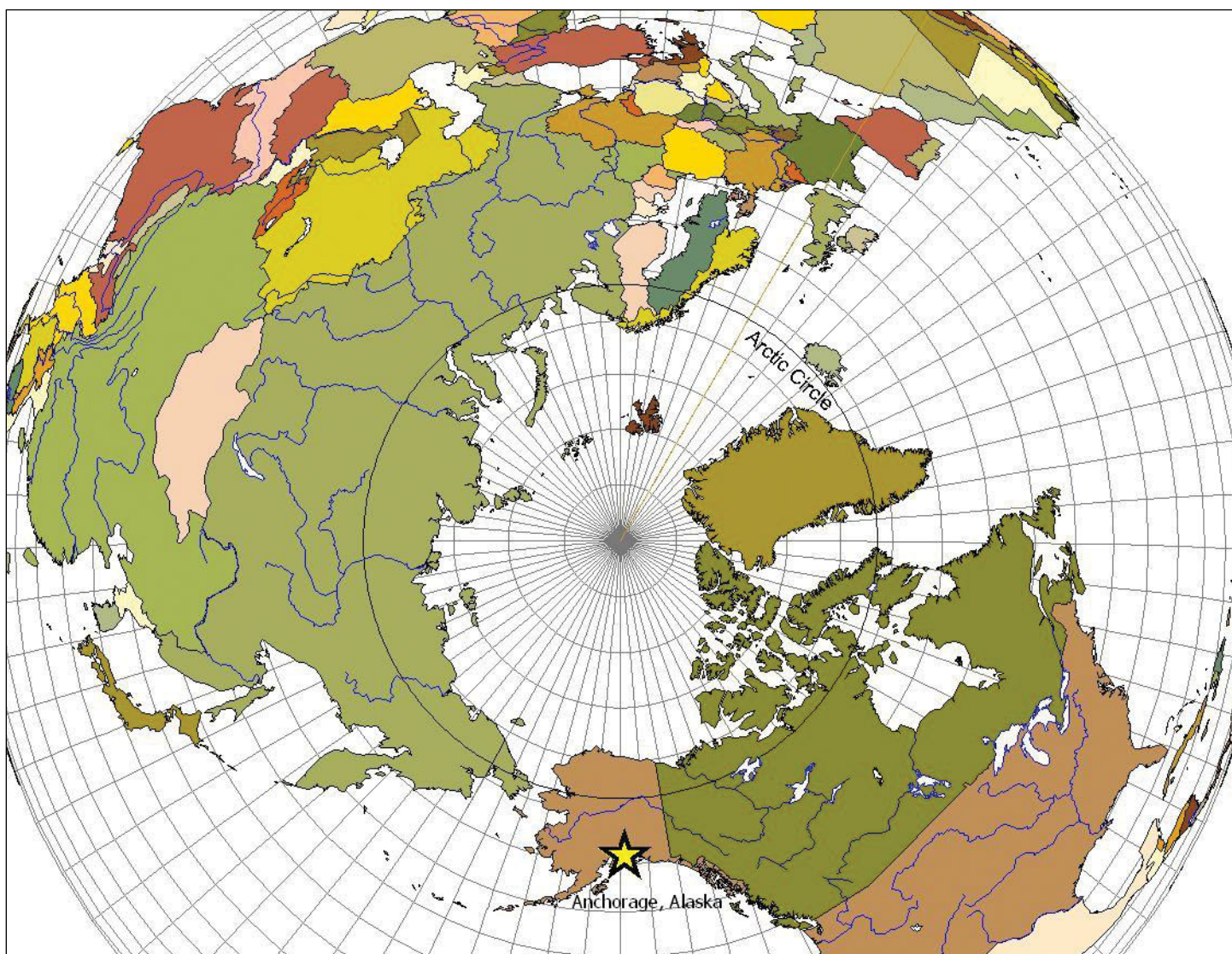




FINAL REPORT AND TECHNICAL PROCEEDINGS





The Arctic Energy Summit: The Arctic as an Emerging Energy Province

International Polar Year Project #299



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Conference photos by Clark James Mishler

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(Electronic version only; available at www.institutenorth.org)

Arctic Energy Summit Technology Conference Agenda
List of Conference Participants
Papers and Presentations
Conference Photo Gallery



28 March 2006

Dear Mr James Hemsath

On behalf of the ICSU/WMO Joint Committee for the International Polar Year 2007-2008 we wish to thank you for submitting a proposal (#299) entitled 'International summit and working group conference on the development and deployment of energy resources in the arctic including remote and rural villages' for consideration as an IPY activity. Success of the IPY depends fundamentally on excellent research and support and on a high level of international coordination, derived from the talents and energy of groups such as yours.

The IPY Joint Committee has now evaluated more than 200 proposals for scientific or educational significance, for consistency with the IPY theme, regions and time frames, for evidence of international collaboration, and for development of effective management plans covering communications, operations, data and education and outreach. The Joint Committee examined each proposal for evidence of involvement by scientists from non-polar nations, for indications of interdisciplinarity within the proposal and of linkages to other IPY activities, and for evidence that activities proposed would contribute to an IPY legacy.

The Joint Committee considers that your proposal as submitted includes very strong scientific, education and outreach components and demonstrates a high level of adherence to IPY themes and goals. The Joint Committee therefore endorses your proposal as a prominent and valued part of the IPY program. The Joint Committee intends that these endorsements will provide assistance as IPY participants seek funding for the work proposed.

The IPY International Programme Office will shortly provide additional guidance for project coordinators and steering groups, including descriptions of initial IPY information management processes. As part of that information exchange, we will expect project coordinators to keep the IPO informed about funding status of their projects and about substantial changes from the projects as proposed. In all cases, we wish you enormous success with your component of the IPY.

Yours sincerely

Co-chairs of Joint Committee

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Foreword

The overarching goal of the Arctic Energy Summit was to create a forum to engage in a dialogue on energy development in the Arctic. The Summit brought together the people of the Arctic to discuss, share and create a balanced approach toward sustainable extractive, renewable and rural power; with the vision of creating energy wealth while eliminating energy poverty.

To assist in the achievement of this goal, Arctic energy was examined as comprising two energy sources, extractive and renewable; and two methods of deployment, external and internal. Extractive sources - oil, gas, coal, natural gas from coal seams, methane hydrates - all have an external component, in which the resource is used outside or external to its source, typically used for the creation of wealth; as well as having an internal deployment for use by the people of the North. Likewise, renewable energy sources - wind, geothermal, hydro and biomass - all can be deployed within, as well as external to, the Arctic.

A very specific internal need required additional focus: the sustainable development of rural energy sources and ways in which to minimize the debilitating costs for energy that the people of the North are forced to carry, even in a subsistence economy.

The goals of the Summit were accomplished through the implementation of three activities - the first an Education and Outreach program, consisting of a website dedicated to Arctic energy and a weekly electronic newsletter (the Arctic Synergy) sharing information of interest on the use of energy in the Arctic. The Technology Conference, facilitating technology transfer, was the second activity; and the third was the creation of an Arctic Energy Action Team that was convened to examine in greater detail specific development opportunities for energy in the Arctic.

It is the belief of the Institute of the North that the Arctic Energy Summit has put a voice and face to energy in the Arctic, helping to shape our culture rather than having it imposed upon us.

The eight Arctic nations have the opportunity to make a true change in how the Arctic is viewed and to create a new energy vision of the North for the people of the North. With vision, energy and action we can lead this change and we can make a difference.

The challenge and decision is ours to make.

“Far better it is to dare mighty things, to win glorious triumphs, even though checkered by failure, than to take rank with those poor spirits who neither enjoy much nor suffer much, because they live in the gray twilight that knows not victory nor defeat.”

Theodore Roosevelt, 1858 - 1919

CHAPTER 1

Executive Summary



An Introduction to the International Polar Year

The fundamental concept of the International Polar Year (IPY) of 2007-2008 was that of an intensive burst of internationally coordinated, interdisciplinary, scientific research and observations focused on the Earth's polar regions. The official observing period of the IPY ran from 1 March 2007 until 1 March 2009. The main geographic focus was the Earth's high latitudes, but studies in any region relevant to the understanding of polar processes or phenomena were encouraged.

The intent of the IPY was to exploit the intellectual resources and science assets of nations worldwide to make major advances in polar knowledge and understanding, while leaving a legacy of new or enhanced observational systems, facilities and infrastructure. Arguably the most important legacies will be a new generation of polar scientists and engineers, as well as an exceptional level of interest and participation from polar residents, schoolchildren, the general public, and decision-makers, worldwide.

The research addressed six themes:

1. To determine the present environmental **status** of the Polar Regions;
2. To quantify and understand past, present and future natural environmental and social **change** in the Polar Regions;
3. To advance understanding on all scales of the **global linkages** and interactions between polar regions and the rest of the globe, and of the processes controlling these;
4. To investigate **new frontiers** of science in the Polar Regions;
5. To use the unique **vantage point** of the Polar Regions to develop and enhance observatories from the interior of the Earth to the Sun and the cosmos beyond;
6. To investigate the **human dimensions** - cultural, historical and social - that shape the sustainability of circumpolar human societies, and to identify their unique contributions to global cultural diversity and citizenship.

The Arctic as an Energy Province

The Arctic is home to nearly 20 percent (U.S. Geological Survey) of the world's energy resources, typically thought of in terms of fossil fuels: oil, gas and coal. In addition to these more traditional resources, the Arctic also has a wealth of renewable energy resources including wind, hydro, tidal and geothermal. The projected doubling of energy use and tripling of electricity demand within the next half century worldwide has resulted in a significant increase in attention paid to the lands of the High North as a source of new energy for the world.



When describing the Arctic, expressions such as Last Frontier, High North, edge of civilization are often used; with an implication of conquering, taking and leaving. A province implies investing, developing, building - taking ownership for the people of the North. The development of the Arctic as an energy province must therefore balance the external and internal application of energy resources to the external and internal needs of the communities of the North - all with the goal of using its energy resources by and for the residents of the Arctic. This report defines this trans-national, Arctic regional approach as the Arctic Energy Province.

The International Polar Year 2007-2008 "is an international program of coordinated interdisciplinary scientific research and observations in the Earth's Polar regions to explore new scientific frontiers, to deepen our understanding of polar processes and their global linkages, to increase our ability to detect changes, to attract and develop the next generation of polar scientists, engineers, and logistic experts and to capture the interest of school children, the public, and decision-makers." (*ICSU Framework for the International Polar Year 2007 – 2008*)

The primary thrust of the IPY is research, especially as it relates to the earth sciences; however, any discussion of the Arctic and polar regions would be remiss if there was no consideration of the extensive oil and gas development work that is occurring in Alaska, the Russian Far East and Siberia as well as the need for energy in the North's rural areas. In addition, there appear to be many unique renewable energy resources within the Arctic, many of which are untapped.

The Arctic Energy Summit was convened for the purposes of creating a dialogue - discussion and sharing of information, technology and approaches in those energy areas of common interest between the Arctic nations - in order to develop the mindset of the Arctic as an energy province, with common characteristics that span national boundaries and incorporate the multicultural values of its people.

The Joint Committee of the International Council for Science (ICSU) and the World Meteorological Organization (WMO) approved the concept in March 2006 and the Arctic Energy Summit was adopted as an official project of the IPY. Furthermore, the project was sanctioned by the Arctic Council and sponsored by the U.S. Department of State.

The Arctic Energy Summit

At the core of the Summit was the Arctic Energy Technology Conference, held in October of 2007 in Anchorage, Alaska. The conference focused on three areas:

1. Extractive energy development - oil, gas, coal bed methane, methane gas hydrates, coal;
2. Rural and renewable power, especially in extreme remote areas; and
3. Environmental, socio-economic and sustainability impacts of energy projects in the Arctic.

The Summit's Education and Outreach effort preceded the Technology Conference and tracked the Summit to its completion, with the goal of capturing the interest of the public and decision-makers, as well as attracting and developing the next



generation of scientists, engineers and leaders. Special attention was focused on the rural areas of the Arctic.

The third component of the Energy Summit was the convening of an Arctic Energy Action Team, tasked with examining a practical way forward for the implementation of key Arctic energy technology. This group examined three areas based on direction from attendees: the development of an extractive energy source - the development of Arctic coal; the development of a key renewable energy source - the development of tidal power in the Arctic; and the implementation of a solution to a specific rural energy problem - transportation fuels in rural communities.



The format of the Technology Conference included presentations of significant research, panel discussions on key areas of sustainability and an industry exposition of products and services, all consistent with the three themes of the conference.

Extractive energy development, while generally a commercial activity, is of significant interest to the energy and security needs of the Arctic nations. The Arctic environment presents special needs and concerns where research into new approaches to development and sources of hydrocarbons will have significant impact in meeting the Arctic nations' and world's energy needs.

Rural and extreme remote power needs are of key interest to Arctic nations, especially as they relate to replacing traditional fuel sources and lowering the cost of expensive electricity generation. Quality of life in these rural villages is dictated by the cost and availability of electricity. Non-technical areas for discussion included cultural and sociological impacts and sustainability of new technologies in remote communities.

The Arctic environment is extremely sensitive. It is easily disturbed and takes many years to recover from an incident, such as damage to the tundra from human traffic, disturbance to wildlife or from oil spills, both onshore and offshore. The continued development of oil, gas and coal in the Arctic will be limited by the ability of industry to minimize damage, respond to events such as an oil spill and remediate the area to bring it back to its original condition.

As mentioned earlier, a major component of the IPY mission is education and outreach. To support this, a bilingual (English/Russian) Arctic energy website, www.arcticenergysummit.org, was developed in the early phases of planning for the purposes of sharing information and results for the conference, including



conference papers and presentations. Leading up to and following the Summit, a weekly electronic newsletter, the Arctic Synergy, provided a wide audience of interested readers with up-to-date information about rural, renewable and extractive energy, and the sustainability of energy in the Arctic.

The third area of the Arctic Energy Summit was the creation and deployment of an Arctic Energy Action Team (AEAT). The Action Team was convened at the Technology Conference with the mission to cooperatively develop an international vision and programmatic way forward on common problems related to the development and deployment of energy in the Arctic. The Action Team was to create a road-map for the enhancement of extractive energy recovery, renewable energy solutions and the deployment of economical and environmentally sensitive energy sources in rural Arctic communities.

The use of and need for energy is essential to economic development and to improve the overall quality of life. From the first water and windmills to grind grain to sophisticated tidal power and large wind turbines, access to affordable power has driven where people live and how they survive. The energy picture painted today is a complex one, especially in the Arctic, where the availability of affordable power is not always assured. The objective of the Arctic Energy Summit is to bring attention to the challenges of developing the various energy assets in the High North and, in this region of energy wealth, to discover ways in which to eliminate energy poverty.

Recommendations from the Summit

Seventeen recommendations relating to the development of energy in the Arctic were generated from the Summit. They are broken down into two categories - technology and sustainability. The technology findings deal specifically with those results or conclusions that evolved from discussion and analysis of the three Arctic energy technology challenges. More detailed discussion on these technologies will be found in the section on the Arctic Energy Action Team.

The sustainability factors are an outgrowth of the discussion on sustainability at the Technology Conference and specifically at the individual panel sessions. While deceptively simple in concept, they are critical to a successful and appropriately deployed Arctic energy project. More than technology advances, the acknowledgment of these sustainability factors will be a key factor in future energy projects; therefore a management system to assure the balanced application of these factors will need to be developed.

It is also important to note that differences in geography, landmass and population density between Arctic nations result in differing viewpoints on the application of energy technology. In general, Scandinavian nations have high population densities and relatively short distances between communities that may allow for lower costs as a result of economy of scale. Iceland, while low in population, has a significant population center that is located within a short distance of its main renewable energy source. Russia and Canada both have long distances between communities; but Russia has a greater number of large communities, allowing for potential economy of scale. Alaska has large distances, relatively harsh terrain and very small population sources, making any opportunity for load sharing difficult. These differences make it more difficult - not impossible - to find areas of



Robert O. Anderson Award

Iceland's President, Ólafur Ragnar Grímsson, received the fourth Robert O. Anderson Sustainable Arctic Award during the Arctic Energy Summit Technology Conference banquet in October 2007 in Anchorage, Alaska.

In presenting the award, Walter J. Hickel, former U.S. Secretary of the Interior, twice governor of Alaska and founder of the Institute, noted the President's vision for "The New North," and for his commitment to alternative energy.

"In his lifetime, he has seen the conversion of Iceland from a coal-dependent economy to a nation that gets most of its heat and electricity from the red-hot core of the earth. What we call geothermal energy" said Hickel. "If Iceland could achieve such a radical change in one generation, enormous changes can succeed all over the world."

The Institute of the North established the Robert O. Anderson Sustainable Arctic Award in 2001 to recognize individuals and organizations that make outstanding contributions towards sustainable development within the Arctic. Anderson was the first recipient, recognized for his vision for advancing enlightened development within a sustainable environment when he served as the president and CEO of Atlantic Richfield and president of the Aspen Institute.



commonality among Arctic nations that could allow a more leveraged opportunity for shared technology development.

The results defined to date tend to be macro in nature, looking toward trends of technology and implementation challenges, rather than specific engineering or research recommendations. The focus of these recommendations is toward long-term sustainable development of energy in the Arctic, balancing the external and internal application of energy resources to the external and internal needs of the communities of the North. Treating the North as a whole assures cooperation across political boundaries and between unique and distinct cultures to meet the common needs of the people of the North.

Sustainability

- First and foremost in the deployment of various energy schemes in the Arctic - whether for the internal use of a resource or for development for export - the following eight sustainability factors must be addressed: policy, human resources, rural energy, transportation, environment, infrastructure, impacts on the people of the North and energy security. These factors are situational and a systems approach to examine the interactions of these factors is recommended to guarantee sustainable deployment of an energy resource.
- Research indicates that while the technology exists to deploy (conceptually) a variety of energy technologies, both renewable and rural, methods are neither specifically hardened for the Arctic environment nor assure the reliability required for remote locations, often at the end of long supply chains. At the same time there is a need for the development of a management process that would allow for quick demonstration and evaluation of Arctic energy technologies. Therefore, it is recommended that the International Energy Agency take on, or a like organization be formed, to develop Arctic energy policy and to coordinate research, testing and deployment of technologies specifically related to Arctic energy.
- Technology in general is not the problem. Technical solutions exist for each challenge area. Economy of scale, however, is the key limiting factor. Reasonable development of any new energy source or asset, either for internal or external use, will require the identification and development of a load anchor or economic hub to provide the base load for the generation or the export of energy. This will be best accomplished by looking for multi-modal uses of that energy source. For example, technology used for power generation might also be combined to meet the needs for transportation power. The identification of these synergies is necessary to develop truly sustainable Arctic energy.
- Infrastructure is a limiting factor to the development and deployment of Arctic energy. Micro- and mini-grid systems must be evaluated and developed as a means to connect rural communities to each other or to development areas. These grids must be viewed as complete infrastructure corridors in order to gain needed economy of scale. An infrastructure corridor should not exist as a single road, pipeline or transmission line; rather, it must contain multiple functions.



Arctic Coal

- One of the fundamental concerns related to the development of Arctic coal is control of how it is used elsewhere in the world. Prevailing air currents tend to bring pollutants to Arctic lands. Therefore, it is essential that the potential impact of adverse effects of the use of coal on the fragile Arctic environment is considered and that potential prevention and mitigation efforts are developed.
- International efforts, including new research, must be encouraged to minimize the release of pollutants during the combustion of Arctic coal. Alternately, the technologies related to the transformation of Arctic coal into a useful energy product through processes such as in situ gasification, coal-to-liquids and coal gasification, should be given priority in the development of Arctic coal.
- Education and communication programs should be developed to assist in a paradigm shift that will allow the world to view coal as a transformational fuel and a transitional hydrocarbon resource, rather than a “dirty” combustion fuel.

Arctic Tidal

- No current technology yet exists that will work in ice conditions. The uses of tidal power will therefore either be limited to far offshore open water areas with expensive long runs of subsea cable; or technologies that might be more robust in ice conditions, such as technologies that are seabed anchored or submerged tethered at a depth below the ice pack.
- Any wave action generation will be likewise limited to ice-free areas or far offshore in open water, again incurring large transmission costs.
- Infrastructure developed to support offshore drilling in the Arctic could be used for the support of any Arctic tidal, ocean current or a wave action facility.

Rural Transportation Fuels

- One third of energy usage in a rural community is attributed to transportation fuels. High costs of these fuels significantly impact rural subsistence lifestyles and the viability of these communities.
- New usage patterns must be developed to reduce fuel consumption, which could include shared usage “in town” or the use of more sophisticated tracking technology to locate hunting herds.
- Immediate application of efficiency technology could lead to immediate impact on the use of transportation fuels. As an example, recent work on retrofitting two-stroke snow machine engines with carburetor injection has been demonstrated to reduce pollutants and increase fuel economy by 30 percent.
- Most gasoline or diesel engines can be converted to a natural gas or propane fuel. While transportation is still expensive, the cost of using a natural gas fuel (including propane) is considerably less expensive than gasoline or diesel. These costs must be weighed against infrastructure modification costs. Local production of these fuels through coal bed methane or biomass could significantly alter the transportation fuel paradigm.



