DYNAMIC DELIVERY

America's Evolving Oil and Natural Gas Transportation Infrastructure

APPENDIX C – LIST OF TOPIC PAPERS

A Report of the National Petroleum Council

December 2019

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Appendix C

LIST OF TOPIC PAPERS

On December 12, 2019, the National Petroleum Council (NPC) in approving this report, *Dynamic Delivery – America's Evolving Oil and Natural Gas Transportation Infrastructure*, also approved the making available of certain materials used in the study process, including detailed, specific subject matter papers prepared or used by the study's task groups. These Topic Papers were working documents that were part of the analyses that led to development of the summary results presented in the report's Executive Summary and Chapters.

These Topic Papers represent the views and conclusions of the authors. The National Petroleum Council has not endorsed or approved the statements and conclusions contained in these documents, but approved the publication of these materials as part of the study process.

The NPC believes that these papers will be of interest to the readers of the report and will help them better understand the results. These materials are being made available in the interest of transparency. This appendix provides a list of the study's 26 Topic Papers, which are available for viewing and downloading from the NPC's publicly accessible website, https://dynamicdelivery.npc.org.

CHAPTER 1

Supply and Demand Task Group

Topic Paper 1-1: Biojet

Authors: *Sarita Williams (Delta Air Lines, Inc.) and Patrick Callan (Monroe Energy, LLC)*

This paper discusses the various pathways to produce Sustainable Aviation Jet Fuel, fuel made from renewable, biologically derived raw materials, which once blended with petroleum jet fuel is suitable for use in an unmodified jet engine. Current and future production levels, as well as some of the regulatory initiatives to promote demand are also described.

CHAPTER 2

Infrastructure Resiliency, Mapping, and Analysis Task Group

No Topic Papers

CHAPTER 3

Permitting, Siting, and Community Engagement for Infrastructure Development Task Group

Topic Paper 3-1: Clean Air Act

Author: *David Pavlich (Phillips 66 Company)*

This paper overviews several aspects of the Clean Air Act as they pertain to modes of infrastructure.

Topic Paper 3-2: Lessons Learned: Case Studies of Select Infrastructure Projects

Authors: *Benjamin Nussdorf (U.S. Department of Energy) and Maria Dunn (Phillips 66 Company)*

This paper details lessons learned from a few projects that experienced permitting challenges across various modes of infrastructure, pipeline, terminals, and railroads.

Topic Paper 3-3: Gas/Electric Coordination and Natural Gas Pipeline Deployment

Author: *N. Jonathan Peress (Environmental Defense Fund)*

Federal energy regulators and energy market participants have identified the need to improve interoperability between the natural gas and electricity wholesale markets as critical to improving reliability and resiliency, and to foster infrastructure deployment. Due to incompatibility within the markets, the largest end-user of natural gas pipelines, natural gas-fired power generators, faces impediments to entering into contracts necessary for pipeline capacity expansion. Power plant takes from pipelines are highly variable; yet the market currently lacks an efficient and transparent pricing structure for the intraday volumetric variability upon which they rely. Conversely, the design of the competitive wholesale electricity markets does not provide competitive generators with sufficient incentives to commit capital needed for expansion to meet their requirements for gas transportation services. These impediments will become more pronounced as additional renewables are deployed, which will increase intraday variability. Thus, energy regulators and market participants should identify and implement market policy solutions for improving coordination and the means for electric generators to contract with pipeline operators to meet their evolving needs.

Topic Paper 3-4: Expanding Government's Role in Educating Tribal Governments on Pipeline Projects

Author: *Lou Thompson (Tribal Energy Resource, LLC)*

This paper discusses opportunities for the Department of Energy to enhance educational programming related to oil and gas infrastructure development with Native American and Alaska Native tribes, which would allow the energy infrastructure industry to work more effectively with tribal governments.

Topic Paper 3-5: The Impacts that NAGPRA has on Energy Development

Author: *Lou Thompson (Tribal Energy Resource, LLC)*

This paper provides background on the Native American Graves Protection and Repatriation Act (NAGPRA) and recommendations for improvement in government and Native American and Alaska Native tribal relations.

