Modeling the Impact on Asia of the Developing Global Natural Gas Market

Presented at the 40th International IAEE Conference

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Singapore

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Navigant Consulting, Inc.

Purpose of the Study

- Shale gas and tight oil development in North America have combined to drastically lower the price of LNG in Asia and elsewhere

- At the same time the economies of Asia have been growing rapidly – and that includes the demand for energy and especially for electricity

- How will this dynamic play out?

- Where will the growth in gas demand be greatest?

- Where will the gas be coming from?

- What needs to be built to meet these demands?

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Study Region

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Approach

- Design and develop a global gas model and database with sufficient detail to produce credible forecasts of gas and LNG production, transport, storage, and consumption over a forecast horizon out to 2050

- Populate the model's database with the latest available and most reliable information available for every country either producing or consuming natural gas

- Split up major gas producers and consumers into sub-country regions to capture internal supply, demand, and transportation aspects of those markets

  - USA, Canada, Mexico, Russia, China, India, Malaysia, Indonesia, and Australia (See Appendix for split-up maps)

- Design a base case and a high-demand-growth scenario for comparison of results

  - High growth focused in gas demand in electricity generation

- Report the results at IAEE in Singapore

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Study Team

- ## RBAC, Inc.
  - Energy market model development specialists
    - GPCM® Natural Gas Market Forecasting System
    - NGL-NA® Natural Gas Liquids Market Forecasting System
    - G2M2® Global Gas Market Modeling System
- ## Navigant Consulting
  - Global consulting with a strong focus in the energy sector
  - Major player in natural gas and electricity market analysis and LNG project evaluation

History Between Our Parties: RBAC & Navigant

Navigant & RBAC: Associated Since 2008

Navigant is a GPCM® North American Natural Gas Forecasting System licensee, holding a multiple-seat license

Navigant has used the GPCM model for many client engagements:

- Economic Impact Reports
- Regulatory Filings for LNG Exports
- Fuels procurement advisory
- Gas market assessments – netback, basis
- Scenario Analysis
- Pipeline and infrastructure support

In 2014 Navigant and RBAC began collaboration on the Global Gas Market Model (G2M2®)

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G2M2® Development Strategy

Navigant and RBAC collaborated on developing G2M2™ by combining our unique skills

NAVIGANT	RBAC
• Model requirements specification • Market intelligence • Data compilation, evaluation, and integration • Reality check: do model results make real market sense?	• Model ownership, design, development, and testing • Database design • System integration • Used proven principles from prior successes with GPCM®, the North American Natural Gas Modeling System

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Data Sources Used for this Study

- Government Agencies

- Regulatory Authorities

- International Organizations

- Industrial Associations

- Company Filings/Reports/Presentations

- Research Institutes

- Academic Institutions

- Media Agencies

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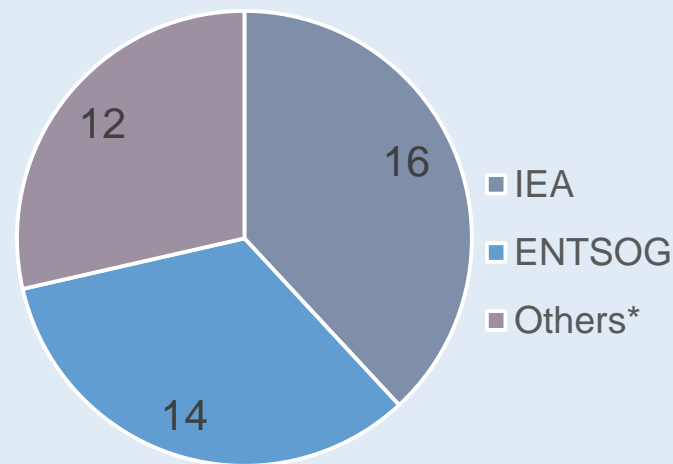
Supply/Demand Outlook Methodology

- **Method 1: Using existing supply/demand outlooks as a benchmark**

  - Review all available demand/supply outlooks from various agencies for each individual country

  - Select one demand outlook and one supply outlook for each individual country that align with Navigant's view of the local market as the benchmark outlooks

  - Adjust the benchmark outlooks to incorporate ongoing changes to reflect local market dynamics

Count of Demand Outlooks by Source

- ENTSOG: 26
- ADB: 8
- IEA: 4
- ERI RAS: 2
- EIA: 2
- Others*: 11
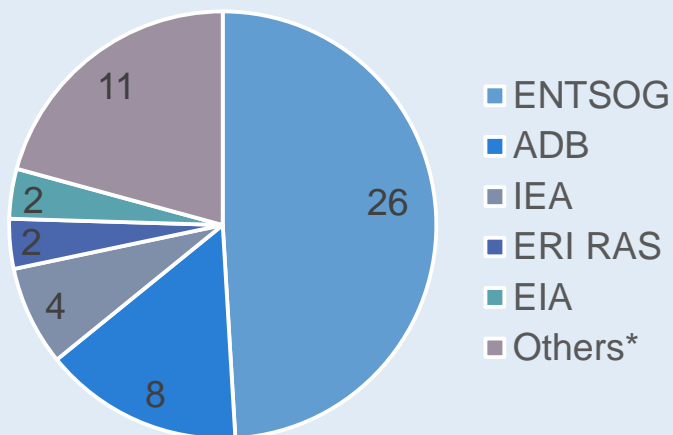
Count of Supply Outlooks by Source

- IEA: 16
- ENTSOG: 14
- Others*: 12

*Others include national governments, international agencies and academic research institutes

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Supply/Demand Outlook Methodology

– **Method 2**: **Economic, demographic and resource estimates used to forecast natural gas supply and demand outlooks**

- Applies to countries with no existing demand or supply outlooks

- **Demand: Using population projection**

  – Extrapolate the natural gas consumption per capita for each country

  – Adjust the extrapolation to align with the country's economic and resource conditions

  – Apply the extrapolated natural gas consumption per capita to the World Bank population projection of each country to derive the demand outlook

- **Supply: Using historical trend**

  – Extrapolate the natural gas production based on historical production trend

  – Adjust the extrapolation to align with the country's economic and resource conditions

  – Derive the supply outlook from the adjusted extrapolation

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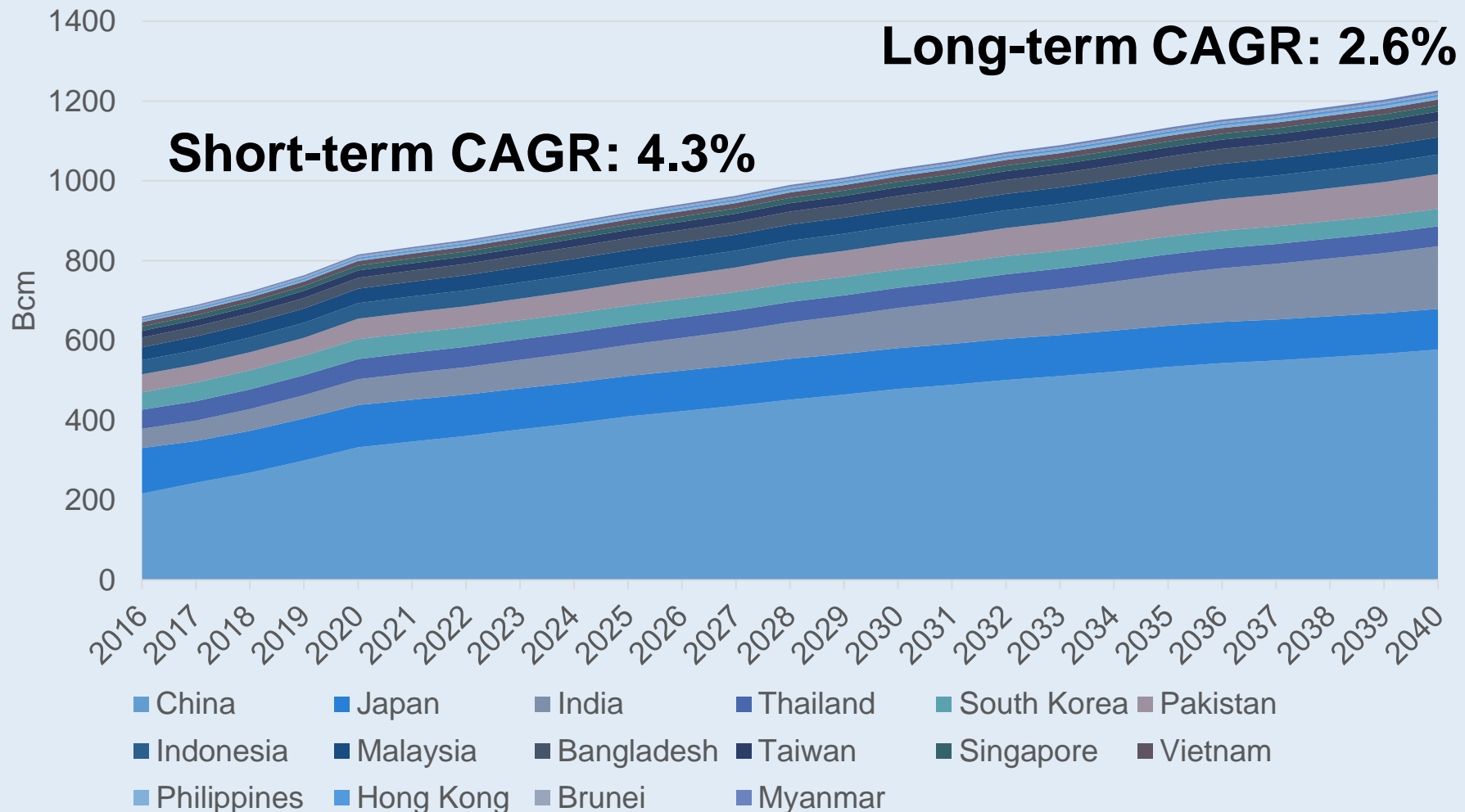# Supply/Demand Outlook Methodology