- Research needs to be focused on small-scale micro-reformers that can produce a synfuel product from natural gas, coal bed methane, gas hydrates and biomass suitable for IC engines.
- Development of a new storage “tank” to contain hydrogen that could be generated from renewable energy sources.
- Creation of new electric engines (and batteries) robust enough for Arctic conditions with the range and capabilities required for a subsistence lifestyle.

Organization of this Report

This report will delve deeper into the details of the three components of the Arctic Energy Summit. Chapter 2 will deal specifically with the Technology Conference, including detailed descriptions of the panel sessions that led to the creation of the eight sustainability factors. Also included is a summary of the papers and presentations, along with a list of the abstracts of presentations and/or papers.

Chapter 3 will report on the results of the Arctic Energy Action Team, including descriptions of the research topics and the results of each of the energy challenges.

Chapter 4 will describe the Education and Outreach program that was a key component of this two-year IPY project.

The appendices complete the report and include a copy of all abstracts. Presentations and papers; the participant list, conference schedule and photo gallery are available at www.institutenorth.org.

Conclusions

As an International Polar Year project, the Arctic Energy Summit was limited in the length of time it had in which to develop a project. During that time the objective was to highlight the Arctic as an emerging energy province. The conclusion that can be drawn from the Technology Conference and the Arctic Energy Action Team is not that there is any unique or special Arctic energy technology, although there are special applications; but rather that there is a need to view the Arctic energy system as a whole and to examine the possibilities for synergies.

The key to this approach is in finding economic anchors for the different technologies that can then serve different applications. For example, a coal mine in Northwest Alaska will require energy for that development, as does the world-class zinc mine to the south. Coal gasification/IGCC could provide power in a clean manner, sequester carbon and potentially create synfuels for use in the area as well as for export. An electric energy corridor could then be created, anchored by the coal mine, bringing less expensive power to the region and the zinc mine, thus creating economic development and jobs.



While the International Polar Year concluded in the spring of 2009, a continuation of an Arctic energy dialogue and coordinated development and deployment can continue to yield results. The Arctic Council had sanctioned the work of the Arctic Energy Summit during this IPY event. Therefore, it is appropriate that the Arctic Council take on the responsibility of continued trans-Arctic work in energy development; and, at the working group level, assure that work continues toward the creation of an organization dedicated to the development of Arctic energy policy as well as the coordination of research, testing and education of technologies specifically related to Arctic energy.

It is worth repeating that the Arctic is a region of great energy wealth that is challenged by great energy poverty. The goal of energy self-sufficiency in the Arctic is one that is not only attainable but will result in taking those first critical steps in eliminating energy poverty for the people of the North.

We have the opportunity to make a change in how the Arctic is viewed and to create a new energy vision of the North for the people of the North.

With vision, energy and action we can lead this change and make a difference.



CHAPTER 2

The Arctic Energy Summit Technology Conference

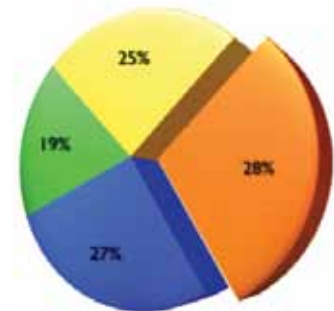
“... transferring needed technology and advancing science ...”



The Technology Conference, an International Polar Year event sanctioned by the eight-nation Arctic Council, convened scientists, academicians, policy makers and people who live in the Arctic to grapple with the Summit theme of the Arctic as an emerging energy province. The Institute of the North organized the summit with the U.S. Department of State as the official host.

The conference focused on three areas: extractive energy development - oil, gas, coal bed methane, methane gas hydrates, coal; rural and renewable power, especially in extreme remote areas; and environmental, socio-economic and sustainability impacts of energy projects in the Arctic. The conference consisted of a series of plenary sessions that discussed the condition of energy development in the Arctic; the presentation of 98 technical papers by scientists and engineers working in the Arctic; and a series of eight panel sessions that covered a range of sustainability factors for Arctic energy development.

The papers and presentations were grouped roughly into four technology areas: 27 percent focused on the development of extractive energy; 19 percent were dedicated to renewable energy; 25 percent examined rural power issues; and 28 percent contemplated sustainability issues such as the environment, education, planning and traditional knowledge.



Presentations were made by representatives of all eight Arctic nations. Overall, the presentations covered a wide sweep of topics including energy security, the integration of renewable energy sources into village power systems, geothermal applications, energy infrastructure, methane hydrates, coal bed methane, the use of snow as a year round refrigerant, Arctic coal, wind and tidal power.

Plenary Sessions

The Technology Conference was organized into three components. The first, as mentioned above, comprised plenary sessions to introduce and conclude the conference. On the opening day, many distinguished speakers, approaching issues from the political and policy spectrum, discussed their views of the Arctic and the importance of the Arctic in the global energy arena. This global context helped set the stage for the panel discussions and the presentation of technology papers that followed.

“We need to work every day to expand energy production,” U.S. Senator Lisa Murkowski told the gathering, “while ***we must also find new technologies to greatly reduce carbon emissions to slow and ultimately stop any climate change that may be occurring as a result.*** We need to increase, not curtail, fossil fuel



production, so it can provide a bridge to the alternative technologies of the future.”

Dr. Dan Arvizu, Director of the U.S. Department of Energy’s National Renewable Energy Laboratory, commented that in order to move ahead with new energy technologies, three areas must be addressed – energy security, economic productivity and its purpose, either a specific vulnerability or opportunity. Dr. Arvizu observed, **“Indigenous renewable energy resources are key to human survival and future village economies in the Arctic.”**

In his keynote speech, the President of Iceland, His Excellency Ólafur Ragnar Grímsson, challenged those at the conference to look to alternative energy sources as Iceland did and to have the political will to make a wholesale change in their energy systems; that the future of energy is in the utilization of all energy resources. President Grímsson stated that, **“no discussion on global energy would be complete without talking about the future of the Arctic.** In order to have cooperation and not competition we must activate the political instruments we have today – the Arctic Council, the Northern Forum and the Northern Research Forum – as well as the networks of leaders, policy makers and scientists gathered at the Arctic Energy Summit.” And finally, he offered, **“This new century will be the century of the North with a new vision of global responsibility for the 21st century.”**

Patricia Cochran, Chair of the Inuit Circumpolar Council and Chair of the Indigenous Peoples Secretariat, spoke of the devastating impact to rural communities by the high cost of energy and the impact on the viability of Alaska indigenous culture. She identified and emphasized “the central role that indigenous people must play on any and all future discussion on energy and energy resources.” She declared that the peoples of the North must be **“full and active partners in the development of strategies for sustainable use of Arctic energy resources.”** She added, “It is critical for others to recognize and respect the fundamental human rights of Arctic indigenous people. **In any discussion on sustainability the concept of equitable must be incorporated as a principal element.”**

James Hemsath, Senior Fellow for Energy at the Institute of the North, framed the conference, stating that the “intent of the conference is about taking action; about investing, developing, building and about taking ownership of our energy resources – whether extractive, renewable, rural or urban – all balanced, all supporting the vision of creating energy wealth while eliminating energy poverty. **We have the opportunity to make a true change in how the Arctic is viewed and to create a new energy vision of the North for the people of the North. With vision, energy and action we can lead this change and we can make a difference.”**

The plenary speakers included (in alphabetical order):

- Dr. Dan Arvizu, Director, National Renewable Energy Laboratory, U.S. Department of Energy
- George Cannelos, Federal Co-Chair, Denali Commission
- Patricia Cochran, Chair, Inuit Circumpolar Council and Chair, Indigenous Peoples Secretariat
- The Honourable Julian Evans, British Consul General



- Bud Fackrell, Senior Vice President, BP Exploration, Alaska
- Rick Fox, Manager, Alaska Assets, Shell Exploration and Production Company
- His Excellency Ólafur Ragnar Grímsson, President of Iceland
- James Hemsath, Senior Fellow for Energy, Institute of the North
- Gov. Walter J. Hickel, former governor, State of Alaska; former Secretary of the Interior
- David Keane, Vice President, BG North America, Caribbean and Global LNG
- U.S. Senator Lisa Murkowski
- Governor Sarah Palin, State of Alaska
- Andrew Revkin, The New York Times
- U.S. Senator Ted Stevens
- Assistant Secretary Daniel Sullivan, U.S. Department of State
- Mead Treadwell, Chair, U.S. Arctic Research Commission
- Dr. Evgeny Velikhov, President, RRC Kurchatov Institute

Panel Sessions

Energy projects in the Arctic are at best fragile: their very existence is subject to a variety of outside forces that could at any time make a project non-viable. The ability to sustain a project, to make it viable over its lifetime, therefore, is dependent on a number of factors that are unrelated to the energy technology itself. No discussion of the development of energy projects in the Arctic will be complete without discussion and understanding of sustainability. In exploring the concept of a sustainable Arctic energy project, three key topics must be examined and addressed: economics, environment and impact on the people of the North.

For an energy project to be successful in the Arctic, as elsewhere in the world, the basis needs to be economically sound and robust (not sensitive to change). While this is not unique to the Arctic, the economic parameters on which a project will be based are. These situational economics must reflect both the costs and the benefits of a given energy project for its locale and the community that it serves. For example, the use of natural gas for electrical generation in a village environment would typically look at the price of fuel and the cost of conversion. But it should also look at the risk-based savings of eliminating barge fuel shipping and maintenance of tanks with the associated elimination of potential spill response.

First and foremost, energy development efforts should seriously consider environmental impacts and should adopt current best practices to minimize harm while also taking into account regional, national and global energy needs. This includes not only the air quality and wildlife issues as detailed in any permitting activity, but carbon footprint as well. Climate change and its impact on the Arctic are well documented; how this will play out in the development of energy projects is less clear. There is the obvious impact on infrastructure (roads, pipeline supports) and tundra access for exploration (seasons are getting shorter); but the less obvious



impacts include increased shipping through northern routes (and resultant environmental impact) and reduced access from rural community to rural community as traditional frozen means of travel (rivers, tundra) become less available.

With regard to carbon footprint, Arctic energy projects must consider CO₂ capture and sequestration. This is an interesting and at present unexplored option. In oil and gas fields, CO₂ is a powerful enhanced oil recovery opportunity. Coal fields provide excellent sequestration capabilities and in those seams where natural gas is available, CO₂ has been shown to increase gas production. Work is currently being done to examine how CO₂ can be sequestered as a hydrate in deep Arctic waters, displacing methane hydrates while maintaining the integrity of the hydrate structure.

Foremost in any discussion on sustainability of Arctic energy projects must be the impact those activities have on the people of the North, both positive and negative. High energy costs have a devastating impact on rural Arctic communities; the development of new technologies to lower not only electrical, but heating and transportation costs must be given priority – especially as it relates to a subsistence lifestyle.

Other areas that must be considered as they relate to sustainability include the maintenance and training necessary for any village-based energy project; the impact of exploration on a subsistence lifestyle, as recently demonstrated in Alaska with concerns of offshore seismic exploration and the impact on whale hunting; the rights and ownership issues of extractive resources on indigenous lands (Alaska Native Claims Settlement Act, Mackenzie Valley Pipeline); and joint ventures between extractive energy use and local energy needs; e.g., an offshore gas development in Bristol Bay could bring natural gas to the Dillingham area, resulting in lower electrical and heating costs and the possibility for an alternative transportation fuel.

Sustainability includes those efforts required by any activity to assure that the project can be maintained without impacting the environment and the people involved. To allow the Arctic to be developed as a true energy province - one that is not to be exploited but stands as its own territory - will require robust and situational economics on all its energy projects while doing no harm to the environment and serving those who reside in our Arctic communities.

Panel sessions were created to discuss the issues of sustainability at the Arctic Energy Technology Conference. In these panel sessions, it was concluded that technology alone will not result in the development of the Arctic as an energy province; sustainability is at the heart of that development. The three sustainability topics discussed above were further refined into eight sustainability factors defined by the panel sessions. To assure the successful implementation of any energy technology requires that the following factors be addressed and incorporated into an energy delivery plan.

1. Policy

Policy decisions, even more than technical capabilities, have a large influence on the selection of technology, projects, economics and funding as they relate to the development of energy projects. Policy determines energy security, land use,



emissions, project economics, fuel prices and, in some cases, which communities survive and which communities do not. The development of the Arctic as an energy province versus an exploitable territory will be determined by the articulation of a comprehensive, integrated energy policy that recognizes industry needs, environmental concerns and collaboration among Arctic nations.

Panelist	Affiliation/Country
Drue Pearce – Co-Moderator	Federal Coordinator, Alaska Natural Gas Transportation Projects / United States
Ólafur Ragnar Grimsson – Co-Moderator	President of Iceland
Odd Raustein	Norwegian Petroleum Directorate / Norway
Jim Strandberg	Former Commissioner, Regulatory Commission of Alaska / United States
Peter Sharp	Energy Secretariat (GDEE), Department of Foreign Affairs and International Trade / Canada
Evgyeny Velikhov	RRC Kurchatov Institute / Russia

Discussions during this panel session resulted in the following points:

- Policymaking is often reactive and driven by unplanned events, as politicians are conditioned to think in short-term, two and four year cycles.
- An effective approach could be that policy can set requirements (environmental, efficiency, etc.) for industry and technological innovation will result.
- Energy projects are long-term, and energy policy needs to be stable and long-term as well.
- Three key intellectual and traditional assumptions about energy that society takes for granted are incorrect and need to be turned on their head:
 - That large energy projects are best;
 - That there is unlimited energy and the only question is how it should be exploited; and
 - That we should maximize energy use.
- Science and business institutions are more likely to move faster than politicians.
- Traditional legal frameworks do not adequately protect the interests of indigenous peoples because those legal, philosophical and intellectual traditions do not account for indigenous traditions.



2. Human Resources

The development and operation of energy facilities in the Arctic will require simultaneous development of human resources in the Arctic, including the provision of those skill sets necessary to bring the next generation of energy projects to fruition. Specific attention must be focused on the energy systems required for rural and remote communities. Achieving this new level of competency will require an entirely new curriculum addressing the breadth of Arctic energy and including engineering, design, operations, maintenance, management, economics and all aspects of care of the environment. For any technology the key required skill sets must be determined in conjunction with the appropriate training and competency program.

Panelist	Affiliation/Country
Robert Lang - Moderator	University of Alaska Anchorage / United States
David Pointing	UNEP Risoe / Denmark
Jan Oddvar Soernes	University of Bodø / Norway
Tonya Garnett	Gwich'in Council International / Canada
Dmitry Chumakov	Ministry for Foreign Affairs / Russia
Alice Galvin	Training and Development, BP Alaska / United States

Discussions within this panel session resulted in the following points:

- Practical access to information is essential for small communities.
- An engineering interface is needed between appropriate technology and communities.
- Education can prevent out-migration.
- There is a need for international cooperation in the development of human resources as energy concerns are global.
- Lessons learned in the North can be used to develop models for a larger world market.

3. Rural Energy in the Arctic

The Arctic is a region of tremendous energy wealth; however, rural Arctic communities are attempting to exist in spite of tremendous energy poverty. These communities - off the electrical grid, off the road system and populated by predominately indigenous people living a subsistence lifestyle - suffer crippling energy costs threatening their very existence. New approaches are needed to prevent the extinction of these communities and to moderate energy costs for electricity, heating and transportation, using both extractive and renewable energy sources. While seemingly redundant, the development of any Arctic energy resource as an export



must first begin with the identification of how that energy source may be used in rural communities in the area.

Panelist	Affiliation/Country
George Cannelos – Moderator	Denali Commission / United States
Bob Swenson	Alaska Division of Geological & Geophysical Surveys / United States
Chris Hladick	City Manager, Unalaska / United States
Ragnar Baldursson	Ministry of Foreign Affairs / Iceland
Connie Fredenberg	Aleutian Pribilof Islands Association / United States
Ryan Colgan	Cold Climate Housing Research Center / United States

Discussions during this panel session resulted in the following points:

- Costs of shipping traditional fuels to rural communities are extremely expensive and limited to a small shipping window.
- Local development of renewable or non-traditional fuels (biomass, coal bed methane) is essential to help communities survive.
- Major energy development (oil and gas) should be required to develop infrastructure to help supply energy resources to local communities.
- Look to land for sustainable solutions (utilizing knowledge acquired over centuries of inhabitation).
- Urban solutions to energy questions cannot be transferred to rural areas but need local solutions:
 - Solutions must be economically and environmentally sustainable.
 - Flexibility is needed; there is no silver bullet, as all renewables are site specific and vary by location.
 - Simplicity is needed; technologies need to be easily understood, managed and maintained.

4. Shipping and Transportation Options

The ability for the Arctic to emerge as a global energy province will be both driven and constrained by transportation. Climate change, while potentially opening new sea routes, is also changing the structure of seasonal river shipping, weakening existing road systems, affecting runways and shortening tundra travel. More open sea travel will necessitate increased air support (search and rescue). The basic logistics paradigm for the Arctic is changing and shipping and transportation options will have to change as well. The discussion must include the impacts on the entire transportation system (marine, ground and air) that extractive and renewable energy development will present.



Panelist	Affiliation/Country
Lawson Brigham – Moderator	U.S. Arctic Research Commission / United States
Bjorn Forsman	SSPA AB / Sweden
Vyacheslav Kuznetsov	RRC Kurchatov Institute / Russia
Alexander Sergeev	RUSHYDRO, Federal Hydrogenation Company / Russia
Frank Bercha	Bercha Group / Canada
Larry Dietrick	Alaska Department of Environmental Conservation / United States
Göran Wilkman	Aker Transportation / Finland

Discussions within this panel session resulted in the following points:

- Advanced cargo shipping is essential in the Arctic, especially combined with a multi-modal understanding of all transportation needs, including road, rail and air.
- Because of the variety of spheres of influence in the Arctic, there are few open seas. A consistent trans-national policy framework will be needed to assure open transportation.
- The noise impacts of shipping and ice breaking will add additional pressure on marine mammals.
- Improving the environmental performance of ships must be given priority as the volume of traffic through Arctic waters increases.
- Search and rescue (SAR) capacity, oil spill response assets and ports of safe harbor must be developed in a context of trans-Arctic availability.

5. Environmental Concerns

The Arctic and its associated cryosphere are home to some of the world's most fragile environments. Prioritized in any energy development endeavor is the requirement to do no harm to the environment. This includes air and water quality, impacts on permafrost and wildlife issues as detailed in any permitting activity, as well as attention to the carbon footprint. Increased offshore exploration and the potential for increased shipping will continue to emphasize the need for improved spill response and for an understanding of the impact these increases will have on fisheries. Renewable energy (battery storage, geothermal impacts, hydro-turbines and wind turbines) also presents a variety of environmental challenges that will require a new generation of solutions. The development and application of all the Arctic's energy assets must address the associated environmental challenges and opportunities.



Panelist	Affiliation/Country
Donald Cobb – Moderator	Fisheries and Oceans / Canada
Heather Fernuik	Civilian Research and Development Foundation / United States
Kari Lampela	Finnish Environment Institute / Finland
Jon Waterhouse	Yukon River Intertribal Watershed Authority / United States
Dmitry Nesterov	Ecoshelf, Ltd. / Russia

Discussion during this panel session resulted in the following points:

- Collaboration is needed between local entities and corporations so that there is an understanding of environmental concerns.
- Indigenous people are interested in developing energy but not at the expense of the environment and animals who live there and who will live long beyond the various forms of energy.
- Lessons learned have informed current practices and we need to focus on examples of successful partnerships.

6. Infrastructures and the Impact of Climate Change

The development of infrastructure (roads, ports, transmission lines, etc.) is a basic economic foundation for the development of an energy technology. The combination of separate infrastructure projects into infrastructure corridors is an opportunity that Arctic nations must embrace to take advantage of full development of any resource. Additionally, as the Arctic continues its long cycle of warming, the infrastructure developed and built in a colder environment will be impacted. This will include roads, harbors, bridges, foundations, transmission lines, pipelines and airstrips, as well as ice roads and rivers (traditional Arctic thoroughfares). The damage will be concentrated in places where permafrost thaws, flooding increases and coastal erosion worsens. At a time when the development of the Arctic as an energy province is essential to global and energy security and when energy costs are rising in rural Arctic communities, the infrastructure necessary for these projects is under attack. In the development and deployment of energy resources in the Arctic, the various impacts – opportunities as well as challenges – of climate change on Arctic infrastructure must be addressed.

