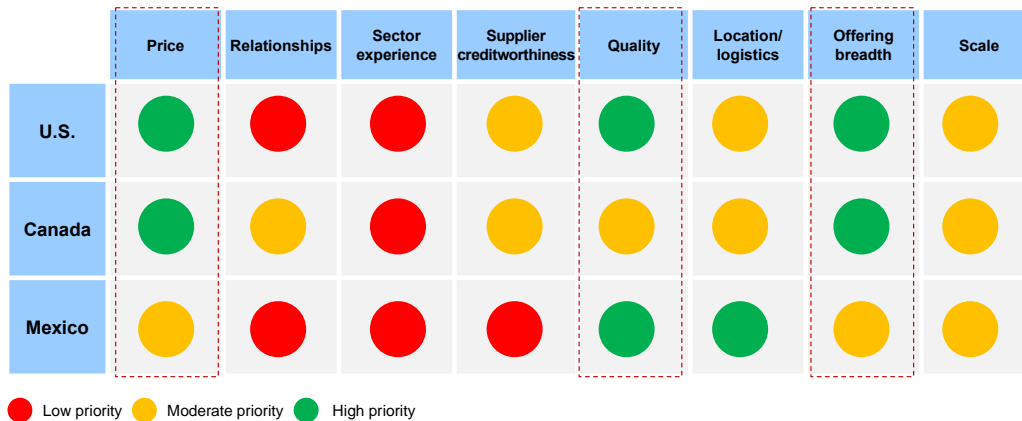
Exhibit 34. Importance of binder pricing and quality for North American end-users.



Collectively, interviews with North American customers show that asphalt binder pricing, product quality, and breadth of grade offerings are three most important criteria used to select asphalt binder suppliers. However, a few other factors were also identified as inputs into the decision-making process as shown in Exhibit 35. Specifically, the following additional factors were mentioned during interviews in decreasing order of importance after the top three factors: (1) location and logistical capabilities, (2) scale i.e. the ability to produce large volumes of asphalt binder, (3) suppliers' creditworthiness given that a lot of customers are building government-funded and expensive infrastructure projects, (4) relationships with asphalt binder suppliers, and (5) experience in supply asphalt binder to a particular customer's end-use sector (e.g., airport infrastructure, freeways, etc.).

Interesting country-specific observations can also be made from Exhibit 35. For example, U.S. and Mexico both identified quality as a high-priority metric in their decision-making process. Canadian industry participants did not list quality as a high-priority metric likely because they already have access to high-quality asphalt binder coupled with the limited number of interviews conducted in Canada as mandated by AI in the scope of this project. Further, Mexico values location and logistical capabilities, while breadth of grade offerings is important to U.S. and Canadian customers. Given these dynamics, Canadian asphalt binder suppliers need to develop appropriate go-to-market strategies with commercial offerings that emphasize (and educate customers on) quality, breadth of offerings, logistical flexibility, and price competitiveness.

Exhibit 35. Selection criteria for North American asphalt binder end-users.



5.3. Customer and end-user needs and pain points

Customer interviews also identified a number of needs and pain points that are not being served adequately by asphalt binder suppliers. Canadian asphalt binder suppliers have an opportunity to differentiate their offerings by recognizing these needs and develop appropriate strategies to address them in their offerings and go-to-market strategies. Exhibit 36 summarizes the key findings from customer interviews including the leading needs and pain points and a select set of interview quotes.

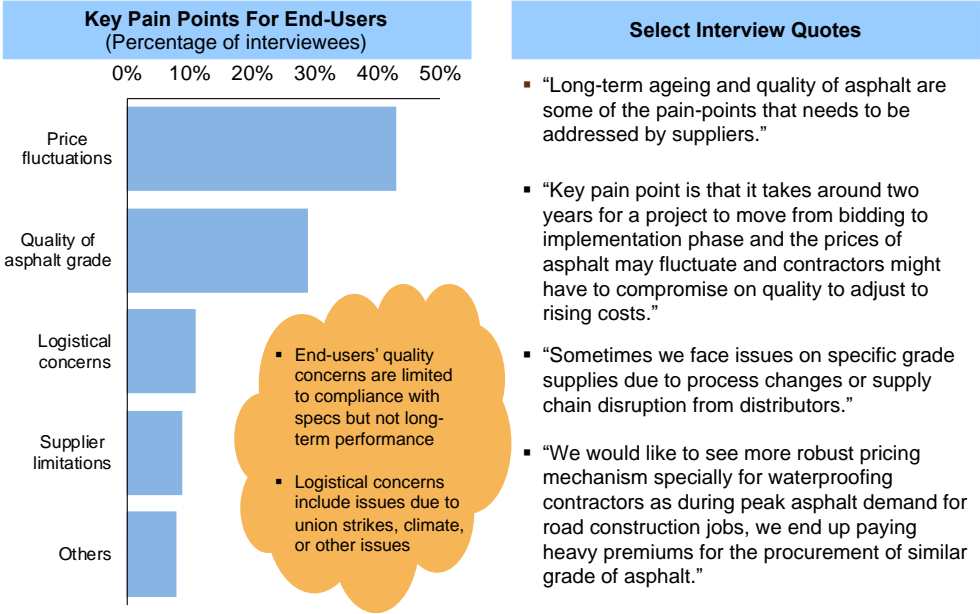
Briefly, fluctuations with asphalt binder prices and asphalt binder grade quality lead the list of customer pain points and needs. Price fluctuation is a key challenge for asphalt binder customers, and most would value options that allow them to lock prices in since asphalt binder applications are typically in infrastructure projects that take anywhere from months to years.