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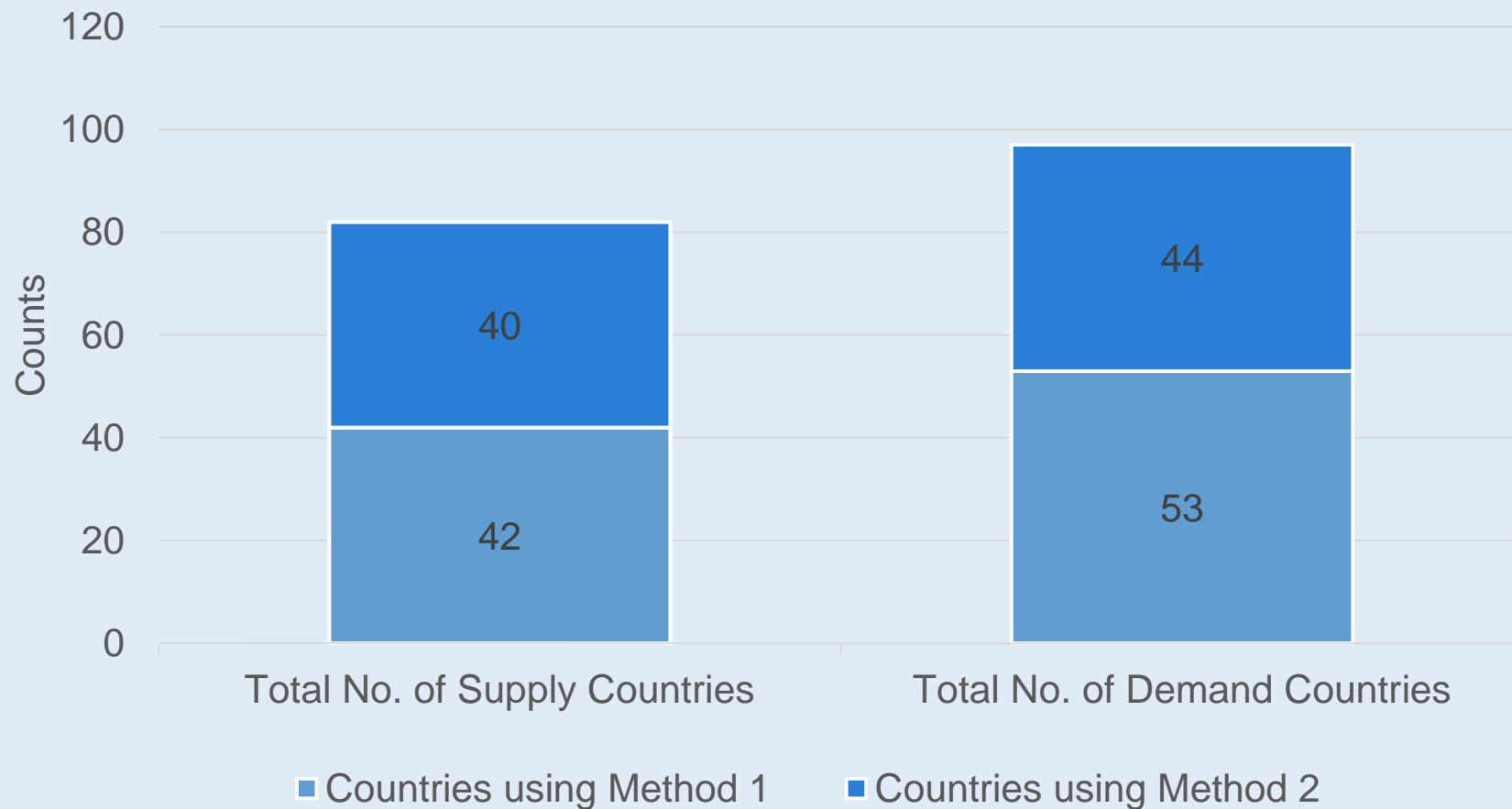
Asian Regional Natural Gas Market Analysis

- Navigant developed a global reference case using relatively conservative supply, demand and infrastructure outlooks
    - This reference case incorporated data for all continents and countries with gas supply and/or demand

- Focusing on Asia, Navigant conducted more detailed research to disaggregate supply and demand for several of its important countries and to model their internal pipeline and LNG infrastructure
    - Russia, China, India, Malaysia, Indonesia, and Australia

- Navigant analyzed the impact of regional incremental natural gas demand for electric generation by developing a High-Growth Scenario involving
    - Increased regional NG ELC demand for China, India and Southeast Asian countries and then
    - And analyzed the impact of incremental ELC demand on regional markets by reviewing supply, demand and price outlooks
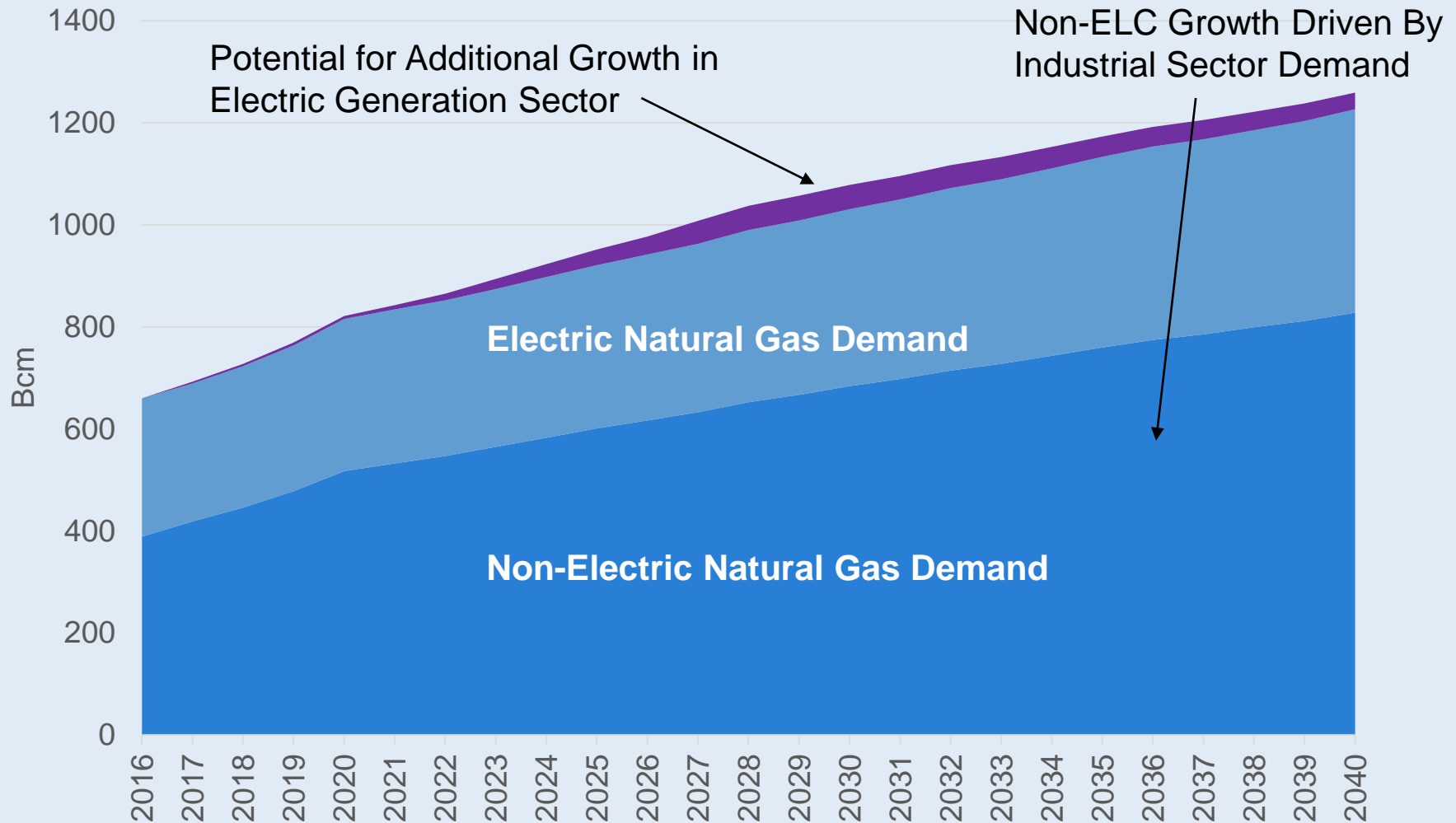
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Reference Case: Regional Demand Outlook by Country (Bcm/yr)

Long-term CAGR: 2.6%

Short-term CAGR: 4.3%

Legend: China, Japan, India, Thailand, South Korea, Pakistan, Indonesia, Malaysia, Bangladesh, Taiwan, Singapore, Vietnam, Philippines, Hong Kong, Brunei, Myanmar

Preliminary Results Meant for Illustrative Purpose Only

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Reference Case: Regional Demand Outlook by Sector (Electricity generation vs Other)

Potential for Additional Growth in Electric Generation Sector

Non-ELC Growth Driven By Industrial Sector Demand

Electric Natural Gas Demand

Non-Electric Natural Gas Demand

Bcm

1400 / 1200 / 1000 / 800 / 600 / 400 / 200 / 0

2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034 2035 2036 2037 2038 2039 2040