Panelist	Affiliation/Country
Peter Larson – Moderator	The Nature Conservancy / United States
Rick Rodriguez	U.S. Coast Guard / United States
Jessica Cherry	University of Alaska Fairbanks / United States
Laurence Byrne	Alaska Department of Natural Resources / United States
Alona Yefimenko	Arctic Council Indigenous Peoples Secretariat / Denmark
Norio Yamamoto	Global Infrastructure Fund Research Foundation / Japan



Discussion within this panel session resulted in the following points:

- Infrastructure in the Arctic is under attack due to changing weather patterns and climate change.
- New opportunities exist for expanded infrastructure in the Arctic due to changing sea ice.
- With increased shipping in the Arctic and “over the top,” new infrastructure for safety, search and rescue, spill response and border security will be needed. This can best be accomplished through partnering with other countries.
- New technical standards and models are needed not only for upgrading current infrastructure, but also for possible relocation of entire facilities.
- More information is needed on climate change impacts combining scientific data with indigenous accounts of historical climate conditions.

7. Impacts of Energy Development on the People of the North

The development of energy projects in the Far North have had and will continue to have significant impact on the people of the North, specifically those indigenous people living a subsistence lifestyle in remote communities. Energy development will have both positive and negative impacts on a community. Extractive development could bring wealth and jobs but impact a subsistence lifestyle. High energy costs drain community resources but the development of new lower cost energy facilities could require a differently trained workforce for operation and maintenance. The total costs of energy development in the Arctic must include the impacts that development will bring to the people of the North.

Panelist	Affiliation/Country
Patricia Cochran – Moderator	Inuit Circumpolar Council / United States
Bernie Funston	Arctic Council SDWG / Canada
Taylor Brelsford	URS Corporation / United States
Craig Fleener	Gwich'in Council International / Canada
Polly Carr-Anaya	Alaska Youth for Environmental Action / United States
Rosemary Ahtuangurauk	Inupiat Social Cultural Communicator / United States

Discussion during this panel session resulted in the following points:

- Increase meaningful partnerships with Alaska Natives and other indigenous people.
- Recognize the immense value of traditional knowledge and elevate it appropriately, moving away from decisions that are driven or dominated by Western science.
- Energy economies and associated impacts (good and bad) have historically been unevenly distributed; benefits do not trickle down to the individuals.



- Energy development causes abrupt changes within surrounding communities. Move forward very carefully and collaboratively, planning for the future and remaining aware of potential positive and negative impacts.

8. Energy Security

The development of the Arctic's energy resource potential has an impact on how the world defines energy security. Different and changing shipping and transportation routes, advocacy by various stakeholder groups, technological advancements, changes in the global geopolitical situation and efforts to protect sensitive Arctic environments - all will have an impact on defining regional and global energy security. The examination of the changing face of energy security and the role played by the emergence of the Arctic as an energy province must be considered.

Panelist	Affiliation/Country
Peter Sharp – Moderator	Energy Secretariat (GDEE). Department of Foreign Affairs and International Trade / Canada
Mead Treadwell	U.S. Arctic Research Commission / United States
Dan Fine	Massachusetts Institute of Technology / United States
Bill Adams	Defence Science Advisory Board / Canada
Susan Lambert	NANA Pacific / United States

Discussion within this panel session resulted in the following points:

- Government is not just the regulator and market, it is the owner and therefore it should seek to leverage and to implement development that protects the security of the Arctic.
- Energy now defines a nation's global role; yet at the same time, energy must be seen as a subset of climate change.
- Three factors must be considered in order to achieve energy security:
 - Ensure local support for Arctic energy projects by engaging the social infrastructure;
 - Minimize environmental impact; and
 - Evolve toward a sustainable energy future by emphasizing efficiency and conservation.
- Overdependence on a given energy source - whether on a fuel source (diesel for rural communities) or long distance transmission systems - in Arctic conditions of harsh weather and long remote distances (including shipping) increases the vulnerability of the communities of the North to uncontrolled price increases or loss of reliability of energy supply.



Arctic Energy Technology Conference Themes

Amid a backdrop of extraordinary environmental changes in the Arctic, more than 300 international delegates from 14 nations explored a wide variety of subjects related to energy development in the Arctic at the Arctic Energy Technology Conference – highlight of the Arctic Energy Summit and primary knowledge transfer vehicle for this International Polar Year project. At the center of the conference were the presentations of nearly 100 technical papers by scientists and engineers working in the Arctic.

The original call for papers envisioned three general areas that were subsequently expanded into the four conference themes described below.

Extractive Energy in the Arctic	Renewable & Rural Energy in the Arctic
Identification, development and deployment of Arctic energy resources such as: <ul style="list-style-type: none"> • Oil • Coal • Gas • Unconventional gas <ul style="list-style-type: none"> ▪ Methane Gas Hydrates ▪ Natural gas from coal seams • GTL and syngas from coal and gas • Transportation: sea routes, pipelines, other (making hydrates for shipping, ISO containers for propane and electrical transmission lines) • Climate change (impact on infrastructure,) oil spill technologies (including oil in ice) 	Alternative solutions for Arctic energy: <ul style="list-style-type: none"> • Wind, wind/diesel, wind/hydrogen • Hydro, in-river, tidal • Geothermal, solar • Fuel cells, biomass • Propane, GTL, rural coal bed methane • Arctic energy audits, energy efficiency • Transmission and transportation systems The deployment of rural power systems in the Arctic: <ul style="list-style-type: none"> • Availability/need • Implementation • Distribution systems • Case studies
Sustainability of Energy in the Arctic	
<ul style="list-style-type: none"> • Social impacts • Environment (spill response, CO2 sequestration) • Economics 	<ul style="list-style-type: none"> • Energy security in the Arctic • Regulatory obstacles and opportunities • Management systems

Renewable and Rural Energy in the Arctic

The quality of life for Arctic residents is highly dependent on the availability and the cost of power. Because of the Arctic's sparse populations, long distances between settlements and the lack of transportation infrastructure, the cost of power is a significant issue for residents. In rural areas of Alaska, for example, the kilowatt-hour charge for electricity can be three to five times higher than the charge in the more urban areas of the state. Since diesel-generated power costs so much, residents in rural areas have been very proactive in utilizing alternative and renewable forms of fuel for power generation.

Due primarily to the distances between villages, centralized power generation and transmission to communities is not always an option as the best and most cost effective way to generate power and distribute it to users. In some areas, fuel for



power generation must be flown in or shipped by barge during the open ice season. Accordingly, rural residents have adapted by utilizing many non-hydrocarbon fuel sources.

Renewable and alternative energy sources are sometimes used to supplement diesel-fired power generation. The substitution of these non-hydrocarbon sources usually results in lower costs for power.

One alternative to diesel generation is a hybrid combination of diesel generation and wind generation. This combination is in operation around the world in locales such as Kotzebue, Alaska, U.S.A.

Iceland is renowned for utilizing geothermal energy, its second largest source of energy, next to hydroelectric. Eighty-five percent of Iceland's homes are heated by geothermal energy. In Russia, geothermal energy is produced on the Kamchatka peninsula. In August 2006, a small plant became operational in Chena Hot Springs, Alaska, U.S.A.

Hydroelectric power generation is utilized around the Arctic. Hydro power is currently the world's largest renewable source of electricity, accounting for 6 percent of worldwide energy supply or about 15 percent of the world's electricity.

Wind has been used as an energy source in combination with diesel generators or as a stand-alone. Most modern wind power is generated in the form of electricity by converting the rotation of turbine blades into electrical current by means of an electrical generator. Currently wind power accounts for 23 percent of electricity use in Denmark.

Ocean energy comprises a series of emerging technologies that use the power of ocean currents, waves and tides to create energy. While very few of these technologies have been implemented on a commercial scale, they show much promise for future development.

Extractive Energy in the Arctic

The Arctic region holds vast amounts of extractive energy resources, possibly greater than 25 percent of global reserves, most of which is offshore beneath thick ice and deep water. The oil and gas contained in this area had been unreachable or far too costly and dangerous to extract. Rising global temperatures, however, are causing formerly impenetrable ice sheets and permafrost to melt and access to Arctic energy resources is increasing.

The reserves and production of oil and natural gas from the region are increasing annually. The current prices for these commodities make exploration and production of oil and gas in the Arctic a reality. Known areas of reserves are the North Slope in Alaska (U.S.); East Siberia, West Siberia, the Timan-Pechora area, South/North Barents (Russia); the area east of Norway; and East Greenland. Potential oil and gas sources include the Vilkitsky area, the Laptev Sea, the Vilyuy area, the Khatanga area and the North Kara Sea (all in Russia); the West Barents Sea north of Russia; Denmark and Norway; the West Greenland area; the Sverdrup area north of Canada; and the Beaufort-Mackenzie area north of Canada and Alaska.

Russia has already discovered significant gas resources in the Barents Sea, including the massive Shtokman field, the largest offshore gas reservoir in the world



with proven reserves of 3,500 billion m³ of gas, seven times more than the annual gas consumption in Europe. There is also significant oil and gas production taking place in Russia, Norway, Denmark, Canada, and the United States.

The Arctic holds significant reserves of coal. It is estimated that the United States and Russia territories have over 44 percent of the world's coal reserves. In Alaska, the measured reserves are estimated at 247 billion metric tons.

With 157 billion metric tons, Russia has the second largest coal reserves in the world. Russian coal mining is concentrated in regions served by the Trans-Siberian Railway, with the Kemerovo, Krasnoyarsk, and Novosibirsk regions accounting for the bulk of the nation's production.

Methane hydrate gas is abundant in the Arctic region. There are tremendous reserves in Alaska, Canada, Russia and Scandinavia. The U.S. Geological Survey estimates that 200,000 trillion cubic feet of methane hydrate gas exists under Alaskan territory outside of the Arctic National Wildlife Refuge. While only a fraction of this amount is extractable, to recover even one percent would double proven U.S. gas reserves. Gas hydrates are known to occur both within and below permafrost in polar areas. Several areas in the Arctic show potential for having gas hydrate accumulations. Three such sources are in North America and four are in Russia. Additionally, the Svalbard archipelago (Norway) and sedimentary basins under the ice cap of Greenland may have pressure and temperature conditions favorable to the formation of gas hydrates.

Sustainability of Energy in the Arctic

As described in the discussion of Panel Sessions, the concept of sustainability may in fact be the most important area for discussion in the development of the Arctic as an energy province. The three topics envisioned in the call for papers – economics, environment and the impact on the people of the North – were further expanded to encompass the eight sustainability factors (Policy, Human Resources, Rural Energy, Transportation, Environment, Infrastructure, Impacts on the People of the North, Security).

Presentations and Papers *(available at www.institutenorth.org)*

Extractive Energy

Twenty-seven papers were presented on the identification, development and deployment of extractive energy resources in the Arctic. The subjects discussed included identification of resources such as methane gas hydrates, coal, oil and gas and unconventional gas sources, as well as coal bed methane from regions as varied as Alaska's North Slope to the Khanty-Mansiysk Autonomous Okrug. The development aspects of these resources were discussed as well, including presentations on a more effective use of coal (grind size) as well as issues on safety training. Transportation issues were a major component of the presentations – the Alaska Gas pipeline, oil transport in the Barents Sea, submarine technologies and spill response in Arctic waters were all discussed.

Presentations were given by delegates from the United States, Russia, Canada, Sweden and Norway. A listing of all submitted abstracts is included in Appendix 1.



Renewable Energy

Nineteen papers were presented on alternative solutions for Arctic energy. Topics included the development of geothermal energy (both large and small scale), the development of hydro (large and micro, tidal and in-river), the deployment of wind energy in a variety of different situations and analysis of rural communities to assure that the appropriate energy resource is being used.

Presentations were given by delegates from the United States, Russia, Canada, Sweden and Iceland. A listing of all submitted abstracts is included in Appendix 2.

Rural Energy

The deployment of energy systems in the rural Arctic is not just a matter of convenience; it is a matter of survival. Isolated communities off any road or power grid must have power systems that are reliable, robust and easy to maintain with minimum outside assistance. These power systems could be extractive based (typically fossil fuels) or based on renewable energy systems (predominately wind powered). Twenty-four presentations were made on the subject of delivering power to rural communities. The technologies discussed included wind-diesel hybrid systems, absorption coolers, waste heat recovery, hybrid micro-systems, flow batteries and fuel cells. With the energy demands in rural communities typically being evenly split between power, heating and transportation, the analysis of power systems captured a great deal of attention. These presentations dealt with looking at rural power from a systems dynamic and integrated energy perspective, and ways to economically balance all of those loads.

Presentations were given by delegates from the United States, Russia and Canada. A listing of all submitted abstracts is included in Appendix 3.

Sustainability

In addition to the eight panel sessions that dealt with the very specific concepts of sustainability, twenty-eight papers were presented that covered a wide variety of subjects from oil spill recovery and remediation to social impacts and education. From both traditional Inupiat knowledge in energy decision making and a Nordic network for sustainable energy systems to youth involvement and community planning, all aspects of sustainability were discussed.

Presentations were given by delegates from the United States, Russia, Canada, Denmark, Finland and Norway. A listing of all submitted abstracts is included in Appendix 4.



CHAPTER 3

The Arctic Energy Action Team

“... leaving a legacy and creating a path forward ...”



The Arctic Energy Action Team was convened at the conclusion of the Arctic Energy Summit Technology Conference in October 2007 and was envisioned as a non-governmental, “open-source” strategic planning team that would address ways to navigate these Arctic energy challenges.

The objective of the Arctic Energy Action Team (AEAT) was to cooperatively develop an international energy vision of the North through a broad coalition of experts and stakeholders in the areas of energy, technology and policy. The AEAT provided a forum and a framework to formulate strategy and identify enabling technologies for the enhancement of extractive and renewable energy recovery, as well as the deployment of economical and environmentally sensitive energy sources to rural Arctic communities.

Specifically, the AEAT was to -

- Identify technology needs for the three challenge areas;
- Identify the barriers that can be eliminated by cooperative action, with commitments needed at local, regional, national and international levels; and
- Identify potential demonstration projects to validate a plan forward, while focusing on the key challenges of extractive, renewable and rural energy.

In addition to examining the variety of technology based approaches, the AEAT was to consider the sustainability factors in any recommendations:

1. Policies necessary to ensure that the energy asset can be developed
2. Development of necessary human resources
3. How the technology can impact high rural energy costs
4. Transportation options and challenges
5. Environmental concerns
6. Infrastructure needed to maximize the benefits of the technology
7. Impacts on the people of the North
8. Energy security locally, regionally and across the Arctic



The Action Team was envisioned as a virtual organization. To allow for effective and open communication, an AEAT Google group was created to post research documents, papers and comments used in developing recommendations for the energy challenges.

Limited budget and time constraints on the volunteer members of the Action Team tended to curtail cooperative work and limit recommendations to higher level policy issues.

Results and Recommendations

Extractive Energy Challenge: The Development of Arctic Coal

Large amounts of high quality coal exist in the Arctic (12 to 15 percent of known world reserves), yet currently it is an underdeveloped asset. The following recommendations are suggested as ways to develop this resource in an environmentally appropriate manner to benefit an export economy, as well as meet local needs.

- Potential technologies that may allow this resource to be utilized include gasification, liquefaction, coal slurry and small-scale mining.
- Scale will always be an issue in the development of this resource; therefore, in order to allow for internal use, demand will have to be coupled with an exportable product.



- Transportation will be a constraint; in many cases tidewater for Arctic coal is limited to ports that may be ice-covered, making the traditional export of coal uneconomical. Therefore, technologies that are transformational must be considered when developing coal. This suggests, specifically, products that will allow pipelines (ultraclean fuels, synthetic gas, hydrogen) or transmission lines (electricity). With this in mind, synergies with local communities can be developed for the local use of a portion of these products.
- CO₂ capture and sequestration in the Arctic is a key enabling technology. Canada's Clean Coal Technology Roadmap (www.cleancoaltrm.gc.ca) is being recommended as a central focus on technology development.
- One of the fundamental concerns related to the development of Arctic coal is control of how it is used elsewhere in the world. Prevailing air currents tend to bring pollutants to Arctic lands. Therefore, it is essential that the potential impact of adverse effects of the use of coal on the fragile Arctic environment is considered and that potential prevention and mitigation efforts are developed.
- International efforts, including new research, must be encouraged to minimize the release of pollutants during the combustion of Arctic coal. Alternately, the technologies related to the transformation of Arctic coal into a useful energy product through processes such as in situ gasification, coal-to-liquids and coal gasification, should be given priority in the development of Arctic coal.
- Education and communication programs should be developed to assist in a paradigm shift that will allow the world to view coal as a transformational fuel and transitional hydrocarbon resource, rather than a "dirty" combustion fuel.

Renewable Energy Challenge: The Development of Tidal Generation

There are large tidal resources in the Arctic. Technology is becoming more readily available to take advantage of this resource in lower latitudes. The following recommendations are suggested as a way forward that will allow this resource to be utilized in Arctic environments.

- A variety of tidal technology applications including partial impoundment (tidal barrages) and technology providers have been identified. There appears to be no application currently being tested in ice conditions.
- No current technology yet exists that will work in ice conditions. The uses of tidal power will therefore either be limited to far offshore open water areas with expensive long runs of subsea cable; or technologies that might be more robust in ice conditions, such as technologies that are seabed anchored or submerged tethered at a depth below the ice pack.
- Any wave action generation will be likewise limited to ice-free areas or far offshore in open water, again incurring large transmission costs.
- Infrastructure developed to support offshore drilling in the Arctic could be used for the support of any Arctic tidal, ocean current or wave action facility.



[Rural Energy Challenge: The Development of Alternative Transportation Fuels](#)

Fully a third of energy usage in a rural community is in transportation fuels (ATVs, snow machines, boats and personal vehicles). High costs of these fuels significantly impact rural subsistence lifestyles and the viability of these communities. The identification of an alternate approach to rural (and remote) transportation fuel needs has been a true challenge. As a fuel, gasoline and diesel are easily transported, easily stored and run in a wide variety of engines. Additionally, diesel fuel (specifically Jet A) can be run in diesel generators, trucks and used as home heat. Any alternative transportation fuel will have to have similar properties. The following recommendations are suggested as a way forward to promote the development of alternative fuels to be utilized in Arctic environments.

- New usage patterns must be developed to reduce the fuel consumption, which might include shared usage “in town” or the use of more sophisticated tracking technology to locate hunting herds.
- Immediate application of efficiency technology could lead to immediate impact on the use of transportation fuels. As an example, recent work on retrofitting two-stroke snow machine engines with carburetor injection has been demonstrated to reduce pollutants and increase fuel economy by 30 percent.
- Most gasoline or diesel engines can be converted to a natural gas or propane fuel. While transportation is still expensive, the cost of using a natural gas fuel (including propane) is considerably less expensive than gasoline or diesel. These costs must be weighed against infrastructure modification costs. Local production of these fuels through coal bed methane or biomass could significantly alter the transportation fuel paradigm.
- Research needs to be focused on small scale micro-reformers that can produce a synfuel product from natural gas, coal bed methane, gas hydrates and biomass suitable for internal combustion engines.
- Development of a new storage “tank” to contain hydrogen that could be generated from renewable energy sources.
- Creation of new electric engines (and batteries) robust enough for Arctic conditions with the range and capabilities required for a subsistence lifestyle.

CHAPTER 4

The Arctic Energy Education and Outreach Program

“... attracting and inspiring the next generation of scientists ...”

The Arctic Energy Summit Website

Education and Outreach - an overarching component of this International Polar Year project - tied all pieces together, from the initial call for papers through the Technology Conference to the Arctic Energy Action Team. In the original implementation plan for the Arctic Energy Summit, adequate levels of funding would have supported the creation of educational materials for public schools; a graduate level Arctic energy course through the University of the Arctic; undergraduate and graduate research in the areas of Arctic energy and power; and development of a web-based and interactive Arctic energy atlas. However, actual funding provided for two very important outreach components: a dedicated English/Russian website and an electronic newsletter, the Arctic Synergy.



The Arctic Synergy

Spanning all the other elements for more than two years was the Summit's signature weekly electronic newsletter, the Arctic Synergy. More than 60 news sources were scanned every week and articles of interest were summarized/excerpted along with a link to its source. Nearly 1,000 subscribers from government, research and industry were kept abreast of news in each of the Summit's four areas - renewable, rural, extractive and sustainable energy in the Arctic.



In addition to providing energy content on a weekly basis, the Arctic Synergy served as a vehicle by which Summit organizers were able to highlight developments relevant to the work of the Arctic Energy Action Team, the follow-on group from the Arctic Energy Summit. Each issue featured either an article written specifically for the Synergy, as it was familiarly called, or offered links to international pieces about coal, rural transportation fuels or hydropower.

The Arctic Synergy put a voice and face to energy in the Arctic. The newsletter gave readers a look at what was happening - from energy technology to policy, from large projects to small, in all eight of the Arctic nations - letting subscribers see and hear from all points of view. The Synergy was a valuable tool and resource in understanding different regional issues and in looking for areas of joint interest and synergy in the development of energy projects.