Many customers identified asphalt binder quality as a pain point and a need but most of them were referring to a supplier’s ability to meet product specifications on a consistent basis over long periods of time and, at least, over the duration of an infrastructure project. Many customers reported suppliers’ continual challenges with meeting product specifications. While this may offer Canadian asphalt binders an opportunity to differentiate their offerings, it should not be confused with customers seeking higher performance outcomes from their asphalt binder suppliers. Most customers are not really seeking performance-differentiated asphalt binder primarily because of limited awareness. Canadian asphalt binder suppliers would have to invest in educating customers on the long-term value of selecting asphalt binders and suppliers based on performance outcomes.

Finally, logistical concerns such as union strikes and climate-related delays and suppliers’ limitations around breadth of offerings were also identified by a few customers as pain points.

In addition, a very limited set of customers also identified other concerns such as sustainability, innovation, and technical support. As the asphalt binder market and broader sustainability concerns grow, customers will demand suppliers to offer more mature and sophisticated product and commercial offerings that Canadian asphalt binder suppliers should evaluate to differentiate themselves.

Exhibit 36. Key pain points for asphalt binder end-users.



5.4. Key differences in Asian and North American markets

A comparison of the research and findings on the Asian and North American asphalt binder markets shared in the preceding sections shows a few key differences in both markets. Reviewing these differences can help producers of Canadian asphalt binders tailor appropriate strategies to each of these markets. Briefly, there are four key differences between these two markets:

- In terms of supplier selection of asphalt binder grades, Asian end-users consider price, quality, and experience as the three most important criteria for binder selection. North American end-users value prices, offering breadth, and quality over other factors.
- Asphalt binder demand growth is promising in North America but the use of recycled asphalt pavement (RAP) is also growing steadily accounting for approximately 20% of the total asphalt demand in the region. Asian contractors are increasingly adopting recycled

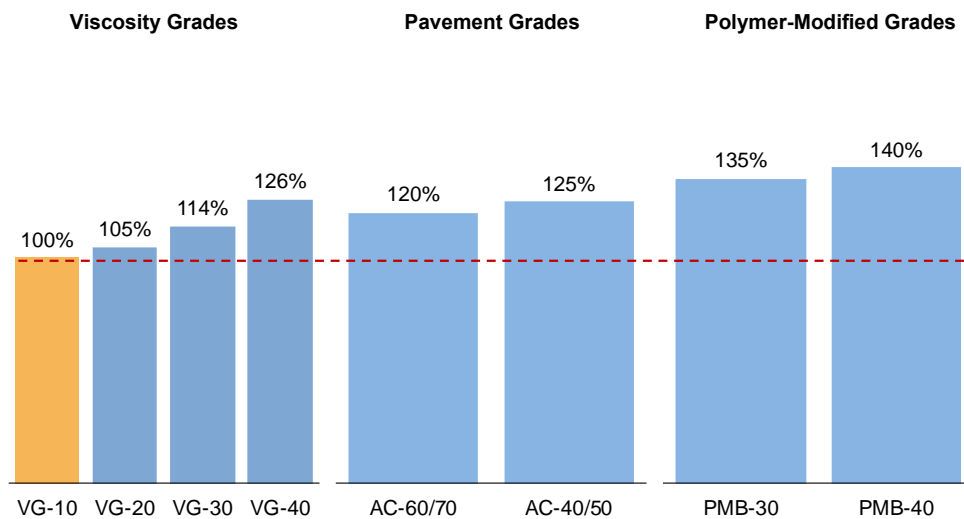
asphalt for pavement jobs to reduce their operational costs but the current usage is well below 5% of the total demand in the key Asian countries.

- Moderate growth for asphalt demand is expected in North America for the construction of highways, expressways, city/rural roads, and airport jobs. U.S. Gulf and west coasts are the most promising regions in North America with the highest growth rates expected in the future. In Asia, on the other hand, robust demand is expected for asphalt grades in highways projects especially in India, Vietnam, Malaysia, Thailand, and Indonesia. Most of these countries have announced several airport projects in the coming years which will drive demand for premium asphalt binder grades in the near-term.
- Asian markets see robust demand for conventional grades such as VG-30, AC-60/70, or AH-70 grades with similar properties. North American asphalt binder markets, on the other hand, have growing demand for high- performance polymer-modified grades which are sold at a premium over conventional grades.