Preliminary Results Meant for Illustrative Purpose Only

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China

- Chinese provincial level natural gas demand in the reference case is benchmarked against IEA's 2015 China outlook with the ELC sector outlooks estimated using National Bureau of Statistics data

- Natural gas demand for electric generation grows from 35 to 63 bcm in the next 10 years. This represents a per capita increase from 25 to 44 mcm per million people, reaching only 7% of pre-shale 2006 U.S. per capita consumption
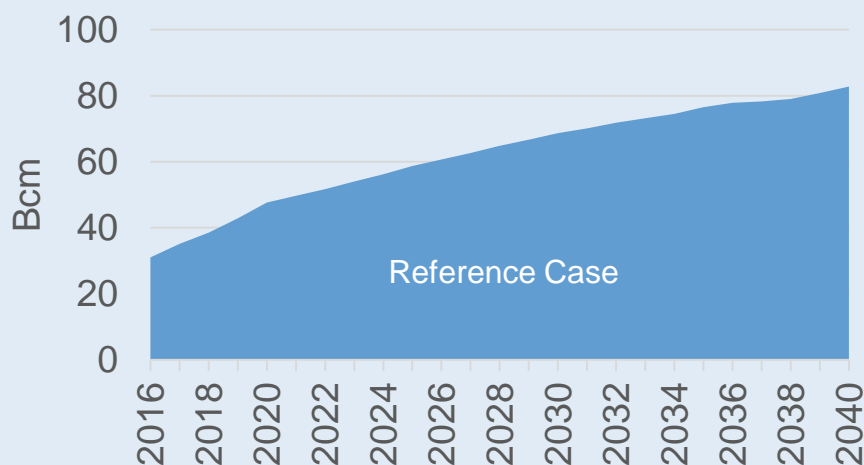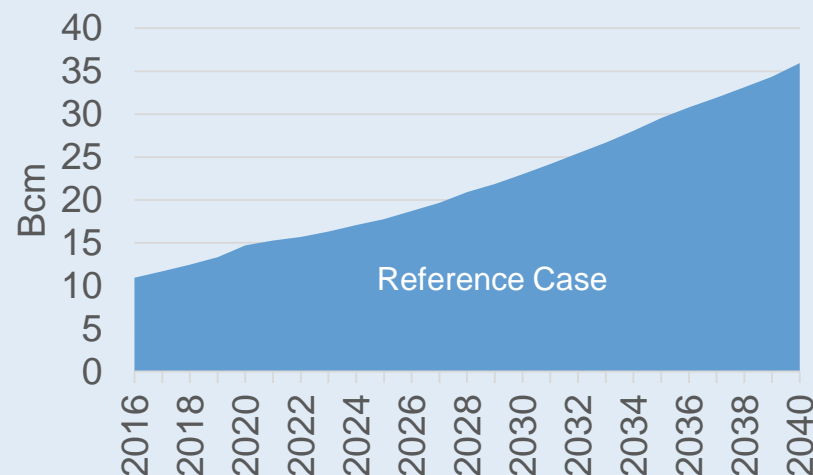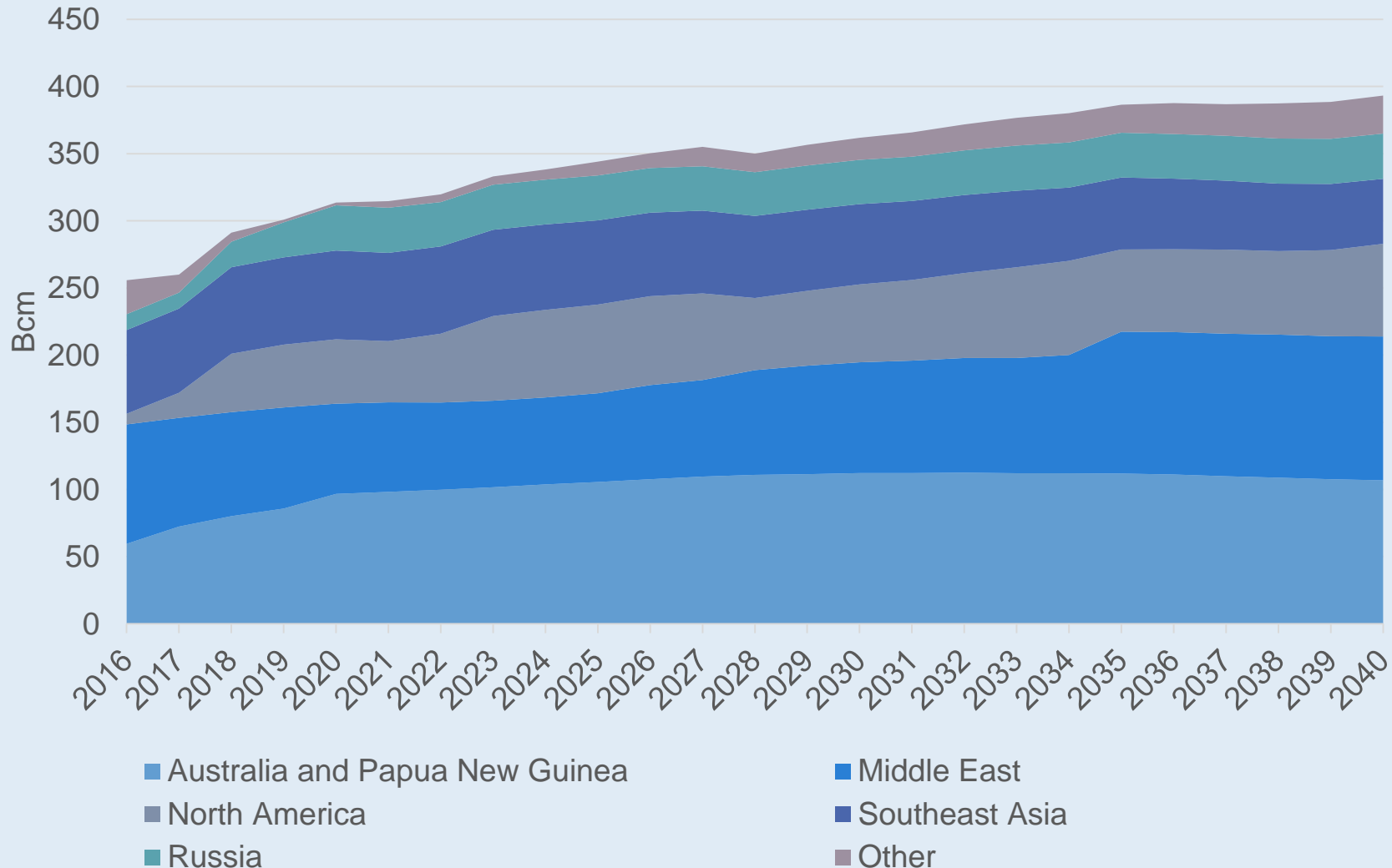
India

- India state/territory level natural gas demand in the reference case is benchmarked against EIA's 2016 India outlook with the ELC sector outlooks estimated using Central Electricity Authority data

- Natural gas demand for electric generation grows from 12 to 20 bcm in the next 10 years. This represents a per capita increase from 9 to 13 mcm per million people, reaching only 2% of pre-shale 2006 U.S. per capita consumption

China ELC Demand

India ELC Demand

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Reference Case: Regional LNG Supply Sources for Study Area

Preliminary Results Meant for Illustrative Purpose Only

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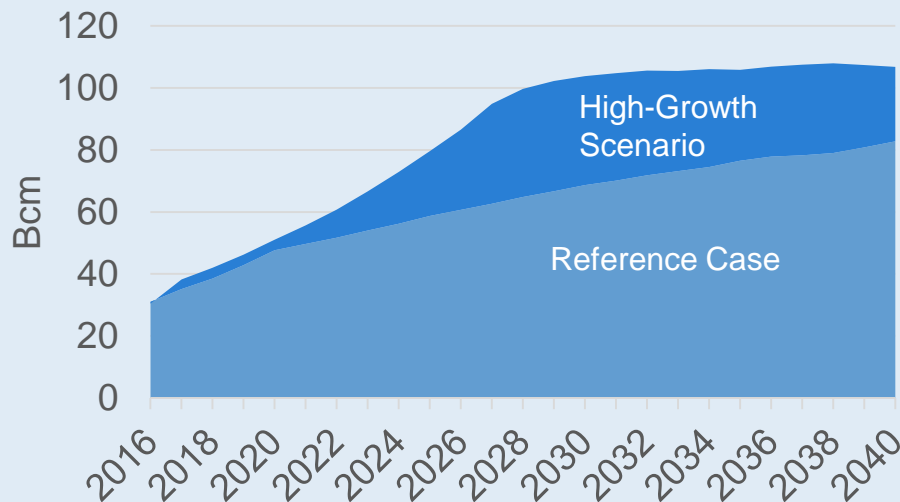# High-Growth Scenario: Incremental ELC Demand

China

- Incremental ELC demand is forecasted using historical heat rates, a projected resource mix from China's 13th 5-year plan and an electric generation outlook from China Electricity Council

- Natural gas demand for electric generation grows from 38 to 95 bcm in the next 10 years. This represents a per capita increase from 28 to 67 mcm per million people, reaching only 11% of U.S. pre-shale 2006 per capita consumption

India

- Incremental ELC demand growth met by increased utilization of existing and under-construction regasification facilities (assumes full utilization of regas)