Because of the widespread interest in the information the Synergy brought to its readers, the Institute of the North has continued to feature energy-related materials in its legacy electronic Arctic newsletter, the Top of the World Telegraph, which reaches nearly a thousand readers around the globe each week.

Education and Youth

Although funding did not allow for full expansion of the educational programs as outlined in the implementation plan, every effort was made to include and engage youth in the Arctic Energy Summit.

A statewide nonprofit group, the Alaska Youth for Environmental Action (a program of the National Wildlife Federation), was involved early in the planning process. Not only did AYEA members make a presentation during the Sustainable Energy track – Sustainable-14 – but students from across the state of Alaska also served a vital role as volunteers and contributors throughout the three-day conference.

In addition, students from a local technology high school were recruited as technical volunteers, helping to record and monitor the breakout sessions. High schools were invited to attend and many classes took advantage of the opportunities provided them.

One of the more popular displays in the Trade Show was a white 1968 Datsun Roadster. As a practical example of their studies into renewable energy sources, students from Atheneum School, a private school in Anchorage, tore out the combustion engine of their teacher's car and replaced it with a bank of batteries. In addition to a presentation made during one of the Sustainable track breakout sessions – Sustainable-04 - a team of students were on hand throughout the exhibition to explain their studies and demonstrate detailed knowledge of their project.

Legacy was an important goal of the International Polar Year: to attract and develop the next generation of polar scientists, engineers, and logistic experts and to capture the interest of school children, the public, and decision-makers. By including students at all levels throughout the Technology Conference, the Arctic Energy Summit succeeded in leaving its legacy.

APPENDIX 1

Extractive Energy Abstracts

Paper #	Presentation Title	Author	Country
EXT-01	Arctic Oil and Gas Activities: Effects and Potential Effects	Dennis Thurston	United States of America
EXT-02	Global and Alaskan Oil Demand and Supply	William Sackinger	United States of America
EXT-03	Program of centralized power supply in the Khanty-Mansiysk Autonomous Okrug-Ugra	Alexander Semenov	Russia
EXT-04	Exploration Results in the Arctic Islands	Robert Meneley	Canada
EXT-05	Hydrocarbon Systems, Basin Analyses, and 2006 Field and Subsurface Data: Bristol Bay, Alaska Peninsula, Frontier Basin	Rocky Reifensstuhl	United States of America
EXT-06	U.S. Geological Survey Circum-Arctic Resource Appraisal	Brenda Pierce	United States of America
EXT-07	Low-sulfur Coals of Arctic Alaska: A Vast Undeveloped Energy Resource	James Clough	United States of America
EXT-08	Creation of Technology for Utilization and Recovery of Coal Seam Methane	Lev Puckov	Russia
EXT-09	Characterization and Quantification of the Methane Hydrate Resource Potential Associated with the Barrow Gas Fields	Tom Walsh	United States of America
EXT-10	Experimental investigation of the possibility of relict gas hydrates formation in frozen sediments	Evgeny Chuvilin	Russia
EXT-11	Development of Methods for Hydrate Fields Exploitation	Dimitry Chumakov	Russia
EXT-12	What if High North Energy Exploitation Fails? An Analysis of What Can Go Wrong	Jan Oddvar Sørnes	Norway
EXT-13	Arctic Gas Hydrate Energy Assessment Studies	Timothy Collett	United States of America
EXT-14	Canada's Unconventional Gas Program	Leah Dell	Canada
EXT-15	Preliminary results from the 2007 Wainwright, Alaska CBNG drilling and testing program	Art Clark	United States of America
EXT-16	Future Marine Transportation of Arctic Energy Resources	Lawson Brigham	United States of America
EXT-17	Oil Spill management in ice conditions in the Baltic Sea.	Bjorn Forsman	Sweden
EXT-18	Oil Shipments in the Barents Region	Bjorn Frantzen	Norway
EXT-19	Impact of High Volatile Content Alaska Coal Grind Size on Combustion in Pulverised Coal Power Plants	Rajive Ganguli	United States of America
EXT-20	Alaska Gas Hydrate Research and Stratigraphic Test Preliminary Results	Robert Hunter	United States of America
EXT-21	Training for Sustainability Life Cycles in Safety Instrumented Systems: Building towards Common Commitments in Arctic Alaska Oil and Gas	John Metzler	United States of America
EXT-22	Experience of Mastering the Oil and Gas Potential in the Khanty-Mansiysk Autonomous Okrug; The Regions Practice in Social and Economic Development of Northern Indigenous Peoples	Veniamin Panov	Russia
EXT-23	Exploration Potential for Natural Gas in Cook Inlet and the Brooks Range Foothills of Alaska	Robert Swenson	United States of America
EXT-24	Arctic escape, evacuation, and rescue	Frank Bercha	Canada
EXT-25	Facilitating the Development of the Alaska Gasline through the Office of Federal Coordinator	Drue Pearce	United States of America
EXT-26	Submarine Technologies for LNG and Global Energy Security Enhancement	Vyacheslav Kuznetsov	Russia
EXT-27	Global Energy Security and the Role of Russia	Evgeny Velikhov	Russia



EXTRACTIVE-01

Arctic Oil and Gas Activities: Effects and Potential Effects

Dennis Thurston

U.S. Department of the Interior Minerals Management Service

U.S.A.

This assessment report is in response to a request from the Ministers of the Arctic Council to update their assessment completed in 1997. It evaluates past, current, and near-future activities, social and economic consequences, environmental effects from pollution, effects from physical impacts and disturbances, and effects on human health associated with oil and gas activities in the Arctic.

The assessment was prepared for the Arctic Monitoring and Assessment Program (AMAP) working group of the Arctic Council with contributions from more than 80 scientists and specialists from many countries, and is scheduled for completion in 2007. It consists of the following chapters: Executive summary; Chapter 1 Introduction; Chapter 2 Oil and gas activities in the Arctic; Chapter 3 Social and economic consequences of oil and gas activities in the Arctic; Chapter 4 Sources, inputs and concentrations of petroleum hydrocarbons, PAHs, and other relevant contaminants in the Arctic; Chapter 5 Effects of pollutants and disturbance on organisms (individual level) and effects of pollutants on human health; Chapter 6 Environmental status and impacts on populations, habitats and ecosystems in the Arctic; Chapter 7 Conclusions and recommendations

The key findings and recommendations of the assessment will be published by AMAP in late 2007 in an Overview Report. At the same time the full assessment will be web-posted for reference before it is formally published in 2008.

EXTRACTIVE-02

Global and Alaskan Oil Demand and Supply

William M. Sackinger

EnergieforschungStiftung

U.S.A.

A discussion is presented of the world demand growth for crude oil over the period 2007-2027, and the probable levels of oil supply which will be made available during that time interval. A chronic shortfall between demand and supply is predicted, with major growth of new oil supply coming from OPEC nations. In 2014 the expansion of oil supplies will reach saturation, and by 2016, the crude oil production and refining chain will be unable to supply sufficient transportation fuels to meet world demand. This will necessitate the production of synthetic transport fuels from natural gas and/or coal. In Alaska, a minimal scenario for North Slope production and final depletion of the major reservoirs is discussed. Sufficient oil production to justify continued operation of the trans-Alaska oil pipeline must come from new oil fields well before 2020, without which the pipeline will shut down. The construction of an Alaskan natural gas pipeline is discussed and is deemed essential at the earliest possible time for Alaskan energy supply and economic growth.



EXTRACTIVE-03

Program of Centralized Power Supply in the Khanty-Mansiysk Autonomous Okrug – Ugra

Alexander Semenov

Govt. of the Khanty-Mansiysk Autonomous Okrug – Ugra
Russian Federation

Today, the Khanty-Mansiysk Autonomous Okrug - Ugra has one of the largest energy sectors in Russia, that ranks 2nd nationwide in terms of electric power generation. The specific character of the energy system is the fact that it is a unified complex – fuel combustion, generation of electricity and its distribution and delivery to consumers. According to the mode of operation and development, the region's energy sector may be subdivided into the centralized sector based on the thermal power plants and decentralized sector, based on self-contained diesel and gas-turbine plants. For long-term development of energy industry, the provision of secure power supply for remote communities of the Khanty-Mansiysk Autonomous Okrug – Ugra, a program called "Centralized Power Supply of the Communities of the Khanty-Mansiysk Autonomous Okrug – Ugra until 2015" has been developed and is being implemented. The program envisages the construction of substations and power transmission lines. The basis for the development of the Pre-Polar Ural's energy infrastructure is the availability of local fuels such as brown coal and the demand for power generating facilities that will be required for the development of the ore-mining sector, as well as the industrial consumers' demand for electric power in the neighboring territories.

EXTRACTIVE-04

Exploration Results in the Canadian Arctic Islands

Robert A Meneley

Robert A. Meneley Enterprises, Ltd.
Canada

Interest in the 20 Tcf of gas discovered in the Canadian Arctic is now reviving after a twenty year hiatus, but there are challenges. The logistical infrastructure to support exploration operations has largely been dismantled and old age is eating away at the experienced professionals that were once available. New ventures that move into the Arctic Islands need to use all of the information that was acquired to critically evaluate their opportunities. New people and new technology are available, but the geology is still the same. This Case Study uses the Sverdrup Basin as an example. The basin was the site of one of the most successful and comprehensive exploration programs conducted in the Frontier Basins in Canada. A careful review of the history of exploration, the geological controls on the size of hydrocarbon accumulations that were found, and the nature of future prospects is used to illustrate the future potential of this basin. The newly developed Truncated Discovery Process assessment permits the prediction of the sizes of the undiscovered fields. Regardless of the method of hydrocarbon assessment that may be used there are very fundamental constraints that are already known that dictate the outcome of future exploration. Similar constraints apply in other basins in Canada. The population in the Arctic Islands is limited and is confined to small settlements and military installations mainly in the eastern Arctic. These are far removed from the discovered gas resources.



EXTRACTIVE-05

Hydrocarbon Systems, Basin Analyses, and 2006 Field and Subsurface Data

Rocky R. Reifenstuhl

Department of Natural Resources

U.S.A.

Hydrocarbon-focused fieldwork (2004-2006) by the Alaska Divisions of Geological & Geophysical Surveys and Oil & Gas provides hydrocarbon system data and basin analyses for the Alaska Peninsula Area Wide Lease Sale (3,500,000 acres onshore; 1,500,000 acres offshore). Eight of 10 wells have oil or gas shows. New data include: organic geochemistry, hydrocarbon typing, total organic carbon, vitrinite reflectance, reservoir quality, sandstone petrography, mercury injection capillary pressure, rockeval, microfossils, coal bed gas adsorption, geologic mapping, and subsurface correlations. Publicly available seismic and field data suggest the presence of structural traps and regional unconformities that may act as traps or seals.

EXTRACTIVE-06

U.S. Geological Survey Circum-Arctic Resource Appraisal

Brenda S. Pierce

United States Geological Survey

U.S.A.

The Arctic contains the world's largest known petroleum province, West Siberian Basin, and several other world-class petroliferous basins such as Timan-Pechora, Northern Alaska, and the Norwegian Sea. Other high northern latitude basins also have a significant potential for future additions to oil and gas reserves. Because of the technological challenges of exploration and development, the Arctic remains largely unexplored with respect to petroleum, and extreme geologic uncertainty characterizes the entire region. In order to quantify the uncertainty surrounding future additions to reserves, the U.S. Geological Survey is conducting a Circum-Arctic Resource Appraisal. The CARA is a consistent, comprehensive, rigorous assessment of conventional oil and gas resources in all sedimentary basins of the Arctic. Because of the sparse data available from most Arctic basins, the standard tools of resource assessment--discovery history analysis, prospect counting, and deposit simulation--are not generally applicable. Instead, the CARA relies primarily upon geological analysis and analog modeling. The Northeast Greenland Shelf has been selected as a prototype for the CARA because it exhibits many typical characteristics of Arctic sedimentary provinces, including the constant presence of sea ice. Using a newly compiled map of Arctic sedimentary successions, over the next two years the USGS, in collaboration with several international organizations, will systematically evaluate the petroleum potential of the Circum-Arctic basins.



EXTRACTIVE-07

Low-sulfur Coals of Arctic Alaska: A Vast Undeveloped Energy Resource

James G. Clough

Alaska Div. of Geological & Geophysical Surveys
U.S.A.

Arctic Alaska remains one of the last underexplored and undeveloped large coal basins in the world. Estimates of Cretaceous and Tertiary low-sulfur coal in deposits north of the Arctic Circle exceed five trillion hypothetical short tons. The coal is low in ash yield and in trace elements of environmental concern, also known as hazardous air pollutants. Mean values, in parts per million, for the HAPs are: antimony, 0.29; arsenic, 2.82; beryllium, 1.0; cadmium, 0.09; chromium, 16; cobalt, 8.2; lead, 5.5; manganese, 108; mercury, 0.05; nickel, 28; selenium, 0.67; and uranium, 1.4. Major differences between the element contents of Cretaceous and Tertiary coals are generally the result of different source areas for the coal-bearing sedimentary rocks. Despite considerable potential, there has never been any commercial coal mining in Arctic Alaska. In contrast, more than 3 million short tons of bituminous coal near Svalbard, Norway are successfully mined annually and then shipped over 1,500 miles south to market. The future of Alaska's Arctic coal might soon change as a major international coal mining company is currently conducting a five-year exploration program to evaluate the potential for mining Cretaceous-age coal in the western Arctic Deadfall syncline region that contain identified coal resources in excess of one billion short tons.

EXTRACTIVE-08

Creation of Technology for Utilization and Recovery of Coal Seam Methane

Lev A. Puckov

Moscow State Mining University
Russian Federation

The report discusses complex resource – saving technologies for the development of high-gas content coal deposits and their preparation for hazardous free effective working. The report also gives the results of industrial pilot projects employing novel mine methane recovery technologies, where methane is produced. And will reflect upon the results of complex degassing by underground seam wells in areas of preliminary degassing; methane recovery technologies; pilot industrial technology for commercial development of coal methane resources outside mine takes; novel technology and equipment tests used to produce coal seam methane based synthetic liquid fuel.



EXTRACTIVE-09

Characterization and Quantification of the Methane Hydrate Resource Potential Associated with the Barrow Gas Fields

Tom Walsh

Petrotechnical Resources of Alaska

U.S.A.

The North Slope of Alaska has significant methane hydrate resource potential, and results of previous studies suggest that gas hydrates exist in the Barrow area. Currently, gas from three producing fields in the Barrow area provides heating and electricity for Barrow, the economic, transportation, and administrative center of the North Slope Borough. As energy demands grow on the North Slope, it is important to characterize, quantify, and evaluate the potential impact of the postulated gas hydrate accumulation to guide future development, and assess the resource value of the hydrates. A two-phase research program is underway, funded jointly by the U.S. Department of Energy and the North Slope Borough, to better understand the nature and occurrence of methane hydrates in the Barrow Gas Fields and to evaluate the potential influence of gas hydrates on gas supply and production. If methane hydrates are proven as a recharge mechanism to the free gas currently in production, this study will impact future development and operation of the Barrow Gas Fields. Assuming continuation through both phases, findings of this project will contribute significantly to understanding the role of gas hydrate in recharging a producing gas field, while providing substantial commercial and social benefits for the NSB.

EXTRACTIVE-10

Experimental Investigation of the Possibility of Relict Gas Hydrates Formation in Frozen Sediments

Evgeny M. Chuvilin

Moscow State University

Russian Federation

The presence of great accumulations of natural gas (mainly methane) in the mass of frozen sediments is often fixed at drilling and operation of various wells in the Arctic areas. Thus gasing from the section of frozen sediments (usually from depths up to 200 meters) reaches hundreds and more of cubic meters a day, and their duration runs up to many months. As the accumulations of natural gas at shallow depth in the mass of frozen sediments are great hence there is a big interest in their practical use, in particular for local gas supply, and in an estimation of their ecological influence on the environment. The special analysis of gas releases from shallow horizons of frozen sediments, accomplished last years for the north of West Siberia, allows speaking that a part of these gas shows is connected with relict gas hydrate formations which could be kept in the permafrost section owing to the effect of self-preservation of gas hydrates at negative temperature. For a substantiation of this statement the complex of experimental investigations was lead. These researches involved an artificial accumulation of methane hydrate in freezing sediments, including sediment samples recovered from gas showing permafrost horizons of the north of West Siberia, and studying of the effect of self-preservation of gas hydrates in frozen soil samples at decrease of equilibrium pressure. This research was funded by Russian Foundation Basic Research No 06-05-91573 and INTAS project No 03-05-4259.



EXTRACTIVE-11

Development of Methods for Hydrated Fields Exploitation

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Gas hydrates are naturally occurring solid compounds of water and gas that are considered as alternative for conventional energy in the near future. In accordance with the latest estimations, potential reserves of gas in hydrates in the world exceed conventional ones in many times. Taking into account instability of oil prices gas hydrates could play a great role in world's energy balance. Gas hydrate fields are usually attributed to shallow ocean water or permafrost regions beyond the Polar Circle. To date more than 300 gas hydrate deposits have been discovered in Russia, USA, Canada, Japan, and India. The most famous are Messoayakha field (Russia), Mallik (Canada), Nankai Trough (offshore Japan). However, the possibility of feasible development of such deposits is still open to question. This report introduces some thermal methods for hydrate field exploitation. They consist in injecting fluent heat-carriers in or under the hydrate formation. Heat-carriers can be injected both from the surface (thermal agents, hot water, steam cycling) and from underlying formation (the deep subterranean thermal water). All presented methods are patented. The 3D mathematical decomposition model is developed which is used for simulation study of different fluids recovery scenarios. Results obtained confirm efficiency of the suggested methods. Also some technical aspects of realization of the methods are discussed.

EXTRACTIVE-12

What if High North Energy Exploitation Fails? An Analysis of What Could Go Wrong

Jan O. Soernes

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Norway

In light of discovered petroleum resources in the Arctic regions, combined with decisions made by Norway and Russia on petroleum activities in the Barents Sea, the High North is increasingly seen as Europe's new energy region. This paper addresses the possibilities for failure in developing High North energy resources because the indicators show the pitfalls are almost equal to the promise. The projection for the Barents Sea Region completed by Brunstad, Mangnus, Swanson, Hønneland, & Øverland (2004) shows that the political relations between Russia and the United States over political issues and between Norway and Russia over drilling rights to the disputed area are substantial. When these problems are combined with the technological challenges of arctic energy production along with indigenous people's rights and ecological and human resource problems, there are clearly many chances of failure in High North energy production. This paper faces these issues head on and makes them the centerpiece by focusing on failure, the complex conditions that surround it, and the story that can be told about it. We introduce three emerging ideas for studying energy management systems—the management of failure, complex adaptive systems (CAS) and narrative theory. These three concepts are applicable because there are so many paths that could lead to failure.



EXTRACTIVE-13

Arctic Gas Hydrate Energy Assessment Studies

Timothy S. Collett

U.S. Geological Survey

U.S.A.

In 1995, the U.S. Geological Survey made the first systematic assessment of the in-place natural gas hydrate resources of the United States. That study suggested that the amount of gas in the hydrate accumulations of northern Alaska probably exceeds the volume of known conventional gas resources on the North Slope. Researchers have long speculated that gas hydrates could eventually be a commercial resource yet technical and economic hurdles have historically made gas hydrate development a distant goal rather than a near-term possibility. This view began to change over the past five years with the realization that this unconventional resource could be developed in conjunction with conventional gas fields. The most significant development was gas hydrate production testing conducted at the Mallik site in Canada's Mackenzie Delta in 2002. The Mallik 2002 Gas Hydrate Production Research Well Program yielded the first modern, fully integrated field study and production test of a natural gas hydrate accumulation. More recently, BP-Alaska with the U.S. Department of Energy and the U.S. Geological Survey have successfully cored, logged, and tested a gas hydrate accumulation on the North Slope of Alaska known as the Mount Elbert Prospect. The Mallik 2002 project along with the Mount Elbert effort has for the first time allowed the rational assessment of the production response of a gas hydrate accumulation.

EXTRACTIVE-15

Preliminary Results from the 2007 Wainwright, Alaska CBNG Drilling and Testing Program

Art Clark

U.S. Geological Survey

U.S.A.

The need for affordable energy sources is acute in remote communities of Alaska where costly diesel fuel must be delivered by barge or plane. Therefore, identifying and developing affordable, local sources of energy remains a high priority in these areas. Alaska's North Slope contains widespread coal resources that may contain significant amounts of coal bed natural gas that, when extracted, could be burned in retrofitted diesel-fired generators. However, in most remote areas, little is known concerning the geologic, hydrologic, and chemical properties that control CBNG occurrence and production potential. Therefore, drilling and testing would provide valuable data for a CBNG-feasibility assessment in a given location. As part of the U.S. Department of Interior Alaska Rural Energy Project, the U.S. Geological Survey and the Bureau of Land Management, in cooperation with the Arctic Slope Regional Corporation and other partners, will drill a projected 2,500 ft exploration and test well in Wainwright, Alaska, during the summer of 2007 to determine whether CBNG represents a viable energy source for the village. Results of the 2007 project will be useful in planning future reservoir and production studies in Wainwright and CBNG assessments near other rural Arctic communities.