Topic Paper 3-6: The Aspen Institute Dialogue on Energy Governance: Stakeholder Engagement Best Practices and Recommendations

Author: *Marilu Hastings (Cynthia and George Mitchell Foundation)*

This paper provides background on practices and recommendations of stakeholder engagement best practices, developed by the Aspen Institute Dialogue on Energy Governance.

Topic Paper 3-7: LNG Pressure Relief Device Testing

Author: *Pat Outtrim (Telluriam Inc.)*

This paper provides background on testing of LNG pressure relief devices.

Topic Paper 3-8: The Merchant Marine Act of 1920

Author: *Matt Woodruff (Kirby Corporation)*

This paper provides background on the Merchant Marine Act of 1920 (the "Jones Act") and its implications in the movement of petroleum cargoes within the United States.

CHAPTER 4

Technology Advancement and Deployment Task Group

Topic Paper 4-1: Technology Commercialization Challenges in the Midstream Oil & Natural Gas Sector

Authors: *Lisa George-Sharpe, Ravi Patel, Karina Pérez-del-Rosario, and Aparna Ramanan (Deloitte)*

Oil and natural gas pipeline and storage technology advancements have been instrumental in the significant improvements in safety, environmental performance, and operational efficiencies and are critical tools for energy access and security. This topic paper will discuss the impact of the midstream sector and how it has evolved, as well as provide a perspective on the various challenges that the midstream industry faces with respect to research, development, commercialization, and adoption of new technologies. If these challenges are fully recognized and understood, the relevant stakeholders can identify effective solutions to overcome them and enable technology advancements to continue to play an important role in propelling the industry forward.

Topic Paper 4-2: Challenges for In-Line Inspection

Authors: *Salvatore R. Paonessa (Enbridge Liquid Pipelines) and Bryan MacKenzie (Enbridge Energy Partners)*

Use of in-line inspection is expanding among pipeline operators. Research and development continues to expand the use cases of in-line inspection technology and to address limitations. In-line inspection can now address lines that were once deemed "unpiggable." New technologies allow these lines to be inspected with minimal modifications to the pipeline. Challenges to further expansion of in-line inspection include inspection tool access, pipe cleanliness, high fluid density, heavy wall thickness, transportation of natural gas liquids, and product flow rate. Development of new technologies and innovative techniques have helped to address these challenges and further expand the boundaries of what inspections are possible.

Topic Paper 4-3: Corrosion Management Technologies and Methodologies

Authors: *Mona Abdolrazaghi, Sherif Hassanien, Yanping Li, Alfonso Garcia, Len Krissa, and Trevor Place (Enbridge Inc.)*

This topic paper describes different aspects of corrosion integrity management and technology advancement. In-line inspection of corrosion uses relatively mature technologies for detecting and sizing metal loss defects. The uncertainties associated with in-line inspection for corrosion features (especially sizing accuracy) vary for different morphologies. Following inspection, there are well established assessment methods to evaluate the risk posed by the corrosion feature. Areas for enhancement include better modeling of pinhole corrosion, corrosion under high strain conditions, and evaluating temperature severity. Corrosion growth rate assessment is susceptible to measurement errors but several techniques are available to aid in its estimation. Uncertainty in corrosion growth rate, in-line

inspection measurements, and field readings can be quantified using statistical assessments supporting probabilistic analysis or calibration of in-line inspection measurements. While corrosion management is mature compared to other threats, the corrosion process is complex and additional research and development will help to better address complex corrosion cases and provide better data to support asset integrity decision making.

Topic Paper 4-4: Crack Detection and Management

Authors: *Steve Potts (The Williams Companies, Inc.), Bryan MacKenzie (Enbridge Energy Partners), Lyndon Lamborn and Mona Abdolrazaghi (Enbridge Inc.), and Thomas Bubenik (DNV GL USA)*

In-line inspection supported by in-the-ditch non-destructive examination has become a critical means of detecting and managing pipeline crack defects. Industry efforts to advance these technologies have improved the ability for tools to properly detect and size crack features. Crack detection and measurement challenges include detection certainty, proper threat identification, measurement uncertainty, data quality, crack evaluation, and others requiring additional research and development. This topic paper addresses additional development needed for in-the-ditch non-destructive examination tools.