- Natural gas demand for electric generation grows from 13 to 43 bcm in the next 10 years. This represents a per capita increase from 10 to 29 mcm per million people, reaching only 5% of U.S. pre-shale 2006 per capita consumption
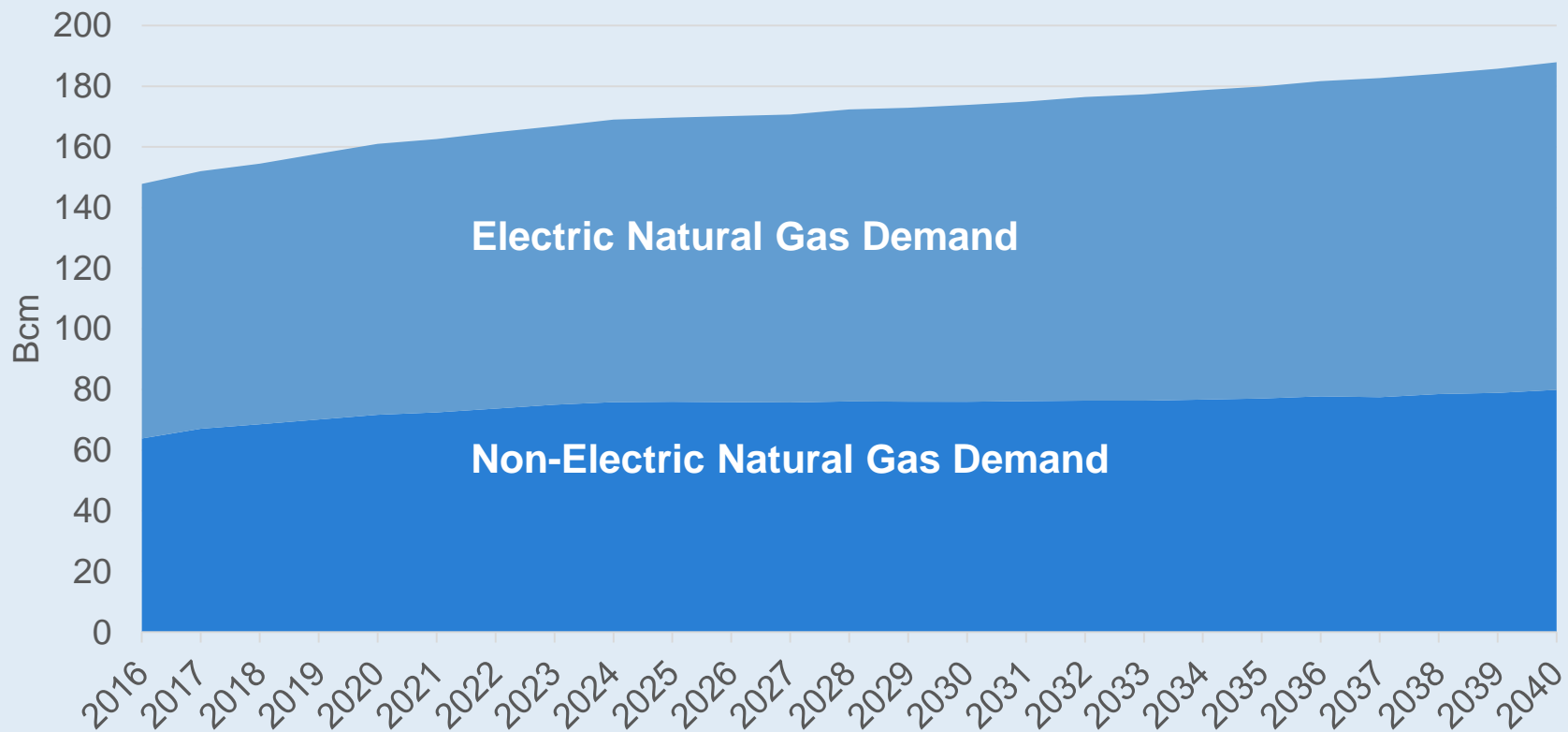

China ELC Demand

India ELC Demand

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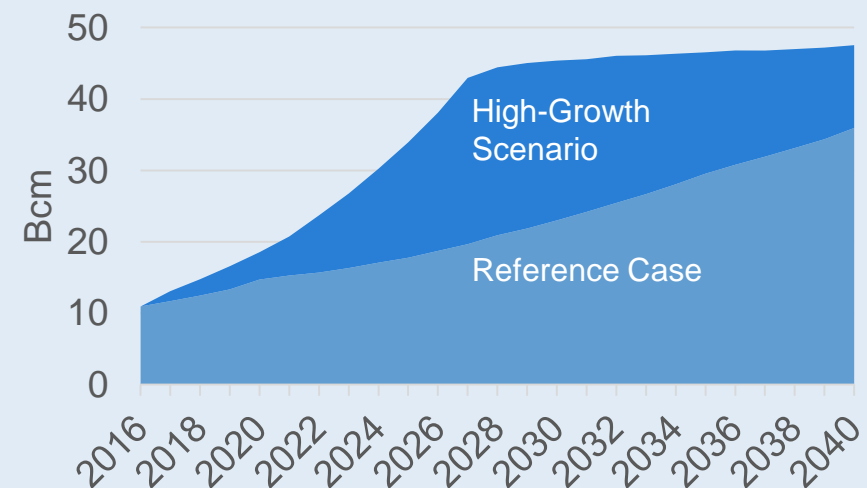
High-Growth Scenario: Southeast Asia Demand

Southeast Asia Demand Growth Constrained by Limited Infrastructure

Due to the geographic features and limited natural gas infrastructure in Southeast Asia, additional demand growth in this region will require significant build-out of pipelines and LNG regasification terminals
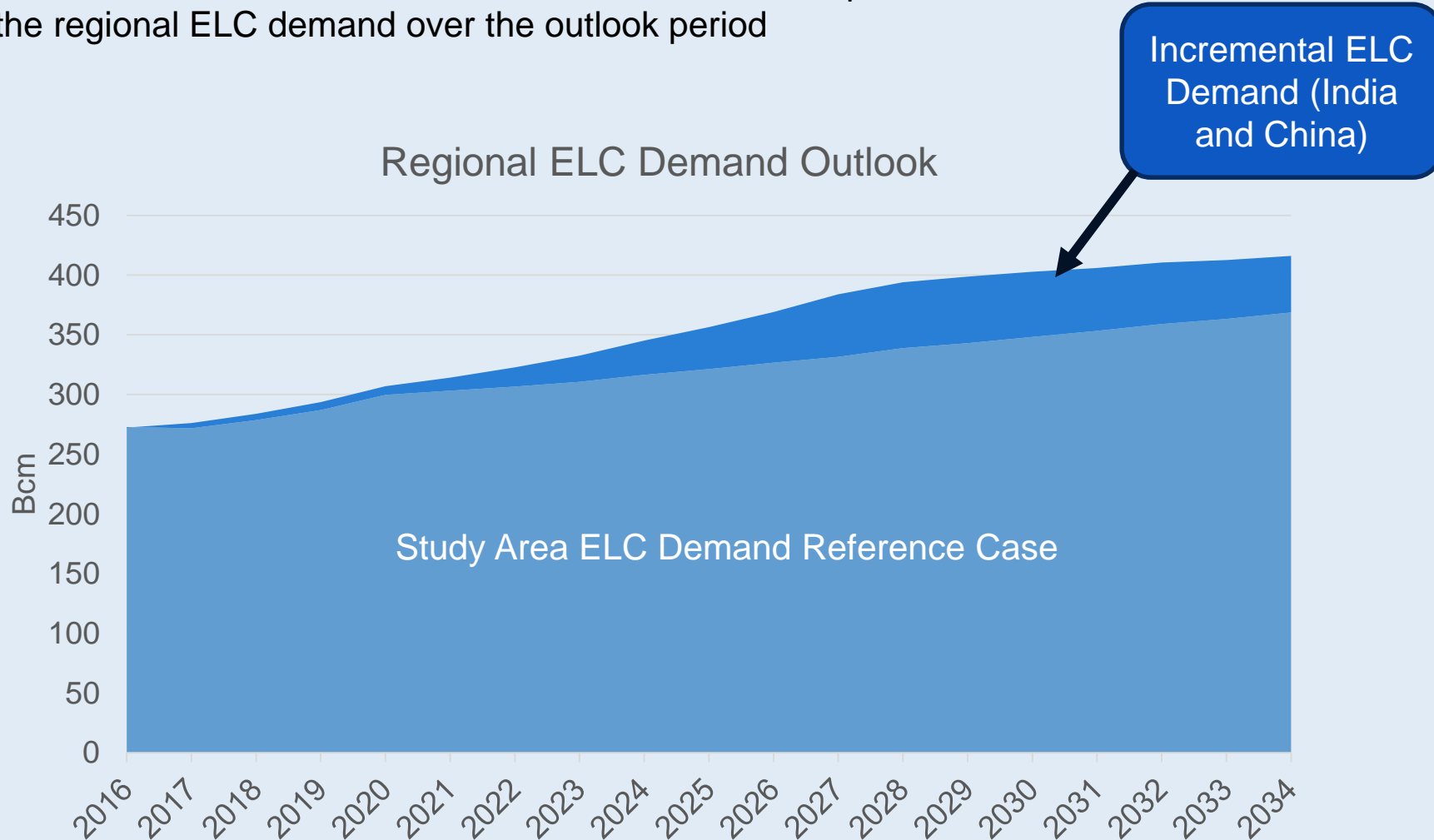
Southeast Asia Demand Outlook (Same as Reference Case)

Preliminary Results Meant for Illustrative Purpose Only NAVIGANT & RBAC Inc.