6.0 Asphalt binder pricing trends

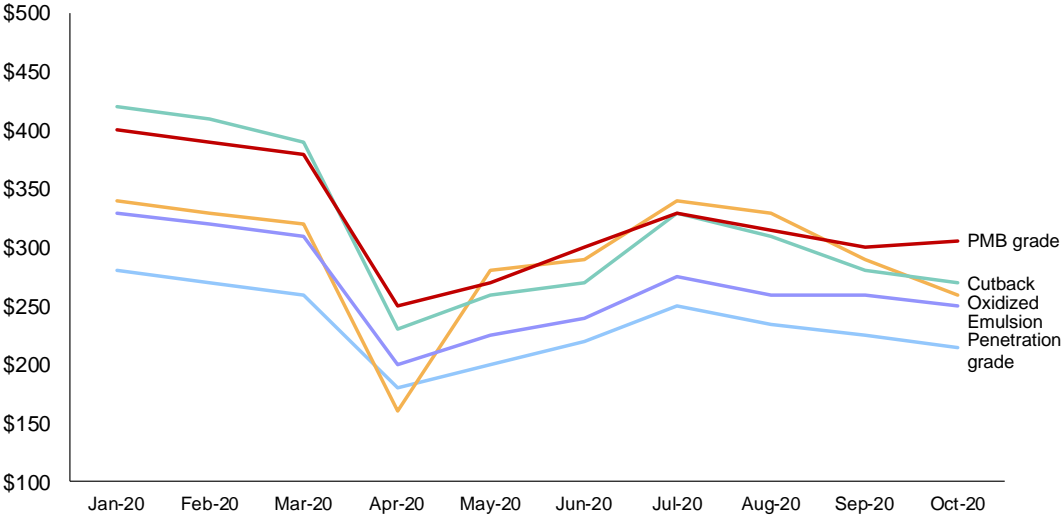
A high-level survey of recent asphalt binder pricing was conducted during this project using secondary research and validated through customer interviews. Exhibit 37 shows the relative pricing trends in Asia across different asphalt binder grades. Benchmarked relative to the viscosity grade, VG-10, other viscosity grades have premiums ranging from 5% to ~25% while pavement grades command price premiums of 20% to 25%. Polymer-modified grades enjoy the best price premiums relative to VG-10 that range from 35% to 40% reflecting their superior performance and specifications. As a point of reference, the VG-10 bulk bitumen was priced at approximately U.S. \$270 per metric ton in India in September 2020.

Exhibit 37. Relative prices of asphalt binder grades in Asia.



In absolute pricing trends, all asphalt binder grades range from U.S. \$200 to U.S. \$450 per ton through most of 2020. Further, most saw a sharp collapse in pricing in March and April 2020 due to COVID-19 but also saw a price recovery by July and August as seen in Exhibit 38. As discussed earlier, penetration grades of asphalt binder have the lowest prices and specialty grades such as polymer-modified bitumen and cutback, oxidized, and emulsion grades all enjoy premiums over the penetration grades. Finally, asphalt binder pricing in Asia is significantly lower than absolute pricing trends in North America.

Exhibit 38. Average asphalt prices by grade in Asia.vii



North American asphalt binder pricing trends are shown in Exhibit 39. Canadian asphalt binder pricing is higher than that in the U.S. by approximately U.S. \$200 per ton. Finally, asphalt binder prices by region for a representative grade – PG 64-22 – are summarized in Exhibit 40. The East coast and the Northwest lead the regions in the U.S. in terms of asphalt binder pricing even if the differences are smaller. The Gulf Coast, Rockies, and the Midwest all have similar pricing and patterns but lower in absolute pricing than that seen on the East coast and in the Northwest. Canadian asphalt binder suppliers should carefully evaluate these pricing trends and patterns for insights and strategies to drive price competitiveness.

Exhibit 39. Average asphalt binder prices in U.S. dollars in North America.^{viii}

