Technologies for Offshore Structures in Extreme Environments to Resist Multiple Natural Hazards

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Global energy demand will be approximately 30 percent higher in 2035 compared to 2010, according to the World Energy Outlook published by the International Energy Agency (IEA). This increase in energy consumption is necessary to fuel a world whose population will grow to nearly 9 billion people and whose economic output will more than double by this time. Even with strong gains in efficiency through energy saving practices and technologies, the IEA forecasts that 75 percent of the energy demand in 2035 will still be met by fossil fuels.

The Arctic, one of the last remaining frontiers on the planet, has significant potential to help meet future global energy demand. The United States Geological Survey estimates that over 20 percent of the world's undiscovered, technically recoverable petroleum resources lie within the Arctic Circle. Nearly 85 percent of these Arctic resources are offshore; which, from an engineering perspective, presents some of the most demanding conditions imaginable.

Engineering challenges in the Arctic include:

- Mobile pack ice and icebergs
- Low temperatures
- Remote location
- Permafrost
- Earthquakes (some areas)
- Sensitive environment
- Severe storms and waves
- Prolonged darkness

Offshore structures used in the oil and gas industry to resist these multiple natural hazards are some of the most advanced structures that people never see – as they are installed nearly entirely below the surface of the water. These structures begin their lives on dry land. They are built, by labor forces numbering into the thousands, to heights that are comparable to modern high-rise buildings. Once complete, they move to the sea, where these structures of monumental size and mass must seemingly defy nature and float – float with the seaworthiness to survive a journey of sometimes thousands of kilometers in open water to the reservoir site. There, they are installed with accuracy that is monitored in millimeters.

Only then are they are ready to begin their lives as an operating platform – with all the hazards associated with some of the world's most inhospitable locations. Offshore structures in the Arctic must be designed to resist various combinations of extreme wave, wind, earthquake and ice/iceberg loads. All the while, with an unrelenting and uncompromising focus on protecting both the natural environment which hosts our activities and the safety of the men and women who carry them out.

The engineering challenges encountered in the Arctic and the state-of-the-art technologies implemented to overcome them are highlighted using the Arkutun-Dagi platform (presently under construction) as an illustrative example. This structure will be installed off the coast of Sakhalin Island in far eastern Russia, just north of Japan in 2012-2013. The Arkutun-Dagi platform must operate in a highly seismic environment – one that is also covered in sea ice up to 2m thick several months of the year. The design, testing and monitoring of state-of-the-art earthquake protection devices that isolate the topsides from damaging earthquake accelerations will be described. In addition, experimental facilities used to determine ice loads on structures will also be discussed.