11. Non-Renewable Resource Development, Transportation, and Energy

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11.1 Introduction

The Western Arctic is supplier and source for a large fraction of the non-renewable resources for the rest of the world. Alaska, Northwestern Canada, and the Yakutia Republic in the former USSR, contain large reserves of oil and gas and also contain vast coal resources, only a portion of which have been explored, discovered, or exploited.

The several predicted effects of climate change on the production, storage, and transportation of oil, gas and coal, on mining, and on infrastructure have important implications both negatively and positively for the economy of the northern hemisphere.

Climate alone is not and will not be an over-riding determiner of the distribution of infrastructure and non-renewable resource development. Rather, human needs and the economic viability of various mines, oil fields, and industries will drive the need for infrastructure. These are inherently political and economic decisions, not scientific decisions. Political and economic decisions will evolve from a competition for fiscal resources. It is within the framework of economic competition that climate-change enters the decision-making process by affecting the costs of doing business or the costs to support human needs.

An economic activity such as a mine or oil field will be judged on the basis of its return on investment and it must compete with similar activities throughout the world for investment dollars. If, for example, thawing of permafrost reduces the costs, the activity becomes more viable. If that thawing increases the costs, the activity is less likely to secure the necessary investment funding. Both increases and decreases in costs of doing business are likely to occur as a result of climate change.

The public decision process, however, is rarely driven by considerations of fiscal return on investment. It is determined rather by social costs, protection of minority interests [from abuses by majority interests], solution of problems beyond the capability of the private sector to solve, and issues of the general welfare. It is to the several governmental bodies that those negatively affected by climate change will often resort for assistance. In the event of major infrastructure losses and social dislocations, the public will probably seek political responses to the problems. Rational economic decisions to climate change problems may be overridden by governmental responses.

In Alaska, for example, taxes and revenue sharing from petroleum production and its infrastructure have represented about 85% of state government revenue and a substantial portion of local government revenue. The North Slope Borough, and numerous villages within the borough, depend on petroleum taxes to provide their citizens with the preponderance of their energy, jobs and services. Citizens of the Fairbanks North Star Borough, for example, derive 36% of their payroll from petroleum (ISER Review, September 1996).

Alaska's existing and developing mines employed 2,580 persons statewide in 1997 and project employment of 3,285 in 1999 (Alaska Minerals Commission 1997). Across the Western Arctic petroleum and mining sustain a substantial level of domestic and export economic activity and the jobs necessary to sustain the population. The combined employment of mining and petroleum averaged about 10,000 in 1996 (Alaska Economic Trends, April 1997).

Energy production by means of hydroelectric systems, fossil fuel, and other less-standard techniques, will be affected by changes in glacial melt, river flow, transpiration, snow accumulation, precipitation, average wind speed, changes in annual temperature, solar radiation, changed physical access to fuels, and impacts on the infrastructure of power generation and transportation.

In Alaska most of the several hundred small rural villages satisfy their total energy requirements with petroleum products imported by boat. Climate effects on the river systems, port facilities, and hindrances or improvements in ocean transportation will have vital impacts on the energy needs and transportation of supplies for the future vitality of these communities.

Rural community residents are supported in large part by governmental transfers (Huskey 1992). For example, in 1995, Norton Sound region received $7,541,000, the Interior region received $5,952,000, and the Lower Kuskokwim region received $7,657,000 which constituted about 60% of the total (Alaska Economic Trends). As climate alters the environment, local residents may be unable to support themselves from subsistence or market sources, leading to considerably magnified effects upon the level of state government transfer obligations.

In addition to the direct effects of climate change, several other associated industries are affected. Principal among these are the insurance and banking industries. The destructive storms recently inundating the Atlantic coast of America have brought US and foreign insurance companies to conclude that their financial risk analysis process, which is based upon past experience, is inappropriate for a changing climate. Natural disasters were 94% more frequent during the 1990s than they were in the 1980s. While the jump may result from normal variations, the increase matches the patterns predicted for global warming.

Seeing these changes as a possible preview of the costs that a changing climate may impose on society, insurers must set their premiums in anticipation of major future losses and change their strategies for dealing with long-term investments. Rising sea levels, changing storm paths and intensity, and storm surges will erode and breach the beaches protecting the huge amount of both insured and uninsured coastal property on the North Pacific, Bering Sea, and Sea of Ohotsk coasts. Rising insurance costs could adversely affect the creation of new infrastructure, jobs, and other elements of the economy based on its creation and maintenance. Changing insurance company and banking investment patterns will affect the creation of new or replacement infrastructure and businesses in the Western Arctic.

11.2 Current and Future Changes

Water resources

Water resources in Alaska will be affected by a myriad of offsetting or enhancing effects that will vary widely across the state. Predictive capability, both in terms of global circulation models and in regional circulation models is insufficient to ascertain which areas of the state will be wetter or drier. Thus, only broad generalizations are possible.