EXTRACTIVE-16

Future Marine Transportation of Arctic Energy Resources

Lawson W. Brigham

U.S. Arctic Research Commission

U.S.A.

The scenarios creation work of the Arctic Council's Arctic Marine Shipping Assessment has identified resources and trade as primary factors in determining the future of Arctic marine activity. During the next three decades regional exploration and development of Arctic oil and gas will plausibly be highly influential in the growth of marine operations in the Arctic Ocean. The continued development of the Snøhvit and Shtokman gas fields on the Norwegian and Russian continental shelves will require substantial marine support operations. In addition, future development of resources in the Pechora and Kara seas, and in the Chukchi and Beaufort seas off Alaska could add significant levels of marine operations to Arctic waters. Several wildcard factors also loom large as important and add considerable uncertainty to the future: the near-term delimitation of the Arctic continental shelves by the Arctic States under the terms of Article 76 of the UN Law of the Sea Treaty; oil and gas developments in the Canadian Arctic, and perhaps in offshore Greenland; the expanded development eastward of the Russian Arctic oil and gas industry; and, the implications of future pipelines in the Russian Arctic and other Arctic regions for Arctic marine transportation. The findings of AMSA scheduled for completion in spring 2009 should provide a framework for the Arctic States to respond to the challenges of increased marine activity including the growth in marine operations already observed in the Arctic oil and gas industry.

EXTRACTIVE-19

Impact of High Volatile Content Alaska Coal Grind Size on Combustion in Pulverised Coal Power Plants

Rajive Ganguli

University of Alaska Fairbanks

U.S.A.

This paper presents findings from an ongoing project that demonstrates that Alaskan coal, which has high volatile matter content, need not be ground as fine as bituminous coal for proper combustion. Since grindability is cited as an issue with Alaska coal, grinding the coal less reduces the impact of the grindability issue. Tests conducted to date at GVEA's Healy Unit #1 have shown that combustion and combustion products such as NO_x and SO_x, have not been affected by burning coarser grinds. The tests have also confirmed that coarser grinds indeed consume less power during grinding.



EXTRACTIVE-20

Alaska Gas Hydrate Research and Stratigraphic Test Preliminary Results

Robert B. Hunter

ASRC Energy Services

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Gas hydrate may contain significant gas resources in both onshore arctic and offshore regions throughout the world. The BP-DOE collaborative research project is designed to help determine whether or not gas hydrate can become a technically and economically recoverable gas resource. Reservoir characterization, development scenario modeling, and associated studies indicated that 0-0.34 Trillion Cubic Meters (0-12 Trillion Cubic Feet [TCF]) gas may be technically recoverable from 0.92 Trillion Cubic Meters (33 TCF) gas-in-place (GIP) Eileen trend gas hydrate beneath industry infrastructure within the Milne Point Unit (MPU), Prudhoe Bay Unit (PBU), and Kuparuk River Unit (KRU) areas on the Alaska North Slope (ANS). Reservoir modeling indicated sufficient potential for technical recovery to justify proceeding into field operations to acquire basic physical reservoir and fluid data to help mitigate the large range of uncertainty in recoverable resource. The BP-DOE collaborative research project was approved to proceed into a field data acquisition program including: 122-183 meters (400-600 feet) core, extensive wireline logs, and wireline production tests within the Mount Elbert gas hydrate prospect in the MPU. Successful drilling and data acquisition in the Mount Elbert-01 stratigraphic test well was completed between February 3-19, 2007. Future studies, if approved by BP and DOE, could acquire additional data and include production testing.

EXTRACTIVE-21

Training for Sustainable Life Cycles in Safety Instrumented Systems

John A. Metzler

Eagre Associates LLC

U.S.A.

Application of the current U.S. and international safety standards for Safety Instrumented Systems to Alaskan Arctic oil-and-gas facilities poses special challenges. These facilities were commissioned long before the standards came into effect. Their age and location affects the choices made by safety-system decision-makers throughout each facility's life cycle. This paper addresses those challenges and recommends a training program that focuses on establishing a common set of commitments within both management and technical teams regarding system understanding, technical definitions and tools, and appropriate work processes. In 2004 the Instrumentation, Systems, and Automation Society released its updated standard for Safety Instrumented Systems. This standard was initially a response to OSHA safety regulations for the hydrocarbon industry. The 1996 ISA standard was quickly adopted by the American National Standards Institute. The 2004 update made the standard identical to the International Electrotechnical Commission standard, IEC61511. The ISA standard sets forth a life-cycle process for SIS requiring both technical and management commitment. The standard provides a life-cycle definition and sets out methods that, for their application, require precise technical knowledge of a wide range of topics. These include statistical and probability analysis applied to hazards, risk and risk mitigation, reliability, availability, failure-mode-and-effect, Markov state migration, and others. The introduction and application of this standard requires training at every level of affected organizations.



EXTRACTIVE-22

Experience of Mastering the Oil and Gas Potential in the Khanty-Mansiysk Autonomous Okrug

Veniamin Panov

Govt. of the Khanty-Mansiysk Autonomous Okrug – Ugra
Russian Federation

The Region's Practice in Social and Economic Development of Northern Indigenous Peoples, Partnership of the Regional Authorities with Oil Producing Companies Khanty-Mansiysk Autonomous Okrug – Ugra is a leader in Russia in terms of oil production, ranks second in terms of gas production. Currently, Ugra produces about 60% of all Russia's oil, which makes up approximately 7% of the world oil production. The development of oil and gas fields, as well as the development of other mineral deposits in the North has a great impact on the indigenous population's traditional lifestyle, since their life is essentially associated with nature. The Okrug's subsoil management system takes into account the peculiarities of the northern indigenous people's lifestyle. Besides, the compromise between the parties' interests (subsoil users and indigenous population) is reached in a civilized manner – through the legislation in effect. Russia is forced to explore and put into production new oil and gas fields, and the State's basic mission in solving the said problems is to manage the hydrocarbon field development with a minimum damage to the environment and people traditionally inhabiting the affected area.

EXTRACTIVE-23

Exploration Potential for Natural Gas in Cook Inlet and the Brooks Range Foothills, Alaska

Robert Swenson

Alaska Department of Natural Resources
U.S.A.

The state's diverse geologic setting and numerous sedimentary basins has led to multiple phases of exploration that have provided preliminary geologic evaluation of nearly all potential petroleum provinces. However, many of these areas remain in a preliminary exploratory phase because the vast majority of drilling activity has been in Cook Inlet and on the North Slope. Exploration within these two basins has focused primarily on finding liquid hydrocarbons, and the effort has been exceedingly successful with more than 23 billion barrels of oil reserves discovered, and a significant volume of natural gas, yet only a relatively small portion of this resource has been brought to market because of the large volume of existing 'stranded' reserves, low commodity price, and the high cost of infrastructure development in remote Alaska. But the outlook for gas production in Alaska has changed. Reserves in Cook Inlet continue to decline and the local market is now conducive to exploration expenditure. The possibility of a gas pipeline between the North Slope and U.S. markets has also renewed interest in gas-prone areas of that prolific basin. Areas that the exploration industry has historically deemed non-prospective are now undergoing significant scrutiny with an additional focus of finding new gas reserves. This presentation will explore our current understanding of natural-gas potential in two of the most prospective onshore basins in Alaska—Cook Inlet and the foothills of the Brooks Range on the North Slope.



EXTRACTIVE-24

Arctic Escape, Evacuation and Rescue

Frank G. Bercha

Bercha Group

Canada

Although adequate escape, evacuation, and rescue (EER) reliability is essential for personnel safety on any manned vessel or installation, whether in open or ice covered waters, the attention dedicated to EER for Arctic conditions has been limited prior to this millennium and still has significant shortcomings today. In the last few years, in consonance with the current resurgence of activity in the Arctic offshore, important developments in the technologies, engineering and analysis, and regulatory provisions relating to Arctic EER have taken place, and are ongoing with considerable positive potential. Increasing emphasis on a regulatory performance based regime has necessitated the development of tools for the evaluation and setting of performance-based goals such as availability and reliability requirements. The technological developments partly resulting from R&D and partly initiated independently by numerous organizations and ongoing in parallel, include conceptual, engineering, and full scale prototype construction, testing, type approval, and implementation of novel evacuation and survival systems and procedures. This paper reviews these recent and ongoing developments in the areas of technology, research and analysis, operational experience, and regulation, and highlights the most promising developments and significant remaining technological gaps, and gives recommendations for future work.

EXTRACTIVE-26

Submarine Technologies for Liquefied Natural Gas and Global Energy Security Enhancement

Vyacheslav Kuznetsov

RRC Kurchatov Institute

Russian Federation

The development of Liquefied Natural Gas (LNG) technologies is essential for natural gas market globalization and for global security strengthening. The possibility of creation and principal parameters of underwater LNG production and transportation technological system has been evaluated by an association of specialized Russia's scientific, design and industrial enterprises' experts under scientific leadership of Russian Research Center "Kurchatov Institute" president academician Evgeny Velikhov. The experts came to conclusion that such system can be created on a base of modern technologies and productions. The moving impulse for the expert research gave the understanding of unacceptability of possible damages caused by terrorist attack against the existing coastal and marine surface technological system for LNG production and transportation. Economic parameters of the LNG underwater transport system have been compared with acting marine surface tanker transportation system, taking into account the possible risks of terrorist attack against objects of such system. The advantages of LNG underwater transportation from Barents and Kara Seas waters to Alaska Arctic Coast along transpolar route has been shown. The American partners took part in this division of the presented expert research.

APPENDIX 2

Renewable Energy Abstracts

Paper #	Presentation Title	Author	Country
REN-01	Geothermal Potential in the Arctic	Ragnar Baldursson	Iceland
REN-02	Overview of Geothermal Prospects in Alaska	David Lockard	United States of America
REN-03	An integrated geoscience investigation and geothermal exploration of Chena Hot Springs as a model for other Alaska geothermal sites	Gwen Holdmann	United States of America
REN-04	Renewable Energy Development in the Aleutian Pribilof Islands	Connie Fredenberg	United States of America
REN-05	Economic impacts of climate variability in the Arctic: the case of hydro-power	Jessica Cherry	United States of America
REN-06	Fire Island and Renewable Energy for Alaska	Steve Gilbert	United States of America
REN-07	Fish Oil as an Alternative Fuel for Conventional Combustors	Jinsheng Wang	Canada
REN-08	Cold Climate Problems of a Micro-Hydroelectric Development on Crow Creek, Alaska	Brian Yanity	United States of America
REN-09	Relevance of Hydrogen Technology for the development of stable energy grids in small communities in the Arctic	Ragnar Baldursson	Iceland
REN-10	Feasibility Analysis of Deploying Photovoltaic Array in a Remote Arctic Community	Richard Weis	United States of America
REN-11	Renewable Energy and Waste Heat Utilization for Greenhouse Production in Rural Communities, Using Chena Hot Springs as a Local Model	Gwen Holdmann	United States of America
REN-12	Status of Wind/Diesel Applications in Arctic Climates	Martina Dabo	United States of America
REN-13	Foundation Design of Wind Towers in Southwestern Alaska	Lorie Dilley	United States of America
REN-14	Renewable Energy and Energy Planning in NW Alaska	Brad Reeve	United States of America
REN-15	Impacts of RETScreen in Canadian Northern and Remote Communities	Ron Alward	Canada
REN-16	Tidal Energy Projects in Alaska	Christopher Sauer	United States of America
REN-17	Snow Cooling - Renewable Energy for Large Parts of the World	Kjell Skogsberg	Sweden
REN-18	Climate and Renewable Energy in Nordic Countries	Arni Snorrason	Iceland
REN-19	The VRB Flow Battery for Load Leveling for Wind Systems	Dennis Witmer	United States of America



RENEWABLE-01

Harnessing Hot Spots in the Arctic

Ragnar Baldursson

Ministry of Foreign Affairs

Iceland

The Arctic is better known for permafrost than geothermal activity, but actually, large areas in the Arctic are rich in geothermal resources, which could be used for space heating or even large scale electrical generation in some locations. Iceland has lead the way in the utilization of these hot resources in the Arctic and some geothermal development has taken place in Russia, in particular in Kamchatka, but the rich geothermal resources in Alaska have hardly been touched except for recreational purposes. Conservative estimates of the geothermal potential in the world for electricity with proven technology put it at a similar level as that of the nuclear industry today. This potential is being revised upwards with the discovery of new geothermal resources and the introduction of new technologies and deep drilling, which may increase the geothermal potential by an order of magnitude. Most of the geothermal resources in the world, including the Arctic, are in sparsely populated areas. Access to energy is a major factor in demographic shifts. Iceland's experience shows that the sustainable utilization of geothermal resources spurs economic development and population growth. The subsidizing of oil for space heating and electricity is one of the main obstacles for the development of geothermal resources in the Arctic regions of the Eurasian and American continents.

RENEWABLE-03

An Integrated Geoscience Investigation and Geothermal Exploration of Chena Hot Springs as a Model for Other Alaska Geothermal Sites

Gwen Holdmann

Chena Hot Springs Resort

U.S.A.

The Chena Hot Springs Geothermal System, located 60 miles northeast of Fairbanks, Alaska, has recently been the focus of an extensive geophysical and geological exploration project. This project, funded under the Department of Energy GRED III Program, has taken place in parallel to the installation of the first geothermal power plant in the State of Alaska at Chena Hot Springs, and is designed to quantify the sustainable production rate of the deep geothermal reservoir. This paper reviews the exploration techniques and results from the Chena GRED III project in the context of other potential geothermal exploration and development in the state. Results from these studies indicate that the geothermal system is located within rocks of the Chena Hot Springs pluton, a composite body of ~81 and 59 million year old intrusives. These intrusives are far too old to be a heat source for the present day geothermal system. Results also suggest that Chena Hot Springs geothermal reservoir temperature is approximately 250°F at a depth of 1500-2500 ft, and represents deep circulation of meteoric water. Heat loss is due to conductivity and mixing upon upwelling with cold groundwater in the main hot spring area. The upflow from depth appears to be occurring at the west end of the thermal anomaly. A deeper drilling program is planned in 2007 to access the deep reservoir and verify the current model.



RENEWABLE-04

Renewable Energy Development in the Aleutian Pribilof Islands

Connie L. Fredenberg

Aleutian Pribilof Islands Association, Inc.

U.S.A.

The Aleutian Pribilof Islands Association, the non-profit tribal consortium for Alaska's 13 Aleut Tribes, first established an alternative energy program in 2003. The goal of this program is to develop an appropriate renewable energy project in every community we serve within the next 10 years. We work directly with the community utility and have active participation from the local Tribe(s) and, when possible, the middle and high school students. To date we have contributed to the successful planning and funding of high penetration wind-diesel projects in both Sand Point and Nikolski. All prerequisite wind energy studies have been completed for St. George and the chosen site has been determined to be environmentally acceptable with an excellent wind resource. The community is actively seeking funding. Preliminary studies in both False Pass and King Cove have indicated that moving the anemometer towers and beginning the monitoring process again is necessary. APIA is in the early stages of working with the BIA Energy and Minerals Division to study geothermal energy development in False Pass, Adak, and possibly on Umnak Island and near Port Moller.

RENEWABLE-05

Economic Impacts of Climate Variability in the Arctic: the Case of Hydropower

Jessica E. Cherry

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U.S.A.

In Scandinavia and throughout the Arctic, hydroelectric power is a major source of electricity generation. This region has a largely snowmelt-driven water supply that arrives in winter via a series of synoptic storms. The magnitude and timing of these storms are strongly controlled by the dominant mode of large-scale atmospheric variability, the North Atlantic Oscillation (NAO). As it turns out, the NAO index (a measure of the pressure gradient between the mid-latitude and sub-polar atmosphere over the North Atlantic) can predict over half of the variability in Norway's potential water resources. Because the NAO controls winter temperatures, it also has a major impact on demand for electricity. Finally, the index can also be used to successfully predict the price for electricity on some regional markets. Implications of the changing climate and global water cycle for hydropower will be discussed.



RENEWABLE-06

Biomass Power Generation for Rural Alaskan Applications Using Binary Power Plant Equipment Coupled With a Thermal Oil Heater **Gwen Holdmann**

Chena Hot Springs Resort
U.S.A.

Alaskan villages are in large part dependent upon diesel reciprocating engines for local power production. These villages spend hundreds of thousands of dollars on diesel fuel each year, dollars which are irrevocably lost from the local economy and a cost borne by all Alaskan residents via the cost equalization program. However, most villages are located in areas with abundant land and potential biomass resources which could be tapped for power production and heating. Biomass is an ideal fuel for power generation because, unlike wind power, it can provide a stable base load with high (99%) availability.

Chena Hot Springs/Chena Power and United Technologies Corporation are collaborating on the design and installation of a small-scale biomass-fueled power plant designed for use in remote Alaskan villages. The power plant is a modified version of the highly successful, award winning 400kW geothermal power plant built by United Technologies and installed at Chena Hot Springs Resort in 2006. Their proven geothermal power plant design will be connected with a state-of-the-art, biomass-fueled thermal oil heater to potentially provide inexpensive, base load power to a vast number of rural Alaskan villages located in diverse regions of the state. A pilot project is planned for installation at the Fairbanks North Star Borough Landfill in 2007, using waste brush, paper, and cardboard diverted from the landfill.

RENEWABLE-07

Fish Oil as an Alternative Fuel for Conventional Combustors **Jinsheng Wang**

Natural Resources Canada
Canada

Fish oil is produced in large quantity by the fish-processing industry. In Alaska alone, eight million gallons of fish oil is produced annually. This by-product has similar calorific value to petroleum distillates and is a renewable energy source. Active studies have been carried out for using fish oil as fuel for diesel engines. However, there are circumstances where using fish oil as fuel for furnaces/boilers for heat/power generation is of greater interest. In this work, we assessed the combustion characteristics for fish oil and its blends with fuel oils, and the potential for burning the blends in conventional furnace/boilers. Combustion tests have been performed in a pilot furnace and two residential boilers. Fish oil and the blends burn readily in the facilities. The emissions are generally lower than burning the pure fuel oil except that of NO, which is somehow higher for blends with residual fuel oil. Overall fish oil and the blends showed good combustion properties and significant economic and environmental benefits are expected.



RENEWABLE-08

Cold Climate Problems of a Micro-Hydroelectric Development on Crow Creek, Alaska

Brian B. Yanity

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A micro-scale hydroelectric plant has been proposed for Crow Creek, a mountain stream located in an off-grid area of the Chugach Range near Girdwood, Alaska. The run-of-river plant design has an expected generation capacity of 125 kW, and could power up to thirty homes and displace polluting diesel generation. The cold-climate hydrology and thermal regime of the stream are crucial in the design of such a facility, with the period of lowest stream flow occurring from March into mid-April. The plant most likely will have to shut down every year for these two months. Solutions for intake ice problems discussed include the inducement of ice cover formation, deep submergence of hydraulic intake works, mechanical ice removal, and even trashrack heating. Also discussed are the physical characteristics of penstocks, the burial and insulation of penstocks to prevent ice blockage, and frazil ice problems. Experience with the cold-climate problems of a hydroelectric plant in the Chugach Range is applicable to small-scale hydroelectric plants in other sub-Arctic regions. The cold-climate problems on Crow Creek will not preclude micro-hydropower development on the stream, but the site demands special design considerations and maintenance procedures.

RENEWABLE-09

The Implications of Hydrogen Economy for the Arctic

Ragnar Baldursson

Ministry of Foreign Affairs

Iceland

Hydrogen can be used as a medium to store energy from any primary sources for use on demand. International cooperation on hydrogen development with the aim of generating a world wide shift towards Hydrogen Economy has been growing in the last few years. The members of the International Partnership for Hydrogen Economy, IPHE, established in 2003 account for over 85% of the world GDP and 2/3 of all energy use and CO₂ emissions. The advent of the Hydrogen Economy and the introduction of hydrogen technology would have far reaching consequences in the Arctic. It would slow down world wide release of green house gasses, which is inducing the accelerating climate change. The use of hydrogen as pollution free fuel in the transportation sector would contribute to the preservation of the delicate ecological balance in the Arctic. Hydrogen can provide means for storing electricity derived from fluctuating or seasonal renewable energy resources such as wind and hydropower. Hydrogen could also be produced economically from the natural gas that is found in enormous quantities in the Arctic thus minimizing the ecological impact of the exploitation of the natural resources of the region.



