What information is needed to successfully respond to changes in arctic environments by 2050?

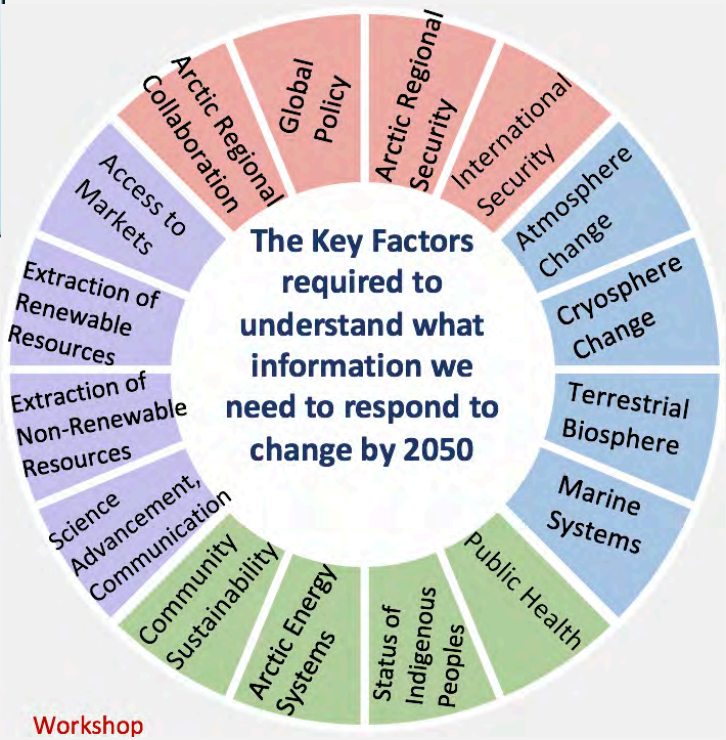
Under conditions of uncertainty we need nimble strategic thinking that does not lock us into investigation, policy processes, or goals that are likely to change as conditions in the Arctic change.

Scenarios are narratives of plausible future Arctics created by the evidence of experts.

The Study of Environmental Arctic Change (SEARCH) facilitated the Arctic Futures 2050 Scenarios Workshop in Seattle, Washington from 20 – 22 April 2018. The workshop represented one part of SEARCH's ongoing effort to forge effective long-term collaborations between Arctic scientists and policy makers.

Working for three days with over 30 scientists, Indigenous Knowledge holders, and policy experts, the objectives of the workshop were to:

- Survey expertise on the changing social and environmental conditions of the Arctic likely to impact policy decisions
- Learn what scenario outcomes are most plausible and consistent from the data you have provided the research team
- Outline research questions that would need to be answered to address policy responses to the plausible scenarios
- Consider next steps to inform Arctic policy with science.



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SEARCH Scenarios Project - Arctic Futures 2050

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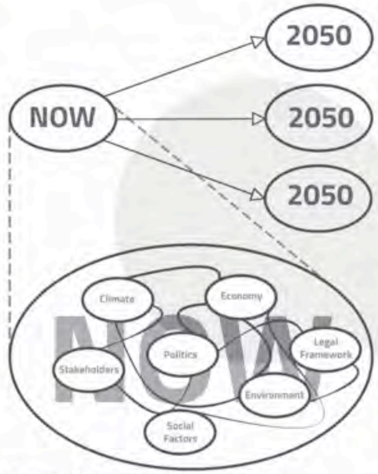
Robustness Analysis: Scenarios for Strategic Planning

Future or Futures?

It is inherently difficult to forecast the future. Thus, think in ***multiple futures***, aka ***scenarios***.

Limit the Field

The present and its future development are defined by many ***Key Factors*** and their interaction. For studying futures of a specific field carefully pick the most important Key Factors. This is done best during a workshop with stakeholders and experts.

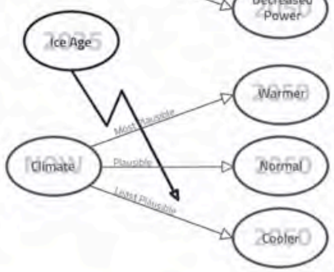


Key Factor - *quo vadis?*

In workshop, assign ***Future Projections*** (2-5) to each Key Factor. Rate their ***Plausibility*** (from 0 to 1). Think outside the box!

