Working Document of the NPC Study:
Arctic Potential: Realizing the Promise of U.S. Arctic Oil and Gas Resources
Made Available March 27, 2015

Paper #6-1

SCOPE OF ARCTIC-RELATED TECHNOLOGIES COVERED

Prepared for the

Technology & Operations Subgroup

On March 27, 2015, the National Petroleum Council (NPC) in approving its report, *Arctic Potential: Realizing the Promise of U.S. Arctic Oil and Gas Resources*, 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 Technology & Operations Subgroup. 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.

The attached paper is one of 46 such working documents used in the study analyses. Appendix D of the final NPC report provides a complete list of the 46 Topic Papers. The full papers can be viewed and downloaded from the report section of the NPC website (www.npc.org).

This page is intentionally left blank.

Topic Paper

(Prepared for the National Petroleum Council Study on Research to Facilitate Prudent Arctic Development)

6-1	Scope of Arctic-Related Technologies Covered
Author(s)	**Jed Hamilton (ExxonMobil)**
Reviewers	**Mitch Winkler (Shell)** **Bill Maddock (BP)** **Peter Noble (Noble and Associates, Ltd)** **Bill Scott (Chevron)**
Date: September 16, 2014	**Revision:** Final

SUMMARY

This topic paper documents the E&P Technology Chapter's initial effort to capture the scope of exploration and production technologies to be covered in the chapter. The primary vehicle chosen for this effort is an Excel spreadsheet (Scope Table) that lists the technology areas considered by the team to be important to cover. Only technologies that have some unique aspect of their application in an Arctic environment were considered. That is, if the technology is applicable to all E&P opportunity areas and its application in the Arctic is no different than that in other areas, then it is not included in the list. If the technology has unique design or operational considerations due to the presence of sea ice, icebergs or permafrost, it is included and the unique aspects are described. The technologies listed in the Scope Table were used to guide the selection of individual Topic Papers to support chapter writing. Not every technology was directly addressed in a Topic Paper. Some technology areas were addressed indirectly in various papers (as marked on the Table). Likewise, other technologies such as Common Operational Picture (included on the table as part of Ice Management), were addressed in separate Topic Papers due to their individual importance.

I. EXPLANATION OF SPREADSHEET

The attached spreadsheet provides a list of technology areas that define the scope of the offshore Arctic exploration and production technology chapter of the NPC Arctic Research study report. Twelve separate technology areas are identified, with two of those further subdivided into the areas of exploration and production. For each technology area, columns provide further information on:

- Detailed examples within the technology area;
- Unique aspects associated with Arctic application of the technology;
- If the technology is required for Exploration or Production or Both;
- If the technology is applicable to shallow water (<100m), deep (>100m) or both;
- Importance of the technology for global Arctic hydrocarbon exploitation and for offshore US Alaska;
- If the technology is covered directly or indirectly in one of the chapter Topic Papers;
- If the technology is considered by the team to be enabling for US Arctic development;
- If the technology can be considered to be associated with a higher prudent development risk factor (e.g., high potential environmental or human impact or high cost) and why;
- If it is currently an active area of research;

- If in the opinion of the team there are significant advancement opportunities in the technology area as opposed to only the normal ongoing incremental, continuous improvement opportunities.