High-Growth Scenario: Incremental Regional Demand

The incremental ELC demand from China and India represents about 10% of the regional ELC demand over the outlook period

Incremental ELC Demand (India and China)

Regional ELC Demand Outlook

Study Area ELC Demand Reference Case

Bcm

450
400
350
300
250
200
150
100
50
0

2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034

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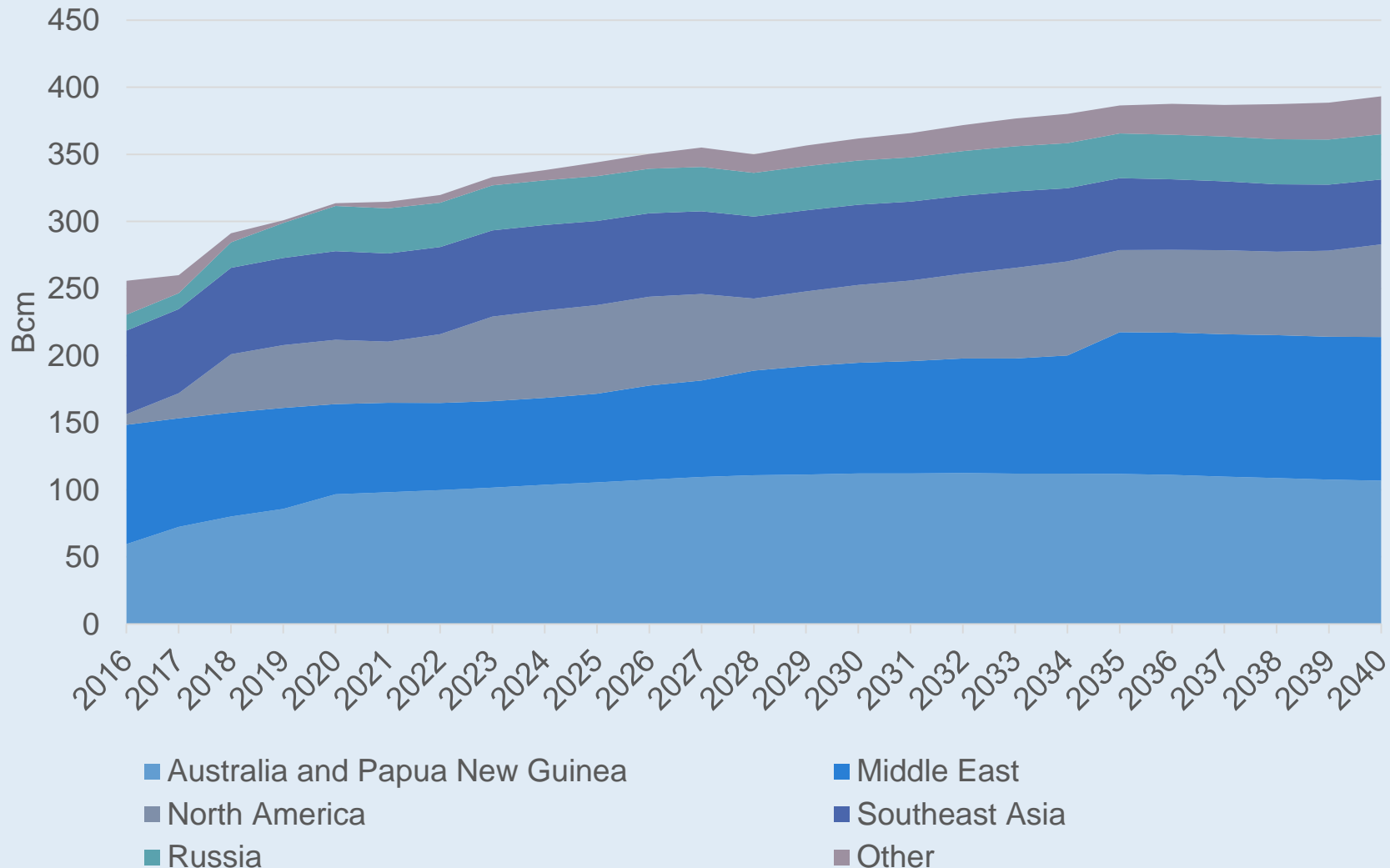
JKM Price: Reference Case vs High-Growth Scenario

Incremental growth of electric natural gas demand from China and India on average will result in 9.3% higher spot market prices over the entire outlook period

JKM Price Outlook*

Reference — — High-Growth Scenario
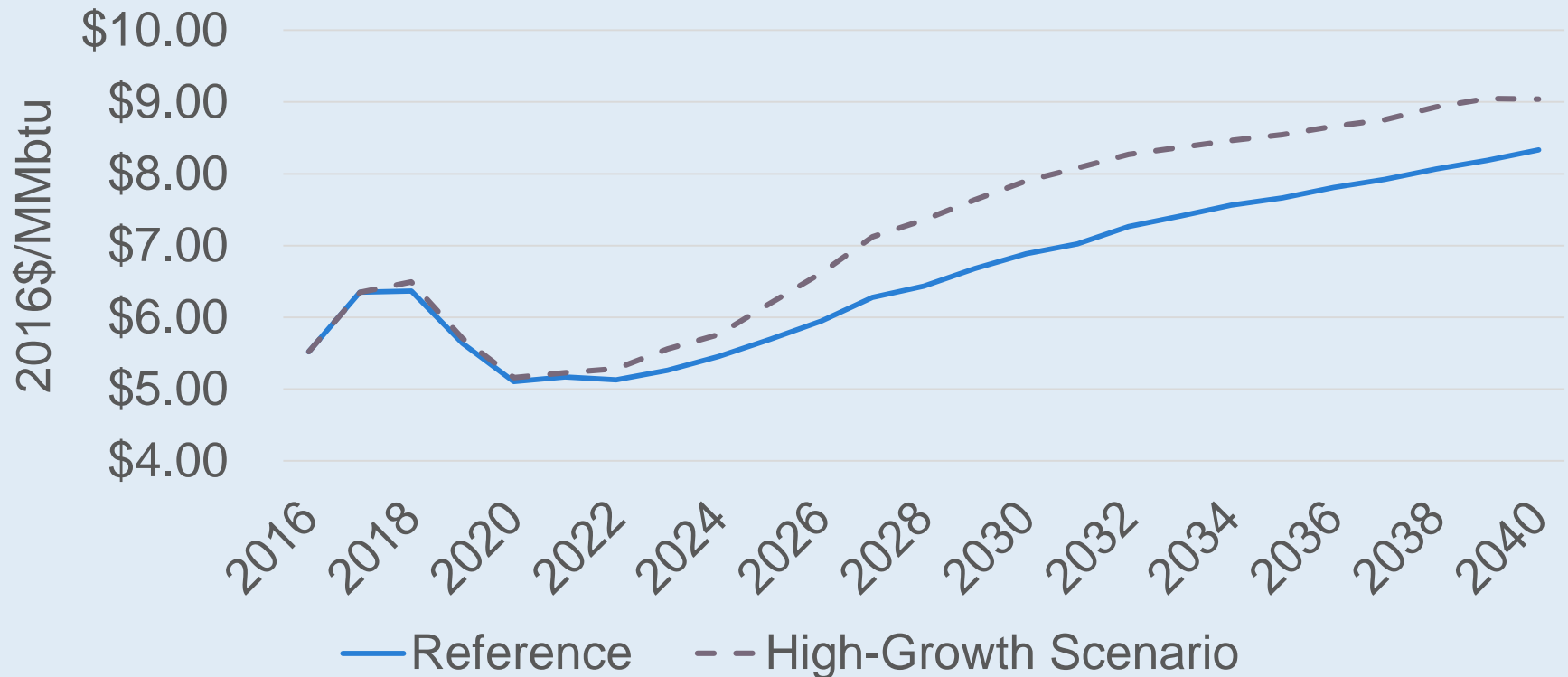
* 2016 JKM price is historical and 2017 JKM price is adjusted using NYMEX future strips

Preliminary Results Meant for Illustrative Purpose Only

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Conclusions from the Study

- Study Area natural gas production growth will be insufficient to meet expected demand growth between now and 2040

- Demand throughout the three sub-regions (Eastern, Southern, and Southeastern Asia) will nearly double as population and per capita consumption continue to increase
    - This growth is expected to be primarily in the industrial and electric power sectors

- India and Pakistan in Southern Asia and China in Eastern Asia have greater optionality of supply: pipeline gas from major producers such as Iran, Turkmenistan, and Russia.
    - In addition, existing LNG import terminals are underutilized so imports can grow

- Southeastern Asia does not have this optionality
    - It is limited to its own production (which is declining) and to LNG imports from the west (Middle East, Africa), south (Australia, PNG) and east (North America)
    - The ability to grow its gas demand for electricity generation will depend on substantial investment in new LNG import capacity

- Continuing growth in supply from Australia and North America will cause LNG prices in Asia to decline to about $5.00 / mmbtu by 2020
    - But … increasing demand will cause them to rise to $8.00 - $9.00 by 2040

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About RBAC

RBAC Inc. licenses economic forecasting tools the energy industry, as well as State and Federal government agencies involved with Energy, Transportation and the Environment. RBAC's principal products include the industry standard GPCM® Natural Gas Market forecasting System™, the GPCM® Base Case Database for North America, and GPCM Viewpoints® on Natural Gas.

We continuously advance our modeling tools through technology, feature development and regularly released updates based on client requests and energy industry needs. Those needs resulted in our development of RBAC's North American Natural Gas Liquids Model (NGL-NA™) and GPCM Daily™.