What if?

Find extreme, low plausibility, disruptive events - ***Wild Cards***. Good strategy is resilient to these. Think outside the box!



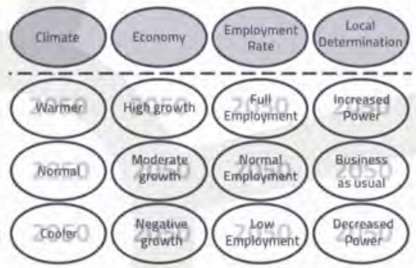
Consistent Pairs

Compare each Future Projection to all other Future Projections. Is it consistent for a pair to appear in the same future? Assign ***pairwise Consistency Values***, from -2 (totally inconsistent) to 2 (totally consistent). This generates the ***Consistency Matrix***. This process is best done by several individuals. Results from participants are merged.

Economy \ Employment Rate	Full Employment	Normal Employment	Low Employment
High growth	1.5	0.0	-0.5
Moderate growth	-0.5	1.0	0.0
Negative growth	-2.0	-0.5	1.0

Projection Bundles

Find all possible bundles of Future Projections. That is, all combinations of Future Projections, one from each Key Factor. This requires ***software support***.



Evaluation: Plausible, Consistent, Robust

Bundle Plausibility: multiply all Plausibility values of a Projection Bundle.

Bundle Consistency: add all pairwise Consistency values of a Projection Bundle.

Partial Inconsistencies: count the occurrence of pairwise Consistency values smaller than -1.

Total Inconsistencies: discard all Projection Bundles with one or more pairwise Consistency value less that -1.5.

Robustness: find Projection Bundles that have ***high*** Plausibility and Consistency values and ***no*** or ***few*** Partial Inconsistencies.

$$R = \left(\frac{\log(P)\cdot|C|}{1+\mathcal{N}(pI)}\right)^{\frac{1}{2}}$$

where R is Robustness, P is Plausibility, |C| is the norm of the Consistency, and N(pI) is the number of Partial Inconsistencies.

Retrieve Raw Scenarios

The list of Projection Bundles is very long; many are similar.

Aim: Find 3-5 dissimilar Projection Bundles, these will be the Raw Scenarios.

Tools:

Distribution Plot: this gives information about the Projection Bundles' quality.

Multidimensional Scaling: maps the high-dimensional Projection Bundles in 2D. Similar Bundles are close together.

Clustering: sorts the Projection Bundles into groups based on similarities.

Morphological Box (shown on right): visualizes Projection Bundles over the set of Future Projections.

Legal Frame-work	Arctic Treaty System	Status Quo	Tense Relation-ships	Armed Conflict	
Global Trade Dynamics	Low Growth	Moderate Growth	High Growth	Industrial Explosion	Collapse of Global Economy
Climate	New Cretate-ous Period	Ice Free - Severe Weather	Seasonal Ice - Shippable	Seasonal Ice - Dangerous	New Ice Age
Safety of Other Routes	Increasing Pressure	Stable in-crease of Traffic	Stable Demand		
Soc.-Econ Impact of Climate	Worldwide Loss & Conflict	Regional Loss & Conflict	Gain & Coopera-tion		
Oil Prices	Unpre-dictable Oscillation	Steady Rise, Pre-dictable	Stable	Cheap Oil	
Maj. Arctic Shipping Desasters	Minimal Impact	Moderate Impact	Maximum Impact	No Disaster - No impact	
Windows of Operation	Limited	Moderate	No limit		
Maritime Insurace Industry	Refusal	Partial	Drive Improve-ments		
Asian Players	Coopera-tion	Collabora-tion	No market Entry		
Transit fees	Economic. Viable Fees	Robbery Knights			
Indig. vs. Commerc. Conflict	Wealth - Low Inter-ference	Wealth - trad. life-style loss	No Inter-ference - No Profit	Inter-ference-Conflict	
Arctic Enforcers	Multilat. Military Force	Multilat. Police Force	Unilateral Territorial Protection	Conflicts Between Enforcers	Arctic Privateers
Propulsion Energy	Nuclear Propul-sion	SkySails	Hydrogen Based Propulsn.	Fossil Fuels	
New Resource Discovery	Arctic Goldrush	Weak De-mand/Re-strictions			
World Trade Patterns	Little Change	Moderate Change	Strong Change		
Regulation in the Arctic	Do As You Wish	Moderate Regulation	EU of the North		
Thermo-haline Circ. Weakens	Wild Card	No Wild Card			
Hot Cold war	Wild Card	No Wild Card			