NPC Arctic Research Study -- Arctic Offshore E&P Technologies Scope

	Technology		Detailed Examples within Technology Area	Unique Aspects Associated with Arctic Application of the Technology	Required for Exploration	Required for Production	Water Depth Shallow, Deep, Both	Importance for Global Arctic	Importance for Alaska Offshore	Covered in Topic Paper	Enabling for Future US Arctic Devel	Prudent Development Elevated Risk Factor? Why?	Area of Active Research	Significant Advancement Opportunities
1	Arctic offshore geophysical data acquisition		air gun alernatives; techiques for acuqiring high fidelity 3D seismic in and under ice; technology to reduce ensonified area	Interaction of ice with acquisition system	X		Both	X	🟡	Y			X	
2	Spill prevention and well integrity		includes well construction, novel means for source control, e.g.,well bore restriction devices; cuttable drill strings	Short open water season, ice interference, sensitive environment, lack of infrastructure, remoteness, darkness, more complex logistics, need for redundancy in equipment, maintenance of spares, having certain drilling equipment staged on site, having to meet additional regulatory compliance	X	X	Both	X	🟢	Y	X	X - high stakeholder sensitivity to oil spill	X	X
3	Bottom-founded structures	Exploration	mobile concepts for varying water depths and seafloor conditions	Ice loads, platform relocation in ice, short installation window, permafrost soils, potential for interaction with drifting ice island	X		Shallow	X	🟢	Y			X	
		Production	concepts to withstand loads from multi-year ice, ice islands, icebergs embedded in pack ice; concepts for maximum water depths	Ice loads, short installation window, permafrost soils, potential for interaction with drifting ice island		X	Shallow	X	🟢	Y	X			
4	Floating structures	Exploration	mooring and drilling riser systems allowing rapid disconnection and reconnection	Ice loads on moored vessel, disconnection, need for ice management, use as containment vessels	X		Both	X	🟢	Y	X	X - increased risk with operational disconnections, need for reliable, significnat ice load reduction	X	X
		Production	very high capacity mooring systems, mooring and drilling riser systems allowing rapid disconnection and reconnection, hull forms that optimize in-ice and open water performance	Extended season capability, ice loads on moored vessel, disconnection, need for ice management		X	Deep	X	🔴	Y				
5	Ice management		remote sensing altenatives that improve ice typing reliability, thickness resolution, and mechancial properties (link with ice chacterization); improved forecasting models; automatic detection of marine mammals; Common Operational Picture system for information management and display and fleet command/control.	Continuous ice surveillance (overlaps with ice char chapter), reduction of ice loads on floating vessels, stationkeeping in ice	X	X	Both	X	🟢	Y	X	X - increased risk with operational disconnections, need for reliable, significant ice load reduction	X	X
6	Winterization		low energy technology and schemes for keeping spaces warm and preventing compartments with liquids from freezing; technology and schemes for mitigating explosion and fire consequneces in enclosed spaces	Personnel safety and operations efficiency in extreme cold climate	X	X	Both	X	🟡	Y/I				
7	Low temperature materials		welding and connection methods for -50 to -60°C steels that can be practically and reliablity executed for plate thicknesses up to 100 mm	Ambient temperatures ≥ -55°C		X	Both	X	🟡	Y/I				
8	Automation and robotics		integrated technologies that can make step change reductions in personnel (requires detailed undersanding of current operation and maintenance practice)	Work under ice, reduction of personnel in harsh location		X	Both	X	🟡	N			X	X
9	Subsea production equipment		high reliability valves, chokes manifolds, control sysems, condition monitoring	Can avoid ice interaction associated with surface-piercing structures, access and maintenance under ice, protection from ice impact in shallower water depths		X	Deep	X	🔴	N		X - risk of leaks needing intervention in ice season		
10	Offtake and shipping		independently acting icebreaking tankers, offloading connections and platform tethering facilities, ice management during offtake, ice rubble avoidance/clearing around platforms	Mooring/connection/station-keeping of tanker in moving ice, icebreaking vessels and support, escort in ice		X	Both	X	🟡	Y		X - higher risk of oil spill during offloading and transport		
11	Offshore pipelines		alternatives to welds for connecting large diameter pipe, deep excavation trenching equipment	Burial to large depth (e.g., >5m) below mudline for ice protection, short installation window, pipe lay in mobile sea ice		X	Both	X	🟢	Y	X	X - risk of oil spill due to ice damage to subsea pipelines	X	
12	Technologies for associated gas			Potentially difficult to inject		X	Both	X	🟡	N	N			?

🟢 high relevance and high impact
🟡 high relevance but low or indeterminate impact
🔴 low relevance or impact

Y/I means yes but indirectly