Additional forecasting tools scheduled for release include:

- G2M2® Global Gas Market Modeling System .Net Ver. 3.5
- GPCM® for MS-SQL

Licensees of RBAC's systems are involved in natural gas exploration and production, LNG infrastructure development and marketing, natural gas marketing and transportation, electric power generation, natural gas distribution, and commodities trading, as well as most of the major consulting firms that service business and planning needs of the energy industry and its bankers.

Dr. Robert Brooks founded RBAC in 1987 based on experience developing several well respected predictive models since his first work on his doctoral research in natural gas transportation economics at MIT in the 70's.

Designing forecasting tools for global energy market prices, basis, and flows is RBAC's core business.

RBAC's staff includes experts in natural gas supply, demand, marketing and transportation as well as the dynamic global pipeline and LNG markets. Our team applies its world class expertise in mathematical modeling, statistical analysis, mathematical algorithm development, software engineering, and database design to current and future challenges, risks and opportunities in energy.

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Navigant is a global consulting firm with a strong focus on the Energy sector

2016 Global Revenue $1,034mm

60 Offices

5,740 Employees

Projects in 42 Countries

Toronto
Canada

London
Birmingham
United Kingdom

Utrecht
Netherlands

Brussels
Belgium

Berlin
Cologne
Germany

Beijing
Shanghai
China

Doha
Qatar

Seoul
South Korea

Abu Dhabi
Dubai
United Arab Emirates

Hong Kong

Trivandrum
Nagercoil
India

Singapore
Republic of Singapore

Arizona	New Jersey
Arkansas	North Carolina
California	Pennsylvania
Connecticut	South Dakota
Colorado	Tennessee
Florida	Texas
Georgia	Vermont
Illinois	Virginia
Indiana	Washington
Massachusetts	Washington DC
Michigan	Wisconsin
New York	**United States**

Disputes, Forensics & Legal Technology
$338mm

Financial Risk & Compliance
$173mm

Energy
$134mm

Healthcare
$389mm

Figures based on Feb 2017

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Our Energy Practice provides a wide range Solution Offerings and Capabilities to our clients
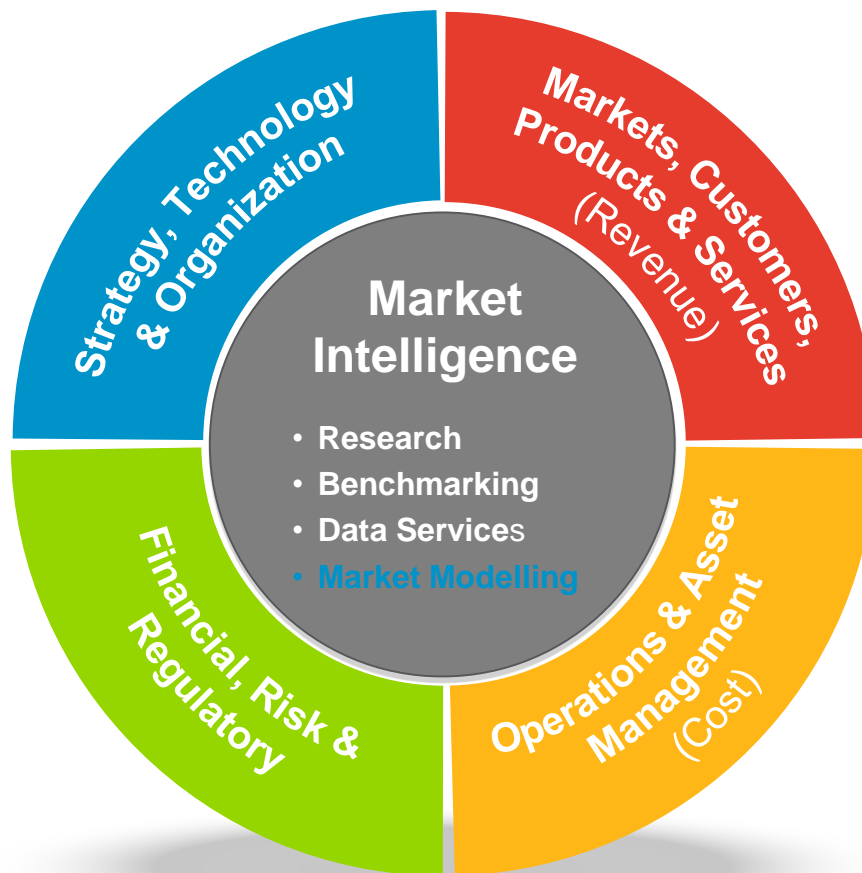
- **Business Strategy and Implementation**
- Innovation and R&D Management
- **Organizational Design**
- **Change Management**
- Technology Advisory
- Merger & Acquisitions
- Integrated Resource Planning

- **Business Case Development**
- **Risk Management**
- Physical and Cybersecurity
- Regulatory Compliance
- Federal and State Regulatory Support
- Policy Development and Code & Standards

Strategy, Technology & Organization

Markets, Customers, Products & Services (Revenue)

Market Intelligence
- **Research**
- **Benchmarking**
- **Data Services**
- **Market Modelling**

Financial, Risk & Regulatory

Operations & Asset Management (Cost)

- **Market Strategy and Pricing**
- **Customer Engagement**
- Emerging Technologies (renewables, distributed generation, storage, micro grids, and others)
- Energy Efficiency
- Demand Response
- Customer Analytics

- **Operational Excellence**
- **Asset Management**
- Grid Operations
- Distributed Resource Management
- Restoration and Outage Management
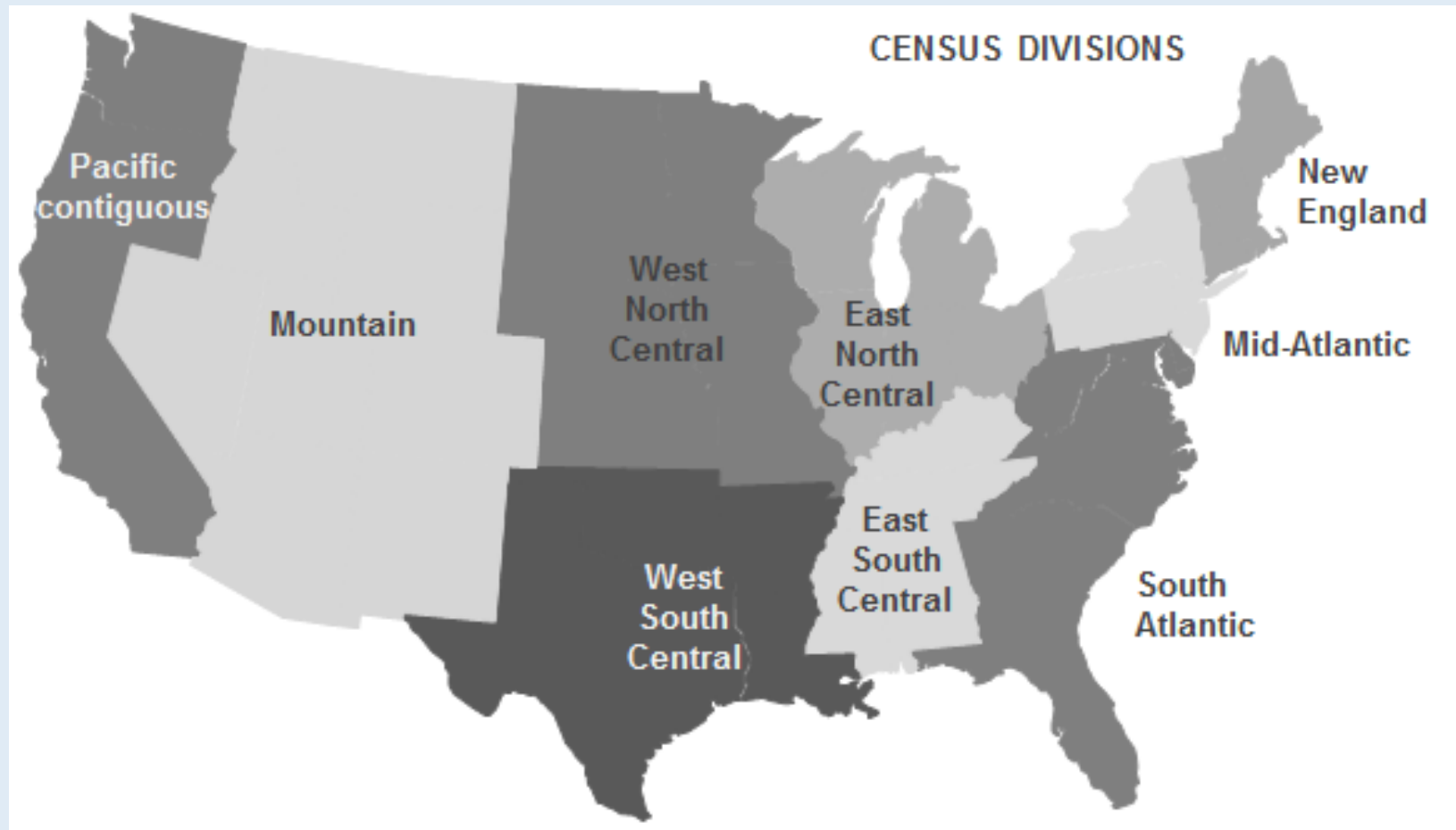- Manufacturing Impact Analysis
- Equipment / Appliance Testing