Write Scenarios

Based on the selected Raw Scenarios write well flowing Scenarios. Use similar Future Projections to point out possible variations. Discuss how the Scenarios are affected under occurrence of Wild Cards.

Open Scenario Processes

Make all above steps available for discussion. Invite all stakeholders to participate. Open discussion improves final product, acceptance, and buy-in.

Info

denamics GmbH provides strategy development processes utilizing scenarios, co-creation, and serious gaming; innovation management in the technology sector, and R&D and project development expertise.

Contact: info@denamics.com and http://denamics.com

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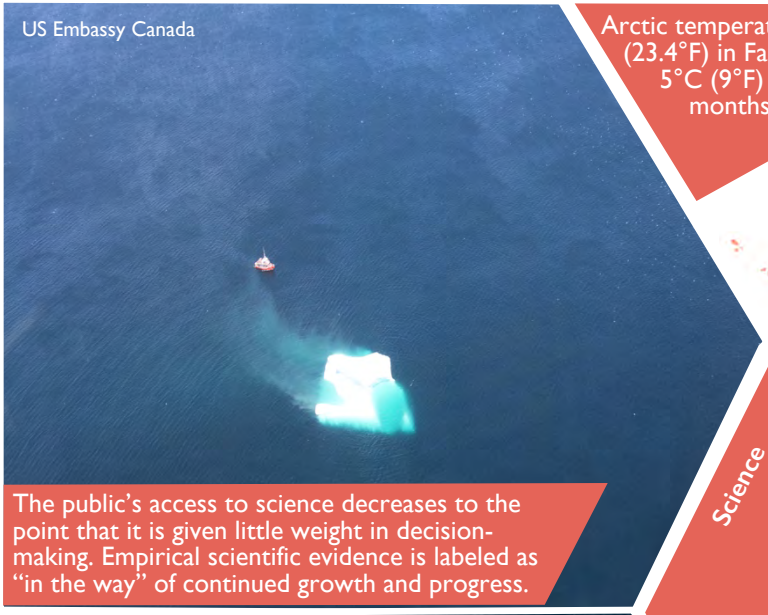
Recommended reference literature

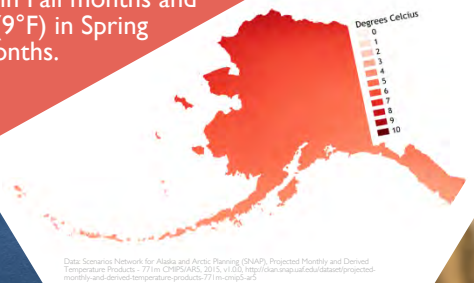
Acknowledgements:
Contact:

What information is needed to successfully respond to changes in arctic environments by 2050?



The public's access to science decreases to the point that it is given little weight in decision-making. Empirical scientific evidence is labeled as "in the way" of continued growth and progress.

Arctic temperatures increase 13°C (23.4°F) in Fall months and 5°C (9°F) in Spring months.



Data: Scenarios Network for Alaska and Arctic Planning (SNAP), Projected Monthly and Derived Temperature Products - 771m CMIP5/ARS, 2015, v1.0.0, http://ckan.snap.uaf.edu/dataset/projected-monthly-and-derived-temperature-products-771m-cmip5-ar5

There are significant intra-Arctic divisions. National agendas are prioritized over collaborative science, resource management, or cultural programs. The Arctic's security is compromised by the eight nations' inability to resolve shared problems.

Emissions - RCP 8.5

Science

Arctic Policy

Scenario #1

An Insecure Arctic in a Warmer World with High Resource Demand

Economics

Global Trends

Local Trends

The renewable resources of the Arctic region are extracted at intensifying rates driven by significant private investment from outside the region. Pressure on world resource markets for non-renewable resources due to political-economic uncertainty has driven commodity prices to sustained high levels.