Topic Paper 4-5: Dent Inspection and Assessment

Authors: *Doug Langer and Muntaseer Kainat (Enbridge Inc.)*

The inspection and assessment of pipeline dents is made challenging by the complex feature shapes and interactions that can occur over the life of the pipeline. Inspection of dents is not always effective, as tools may not be able to identify cracking located in dents; this leads to a greater need for effective assessments. Assessment techniques are typically developed for plain dents and advanced analysis is often required when there are complex dent shapes or interacting features. Field inspection is a useful tool for assessing dents but there remains some debate in the industry about how to define a safe operating pressure. This topic paper proposes several enhancements to improve dent management.

Topic Paper 4-6: Use of Inspection Technology to Characterize Material Properties

Authors: *Rob MacKenzie, Millan Sen, and Bryan MacKenzie (Enbridge Inc.) and Sean Moran (The Williams Companies, Inc.)*

Pipeline operators sometimes do not have complete records of the pipeline material properties for each joint of pipe due to the age of the asset or available records. This information is important for validation of operator records, integrity decision making, and optimization of in-service welding procedures. In-line and in-the-ditch inspection techniques allow gathering of data for sufficient characterization of these properties while minimizing costly destructive testing. Standards and recommended practices facilitate inclusion of these tests into industry best practices but there remain regulatory barriers for the use of these test results. This topic paper addresses continued research and development underway to enhance the capabilities and accuracy of these techniques as a means of continuous improvement.

Topic Paper 4-7: Use of Data Integration to Support Integrity Assessment

Authors: *David Heaney (Phillips 66 Company), Bryan MacKenzie (Enbridge Inc.), and Thomas Bubenik (DNV GL USA)*

The alignment and integration of in-line and field inspection data is a critical part of determining the location and severity of potential threats. Operators use a wide range of data to provide a combined understanding of the conditions affecting a given inspection result. Performing assessments using integrated data has challenges related to the data sources, data alignment, spatial and measurement accuracy, variability in input parameters, and analysis methods. These challenges can lead to overly conservative results and unnecessary mitigations. This topic paper addresses industry advancements—including technology advancement, research, and industry best practices—in integrating data to better support asset integrity programs.

Topic Paper 4-8: Pipelines Crossing Under Roads/Railroads: Cased Crossings vs. Engineered Uncased Crossings

Author: *Tara Podnar-McMahan (DNV GL USA)*

The improvements in horizontal directional drilling (HDD) have enabled natural gas and liquid petroleum pipelines to be installed under roads, rivers, levees, and railroads utilizing engineered designs that do not require a pipe casing or open cutting of ground surfaces. Historically, casings have been installed routinely at sites requiring additional structural support and mechanical protection in locations such as highway and railroad crossings. While offering structural support and mechanical protection, the casings themselves are susceptible to pipeline integrity threats that are unique to cased crossings. This topic paper addresses HDD technology development, the benefits of HDD for installing pipe, and the regulatory challenges to deploying HDD.

Topic Paper 4-9: Reciprocating Compressors and Methane Slip

Authors: *Chris S. Nowak (Kinder Morgan) and Greg Beshouri (Hoerbiger Engine Division)*

As natural gas reciprocating engines run leaner to minimize criteria pollutant emissions, uncombusted hydrocarbons (including methane) in the emissions increase. The uncombusted hydrocarbons are referred to as methane slip. This topic paper proposes funding of a computational fluid dynamic (CFD) investigation to isolate the relative effects of temperature, partially reacted chemical species (a.k.a. radicals), and turbulent jet mixing on ignition performance. The topic paper also addresses the need for cost effective methods for field quantification of methane in the exhaust.

Topic Paper 4-10: Methane Leak Rate Quantification versus Detection

Author: *David Felcman (Enbridge Inc.)*

Historical gas transmission and storage leak studies have shown that a small number of large leaks contribute the majority of leak emissions and a large number of small leaks have a very small contribution to total leak emissions. Current technology identifies a leak but does not quantify the leak rate to prioritize resources to efficiently and effectively address the largest leaks. This topic paper addresses development and deployment of technologies that will identify, locate, and quantify the leak flow rate.