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Appendix: Country Split-Ups

- United States
- Canada
- Mexico
- Russia
- China
- India
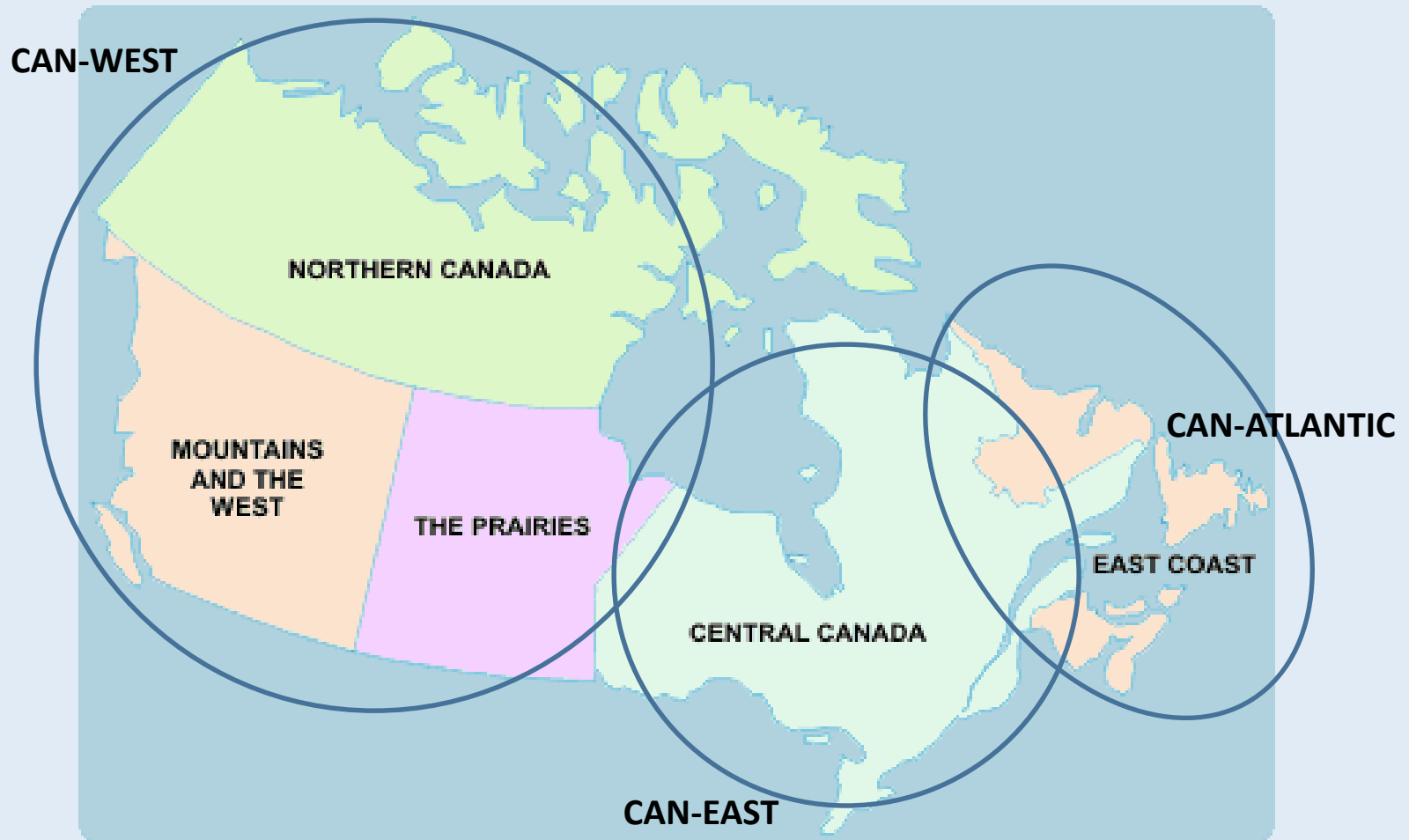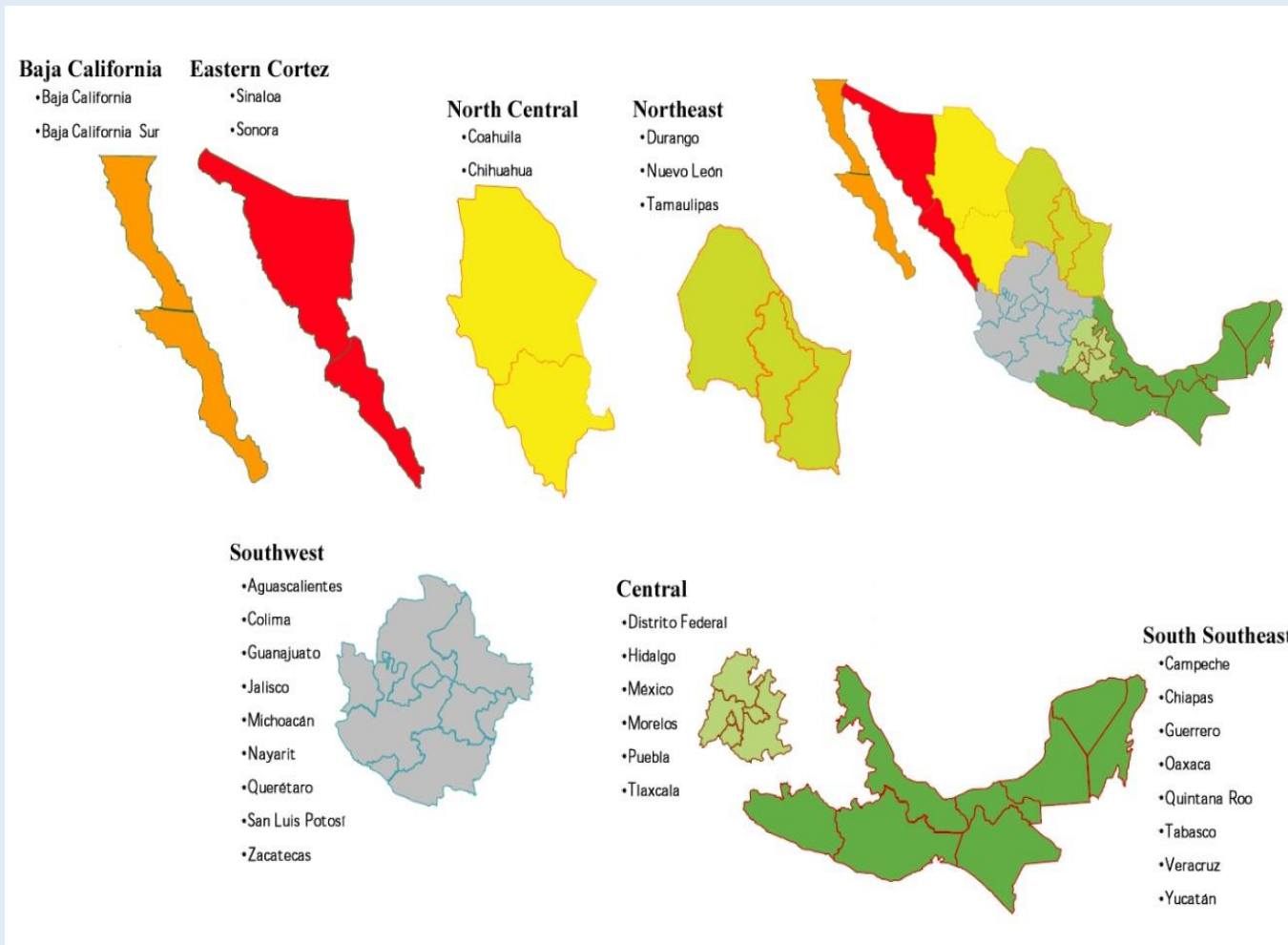- Indonesia
- Malaysia
- Australia

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United States

CENSUS DIVISIONS

NAVIGANT & RBAC Inc.

Canada

Mexico

Baja California
- Baja California
- Baja California Sur

Eastern Cortez
- Sinaloa
- Sonora

North Central
- Coahuila
- Chihuahua

Northeast
- Durango
- Nuevo León
- Tamaulipas

Southwest
- Aguascalientes
- Colima
- Guanajuato
- Jalisco
- Michoacán
- Nayarit
- Querétaro
- San Luis Potosí
- Zacatecas

Central
- Distrito Federal
- Hidalgo
- México
- Morelos
- Puebla
- Tlaxcala

South Southeast
- Campeche
- Chiapas
- Guerrero
- Oaxaca
- Quintana Roo
- Tabasco
- Veracruz
- Yucatán

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Russia (plus Yamal and Sakhalin)

FEDERAL DISTRICTS OF RUSSIA

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China Region
- Northeast
- North
- East
- Central
- Northwest
- Southwest
- West
- South