Arctic peoples lose economic and territorial control as outside interests exploit internal divisions and promise wealth. Arctic Indigenous peoples and their demands for territory and management authority, and recognition of IK and language are viewed as barriers to progress.

Nations withdraw into domestic agendas and reduce engagement. Arctic states loose economic and territorial control as nations and multinational companies exploit internal divisions and promise wealth.

SEARCH Scenarios Project - Arctic Futures 2050

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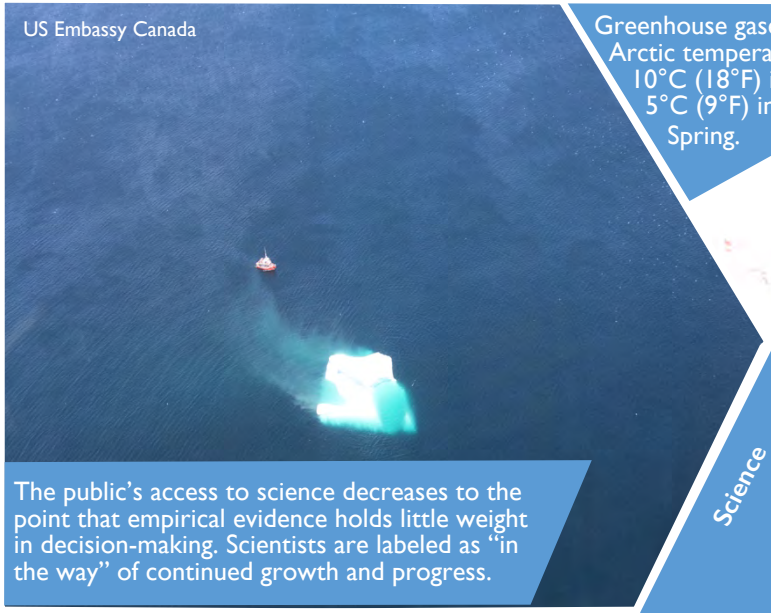
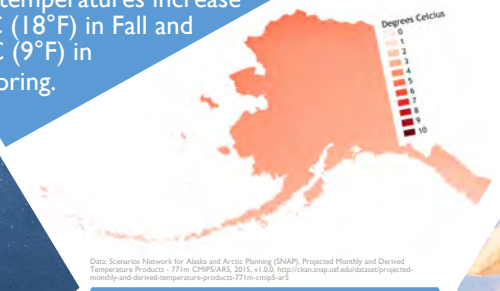


The public's access to science decreases to the point that empirical evidence holds little weight in decision-making. Scientists are labeled as "in the way" of continued growth and progress.

Greenhouse gases have yet to peak. Arctic temperatures increase 10°C (18°F) in Fall and 5°C (9°F) in Spring.



Data: Scenarios Network for Alaska and Arctic Planning (SNAP), Projected Monthly and Derived Temperature Products - 771m CMIP5/AR5, 2015, v1.0.0, http://ckan.snap.uaf.edu/dataset/projected-monthly-and-derived-temperature-products-771m-cmip5-ar5

Arctic nations focus on national policies with an emphasis on resource development and national security.

US Coast Guard

Emissions - RCP 6.0

Scenario #2

Arctic with Incremental Social Trends but Transformative Atmospheric and Marine Change