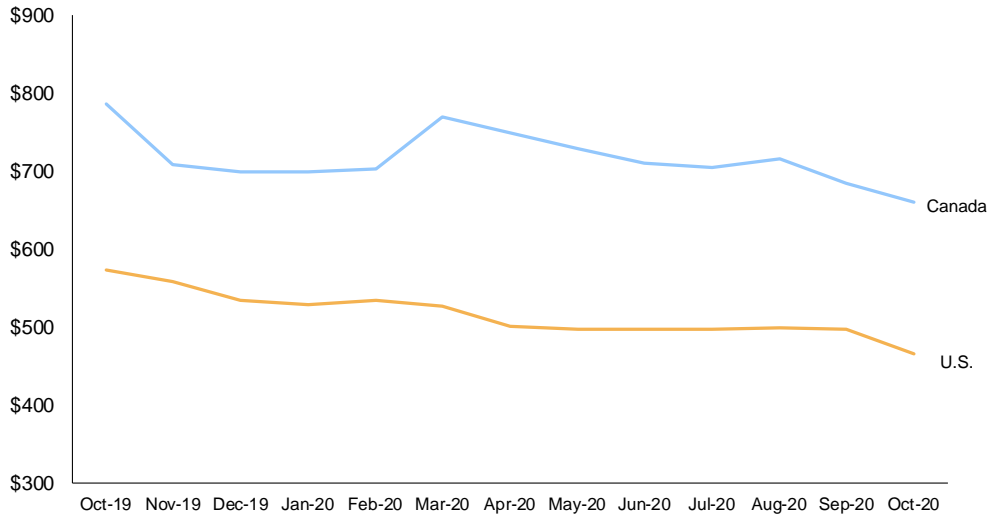
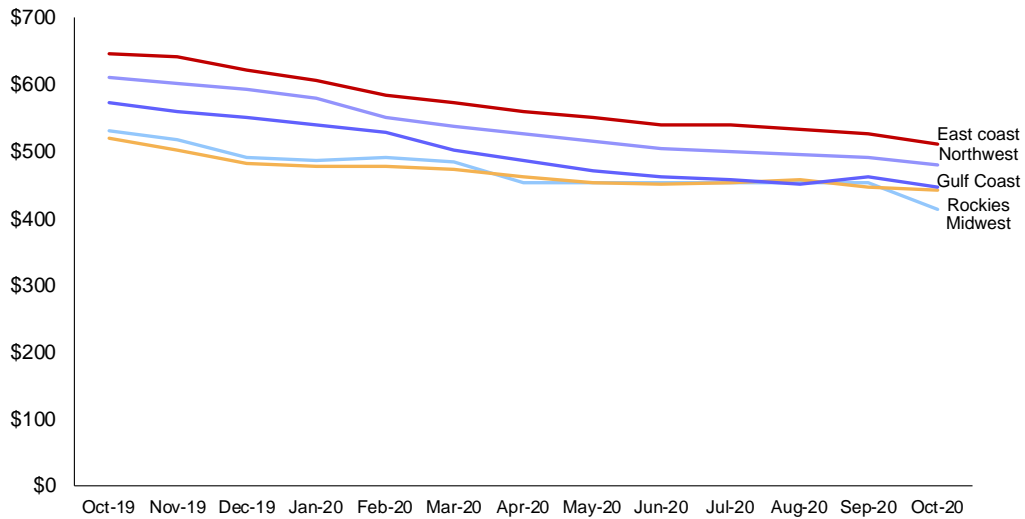


Exhibit 40. Average asphalt grade PG 64-22 prices in U.S. dollars by region.^{ix}



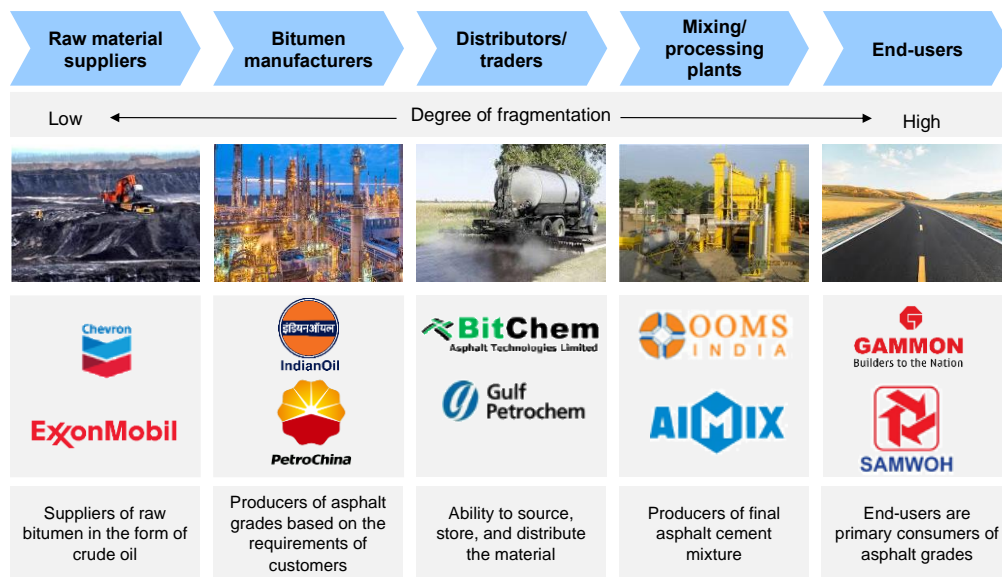
7.0 Supply chain and logistics

An understanding of the supply chain and logistical features of the asphalt binder industry and market can help Canadian suppliers better define engagement points and commercial strategies. To that end, this study has briefly reviewed these aspects of the market based on both primary and secondary research. Like in any market, supply chain and logistics play an important role in the asphalt binder industry but their importance is only growing as infrastructure development expands into more difficult, remote, and traditionally underserved regions of the world. As a result, in addition to the quality of asphalt binder, the scale and complexity of logistics and the supply chain also change creating new challenges for asphalt binder suppliers.

7.1. Asphalt binder supply chain overview

There are several ways to represent the asphalt binder supply chain with each industry participant viewing it in different ways. Broadly, there are five key segments in the asphalt binder supply chain as illustrated in Exhibit 41. The supply chain begins with raw material suppliers that include large oil exploration and production companies including oil sands miners such as ExxonMobil, Chevron, and Suncor followed by bitumen manufacturers who are usually petroleum refiners such as Indian Oil and PetroChina. Distributors and traders initiate the sales and commercial parts of the value chain followed by service providers such as mixing and processing plants that actually produce the final asphalt cement mixture with end-users and customers terminating the supply chain.