RENEWABLE-10

Feasibility Analysis of Deploying Photovoltaic Array in a Remote Arctic Community

Ashish N. Agrawal

Aiken Global Group, LLC

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This paper presents a Feasibility Analysis of Deploying Photovoltaic Array in a Remote Arctic Community. We have developed a MATLAB Simulink model that computes the annual solar flux at a given latitude. The Simulink model is used to compute the annual solar flux at Wales, a small village in Alaska. For Wales, Alaska, we compared the annual electrical load profile, the annual surface temperature profile, and the estimated annual solar flux profile. We found a strong positive correlation between the surface temperature and the solar flux, a strong negative correlation between the electrical load profile and the surface temperature, and a weak negative correlation between the electrical load and the solar flux. Since the correlation between the electrical load and the solar flux is negative and weak, and because the solar flux at Wales is poor during winter months, a PV array by itself is not an economically feasible option for supplying the energy demand at Wales, Alaska. Therefore, other source of electricity, such as wind power, diesel electric generators, battery bank, should be incorporated with a PV array to supply the electricity demand of Wales.

RENEWABLE-11

Renewable Energy and Waste Heat Utilization for Greenhouse Production in Rural Communities, Using Chena Hot Springs as a Local Model

Gwen Holdmann

Chena Hot Springs Resort

U.S.A.

In July, 2006 Chena Hot Springs Resort erected a 6000 ft² hydroponic production greenhouse to supply produce to the resort restaurant. This project has been an expansion of a collaborative three year project with the University of Alaska to assess the feasibility of local onsite production at remote and semi remote sites in Alaska. Chena Hot Springs Resort is located 33 miles from the nearest transmission grid, and provides power to the site via a 400kW geothermal power plant. The geothermal power plant replaced a 400kW diesel genset, and reduced the cost of power onsite from 30¢/kW to 6¢/kW. This reduction in power cost has made the greenhouse expansion possible. Additionally, heat for the greenhouse is supplied through geothermal water pumped from a shallow well as part of an extensive district heating system. Examples of crops include: tomatoes, lettuce, herbs, green beans, cucumbers, bedding plants, and raspberries. This paper will consider the greenhouse project at Chena as a model for other potential production greenhouse projects throughout the State. There are many opportunities for using waste heat and excess power generated at off-peak hours and months in rural communities for establishing local greenhouse production facilities. This paper will review the technical challenges for installing and operating such a facility, as well as consider the project from an economic standpoint.



RENEWABLE-12

Status of Wind/Diesel Applications in Arctic Climates

Edward I. Baring-Gould

National Renewable Energy Laboratory
U.S.A.

The rising cost of diesel fuel and the environmental regulation for its transportation, use and storage, combined with the clear impacts of increased arctic temperatures, is driving remote communities to look at alternative methods of providing power. Over the last few years wind has become increasingly used to reduce diesel fuel consumption, providing economic, environmental, and security benefits to the energy supply of communities from Alaska to Antarctica. This summary paper describes the current state of the art of wind-diesel systems, will review the operation of wind-diesel plants in cold climates, discuss current research activities pertaining to these systems and address their technical and commercial challenges. Wind-diesel system architectures, dispatch strategies, and operating experience from a variety of wind-diesel systems in Alaska will be reviewed. Specific focus will also be given to the control of power systems with large amounts of wind generation and the complexities of replacing diesel engine waste heat with excess wind energy, a key factor in assessing power plants for retrofit. A brief overview of steps for assessing the viability of retrofitting diesel power systems with wind technologies will also be provided. Because of the large number of isolated diesel mini-grids, the market for adding wind to these systems is substantial, specifically in arctic climates and on islands that rely on diesel only power generation.

RENEWABLE-13

Foundation Design of Wind Towers in Southwestern Alaska

Lorie M Dilley

Hattenburg Dilley & Linnell
U.S.A.

Alaska Village Electric Cooperative an electric utility cooperative comprised of 51 Alaska villages has made a concerted effort to install wind turbines in their villages in an effort to reduce the overall cost of electrical generation. The soil in three of these villages is composed of sands and silts with ground temperatures of between 30 and 32°F. Kasigluk was the first village to have three wind towers installed. The presence of warm, degrading permafrost has led to innovative foundation design including the use of helical piers to support a steel, ring foundation. Uplift forces imposed on the foundation were approximately 100 kips. The piers were designed to be 20-inches in diameter and 50 feet deep with two 36-inch diameter helices. The piers were installed in Kasigluk on February 2006 by STG, Inc. In March 2006 an uplift pile load test was conducted on the installed piers in order to determine the actual working load that each pier can sustain. The wind towers in Kasigluk are currently operational. Refinement of the design has been conducted for the next two villages to have wind towers installed.



RENEWABLE-15

Impacts of RETScreen in Canadian Northern and Remote Communities

Ron Alward

Natural Resources Canada

Canada

RETScreen is a clean energy decision-support and capacity building tool that was developed by engineers at CETC-Varennes, Quebec in an effort to get clean energy technologies routinely considered by planners and decision-makers at the initial project planning stage. It developed out of working on renewable energy projects in India and in remote Aboriginal communities in northern Canada. The new Version 4 software's capabilities have been expanded from renewable energy, cogeneration and district energy systems, to include a full array of clean power, heating and cooling technologies, and energy efficiency measures. It is available in 21 languages that cover roughly 2/3 of the world's population and its climate data now covers the entire surface of the planet. RETScreen has been used since 1998 to assist and initiate projects in over 200 Aboriginal and northern Canadian communities. Projects include solar air and water heating, photovoltaic, hydro and wind power generation, combined heat and power and ground source heat pumps. Several of these projects are described and discussed in this paper. RETScreen maintains a project implementation and support network in the north through Arctic energy groups, government agencies, and a network of consultants.

RENEWABLE-16

Tidal Energy Projects in Alaska

Christopher R. Sauer

Ocean Renewable Power Company

U.S.A.

Ocean Renewable Power Company has developed ocean current generation technology for producing emission-free electricity from tidal currents. The core of the proprietary technology is the turbine generator unit, which utilizes 2 horizontal cross flow turbines attached to a permanent magnet generator between them, all on a single direct drive shaft. ORPC plans a demonstration project of its TGU at its Cook Inlet/Knik Arm tidal site in May 2008. Once proven, OCGen technology can be used in large tidal projects connected to the grid and in smaller distributed generation projects in remote coastal and island communities where tidal and river currents are sufficient. Remote OCGen projects could significantly reduce costs of electricity in remote communities.



RENEWABLE-17

Snow Cooling – Renewable Energy for Large Parts of the World

Kjell Skogsberg

Snowpower AB

Sweden

The world's cooling demand has increased considerably during the last decades. Conventional cooling is often produced by electrically driven devices. One electricity efficient alternative is to use stored snow and ice for cooling during the summer. The snow/ice can be stored in different ways.

In open pond storage the main part of the melt losses occurs at the top, while heat transfer from the rain and ground is usually relatively small. The snow must therefore be thermally insulated. There are different insulation alternatives such as wood chips, plastic insulation sheets, gravel and solid. A 0.2 m wood chips layer is used in a snow cooling plant in Sundsvall, Sweden. The Sundsvall Regional Hospital snow cooling plant has successfully operated since 1999. Natural and artificial snow is stored in a shallow watertight pond. During these years, the plant has delivered the main part of the cooling without one hour of operation failure. This presentation considers snow storage in general and focuses on the design of open pond snow storage.

RENEWABLE-18

Climate and Renewable Energy in the Nordic Countries

Árni Snorrason

National Energy Authority

Iceland

An increase of uncertainty about the future of renewable resources under climate change is a key issue for the energy sector. Some renewable energy resources will likely increase their productivity; on the other hand, changes in the seasonal and geographical patterns of production and demand need to be managed.

The Nordic research project Climate and Energy with funding from the Nordic Energy Research and the Nordic energy sector was initiated in 2003 and concluded in 2006. The main objective of the project was to make a comprehensive assessment of the impact of climate change on renewable energy resources in the Nordic area including hydropower, wind power, bio-fuels and solar energy looking towards the end of the 21st Century. The project deals with renewable energy by establishing qualitative scenarios for the future energy system and through quantitative system simulations for these scenarios. The project will demonstrate the effect of climate change for renewable energy including hydropower and for energy system stability. Furthermore, the project will assess the development of the Nordic electricity system for the next 20-30 years. It will also address how the conditions for production of renewable energy in the Nordic area might change due to global warming and it will focus on the potential production and the future safety of the production systems as well as on uncertainties.



RENEWABLE-19

The VRB Flow Battery for Load Leveling for Wind Systems

Dennis Witmer

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One major impediment to the use of renewable power in off grid communities is the mismatch between the availability of the resource and the load profile. Current batteries can be used, but are cost prohibitive in implementation. This paper will discuss the current testing of the VRB flow battery currently being tested in the laboratory at UAF. The supplier of this battery claims several advantages over other current battery technologies, including the ability to expand the total capacity of the battery through the addition of relatively inexpensive tanks, the lack of degradation mechanisms due to cross contamination, and a claim of extremely good durability (14,000 cycles to failure), and a deep cycling ability.



APPENDIX 3

Rural Energy Abstracts

Paper #	Presentation Title	Author	Country
RUR-01	Power Engineering of Russia's North-East	Alexander Antonenko	Russia
RUR-02	An Integrated village energy analysis model allowing for comparison of different supply options with respect to the total energy demands of a small community	Steve Colt	United States of America
RUR-03	Renewable Power in Rural Alaska: Improved Opportunities for Economic Deployment	Peter Crimp	United States of America
RUR-04	A Systems Dynamic Approach to Model a Multimodal Energy System in Rural Arctic Communities	James Hemsath	United States of America
RUR-05	Interhemispheric Tunnel & Rail Group Proposal	George Koumal	United States of America
RUR-06	Experimental Study of Heat Recovery from Diesel Exhaust for Alaskan Village Diesel Generators	Chuen-Sen Lin	United States of America
RUR-07	Load and Temperature Profiling for Improvements in Efficiency and Operational Lifetime of Diesel Electric Generators in Alaska Rural Villages	Richard Wies	United States of America
RUR-08	Wind-Diesel Systems for Isolated Arctic Communities	Jesse Stowel	United States of America
RUR-09	Hybrid Micro Energy Project (HMEP) – A comprehensive year-round approach to powering the Arctic	John Davies	United States of America
RUR-10	Pre-payment Utility Meters - Encouraging Greater Conservation and Efficiency in Rural Alaska Villages	Michael Brubaker	United States of America
RUR-11	Advanced Residential Energy Technologies for Harsh Northern Climate	Evgueniy Entchev	Canada
RUR-12	Life Cycle Cost, Efficiency and Environmental Impact Analysis for Integrating Renewable Energy Sources into Standalone Village Power Systems in Remote Arctic Climates	Richard Wies	United States of America
RUR-13	The Aurora Ice Museum absorption refrigeration system: An example of using absorption chilling to reduce refrigeration expenses in high energy cost communities	Gwen Holdmann	United States of America
RUR-14	Economic Wind Power Development in Rural Alaska	Martina Dabo	United States of America
RUR-16	The Optimization of local Generation Unit's Fuel Balance in Sakha Republic of Russia	Konstantin Ilkovsky	Russia
RUR-17	PolarPower.Org – Sharing knowledge about power systems for polar regions	Roy Stehle	United States of America
RUR-18	Ivotuk: An Autonomous Power and Communications System on Alaska's North Slope	Tracy Dahl	United States of America
RUR-19	Alaska Military's Arctic Energy Challenges at Remote Sites	David Fosbrook	United States of America
RUR-20	An Amalgamated Approach to Rural Generation: A Case Study in Sustainability	Jay Hermanson	United States of America
RUR-21	Energy in Community Planning	Brent Petrie	United States of America
RUR-22	Alaska/British Columbia Intertie	Jim Strandberg	United States of America
RUR-23	Integrated Systems Approach for Wood Energy in Alaska Rural Villages	Charles Parker	United States of America
RUR-24	Energy Alternatives in the Yukon River Watershed	Jon Waterhouse	United States of America
RUR-25	Fuel Cells and Hydrogen for Rural Alaska: A Reality Check	Dennis Witmer	United States of America



RURAL-01

Power Engineering of Russia's Northeast

Alexander A. Antonenko

Sakha Republic

Russian Federation

General challenges include distinguishing traits of Russia's Northeast, specific properties of the power industry and the power supply systems of Russia's North-East. Issues include the state of the power industry in the Sakha Republic (Yakutia), its structure and main generating supplies. Small-scale power engineering projects include diesel power engineering and the complex approaches to possible power solutions in the Sakha Republic (Yakutia). Small-output heat power plants aim to replace diesel power stations and boilers for maximum reduction in usage of expensive imported diesel fuel for power generation. Non-traditional renewable sources of energy include the development of electrical power – small and micro hydropower stations and wind power stations. The prospective: implement advanced development of power infrastructure of the region. Includes projection of the South Yakutia hydropower complex, as well as unification of power districts of Yakutia, and studies of usage efficiency of small-scale nuclear power stations in certain districts of the Sakha Republic.

RURAL-02

Integrated Villages Energy Analysis Model

Steve Colt

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U.S.A.

Rational energy planning requires simultaneous attention to electricity, space heat, and transportation end uses. We present a simple integrated village energy analysis model that allows for comparison of different supply options with respect to the total energy demands of a small community. The Alaska Village Energy Model (AVEM) allows for rapid demand projections based on readily available data and provides a common platform for evaluating multiple supply options against the same conditions and assumptions. The paper concludes with a case study application of the model to a prototype village using an integrated wind-hydrogen-diesel energy supply system.



RURAL-03

Renewable Power in Rural Alaska: Improved Opportunities for Economic Deployment

Peter M. Crimp

Alaska Energy Authority

U.S.A.

Sharp increases in the price of distillate fuel have led to wider economic opportunities for local renewable energy resources in the over 180 rural Alaskan communities that are served by electrical micro grids isolated from larger population centers. Between 2002 and 2006 the median price of diesel fuel for utility power generation in rural Alaska increased by 67% to \$0.62/L. During this period the median unsubsidized residential cost of power increased by 20% to \$0.468/kWh. The Alaska Rural Energy Plan, based on 2002 fuel costs, indicated widespread opportunities for cost-saving measures from end use efficiency, diesel generation efficiency, diesel combined heat and power, and wind energy. This paper assesses economics for these measures as well as small hydroelectric, geothermal, and biomass-fired combined heat and power under a range of future oil price assumptions.

RURAL-04

Systems Dynamic Approach to Model a Multimodal Energy System in Rural Arctic Communities

James R. Hemsath

IntegrityOne, LLC

U.S.A.

Alaska is a vast storehouse of extractive energy sources -- oil, natural gas, and coal -- but it's poor in affordable power in its rural, predominately Native Alaskan, villages. This power is generated predominately by diesel generators where the diesel fuel is barged to the villages during the short 2-3 month shipping season. Alternative sources of power will come from a variety of sources such as wind-hybrids, in-river hydro, geothermal, propane and coal bed methane.

A new methodology is needed that addresses the total system energy needs for a community; the influences of a variety of different and sometimes competing factors including climate, environmental, cost, training and governmental policies; and the variety of energy technologies. This paper will describe the development of a system dynamic model of the energy requirements of a typical Arctic community, addressing the variety of potential energy inputs to that community in conjunction with the total energy demands. Causal loops that define the interaction of the system will be developed and examined. These loops will address a variety of costs as well as policies. The purpose of this model is to quantify the interactions of an Arctic rural energy system.



RURAL-05

Interhemispheric Tunnel & Rail Group Proposal

George Koumal

Interhemispheric Bering Strait Tunnel & Rail Group

U.S.A.

The Interhemispheric Bering Strait Tunnel & Rail Group, Inc., an Alaska non-profit corporation, proposes to construct and operate an electric traction, common carrier railroad, connecting Chinese and Russian railroads with North American rail systems. The 4,500 miles of new track will provide overland transportation and access to vast reaches of northwestern Canada, western Alaska and the northerly Russian Far East. Linkage with Chinese rail, probably at Heilongjiang, will assure sufficient freight tonnage between Asia and North America to amortize capital investment, defray operating expenses, and produce an annual surplus. The railroad will source energy/power from discrete, well-known sites along its trackage, and provide distribution from its right-of-way through much of the northern hemisphere. Sixty percent of the hydroelectric capacity of the world is situated in eastern Siberia. Multiple thousands of non-greenhouse-gas megawatts will supply of the Arctic. Oil and natural gas shipments are likewise enabled across the northland. Rich coal deposits will be available to the railroad; as technology develops, coal will yield greenhouse-gas-free energy without the old-fashioned boiler combustion. Fiber optic cables laid along the route will provide extensive computer and voice communication to enable efficient dispatch of the energy where needed at any time of the diurnal cycle.

RURAL-06

Experimental Study of Heat Recovery from Diesel Exhaust for Alaskan Village Diesel Generators

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In rural Alaska, there are nearly 180 villages consuming about 374,000 MWh of electric energy annually from individual diesel generator facilities. For modern diesel engines, about 40% of fuel energy is released as waste heat from engine exhaust and turbocharger compressed air. If 60% of the released heat was put to appropriate use, there would be a great fuel savings. The purpose of this study was to select an appropriate exhaust heat recovery application for Alaskan village diesel generators and to study its feasibility and economic effect. Recovery of heat from the exhaust of the Alaskan village diesel generators has long been avoided due to the probable problems of corrosion caused by sulfuric acid and performance deterioration caused by corrosion and exhaust soot accumulation. Since the new regulation requires diesel engines to use ultra low sulfur diesel fuel, the intensity of corrosion and performance deterioration problems may be reduced mostly and the exhaust heat recovery system may become feasible and economical. This report presents the selection process of an appropriate heat recovery application for Alaskan village diesel generators, the design of an experimental heat recovery system for testing, and the testing result of the effect of exhaust on the fouling factor and corrosion of the heat recovery system. Also included in this report is the result obtained from feasibility study and economic analysis.



RURAL-08

Wind-Diesel Systems for Isolated Arctic Communities

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Northern Power

U.S.A.

The use of hybrid power generation systems for small, remote villages utilizing wind turbines and diesel engines has been studied extensively for years, but the cost of energy for these systems has historically limited their practical implementation. Recent advancements in wind turbine technology combined with ever increasing fuel prices have created a renewed market interest in these hybrid power systems. Wind turbines installed in these remote grids can provide a large percentage of the required energy versus the traditional low-penetration system that has been prevalent to date. This significantly reduces the amount of diesel fuel that must be purchased, transported and stored in these isolated communities. This paper will present the market needs and specific technical challenges of high penetration wind-diesel system design for isolated grids in cold climates and offer real solutions to address those challenges. It will highlight recent technology developments in the areas of power conversion, system control, and short-term energy storage that are particularly applicable to high penetration hybrid systems. It will draw from Northern Power's extensive experience implementing wind-diesel systems in rural Alaska, and offer next steps for advancing the state-of-the-art in wind-diesel technology.

RURAL-10

Pre-payment Utility Meters - Encouraging Greater Conservation and Efficiency in Rural Alaska Villages

Michael Y. Brubaker

Aleutian Pribilof Islands Association

U.S.A.

Arctic villages are challenged to provide basic services. In Alaska, rural economies are depressed, costs have increased and local governments are trying to operate with reduced revenues. They have been forced to reduce services, delay critical maintenance and layoff staff. Consequently, there is interest by local governments to demonstrate models of sustainability. In the Aleut Region, the Aleutian Pribilof Islands Association has been using administrative training, development of renewable energy and pre-payment utility meters to help increase efficiency. The prepayment systems require customers to pay for services (water, sewer, trash, electricity) in advance, rather than through the usual process of monthly billing. A digital display within the home tells the customer how much electricity is being used and the cost. After converting one village to a prepayment system collections increased by 50%, all surveyed households reported decreases in energy use, and the city reported a 15% decrease in demand at the power plant. This presentation will explore pre-payment meters as a model for appropriate development and sustainability.



RURAL-11

Advanced Residential Energy Technologies for Harsh Northern Climate

Evgueniy Entchev

CANMET

Canada

Advanced energy technologies such as fuel cells, Stirling engine, combined space and water heating systems are a relatively new approach for heat and power generation in Northern Territories. The extreme outdoor conditions and lack of efficient building technologies have been for a long time the main barriers preventing applications of novel high efficiency technologies in the remote communities. Recently, the advanced building technologies challenged the heating industry to develop more efficient and environmental friendly energy systems to meet the lower heating loads and increased demand for a comfortable living environment. This paper will present the results from the performance evaluation of a combined heating system installed in two houses in Yellowknife, NWT and previous laboratory testing in Ottawa. The results from field evaluation of a residential size 5kWel solid oxide fuel cell and 1kWel Stirling engine will be also be discussed. The paper will also present specific procedures that may be necessary to further optimize the performance of advanced energy systems in northern applications.

RURAL-12

Load and Temperature Profiling for Improvements in Efficiency and Operational Lifetime of Diesel Electric Generators in Alaska Rural Villages

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University of Alaska Fairbanks

U.S.A.