Science

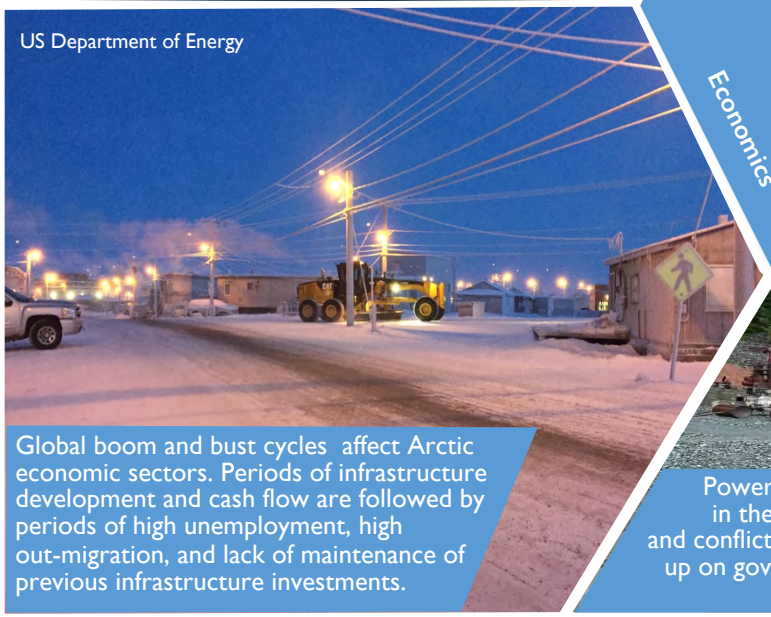
Arctic Policy

Economics

Global Trends

Local Trends

US Department of Energy



Global boom and bust cycles affect Arctic economic sectors. Periods of infrastructure development and cash flow are followed by periods of high unemployment, high out-migration, and lack of maintenance of previous infrastructure investments.

Powerful industries shape land and ocean use in their best interest, leading to competition and conflict with local stakeholders. Arctic peoples give up on governance structures to improve community sustainability.

Nations withdraw into domestic agendas and exhibit reduced international engagement. Seabed and Arctic Ocean conflicts, along with other disagreements, strain cooperation. Funding for the Arctic Council and pan-Arctic collaboration drops.

US Coast Guard

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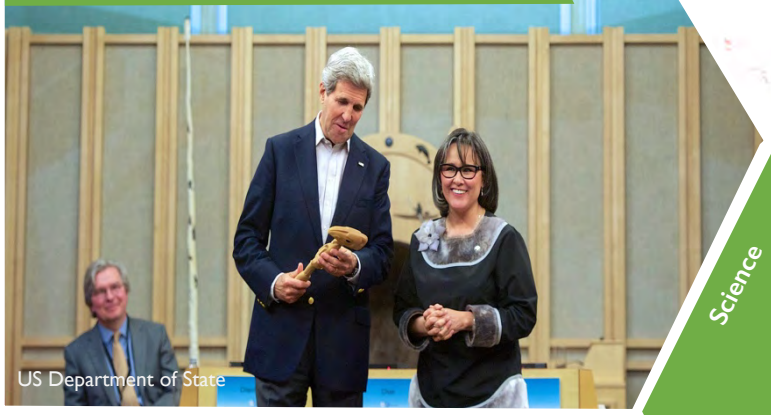
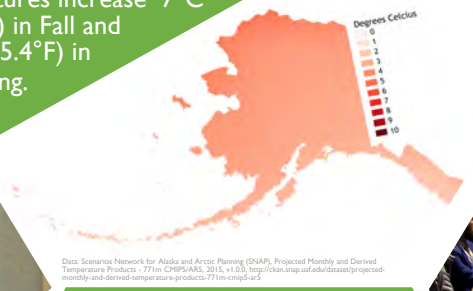
In science, there is a radical shift in the modes of knowledge acquisition and dissemination. Across the Arctic, nations include local and traditional knowledge in educational processes, formation of regulatory mechanisms, environmental management, and the Arctic Council.



Emissions peak in 2080. Arctic temperatures increase 7°C (12.6°F) in Fall and 3°C (5.4°F) in Spring.



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Emissions - RCP 6.0

Scenario #4

Late Century Decline in Emissions and Little Change in Governance Systems

Science

Arctic Policy

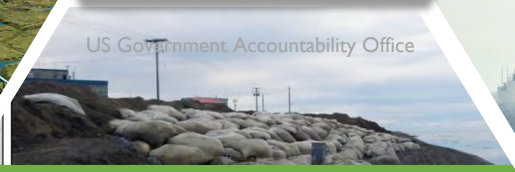
Economics

Global Trends

Local Trends

The Arctic Council facilitates cooperation, but strong national interests from outside the Arctic result in strained relationships among Arctic states. National and subnational governments decrease funding of Arctic populations.