Exhibit 41. An illustrative view of the asphalt binder supply chain.

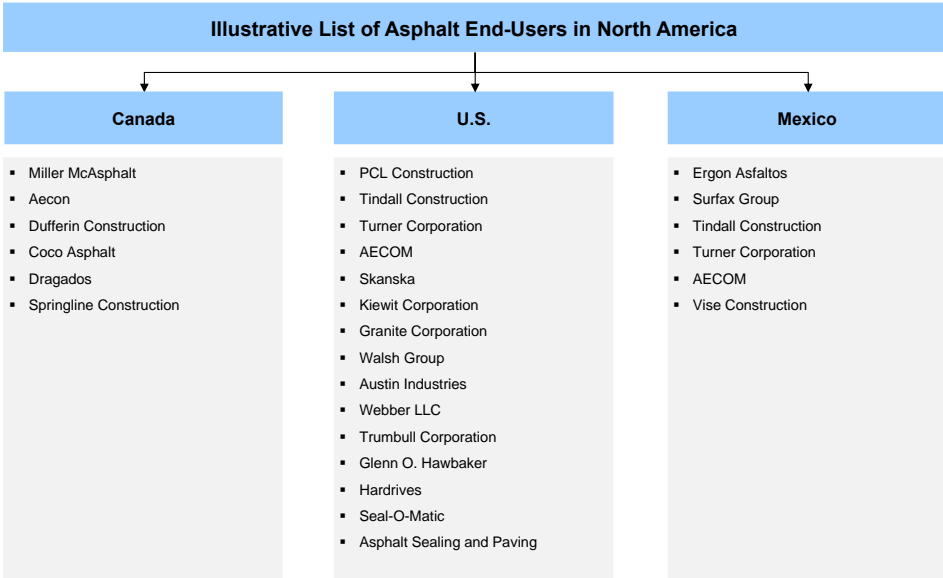


The upstream parts of the supply chain -- i.e., oil producers and refiners -- is highly concentrated with a handful of companies in each region dominating the market. As one goes down the supply chain, the degree of fragmented starts rising rapidly. There are several distributors and traders with most of them focusing on specific countries and limited to scale at the regional levels. Finally, the market gets really fragmented with a wide range of end-users and customers across a broad range of market segments ranging from infrastructure developers to residential and commercial construction companies. An illustrative list of asphalt binder users in Asia and North America are provided in Exhibits 42 and 43.

Exhibit 42. An illustrative list of asphalt binder end-users in Asia.

Illustrative List of Asphalt End-Users in Asia					
China	India	Indonesia	Singapore	Thailand	Vietnam
<ul style="list-style-type: none"> ▪ China Gezhouba Group ▪ China Railway Construction ▪ Shanghai Construction ▪ Yunnan Construction ▪ China Road and Bridge Corp. ▪ Shaanxi Construction ▪ Hunan Construction ▪ China State Construction 	<ul style="list-style-type: none"> ▪ National Highway Authority of India ▪ Border Roads Organization ▪ BitChem Asphalt ▪ Ooms Polymers ▪ Tinna Rubber ▪ Gammon India ▪ IRCON International ▪ Dilip Buildcon ▪ Ashoka Buildcon ▪ PNC Infra ▪ Sadbhav Engineering ▪ Hindustan Construction 	<ul style="list-style-type: none"> ▪ Nakano Corporation ▪ PT Hutama Karya ▪ PT Wijaya Karya ▪ Pembangunan Perumahan 	<ul style="list-style-type: none"> ▪ Samsung Engineering ▪ Samwoh Corporation ▪ Shimizu ▪ Penta-Ocean Construction ▪ KTC ▪ Koh Brothers 	<ul style="list-style-type: none"> ▪ Italian Thai ▪ CH Karnchang ▪ Sino Thai ▪ NSL Construction ▪ Samsung Engineering ▪ Toan Trung 	<ul style="list-style-type: none"> ▪ POSOC E&C ▪ Vinaconex ▪ Hoa Binh Construction ▪ BMT ▪ Phuoc Thinh Phat ▪ Toan Trung ▪ Phuong Thien Nguyen ▪ Coteccons Construction ▪ Ricons Construction