Precipitation Trends

Global-circulation models generally predict 50-100 percent increases in precipitation in high latitudes. Although the increases may be less than this overall in Alaska, precipitation increases statewide in the range of 10-30 percent are commonly expected. Locally, however, precipitation is controlled by storm tracks interacting with the mountain ranges of the coastal and interior Alaska. This interaction may result in large precipitation shadows in which precipitation is locally decreased at the same time that increased temperatures are causing higher rates of evapotranspiration. The result may be local areas that are significantly drier than has been typical this century, whereas the state will be generally wetter overall.

At least for the southern half of the state, the position of the Aleutian low determines which areas receive more or less precipitation. An easterly position feeds cyclonic storm tracks into Southeastern Alaska. A more westerly position of the Aleutian low feeds storm tracks into south-central and Western Alaska. (See also Chapter 7.) During the 5-year period 1977 - 1981, for example, Pacific winter storms delivered large volumes of snow to the Kenai Mountains in South-central Alaska. This increased snow resulted in positive mass balances for Wolverine Glacier in four out of the five years, in spite of increased melting brought on by slightly higher temperatures. During the same time, Gulkana Glacier in the Alaska Range had a positive balance in only one year.

In Northern Alaska, warmer temperatures, a longer ice-free season, and more open water on the Arctic Ocean will lead to increased rates of evaporation. This evaporated water will then be available for delivery as rain and snow in coastal and uplands areas. During both winter and summer, precipitation is likely to increase.

Permafrost and the Effects of Thawing

Thawing of permafrost in Interior and northern Alaska will increase rates of infiltration and amount of storage in aquifers and the active layer. This will generally result in decreased flood peaks and increased base level flows. The reduction of peak flow caused by increased infiltration of rain into the aquifer is likely to be offset, however, by increased frequency and quantity of precipitation. Similarly, the increase in base level flow may be offset by increased rates of evapo-transpiration and by decreasing volumes of melt water from glaciers. Base level flow reductions associated with recession of glaciers will be most severe in basins with small glaciers that disappear during a warmer climate.

One of the biggest impacts of melting glaciers and snow fields may be to the hydropower industry. Most of Alaska's major hydropower sites obtain large volumes of water from melting glaciers. Glaciers are an excellent buffer in the rainfall-runoff relation, slowing their melt as rains increase during cool, rainy weather and increasing their melt when rains stop during hot, dry weather. As glaciers become significantly smaller, flow variability will increase, resulting in the need for larger reservoirs to meet power demands during low-flow periods.

Summer base level flow in streams is critical to water transportation. A warmer climate is likely to yield a longer shipping season in most of Alaska's major rivers. Some streams draining areas with decreased runoff, however, may have periodic summer flows too low to permit barge traffic. Most north-flowing rivers in Alaska have no winter base level flow; the rivers stop flowing from December until spring breakup in May or June.

As the climate warms, aquifers may develop in alluvial fans along the front of the Brooks Range. These may lead to more persistent winter base level flow. This increased winter base level flow may produce icings in streams, ditches, and culverts that are currently free of icings during much of the winter. Icings along roadways will generally increase maintenance costs.

In the interior basins, such as the Fairbanks region, permafrost under the valley bottoms acts as a confining layer to retard the flow of deep ground upward into the stream. Slowing this upward flow in the valley bottoms is important to maintaining water levels under adjacent hill slopes. As the permafrost thaws, flow to the creeks is less impeded, and water tables under the hills decreases. In the Fairbanks area, thawing of permafrost in the valley bottoms may result in many wells having to be deepened or drilled in new locations.

Sewage Disposal

Increasing exploration and development of Alaska's mineral and renewable resources and its growing population will put increasing pressure on sewage-treatment facilities. The effects of climate change, however, are likely to be largely positive and will partially offset the impacts of the larger system capacities that will be required to meet the expanded demands. Less extensive permafrost, increased depth to the water table, and increased ground-water fluxes will generally enhance the performance of systems that discharge to the subsurface. Increased stream flow, particularly base flow, and decreased ice cover will enhance the aeration and dilution of effluent from waste-disposal systems that discharge to streams.

Water Engineering, Design, and Effects

Water is a construction material in northern Alaska, where fresh water is applied to the land surface to create ice roads. Warmer temperatures on the North Slope will decrease the amount of fresh water that is locked up each winter when many lakes freeze nearly to the bottom. This will leave more water available for construction of ice roads. Although more water will be available, a shorter season of freezing will result in less time during which the roads can be used.

Although water is used for ice roads, it may pose a hazard to conventional roads, pipelines, and other infrastructure. Storms are likely to be more frequent and more intense with warming. Bridges and culverts designed for the climate of the mid-twentieth century may be under-designed for the 21st century. Migrating stream channels, which generally shift during periods of high flow will also be a hazard. Of particular concern are the roads and pipelines built across alluvial fans in mountain regions. There floods are often quick and intense, and flood frequencies are poorly defined. Channel avulsion may quickly shift the flow into an area where the infrastructure is not adequately protected. The Trans-Alaska Oil pipeline has already been exposed in one such area.