Booms and busts affect the Arctic along with other nations. Investments for the increasing extraction of renewable and non-renewable resources comes from outside the region.



Progress for Indigenous rights occurs locally where Indigenous peoples and their allies practice mixed-subsistence livelihoods. In these locations, managers and officials are often Indigenous, and communities can fly under the radar of higher-level regulatory authorities.

Globally, international security is weak, however, wealthy nations maintain fairly high security, outside of domestic terrorism.

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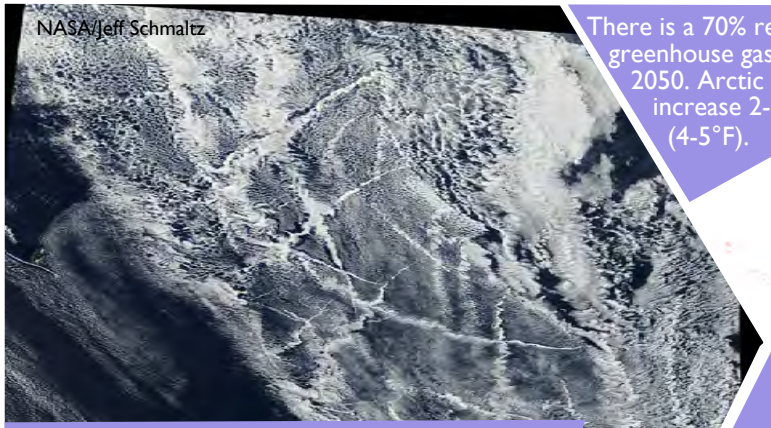
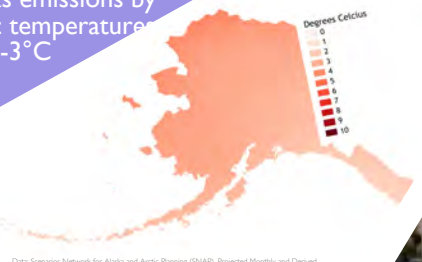

NASA/Jeff Schmaltz

There is a 70% reduction in greenhouse gas emissions by 2050. Arctic temperatures increase 2-3°C (4-5°F).



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Arctic nations cannot resolve their own Northern priorities or achieve circumpolar cooperation. Lack of collaboration degrades public health services and climate sensitive diseases break out in multiple Arctic locations in the 2030s.


National Guard

Geoengineering has gained a foothold in the area of fixing the planet's problems. Profits are to be made and state budgets to be secured, fitting the United States' and other nations' pursuit of continued economic growth. Geoengineering solutions pits scientists against one another.

Emissions - RCP 2.6

Science

Arctic Policy

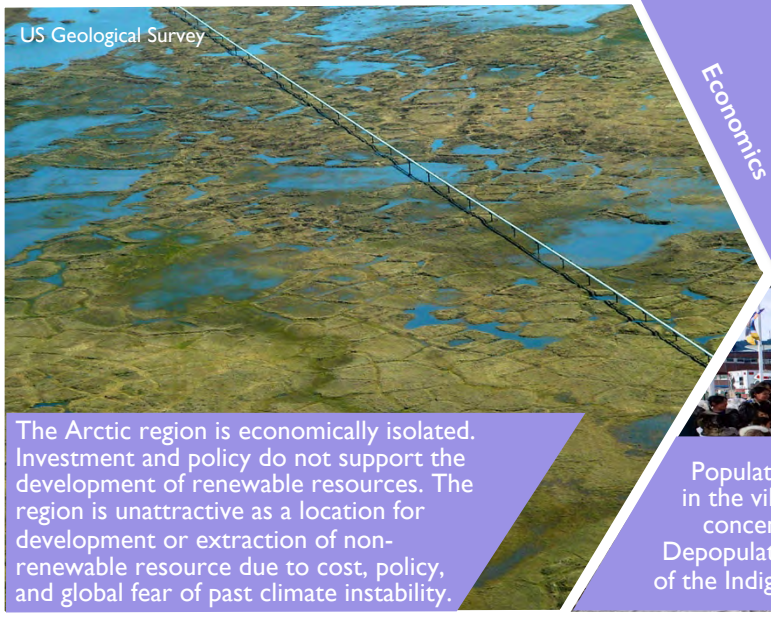
Scenario #6

Emissions Reduced in an Insecure World and Depopulating Arctic

Economics

Global Trends

Local Trends


US Geological Survey

The Arctic region is economically isolated. Investment and policy do not support the development of renewable resources. The region is unattractive as a location for development or extraction of non-renewable resource due to cost, policy, and global fear of past climate instability.