Electric power systems in Alaska rural villages generally consist of diesel electric generators (DEGs) serving relatively low and highly cyclical loads the majority of the time. Methods of improving the efficiency and operational lifetime of these systems are to load the DEGs closer to their rated capacity, employ heat recovery and utilize turbochargers. The efficiency of the DEG engine is directly coupled to the electric load, engine operating temperature and the ambient air temperature. While lower ambient air temperature can increase engine efficiency due to rejecting heat to a lower temperature, it can also reduce engine efficiency due to a number of cold climate considerations including the use of diesel #1 [lower Btu/liter] and the heating of fuel stored in outside tanks. This paper investigates the relationship between village electrical loads, ambient air temperatures and efficiency and operational lifetime of DEGs. Load and ambient air temperature profiles for a representative set of Alaska rural villages are categorized and analyzed to determine correlations between electrical loads, ambient air temperature, DEG engine efficiency and DEG operational lifetime. The results are used to demonstrate how load and temperature profiling could be used in conjunction with generation scheduling and heat recovery techniques for improving the efficiency and operational lifetime of DEGs in Alaska rural villages.



RURAL-13

The Aurora Ice Museum Absorption Refrigeration System

Gwen Holdmann

Chena Hot Springs Resort

U.S.A.

In January 2005, a double lift absorption chiller was installed in the Aurora Ice Museum at Chena Hot Springs, Alaska. The Aurora Ice Museum is the world's only primarily ice structure which is open year round. Inside the building are hundred of tons of fantastic ice architecture and life size sculptures which represent thousands of hours of work by world class artists completed over 2-1/2 years. Prior to the installation of the absorption chiller, the Ice Museum was cooled using a 200 ton Trane vapor compressor air conditioning system reprogrammed to cool a CaCl₂ brine to 0°F. While the vapor compression system was adequate in providing refrigeration to the building, the cost to operate the system was quickly determined to be prohibitive. A dedicated 500kW diesel generator was required to operate the system, at a cost of \$600 per day in fuel. A more economically sound alternative was sought. The solution has been using the local geothermal resource to drive an absorption refrigeration cycle to provide the necessary cooling. While the geothermal resource driving the system at Chena is relatively site-specific, the same absorption chiller could operate off any waste heat source, including jacket water from a diesel genset. Because refrigeration loads are often highest at times when heating requirements are at a minimum, absorption chilling can compliment and enhance efficiency for existing and planned projects with a waste heat component.

RURAL-14

Economic Wind Power Development in Rural Alaska

Martina Dabo

State of Alaska Dept. of Commerce and Economic Development

U.S.A.

The recent volatility in diesel fuel prices has driven the cost of electricity production in rural Alaska to historic highs. We conducted pre-feasibility studies to produce a screening report for the Alaska Rural Energy Plan. It concluded that wind power is a viable option to reduce the cost of energy to many rural Alaska villages. The economic feasibility of wind power depends on several factors: the wind resource, state and federal policies, the costs of financing, diesel fuel, and other system components, social factors such as landownership and O&M strategies, and additional Arctic-specific physical factors such as the climate, remote location, and permafrost. Using NREL's HOMER Micropower Optimization Model we evaluated the economics of a wide range of wind-diesel hybrid power system designs for multiple remote Alaskan villages. Incorporating all of the factors listed above we created a matrix for economic wind development in rural villages and developed a best practices guide for economic wind development in rural Alaska. The regional approach we recommend uses a hub city to rationalize bulk purchases, O&M training and institutional management of the implementation and execution of regional wind development.



RURAL-15

NorthWind100: The 100 kW Arctic Wind Turbine

Brett Pingree

Distributed Energy Systems

U.S.A.

This paper describes the practical experience that Northern Power has accrued with its fleet of NorthWind 100's in the Arctic and Bering Sea locations of Alaska. The NorthWind100 is a wind turbine optimized for cold climate and wind diesel applications, and has been installed and running in the Arctic or near Arctic locations for about five years. Key features discussed in the paper cover logistics, material sourcing and qualifying, interactions with local communities, quantity and caliber of field service technicians needed, environmental considerations, remote software capabilities, and many other factors that influence the real world problem solving that goes on when an Arctic installed wind turbine needs help. We will use case studies of several arctic and near arctic sites to illustrate the viability of wind energy in arctic environments.

Underwriters Laboratories certified the NW100 turbine to the IEC 61400-1 wind turbine design standard. In late 2002, a prototype turbine was installed above the Arctic Circle in Kotzebue, Alaska for evaluation under the DOE/EPRI Turbine Verification Program. Six units were installed for a commercial customer in the villages of Toksook Bay and Kasigluk, AK between 2005 and 2006. Seven more turbines are to be installed in the villages of Hooper Bay and Chevak, villages in the Yukon delta, in the summer of 2007.

RURAL-16

The Optimization of Local Generation Unit's Fuel Balance in the Sakha Republic (Yakutia), Russia

Konstantin Ilkovsky

Yakutskenergo, JSC

Russian Federation

Local power utility area characteristics: extreme low winter temperature up to -60C; long heating season up to 300 days per year; large service territory – 2.2 million. sq. km; population size – 150,000; low population density – less than 70 people per 1000 sq. km; number of settlements – 175; diesel gen sets number – 161; heating generator units – 365; overhead lines density – 1.82 m/sq km; generation output – 420 million. kWh; annual sales – 320 million. kWh; annual diesel fuel consumption – 118.000 metric tones. Local power utility problems: high electricity cost – 46 cents/kWh in 2007 due to fuel balance structure which reflects high cost of diesel fuel – 65%; seasonal diesel fuel delivery and logistics difficulties, short transportation period (from 3 weeks up to 4 month), difficult transportation scheme with changes of the career with different types of transportation, which create 1.5 year stocks; high fuel consumption per kWh due to old diesel generator units, overloading of equipment, old overhead lines; high power losses in distribution lines; big annual loans portfolio, big stocks of the diesel fuel, which influence on corporate financial stability. Complex problem solution by program method: technical renovation difficulties by own resources funds, generated by local power utility; the annual investment needs about \$138 M, the company's revenue is about \$4 M. Targeted goals and results: low cost of power and rates for electricity; technical renovation; fuel balance change with increasing coal fuel portion from local deposits; quality of life increasing in the Northern and Arctic districts of the Sakha Republic (Yakutia); lowering ecological impacts.



RURAL-18

Ivotuk: An Autonomous Power and Communications System on Alaska's North Slope

Tracy S. Dahl

VECO Polar Resources

U.S.A.

Funded by the US National Science Foundation, this hybrid power system provides a year-round power and communications hub for an autonomous instrument platform located at the Ivotuk field research site on Alaska's North Slope. Carbon flux cycling, gas exchange, and meteorological data are collected, archived, and relayed by a satellite link to researcher's home institutions. The Ivotuk power and communications system has gradually evolved and improved over the years, not only fulfilling the immediate requirements of the science project, but also serving as a testing and development platform for technology necessary in the support of Arctic research. There are continuing issues related to the original contractor's system design. Recharging batteries via diesel engine generator requires very significant compromises between engine health, fuel consumption, and battery health. There are advantages to utilizing a hybrid approach, incorporating renewable energy to augment conventional generator systems. This presentation will describe approaches to a hybrid system that has had success in an unmanned Arctic tundra environment. Renewable energy components were added to the system in 2004 to help obtain greater efficiency and longer service intervals. An August 2007 annual maintenance visit will incorporate further upgrades to enhance the performance of the system, including an additional solar array and technology to promote long-term battery health.

RURAL-20

An Amalgamated Approach at Rural Power Generation: A Case Study in Sustainability

Jay Hermanson

NANA Pacific

U.S.A.

Over the years, AVEC has developed new village power projects in many rural Alaskan communities. AVEC's approach is sustainable in nature due to the appropriate use of partnerships and collaboration; technology; and improved and integrated business process. The synergistic effect encourages long-term sustainability of a rural power generation system for sub-regions and communities throughout rural Alaska.

AVEC generally collaborates with the local school district, Traditional/Tribal Council, and city council in the development of amalgamated facilities. In the past, these entities likely had separate facilities, involving individual O&M, permitting, and improvements. With the amalgamated approach, tank farms are co-located, co-developed, and co-operated. During the development process, AVEC looks at a variety of technological options, including alternative and renewable energy options such as wind/diesel, recovered heat, tie lines, and energy efficiency. AVEC also has a business plan for a given project that ties all of these sustainability tactics together. The business plan includes a replacement and renewal account, which will provide community capital for future replacement and improvement. This presentation will demonstrate how this amalgamated approach promotes sustainability and cost savings for rural energy and power providers and ratepayers. Multiple case studies and examples from across Alaska will be integrated into the presentation.



RURAL-23

Integrated Systems Approach for Wood Energy in Alaska Rural Villages

William A. Wall

Alaska Village Initiatives

U.S.A.

AVI has completed initial development of an integrated community based model to displace significant amounts of diesel fuel used in an interior Alaska Villages for heat and electricity with wood energy. The model program is based on analysis of the village of Fort Yukon and the surrounding Yukon Flats region. If fully implemented and successful the program will create whole new economic base and industry in Interior Alaska through renewable energy and help stabilize energy prices. The program is focused on supporting villages to generate there own heat and power through use of local resources and developing local economies. The model links an ecological approach to forest management and subsistence wildlife management to economically viable wood harvest and delivery systems. In this model energy production must be based at the local level if benefits are to accrue to villages rather than to large scale wood utilization projects. This presentation will describe the key components of the program.

RURAL-24

Energy Alternatives in the Yukon River Watershed

Jon Waterhouse

Yukon River Inter-Tribal Watershed Council

U.S.A.

The Yukon River Inter-Tribal Watershed Council is a coalition of 65 Tribes and First Nations who rely on the Yukon River for survival and are united in protecting the ecological and cultural integrity of the basin. Along with renewable energy and energy efficiency, the YRITWC has initiated a search for innovative solutions to high energy costs and solid waste disposal challenges. One technology that has been identified and implemented is the REOS system. The REOS system combines used oil with existing diesel or heating fuel on a molecular level to produce a superior, cleaner burning fuel that also reduces maintenance and extends life of fuel burning equipment. Currently the YRITWC has a REOS base station in Nenana, Alaska, which is the transfer site for barges traveling the Yukon River. The REOS unit in Nenana costs approximately \$65,000 for the machine and \$25,000 for the building and accessories and is providing heat for the Tribal office and health clinic. This is a fully automatic system that processes used oil from Yukon River communities. The YRITWC is also developing a fully portable REOS system that will be sized to fit in a Cessna Grand Caravan airplane for remote use and immediate response throughout the watershed. This unit will be ready for use in August 2007. Implementing the REOS technology is the beginning of an integrated system to manage, recycle, and reduce energy and solid waste in the Yukon River watershed.



RURAL-25

Fuel Cells and Hydrogen for Rural Alaska: A Reality Check

Dennis Witmer

University of Alaska Fairbanks

U.S.A.

Hydrogen powered fuel cells have been proposed as the perfect solution for completely renewable, environmentally benign energy for rural Alaska (and the world). Unfortunately, there are significant engineering issues associated with this solution.

This paper will review the current state of the art in fuel cell and hydrogen development based on independent third party testing of more than ten fuel cells and hydrogen production devices at the University of Alaska Fairbanks. The discussion will include the current state of development on both PEM and SOFC fuel cells, as well as the production of hydrogen, both through electrolysis and hydrocarbon reformation, compression and storage issues. This discussion will include details on the thermodynamic efficiency of both individual components and of complete systems. An economic analysis based on current technology pricing will also be included.



APPENDIX 4

Sustainability Abstracts

Paper #	Presentation Title	Author	Country
SUS-01	"Above-Ground" Issues Affecting Energy Development in the Arctic	Rachel Halpern	United States of America
SUS-02	Defining "Energy Security" in the Arctic Context in a Sustainable Development World	Peter Sharp	Canada
SUS-03	"The Alaska Energy Board: Applying lessons learned from the Denali Commission and the 2002 United Nations Global Summit on Sustainable Development"	Jeff Staser	United States of America
SUS-04	Energy Education for Secondary Schools	Kevin Holthaus	United States of America
SUS-05	Education and outreach activities through the Black Sea and the Caspian Sea International Environmental Information Center	Marion (Kay) Thompson	United States of America
SUS-06	Sustainable development principles in training of oil and gas specialist for Arctic region. Russian view and experience	Dimitry Chumakov	Russia
SUS-07	Aerospace Information Management	Jan Oddvar Sørnes	Norway
SUS-08	Arctic Energy and Cumulative Effects: Growing Demands	Anne Southam	United States of America
SUS-09	Integrated Management Plan	Odd Raustein	Norway
SUS-10	Oil spill response in cold and ice conditions, experiences and developments in Baltic Sea States	Kari Lampela	Finland
SUS-11	Extending Oil Spill Occurrence Rates from the Gulf of Mexico to the Beaufort and Chukchi Seas	Ted Eschenbach	United States of America
SUS-12	Promoting Sustainable Oil and Gas Development in Alaska's Arctic Seas through the Local-Scale Integration of Geophysical and Traditional Knowledge	Matthew Druckenmiller	United States of America
SUS-13	Ecosystem Habitat Mapping Studies: Preparing for Renewed Hydrocarbon Development in the Canadian Beaufort Sea	Donald Cobb	Canada
SUS-14	The Youth Movement: A profile of the Alaska Youth for Environmental Action (AYEA) program	Polly Carr	United States of America
SUS-15	The Role the WL Project has in the Development of Arctic Energy Resources	Alexander Sergeev	Russia
SUS-16	Climate monitoring in the Arctic: benefits for science and industry	Jessica Cherry	United States of America
SUS-17	Analysis of Disturbance to Vegetation and Changes in Active Layer Depths Resulting from Different Ice Road Construction Methods	Laurence Byrne	United States of America
SUS-18	Estimating the Value of Alaska Public Infrastructure at Risk to Climate Change	Peter Larsen	United States of America
SUS-19	Energy Development in the Arctic: A Fine Balance?	Gabrielle Slowey	Canada
SUS-20	Social Impacts of Energy Sustainability in Kivalina	Jon Isaacs	United States of America
SUS-21	Community Energy Planning in NWT	Aleta Fowler	Canada
SUS-22	The Nordic network for sustainable energy systems in isolated locations	David Pointing	Denmark
SUS-23	A Toolkit for Community Energy Planning in Northern Canadian Communities	Andrew Robinson	Canada
SUS-24	A Review of the Sustainable Design Approach for the South Pole Station Modernization Project	Steven Theno	United States of America
SUS-25	Inupiat Traditional Knowledge and Energy Development Decisions	Taylor Brelsford	United States of America
SUS-27	Arctic Soils Monitoring, Oil Spill Bioremediation, Remote Sensing Technologies: Fruits of International Collaborations	Heather Fernuik	United States of America
SUS-28	A Review of the Diesel-Engine Generator Exhaust Design Approach for the South Pole Station Power Plant	Steven Theno	United States of America



SUSTAINABLE-01

“Above-Ground” Issues Affecting Energy Development in the Arctic

Rachel Halpern

U.S. Department of Commerce

U.S.A.

Companies wishing to develop energy resources in the Arctic will face not only technical challenges, but political, legal, and regulatory challenges as well. There are five different countries (U.S., Canada, Norway, Denmark, and Russia) that control portions of the Arctic that contain hydrocarbon resources. Each country has different policies, laws, and regulations regarding oil and gas development and transportation, and these differences will affect how and by whom resources are developed, and how and where they are transported.

This paper will attempt to provide an overview of each of the five Arctic countries’ political, legal, and regulatory frameworks for the development and transportation of oil and gas, and the implications for the world energy industry and world energy markets.

SUSTAINABLE-02

Defining “Energy Security” in the Arctic Context in a Sustainable Development World

Peter Sharp

Department of Foreign Affairs and International Trade Canada

Canada

The Arctic is the last frontier for energy exploration and important for ongoing Arctic Council consideration. The “Arctic Energy Summit” is an IPY activity focusing on energy development, its impact on northern communities and the need to balance (clean) energy realities with environmental stewardship and climate change. Its main objective is to examine technology and technical issues in relation to the Arctic as an energy province and will profile associated technology, RD&D/S&T/resource development projects, infrastructure, science, and policy.

Surrounding this technology-based approach are challenges posed by broader energy security and sustainability considerations and its application to a diverse Arctic region. Global energy demand is projected to grow 57% between 2000-2020 with related energy security and environment concerns. “Energy” overwhelmingly means fossil-fuels and projected to remain so until at least mid-century. With easily accessible cheap oil a thing of the past, unconventional and remote energy resources such as the Arctic, potentially containing 25% of global resources, are commercially more attractive.

What does “Energy Security” mean in the Arctic context for energy policymaking, sustainable development, country relations, and institution building? In examining Arctic energy security issues alongside the Summit’s technology and education/outreach work, this research paper would provide a broader context to Arctic Council (Energy Working Group) dialogue on: 1) The matrix of Arctic-based energy security issues; 2) Potential areas for common ground, best practices and cooperation between Arctic states in core energy supply/demand policy areas: e.g., governance, development, corporate social responsibility, investment, resource management, environment, physical security.



SUSTAINABLE-03

The Alaska Energy Board: Applying lessons learned from the Denali Commission and the 2002 United Nations Global Summit on Sustainable Development

Jeff Staser

Staser Group, LLC
U.S.A.

There is a better way to integrate social, physical, economic and environmental sciences into the governance process required to achieve sustainable energy in Arctic environs. Among these four sciences, arguably and imperfectly, economic science dominates; therefore the next logical step in deliberate institutional evolution is to synthesize governance with newly gained economic insights from the social, physical and environmental sciences.

Breakthroughs in this area achieved by Nobel Laureates Dr. Douglas North (1993) and Dr. Vernon Smith (2002) underscore the fact that research into sustainable energy for the Arctic must be informed by on-going research into other areas in order to achieve holistic sustainability. Essentially their research applies theory and quantitative methods to explain institutional change which leads us to conclude that sustainability is collective economic behavior that lends itself to empirical economic analysis.

Collective economic behavior, defined by the Alaska Energy Board (AEB) as “the art of collaboration”, promises effective solutions to all sustainable energy challenges in the Arctic. Indeed, collaboration offers the only long term solutions. However collaboration is often confused with governance. Governance alone is inadequate, and in fact traditional governance structures may obscure other than political considerations.

Extant global, international, national, state, regional, local and tribal governance structures all represent vested political interests within the larger and truly holistic potential economic collaboration envisioned by the AEB. Government is only part of the necessary and sufficient building blocks of sustainability. The AEB is pursuing principles and guidelines, decision support systems, and technological solutions that synthesize the research of others into a new form of governance – an adaptive economic collaboration.



SUSTAINABLE-04

Energy Education for Secondary Schools

Kevin Holthaus

Atheneum School

U.S.A.

At Atheneum School, we believe that we must not only change the way we live, but we must start to educate the future students of our generation. We propose a method of educating high school students that gives them firsthand experience with new energy technologies, and engages them in rigorous discussion to evaluate options. In our renewable energy class we have been exploring ways to improve the world's energy use in terms of efficiency and waste. We started by researching the pros and cons of both extractive and renewable energy recourses. Now we are converting a gas-powered car to a fully electric, battery-powered car. One of our current tenth grade students has gone so far as to start his own energy company that is producing water wheels to generate electricity. Others have become active in recycling and participated in statewide energy conferences. This shows that when active discussion is coupled with first hand experience, students will be eager to change their lives and those of their families and friends for the better. In order to change the way we live in the future, we need to change the way we are being educated now.

SUSTAINABLE-05

Education and Outreach Activities through the Black Sea and the Caspian Sea International Environmental Information Center

Marion (Kay) Thompson

U.S. Department of Energy

U.S.A.

The international Black Sea and Caspian Sea Environmental Information Center is a valuable educational, outreach, and communications resource to aid in the prevention of oil spills and, in the case of a spill, quick, effective clean-up action. Prevention and remediation are essential to protecting and maintaining the environment. The BCSEIC provides up-to-date, reliable, and easily accessible research and information. In addition, the web site serves as an international platform for discussion and sharing experiences on how to prevent and respond to oil spills with a focus on delivery and exchange of practical and real life information and dialogue. There is no cost or registration required for using the site. This BCSEIC offers information on region- and country-specific initiatives as well as information with worldwide applications. Interested organizations are encouraged to promote their technologies, services, or research activities through the web site. The site is being accessed at roughly 1,000 hits per day from 115 countries all over world. The oil industry strongly endorses the Black Sea and Caspian Sea Environmental Information Center and has representatives participate in all of the Center's workshops. The BCSEIC's goal as a regional information and communications center is to facilitate cooperation among the countries of the region to help prevent oil spills and to develop contingency plans should a spill occur.