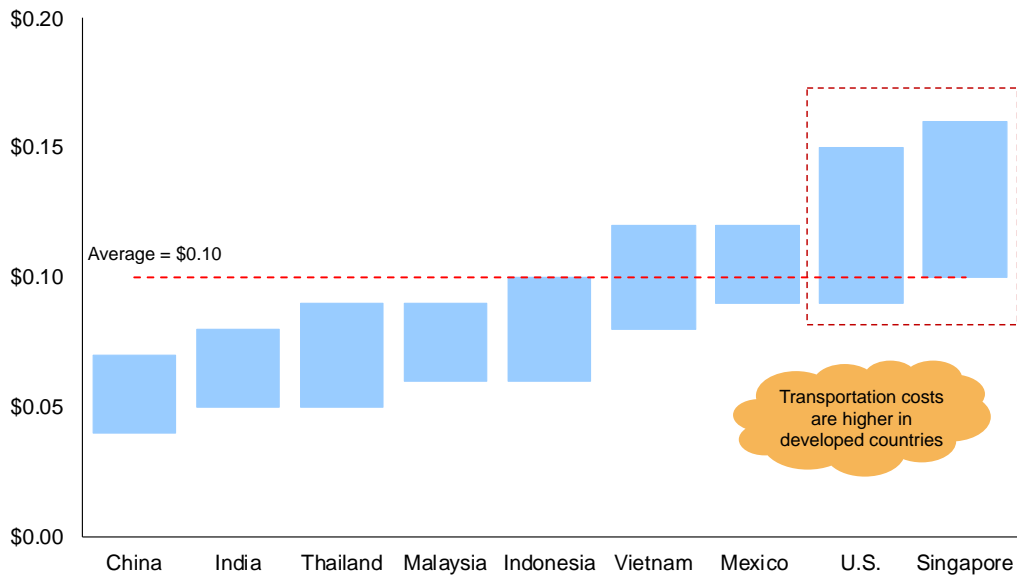
Exhibit 43. An illustrative list of asphalt binder end-users in North America.



7.2. Transportation costs and logistics

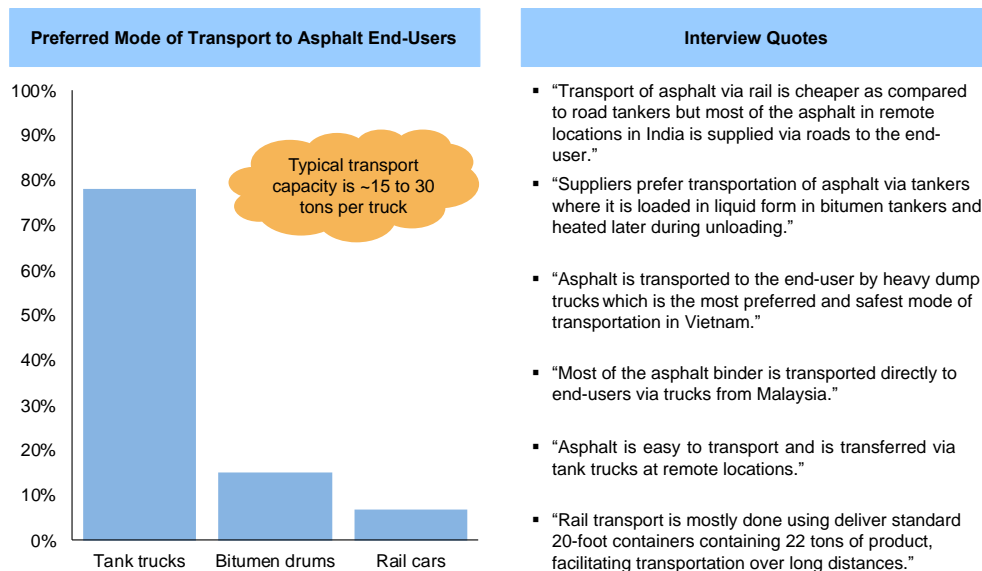
Transportation costs can significantly impact the costs and economics of a customer’s project. As a result, transportation costs play an important role in customer preferences on both asphalt binder grades and suppliers. There is a wide variation in transportation costs even within a specific market or country, and certainly so across countries in Asia and North America. Exhibit 44 shows that transportation costs can vary from U.S. \$0.04 to U.S. \$0.07 per mile per ton on the low end to as much as U.S. \$0.10 to U.S. \$0.16 per mile per ton on the high end. Developed markets such as the U.S. and Singapore have much higher transportation costs in comparison to emerging economies such as China and India. On average, across the different countries assessed during this project, asphalt binder transportation costs are U.S. \$0.10 per mile per ton.

Exhibit 44. Average costs of road transportation in U.S. dollars per mile per ton by country.



Asphalt binder suppliers and customers have several options around transportation modes and logistics. For example, for local transport, customers and suppliers can use tank trucks, bitumen drums, or rail cars to move asphalt binder to end-users. Exhibit 45 shows that the preferred mode of transportation is dominated by tank trucks, which accounts for nearly 80% of customer preferences. This choice has become particularly preferred in recent years as infrastructure projects expand into remote areas where tank trucks offer far more flexibility over the other options. In general, transportation of asphalt via railcars is the cheapest mode of transport followed by transportation in bitumen drums and tank trucks, respectively. Experts interviewed suggested that it costs 15% to 20% less to transport asphalt via railcars as compared to other modes of transport but end-users still prefer transportation via tank trucks to deliver asphalt and achieve last-mile connectivity.

Exhibit 45. Preferred mode of transport to asphalt end-users.



Similarly, Exhibit 46 shows that asphalt binder can be transported over long distances in multiple ways including via bitumen vessels or shipping containers such as "Bitutainers" and Tianjin China Bitumen Shipping Containers, in used or new drums, and poly bags. There are several factors that suppliers and end-users will consider while making their decision around the logistical options. These include cost, storage, handling, waste generation, and environmental impact, along with various other factors.

Exhibit 46. Various modes of transporting asphalt binders.