US Department of State

Populations in the high Arctic dwindle, more so in the villages than the hubs. Adaptation becomes concentrated mainly in urban Arctic enclaves. Depopulation fractures social networks, the vibrancy of the Indigenous cultures and languages are imperiled.

The United Nations looses its ability to mediate communication or debate. Global instability in governance is the norm. Nations withdraw into domestic agendas and reduce engagement.


US Department of Defense

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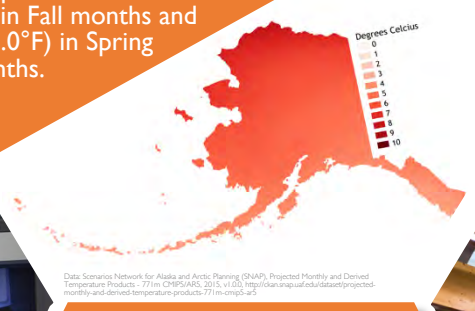
Scientific research in the Arctic improves the global system-level understanding of climate change. Science effectively serves the public. There is a general acceptance that science "has the answers". The number of technocrats as decision-makers increases.

Arctic temperatures increase 13°C (23.4°F) in Fall months and 5°C (9.0°F) in Spring months.



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Highly collaborative international partnerships exist between Arctic and non-Arctic nations. Arctic countries feel strongly secure in the region and non-arctic nations feel they have dependable and fair relationships.

Emissions - RCP 8.5

Science

Arctic Policy

Scenario #7

Significant Global Collaboration for Adaptation to Rising Emissions

Economics

Global Trends

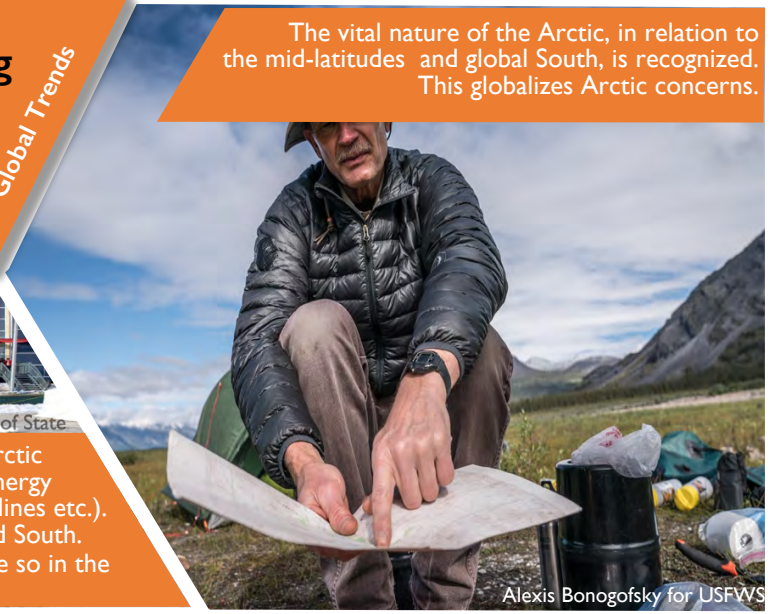
Local Trends

US Department of Energy

Oil and gas extraction and mining boom increases infrastructure and travel routes in remote Arctic locations. The flow of goods moves in both directions. Renewable resources of the region are extracted at intensifying rates driven by significant private investment from outside the region.

Arctic states connect their remote Arctic settlements and outposts to a large energy infrastructure system (pipelines and power lines etc.). In return, much of this energy is exported South. Populations in the high Arctic dwindle, more so in the villages than the hubs.

The vital nature of the Arctic, in relation to the mid-latitudes and global South, is recognized. This globalizes Arctic concerns.



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