Topic Paper 4-11: LNG Shipping and Terminal Handling

Authors: *Shahzaad Mohammed and Guy Nicholls (Cheniere Energy Inc.)*

The global LNG market is well developed with mature standards, regulations, and industry organizations. These standards, regulations, and industry organizations ensure safe transit and storage of LNG. Under this well-regulated system, voyages and tonnage of cargo have increased dramatically and safely since 2010. The size and capacity of LNG tankers has also increased to further address market demand. Traffic management at ports and terminals is well developed with specific tugs dedicated to LNG vessels. Ship-to-shore transfer operations are equipped with emergency shutdown systems and specially designed loading arms. Development and exercising of emergency response plans further ensure the safe operations of the LNG shipping and storage industry.

Topic Paper 4-12: American Waterway Operators – Responsible Carriers Program & USCG Subchapter M

Author: *Zach McGavitt (Kirby Inland Marine, LP)*

The American Waterway Operators (AWO) is an industry association for the tugboat, towboat, and barge industry and has long been the only standard for safety management systems in the U.S. inland tugboat and towboat industry. As participation in this industry group has always been voluntary, there was still a segment of the industry operators that were not held to any baseline of a standard when it came to risk management with a safety management system. The implementation of Subchapter M now sets a minimum standard for all commercial vessels operating in the United States.

Topic Paper 4-13: European Union Cybersecurity Response to Attacks on Critical Infrastructure

Author: *Jason Haward-Grau (PAS Global, LLC)*

The United States has not experienced direct cybersecurity attacks on industrial control system networks that have resulted in confirmed material disruption of service. However, there have been several attacks on power and utility networks in other countries such as Ukraine. These attacks have resulted in the accelerated development of European Union cybersecurity policies, which in turn have established a legal directive on cybersecurity for the protection of critical infrastructure. This topic paper addresses the relevance to the United States of attacks on European critical infrastructure and the applicability of EU cybersecurity approaches to the United States.

Topic Paper 4-14: Purdue Model Framework for Industrial Control Systems & Cybersecurity Segmentation

Author: *David Garton (Plains All American Pipeline)*

The Purdue Enterprise Reference Architecture is based upon the commonly used architectural reference model authored in the 1990s for control systems. The Purdue model provides a framework for segmenting industrial control system networks from corporate enterprise networks and the internet. The model is used as a baseline architecture for all industrial control system frameworks such as API 1164 and NIST 800-82. To understand the complexity of the OT environment, the Extended Purdue model was developed which is derived from the generic ICS model and applies specific risk layers and security zones. A conceptual visualization is displayed at the end of this topic paper to assist in applying these zones theories for practical consumption.

Topic Paper 4-15: The API 1164 Framework and Cybersecurity Considerations for Pipeline Transportation and Storage

Authors: *Joey Hewitt (Plains All American Pipeline), Curt Wiggins (Chevron Pipeline & Power), Thomas Penn (Enbridge Pipelines Inc.), Amy Bejtlich (Dragos, Inc.), and Kent Knudson (Plains All American Pipeline)*

The API 1164 was initially developed after the terrorist attacks on September 11, 2001, for pipeline and SCADA systems. The current framework is being broadened to apply to modern control systems being used within midstream companies. The framework primarily focuses on pipelines, but it could be expanded to other assets, such as storage. This topic paper provides guidance on the continued implementation of the API 1164 framework as the Technology Advancement and Deployment chapter recommends.

Topic Paper 4-16: Cybersecurity Considerations Relating to Marine Transportation

Author: *John Jorgensen (ABS)*

Marine cybersecurity requirements revolve around two main factors: system reliability for safe operations, and holistic security that encompasses the broad view of protecting the crew, ship and cargo. Mariners and operators need ways to understand the integration of cybersecurity in their greater context of transportation and cargo handling functions. This paper addresses an approach that merges cybersecurity with ship operations.

Topic Paper 4-17: Cybersecurity Considerations Relating to Rail Transportation

Authors: *Tom Farmer (Association of American Railroads) and Rick Holmes (Union Pacific Railroad)*

For security of information technology networks and systems and sustained safe and efficient train operations, America's major railroads have taken proactive and multi-faceted steps to prevent, respond to, and build resiliency against cyber threats. Implementing security programs guided by internationally recognized standards, railroads perform thorough assessments of potential vulnerabilities; implement protective countermeasures; and recruit and train specialized cybersecurity staff. Even the most effective cybersecurity plans and procedures will falter if useful information on cyber threats is not shared, which is why timely and comprehensive intelligence and information sharing between government security agencies and railroads is essential if cybersecurity efforts are to succeed.