	1 Bitumen vessel, terminal, and tanker	2 Used or new drums	3 Poly bags
Shipping method	Special heated cargo vessels	Standard 18-20 MT containers	Standard 20MT containers
Reliability	Limited availability	Excellent	Excellent
Shipping cost	Expensive	Affordable	Affordable
Storage	Extremely capital intensive in bulk terminals with high operating costs	Standard warehouses or directly on site	Standard warehouses or directly on site
Handling	Bulk road tankers to deliver directly on site	Forklifts, 5-6 drums/MT, used drums can leak	All bags double slinged and self-stabilizing
Ground transport	Expensive bitumen tankers	Cheap and affordable	Cheap and affordable
Wastage	A small percentage will always remain in the vessel	About 3-5% is always left in the drum and is wasted	All of the transported cargo is consumed
Environmental impact	Large carbon footprint for entire supply chain	Very poor	Outer lining is 100% recyclable

7.3. Innovation and technology advances

A final set of insights from the primary and secondary research completed during this project identified a number of innovations and technology advances that are coming to the asphalt binder industry. Industry participants have identified three areas where several new developments are underway, and these are described briefly here.

- Sustainability has emerged as a major driver leading to growing innovation focused on the use of recycled asphalt in infrastructure projects. Not only is recycled asphalt finding applications in developed economies, but a number of emerging economies led by China are increasingly mandating a significant share of recycled asphalt in infrastructure projects.
- Cold-mix bituminous emulsion, which eliminates the need for high temperatures while laying asphalt, is increasingly being used around the world. Some of the major advantages of cold-mix bitumen are energy savings, significant reductions in pollution, and safer working conditions among others.
- A third innovation that is resonating in the asphalt binder market is the perpetual pavement concept, which is derived from a mechanistic principle that thick hot mix asphalt pavements with appropriate material combinations will structurally outlive traditional designs while sustaining high traffic volumes and loads. With perpetual pavements, the potential for

traditional fatigue cracking is reduced, and pavement distress is typically confined to the upper layer of the structure.

8.0 Strategic implications

The findings and observations from the preceding sections in this report offer six strategic implications that should be carefully considered by Canadian asphalt binder suppliers.

- In Asia, Canadian asphalt has the best application opportunities in expressways, highways, and some airports as shown in Exhibit 47. Further, China, India, Singapore, Vietnam, and Malaysia have the best opportunities in these market segments and should be the countries where Canadian asphalt binder suppliers should focus their initial efforts on.

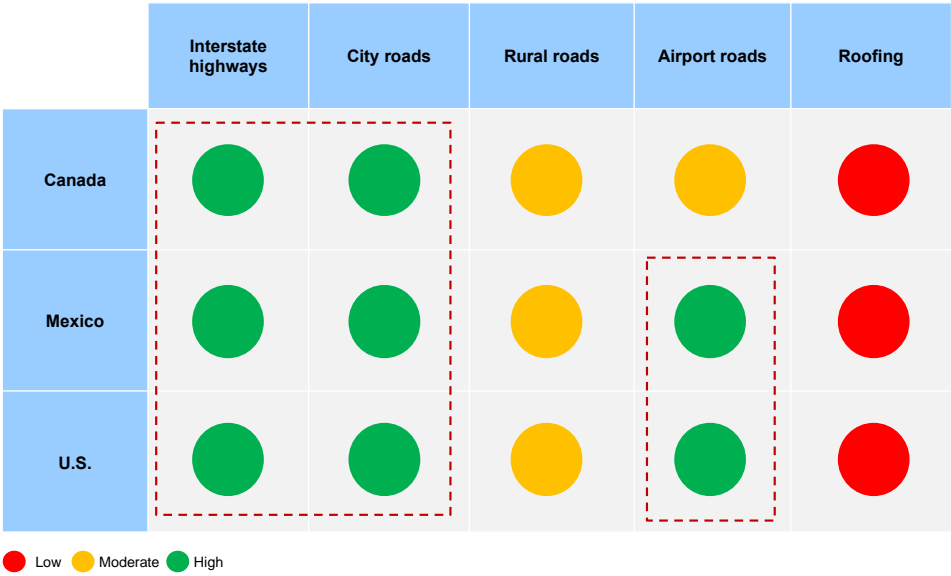
Exhibit 47. Potential markets for Canadian asphalt in Asia.

	Expressways	Highways	City roads	Rural roads	Airport roads	Roofing
China	High	High	Moderate	Low	High	Low
India	High	High	Moderate	Low	Moderate	Moderate
Indonesia	Moderate	Moderate	Moderate	Low	Moderate	Moderate
Singapore	High	Moderate	Low	Low	High	Moderate
Thailand	Moderate	Moderate	Moderate	Low	High	Moderate
Vietnam	High	High	Moderate	Low	Low	Low
Malaysia	High	High	Moderate	Low	Moderate	Moderate

● Low ● Moderate ● High

- North American application opportunities for Canadian asphalt are led by interstate highways, city roads, and airports as shown in Exhibit 48. U.S. and Mexico along with Canada are all equally positioned in terms of opportunities in these market segments and Canadian asphalt binder suppliers should consider other factors in prioritizing the countries where they will further intensify business development efforts.

Exhibit 48. Potential markets for Canadian asphalt in North America.