11.3 Oil and Gas

Oil and gas exploration and production will continue to shape the direction of the Western Arctic economy. The petroleum industry is the largest component of the Alaskan economy, in recent years contributing roughly $15 billion annually, or 70% of Alaska's gross state product (Institute of Social and Economic Research 1997). Current stresses on the Alaskan economy arise from the continued decline of petroleum production from the North Slope, which peaked in 1988. Possible new exploration and development in the northeastern National Petroleum Reserve in Alaska may offset this decline in the future.

Exploration and Development

Almost 30% of the nation's undiscovered technically recoverable conventional oil resources are estimated to occur in Alaska (U.S. Geological Survey 1995). Current pressures on the petroleum industry include the need to locate and develop new resources in increasingly hostile and environmentally sensitive locations throughout the Western Arctic. Off-shore and ice-rich remote area exploration and drilling involves use of more complicated technologies which dramatically increase costs. In Alaska, the Kuukpuk, Thesis Island, Jones Island, Sandpiper, North Star, Endicott, Liberty, Badami, and Pt. Thompson units on the North Slope, a sizable portion or all of the units lie off-shore. Continuous changes in land and ocean climate conditions will require completely changing the engineering techniques originally devised for present environmental conditions.

Decreased ice cover, changes in wind and ice drift patterns, release of previously shore-fast glacier ice all provide threats to shoreside or off-shore infrastructure affecting the cost and complexity of off-shore Arctic oil extraction. Providing ice reinforced structures and ocean bottom pipelines capable of resisting the forces of ice islands and the ice pack will be necessary. Transportation of petroleum field development and maintenance supplies will change and may become much more difficult as well.

Transportation

Because increasing technologies permit smaller surface disturbance in the development of oil fields, the greatest impact from changing climate will be effects on maintenance of the transportation infrastructure needed to deliver the petroleum to refineries and the market. Sustained production of petroleum in Northern Alaska will require increasing demand for sand and gravel to maintain haul roads, pipelines and airports that deteriorate due to melting permafrost. Rising sea levels and coastal erosion may affect the locations near Cook Inlet and elsewhere in the Western Arctic where refineries are currently located on shore-side locations, and likewise may affect the associated port facilities. With reduced sea ice, however, there may be an increased probability of ocean transportation of crude oil and liquefied gas which could lower costs and increase markets for these Arctic resources.

Consumption, Demand, and Market Trends

International commitments to reduce greenhouse gas emissions imply potentially substantial economic losses for Alaska's petroleum industry, a major contributor to the state's economy and a significant source of nationwide production. Alaska has the two largest producing oil fields in North America, accounting for 25 percent of U.S. production (State of Alaska 1995 b.1). Royalties and taxes on oil make up nearly 85 percent of the funding for state government, and the oil and gas industry contributes both directly and indirectly to virtually every sector of the state's economy (State of Alaska 1995 b.5).

Ironically, the very dependence of the state's economy on petroleum creates an unfavorable investment climate by increasing the vulnerability of the petroleum industry to higher tax rates (State of Alaska 1996,6). High exploration and production costs have discouraged some companies from staying in Alaska. Declining productivity of the North Slope, which is expected to decrease at a rate of about 5 percent per year, has state and industry officials investigating the possibility of constructing a natural gas pipeline to supplement area income. There are possibilities, however, that improved technologies and new discoveries may reduce the rate of decline in total production.

Climate change can increase the demand for oil to generate energy for cooling in lower latitudes. Increased temperatures in Arctic areas may decrease the local fuel requirements, but while total per capita consumption may still be high, the total consumption is low in the North compared to southern areas.

Policy

Politically, measures to reduce greenhouse gas emissions such as a carbon tax, may provide a strong incentive for petroleum producers/exporters and the citizens of Alaska to unify around the objective of achieving special subsidies or exemptions. Other stresses such as rising sea levels and coastal degradation in areas such as Prudhoe Bay, may lead to requests for disaster relief. Because of the importance of petroleum to the Alaska economy, political developments affecting oil prices or consumption can be expected to have large but unpredictable impacts.

Mining

The mineral industry in the Western Arctic has some of the greatest resource potential in the world as yet largely untapped. Advancing technologies and geological concepts and access to new areas in the Russian Far East make it feasible to pursue mineral targets that were previously impossible. Economic and political decisions related to changing climatic conditions will determine when and whether these targets are exploited.

In Alaska, the most important economic minerals are, in order, zinc, gold, lead, coal, sand and gravel, building stone, silver, copper and jade/soapstone. In 1996, the value of Alaska's mineral production was estimated at $551 million (Alaska Minerals Commission 1997). The benefit to the nation is significant; Alaska's Red Dog mine (located North of Kotzebue, Alaska), for example, is the world's largest zinc producer and supplies approximately 7 percent of the world's production.

In many ways the mining industry will benefit from increased average temperatures. Easier access to, extraction and transportation of ore may result. Although placer operations currently provide about two-thirds of the gold being mined, future production is expected to