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India
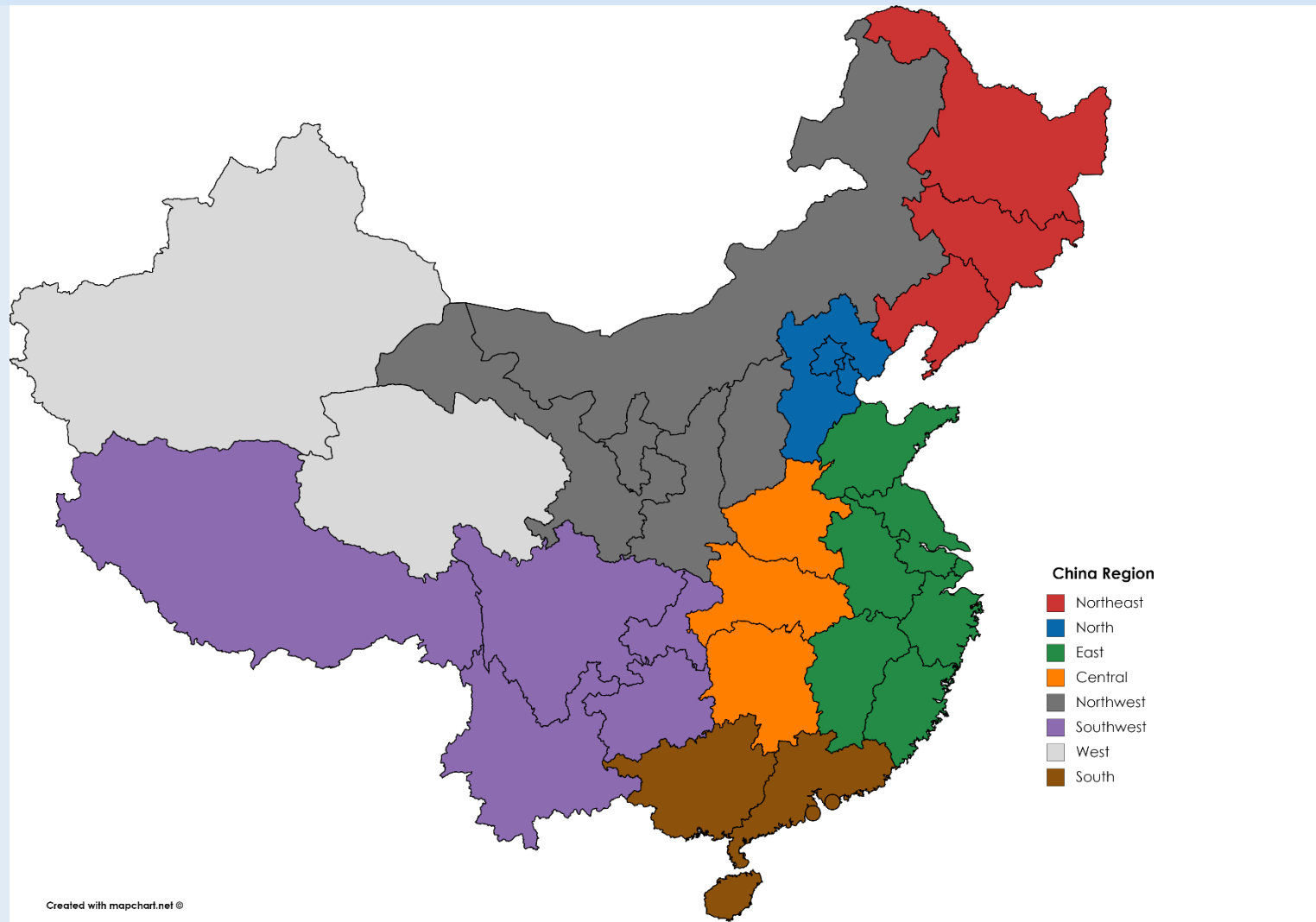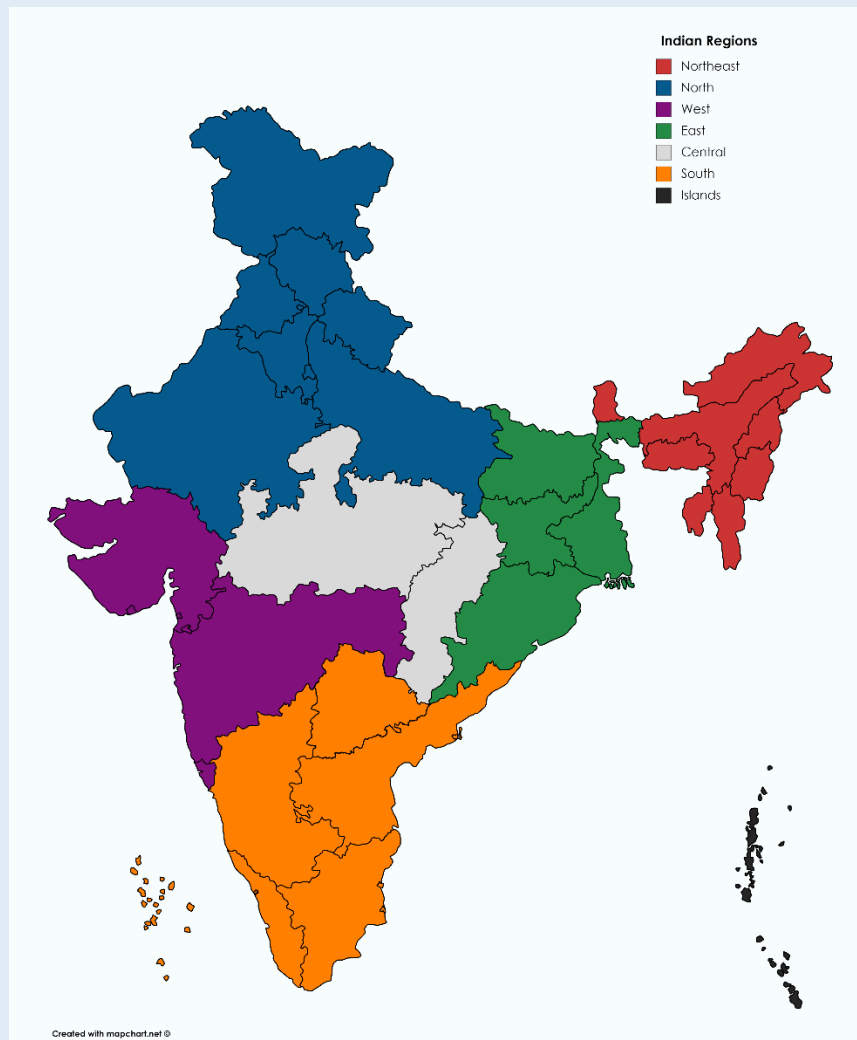
Indonesia (Some states aggregated)

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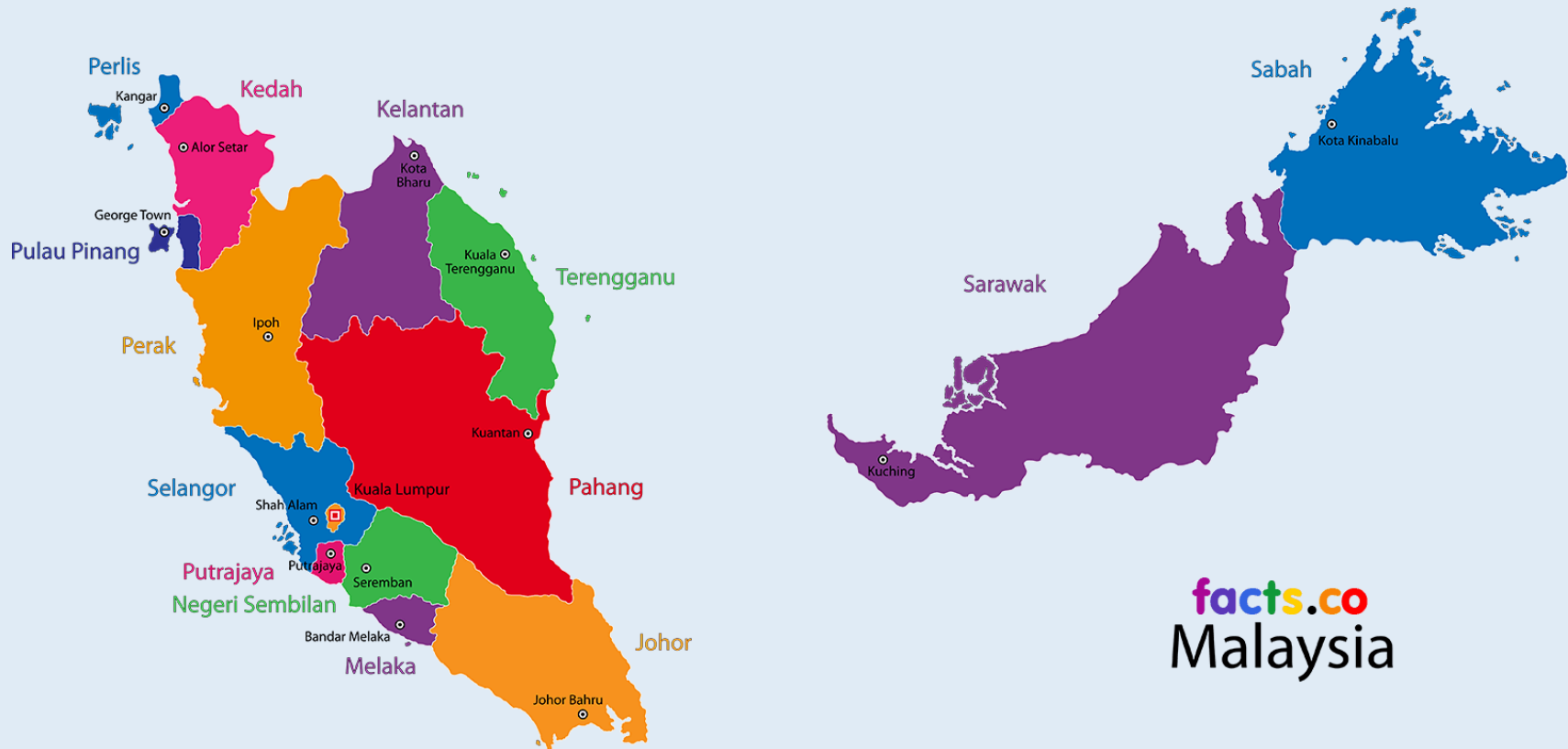
Australia (plus NW offshore)

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