- Asian and North American asphalt markets offer attractive growth rates and routinely import volumes and, therefore, should be engaged creatively by Canadian asphalt producers.
- Asphalt supply into Asia will get more competitive as many local players including refiners, distributors, and blenders are all trying to expand their presence across the value chain.
- Some end-users buy asphalt directly from distributors or traders and Alberta suppliers can benefit by building relationships and trade agreements with both end-users and distributors.
- Asphalt quality is prioritized for airports and expressways in Asia but end-users have limited understanding of performance and rely on specifications to assess quality. Canadian asphalt producers will need to educate these markets on the value and measurement of performance while competing on price in the near-term.

9.0 Findings and conclusions

- The asphalt markets in Asia and North America are driven by rapid urbanization, growing infrastructure investments, increasing mobility, and residential and other construction growth.
- The global demand for asphalt will be ~143 MMTPA in 2020 which is expected to grow at 3.6% annually to reach ~174 million tons per year by 2025.
- In 2020, the total demand for key countries in Asia was ~39 MMTPA which is expected to grow at 3.0% annually to 45 MMTPA by 2025.
- Most of the demand is in China (~30 MMTPA) in 2020 followed by India (~6.0 MMTPA), and Thailand (~1.2 MMTPA). Demand in China, India, and Thailand is expected to grow annually at 2.2%, 5.9%, and 5.0%, respectively, i.e., faster than in China.
- Asphalt demand in Indonesia is ~1.2 MMTPA in 2020 followed by Vietnam at ~0.7 MMTPA, Malaysia at 0.2 MMTPA, and Singapore at ~0.15 MMTPA. Demand in Indonesia, Vietnam, Malaysia, and Singapore is expected to grow annually at 4.3%, 4.4%, 3.9%, and 2.6%, respectively-all higher than in China.
- Asphalt demand in U.S. and Mexico is ~26.6 MMTPA and ~1.7 MMTPA in 2020 which is expected to grow annually at 3.1% and 3.2%, respectively, through 2025.
- In the U.S., most of the demand is in the Midwest (~9.1 MMTPA) followed by the East (~7.5 MMTPA) and the Gulf coast (~3.9 MMTPA). Demand in Midwest, East Coast, and Gulf Coast is expected to grow annually at 2.1%, 3.1%, and 5.2%, respectively.
- The demand for asphalt in the Rockies and West Coast is 2.1 MMTPA and 3.9 MMTPA, respectively, in 2020 which is expected to grow annually at 3.0% and 3.9%, respectively.
- Nearly ~75% of the Asian asphalt demand is for conventional grades such as VG-30 and AC-60/70 followed by emulsions and polymer-modified grades. In North America, demand is a function of climatic conditions and local needs with more preference for higher temperature grades in southern region and lower temperature grades for colder climates.
- Viscosity grades VG-30 and VG-10 are the most widely used grades in India. Other countries such as Vietnam, Thailand, Singapore, Malaysia, and Indonesia use pavement grades with AC-60/70 being the most popular and widely used grade. North America uses the superpave grading system with PG 64-22 and PG 64-28 being the most popular grades.

- Conventional grades can be used for applications such as construction of highway road, expressways, city roads, airport runways and waterproofing jobs. Emulsions are used in city and rural roads whereas polymer grades are mostly used in expressways and airport roads.
- Supplier selection is based on prices, relationships, sector experience, supplier creditworthiness, quality, logistic capabilities, offering breadth, and scale of the asphalt supplier. Asphalt prices, relationships, and quality are important criteria for supplier selection in Asia. North American end-users value prices, offering breadth, and quality as important factors for supplier selection.
- End-users have several pain-points such as price fluctuations, quality issues, and logistical concerns. Contractors look for pricing stability during demand fluctuations, consistent supply of required grade during project execution work without compromising the quality.
- Polymer-modified grades such as PMB-30 are priced at a ~35% premium over VG-10 grade. Widely-used grades such as VG-30 and AC-60/70 also sell at a ~25% premium over VG-10. In North America, asphalt prices per ton in the U.S. range \$450 to \$600 and \$650-\$700 in Canada.
- Most of the asphalt is transported via tank trucks although a few end-users procure small volumes via bitumen drums. Transportation costs range from \$0.07 to \$0.15 per ton per mile of distance with transportation costs higher in developed nations such as U.S. and Singapore.
- In Asia, Canadian asphalt has the best application opportunities in expressways, highways, and some airports and North American application opportunities for Canadian asphalt are led by interstate highways, city roads, and airports.
- Finally, Canadian asphalt binders will have to invest in educating end-users and the broader market around the value of selecting suppliers based on performance outcomes in order to identify new opportunities and differentiate themselves against growing competition.

Notes

ⁱ World Bank

ⁱⁱ BMI

ⁱⁱⁱ The U.S. Central Intelligence Agency Factbook

^{iv} The U.S. Central Intelligence Agency Factbook

^v World Bank, Oxford Economics

^{vi} National Asphalt Pavement Association

^{vii} Indian Oil Corporation

^{viii} National Asphalt Pavement Association

^{ix} National Asphalt Pavement Association and Poten & Partners



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