SUSTAINABLE-06

Sustainable Development Principles in Training of Oil and Gas Specialist for Arctic Region

Valeri V. Salygin

International Institute of Energy Policy and Diplomacy

Russian Federation

In the twentieth century the world energy was developing as a leading industry in world economy, as a real basis for economic progress and welfare. However today achievement of these goals will require a different approach based on the principles of sustainable development. Today we should acknowledge the need for a change and get down to reforms and modernization of energy sector, the system of education and training of a new generation of energy professionals who will apply the principles of sustainable development in their professional duties. This should be the key approach for oil and gas E&P business worldwide and in a very tangible and fragile Arctic region, rich with energy resources. Today no one doubts the need of promotion of the principles of sustainable development in education which plays a unique role in comprehension of those principles by the society. Creation of effective system of education and training for world and Arctic energy industry should be oriented on solution of key problems in exploration and production of oil and gas, rational and efficient use of energy resources, shift to alternative clean energy. However such capabilities are limited to a few countries and Russia is committed to the principles of sustainable development.

SUSTAINABLE-07

Aerospace Information Management

Anatoli Bourmistrov

Bodø University College

Norway

The High North has received much attention during recent years because of enormous reserves of natural resources. Development and use of these resources are however associated with many societal, climatic and environmental challenges. The demand for monitoring and surveillance information related e.g. to environmental, transportation, infrastructure, and climatic issues for making resource management in the High North more efficient is therefore increasing. Luckily, liberalization and changing regulation in the space industry, reduced cost of satellite delivery and operations open up many opportunities for public and private initiatives of using information and space technologies for resource management applications and, therefore, realization of the economic growth potential of the High North. This paper discusses opportunities and challenges of the international cooperation of using space technology for the resource management purposes in the High North. Based on the perspectives of Norwegian-Russian cooperation in developing resources in the Barents Sea, the paper focuses also on the implication for the international cooperation in education and research. Particularly, this is exemplified with a description of the international joint-degree Master of Science program in Aerospace Information Management, developed between Bodø Graduate School of Business (Norway) and Baltic State Technical University, St. Petersburg, (Russia).



SUSTAINABLE-08

Arctic Energy and Cumulative Effects: Growing Demands

Anne L. Southam

URS Corporation

U.S.A.

The growing demand for energy spurs exploration and development of energy resources in the arctic environment. However, the task of cumulative effects analysis for these activities can be daunting. There are numerous interactions between energy development activities and arctic resources, as well as factors related to reduced footprint, common use of facilities, and data uncertainty. Scientists are striving to better assess these interactions, particularly with increased claims that regulators are not doing enough to protect arctic resources such as polar bears and walrus against the potential combined threat of oil and gas exploration and global warming. This paper describes examples of cumulative effects issues on the North Slope of Alaska and a methodology that can be used to address complex cumulative effects and compliance issues within the National Environmental Policy Act and Council on Environmental Quality guidelines. The step-by-step process provides analysts with the ability to assess cumulative effects for each component of the biological and human environment within the project scope and demonstrates trade-offs among alternatives and interactions. While cumulative effects analysis is an evolving practice, adaptation of this methodology could expedite future energy-related NEPA compliance efforts and has the potential to save time and money.

SUSTAINABLE-09

Environmental Issues in the Arctic

William I. Stillings

World Environmental Service Tech LLC

U.S.A.

Now That I Have It, What the Hell Do I Do With It? When companies consider developing Arctic or Sub-Arctic resources; the largest challenge facing a cost effective project is how to get the product to market. Arctic projects have to be large to justify the developmental costs. Companies spend billions of dollars on the technology to transport their product to the world's markets. However, in the project planning, and budgeting, often inadequate attention is given to the handling and disposal of waste products. This creates two problems: because the waste streams are not envisioned, safe, effective, and legal disposal options are not built into the project plan; since there is little pre-planned budget, once waste is recognized, there is no budget to manage it. With an adequate plan and budget, the fragile Arctic environment is at risk. The paper will highlight the Arctic planning challenges when dealing with waste: what do you do when you move several 100 or 1000 construction workers into the Arctic; tires, batteries, mercury fluorescent bulbs, scrap metal, aerosol cans, anti-freeze. Houston, we've got a problem – we have just had a spill!



SUSTAINABLE-10

Oil Spill Response in Cold and Ice Conditions

Kari I. Lampela

Finnish Environment Institute

Finland

Arctic and Sub-Arctic conditions form a special challenge to oil recovery operations. Ice is often the most problematic element in oil recovery operations in sea are. Ice flows and drifting ice will decrease significantly the use of conventional oil recovery methods or even stop the oil combating operations completely. All the nine countries around of the Baltic Sea in the Northern part of Europe can face ice problems in their maritime transport. Especially Finland is one of the few countries in the world, where every harbor have ice during even a normal winter. Taking into account the dramatic increase of oil transport in the Gulf of Finland, the country has been obliged in recent years to concentrate in developing mechanical oil recovery methods, also in ice conditions. This paper giver an overview of the development of mechanical oil recovery equipments and methods in the Baltic States, mainly in Finland. Different laboratory and field trials are referred together with the experiences of their use in connection of real accidents. The different response vessel constructions and the use of them in oil response in ice are discussed as well. The paper will introduce skimmers, which can be used in ice conditions, the results of trials, where commercial oil transfer pumps were tested with really high viscosity oils and traditional and novel constructions of ice going response vessels.

SUSTAINABLE-11

Extending Oil Spill Occurrence Rates from the Gulf of Mexico to the Beaufort and Chukchi Seas

Ted G. Eschenbach

TGE Consulting

U.S.A.

This paper reports some results from a recently completed study done for the federal Minerals Management Service. Estimating oil spill occurrence rates for potential projects located in OCS areas of the Beaufort and Chukchi Seas requires two stages. First, statistically valid estimates with confidence intervals must be developed for historical databases, which are dominated by Gulf of Mexico production. Previously reported results from the study for Poisson models of pipeline and platform oil spills are briefly summarized here. This includes discussion of the advantages and disadvantages of several exposure variables – time, oil production, pipeline mile-years, and platform-years. Weibull and lognormal models for spill volumes are developed and used to support analyses at spill thresholds of 50, 100, 500, and 1000 barrels. The second stage is to extend these results to the Arctic, which is the focus of this paper. Many spill causes occur both in the Gulf of Mexico and the Arctic. Examples include human error, work boat anchors, and corrosion. Other causes occur only in the Gulf of Mexico, such as hurricanes, fishing trawlers, and dragging anchors from ships. Still others occur only in the Arctic, such as strudel scour, thaw settlement, and ice keel gouging. Multiple approaches are used to develop statistically valid estimates. Their results are compared to provide a basis for estimated spill rates that are applied to a development scenario in the Beaufort Sea.



SUSTAINABLE-12

Promoting Sustainable Oil and Gas Development in Alaska's Arctic Seas through the Local-Scale Integration of Geophysical and Traditional Knowledge

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Increased oil and gas activities in Alaska's Beaufort and Chukchi Seas may serve as a catalyst to investigate the research methodologies and institutional practices that incorporate local and traditional knowledge, thus promoting a sustainable future for North Slope communities and the oil and gas industry itself. Most climate models and sea-ice investigations operate at resolutions not suited for observing local-scale processes and variability; therefore, critical information required by local institutions and oil and gas developers is often not readily available. Given that many Inupiat Eskimos possess a valuable and nonreplicable understanding of local and regional sea-ice dynamics and unexpected and rare sea-ice events, their knowledge may greatly contribute to decisions made regarding oil and gas development and oil spill response planning and operations. A systematic investigation of local-scale sea-ice system services and sea-ice hazards provides a framework for identifying stakeholder-relevant sea-ice variables and documenting LTK. This work will discuss methods of: (1) investigating the land fast ice and adjacent pack ice in the Beaufort and Chukchi Seas using geophysical techniques, such as SAR satellite imagery and coastal radar, and the observations of Inupiat sea-ice experts, and (2) documenting SISS and hazards as they relate to oil.

SUSTAINABLE-13

Ecosystem Habitat Mapping Studies: Renewed Hydrocarbon Development in the Canadian Beaufort Sea

Donald G. Cobb

Fisheries and Oceans Canada
Canada

The proposed Mackenzie Gas Pipeline has led to heightened interest by industry to develop hydrocarbon resources in the near-shore and off-shore Beaufort Sea. A multi-disciplinary marine research program is underway in order to prepare the Canadian Government, Inuvialuit and Industry to plan together for the sustainable development of these resources. The program has two objectives: to understand marine geo-hazards associated with hydrocarbon development, and to enhance our understand of the Beaufort Sea marine ecosystem in order to identify unique or ecologically significant areas which might require special planning or mitigation to ensure they remain unperturbed. These two program objectives are being met in a study using the Canadian Coast Guard vessel CCGS Nahidik. This presentation will provide an overview of the program and some of the findings to date.



SUSTAINABLE-14

Energy and Water Saving Techniques Identified at Fort Wainwright, Alaska

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This paper presents the different energy saving techniques identified at Fort Wainwright military installation, Alaska. These energy saving techniques can be used by other installations like the University of Alaska system, Department of Transportation, and other commercial installations to implement energy conservation projects. The paper focuses on the areas of energy savings where the residents do not pay for the cost of energy hence care little for energy savings and conservation. The various identified projects in this analysis includes the energy saving by the use of energy efficient headbolt outlets, properly designed building envelop, lighting system, vending machines, coolers, heating, ventilation and air conditioning system. The paper presents the life cycle cost analysis including energy savings, payback period calculation, and savings to investment ratio calculation for various identified energy saving projects. The paper also covers various instruments that can be used to measure different component of energy and the financial programs available for such installations to implement energy conservation projects.

SUSTAINABLE-15

Climate Change Mitigation Possibilities in the Energy Sector: an Arctic Perspective

Maria Pettersson

Luleå University of Technology
Sweden

Not all regions in a weak position vis-à-vis climate change are recognized by the international Climate Regime. The Arctic region is – although it is generally considered to be particularly vulnerable to climate change – not paid any explicit attention in the text of the UNFCCC or the Kyoto Protocol. Still, the IPCC's third assessment report as well as the ACIA-report predicts major ecological, sociological and economic impacts of climate change in the Arctic; the sea-ice is melting; the permafrost is thawing exposing the already susceptible ecosystems to an even greater risk of e.g., species extinction, and endangering the livelihood of, primarily the indigenous, peoples in the Arctic. At the same time, the Arctic is rich in natural resources, particularly energy resources; immense reserves of oil, coal and gas, as well as renewable energy resources, such as wind and water, are located within the Arctic areas. This paper deals with climate change mitigation possibilities in the energy sector in the Arctic region. What implications follow for instance from, on the one hand, the Arctic's special vulnerability in relation to climate change, and, the other hand, the prosperous occurrence of energy resources in the Arctic region? The aim of the paper is thus to analyze the interrelation between climate change, energy and the Arctic and, subsequently, to consider if there are any joint Arctic mitigation possibilities in the energy sector.



SUSTAINABLE-16

Climate Monitoring in the Arctic: Benefits for Science and Industry

Jessica E. Cherry

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Existing measurements of climate parameters in the Arctic may not be sufficient for answering fundamental questions about global change or for predicting operational conditions for the extractive industry. These observations are sparse, short-lived, and may show instrumental biases due to the harsh environmental conditions. Short-term weather prediction in the arctic region lacks skill, in part due to these observational shortcomings. New tools and potential opportunities for improving estimates of short-term weather conditions and long-term climate trends will be discussed.

SUSTAINABLE-17

Analysis of Disturbance to Vegetation and Changes in Active Layer Depths Resulting from Different Ice Road Construction Methods

Laurence C. Byrne

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Ice roads are used to access remote locations for the purpose of oil & gas exploration and oilfield development. In some years ice road construction has been delayed due to warm temperatures or low snowfall. New methods of ice road construction have been developed to allow contractors to gain an earlier start on ice road construction, and thereby extend the winter construction season. This paper compares the starting dates and disturbance levels for 5 construction methods. Construction methods are ranked in ascending order of disturbance to the tundra. Timing, method of construction and vegetation type were factors affecting the level of disturbance. Variables found useful in documenting disturbance were active layer depth and tussock disturbance level. Construction using pre-packing and side-casting water from a Rolligon vehicle had the earliest start and lowest impact. Active layer depth in moist sedge tundra was significantly greater in early season ice road construction the following summer compared to the adjacent tundra. Other construction methods did not result in significant active layer depth changes. Intensity of tussock disturbance varied, depending on the method and timing of ice road construction. Both impacts were greatly attenuated by the fourth summer following construction. The results from this study can be used to help contractors choose construction methods that allow early ice road construction while minimizing impacts on the tundra vegetation.



SUSTAINABLE-18

Estimating the Value of Alaska Public Infrastructure at Risk to Climate Change

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Public works built on permafrost or on eroding river banks and coastal shorelines are at risk of degradation or complete loss due to impacts of long-term temperature rise. A database of public infrastructure was compiled by the Institute of Social and Economic Research at the University of Alaska Anchorage to assess vulnerability to and ultimately the public cost leading from ever changing site conditions caused by abrupt climate change. The coastal or riverine location of individual items is noted in the database, along with the regional prevalence of continuous, discontinuous, or sporadic permafrost. Regional projections of temperature and precipitation changes for the years 2030 and 2080 were attained from the Lawrence Livermore National Laboratory and the National Center for Atmospheric Research. Algorithms were formulated to estimate the additional replacement costs due to the reduced useful life of public works associated with melting of permafrost, flooding, or erosion. Climate projections and related economic impacts are coupled and results report relative risk by type of infrastructure and location. Long-lived structures, such as bridges, larger public buildings, and major pipelines appear to have the greatest potential public cost as their site conditions continue to change over many decades. Shorter lived works, such as roads and airport runways, are not as vulnerable, since their routine use requires more frequent replacement regardless of climate change.

SUSTAINABLE-19

A Renewed North? Resources, Corporations and First Nations in Canada

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Questions about First Nation self-determination and resource development were prominent in the 1970s as pressure for oil and gas development emerged across the Canadian North. In the past thirty years unprecedented changes in First Nations-state relations have occurred, including the negotiation of land claim settlements and self-government agreements. What remains unchanged however is the continued global demand for finite resources and the development of non-renewable resources on First Nations lands. In this dynamic environment, the question must be asked: are changes in governance providing First Nations peoples sufficient tools and opportunities required to meet their goals of political, economic and social well-being? Offering a view from one remote Arctic community, this paper draws on preliminary fieldwork findings to identify ways in which one self-determining First Nation in northern Canada, the Vuntut Gwitchin of Old Crow, YK, is responding to the needs of its constituents while also carving out space within the global marketplace. Working in partnership with the VGFI I seek to determine if changes in governance have given them enough control over the impact that economic development has on them. This paper represents a preliminary effort to conceptualize the role of First Nations in a post-claims era, and forms part of a larger IPY project.



SUSTAINABLE-20

Social Impacts of Energy Sustainability in Kivalina

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Several Alaskan coastal communities are faced with relocation due to climate change. Design and delivery of pragmatic, sustainable energy systems are critical components of relocation. New community sites must address energy requirements. High per capita energy costs for villages sustained on subsistence-based economies increase community's relocation and energy challenges. Traditional village social systems may reject sites that provide best opportunities for these systems, or may be deficient in the capacity to manage and maintain sustainable and/or alternative energy systems.

Kivalina offers a case study of challenges that face coastal communities in Alaska's Arctic. Kivalina evaluated physical environment, construction, utilities, social, and economic factors of six sites. Locations most favored by the community are geotechnically less stable yet present opportunities for sustainable energy systems (wind and tidal). Conversely, safest sites from coastal erosion and climate change have potentially higher social and energy costs as the distance increases from tidewater. This paper explores nexus of sustainable energy solutions with socioeconomic issues rural Arctic community planning presents. It offers recommendations for cost efficient and sustainable energy planning for coastal Alaskan Arctic villages, including facility co-location and weatherization, and discusses social issues needed to overcome in order to implement alternative sources, i.e. wind and LNG.

SUSTAINABLE-21

Community Energy Planning in Northwest Territories

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Northwest Territories undertook the Community Energy Planning process in 2003. Since then, nearly all of the 33 NWT communities have engaged in this process. CEP allows a community to examine how they are receiving their power (and the impacts of this), where the power is being used and the options open to them. Energy efficiencies and behavioral changes are often the first step. But in an era of almost hyper-awareness of the impacts of climate change, communities realize mitigation can be adaptation. The practice of trucking in fuel to use for local transportation assumes the absurd. And local exploration into local resources results in integration of solar applications; feasibility work into wind and small hydro potential; shifts to use of pellet stoves and a return to wood stoves. It becomes a way of thinking that can underlie community decisions about infrastructure, housing, transportation, community planning and behavior, which ultimately results in greater sustainability.



SUSTAINABLE-22

The Nordic Network for Sustainable Energy Systems in Isolated Locations

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The Arctic region includes remote and isolated communities from the Nordic countries: Denmark, the Faroe Islands, Greenland, Finland, Åland, Iceland, Norway and Sweden. These communities need to use more sustainable energy services due to the high costs, limited service and potential for environmental impacts of their energy systems. Technical, social and economic barriers prevent the communities from understanding the options available and identifying and accessing appropriate solutions. The most significant barrier at this time, however, is a lack of effective and relevant communication and knowledge-sharing between interested stakeholders (particularly the communities). A project was subsequently established in 2007 to create and stimulate a network of relevant and motivated stakeholders from the Nordic region. 16 partners from industry, government, research and educational institutions, and representatives of Nordic communities, are the core network members. The network provides a framework for communication and knowledge sharing, and a forum for participants to find relevant partners and/or the knowledge and skills required to 'get sustainable energy projects happening' in isolated areas of the Nordic region. This paper will review the organization and activities of the network, particularly efforts to build capabilities in the communities, integrate sustainable energy-related knowledge into two Nordic educational institutions, and make international linkages.

SUSTAINABLE-23

A Toolkit for Community Energy Planning in Northern Canadian Communities

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Northern Canadian communities are highly dependent on imported fossil fuels to supply their energy needs. In the past, many communities could not easily access the tools they need to assess their own energy supply system, nor were they actively involved in working to improve the system. Community energy planning is a way of changing that. A Community Energy Plan shows what a community decides to do, over time, to change how they use energy – to find better ways to make and use energy. The Arctic Energy Alliance, in cooperation with communities in the Northwest Territories has developed a 6-step process for community energy planning. The process is documented in a toolkit of plain language guidelines, spreadsheets, templates and posters that allow communities large and small to create and implement their own community energy plan. Community Energy Planning has been around as a concept in the Canadian north at least since the early 1980's when it was proposed as a response to the high prices of oil at that time. Recently, there has been renewed interest in community-based energy planning in Canada's Northwest Territories. Two communities are implementing energy plans that cover all aspects of energy use. The remaining 31 communities are expected to complete energy plans by 2010.



SUSTAINABLE-24

A Review of the Sustainable Design Approach for the South Pole Station Modernization Project: The Amundsen Scott South Pole Station, Antarctica

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This paper discusses the sustainable design approach of the 3rd generation US Research Station, Amundsen Scott South Pole Station. It reviews selection of materials, systems, energy efficiency, waste heat recovery, fuel types/handling, physical arrangement of program space, constructability, safety, reliability, maintainability, growth and change.

The Station, located in an extreme cold regions environment, average temperature is -56F. Design low temperature dips below -100F. Station physiological altitude exceeds 10,000'. The remote site is air accessible only during a 3-month Austral summer season.

The paper highlights design challenges, criteria/constraints driven by extreme climate, remoteness, and sustainable ethic. Examples include: the need to establish and achieve a rigorous annual energy budget; the development of a building envelope that was site constructible at -20F temperatures, minimized conduction losses at very high temperature differentials, minimized infiltration and minimized moisture transmission at very high vapor pressure differentials; the need to accommodate snow accumulation on the surface and year round drifting snow conditions; the need to provide fail-safe systems, back-up capabilities and self-contained emergency facilities to accommodate a catastrophic event; the need to implement the station through phased construction and operational transition; the need to achieve quality, healthy, productive indoor environment; and the goal to minimize the overall station footprint.

The design is specific to the South Pole Station. However, the design approach draws on the knowledge and lessons learned from both Arctic and Antarctic experiences, and the sustainable solutions may provide a model for future work in the Arctic.

SUSTAINABLE-25

Inupiat Traditional Knowledge and Energy Development Decisions

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The critical contribution of Inupiat traditional knowledge for resource management was widely acknowledged in the late 1970's controversy surrounding an international moratorium on bowhead subsistence whaling. A multi-million dollar research program undertaken by the North Slope Borough demonstrated that Inupiat Elders' understanding of bowhead population trends was accurate, and subsistence harvest allocations were adjusted accordingly. By the late 1990's, Inupiat traditional knowledge was routinely acknowledged and described in environmental review documents, but less commonly cited as the basis of management, design, and mitigation decisions. Traditional knowledge has great potential to contribute to sustainable resource development, and strengthen partnerships between indigenous people, resource industries, and government in the process. This paper examines the current state of incorporating Inupiat traditional knowledge into North Slope energy decisions, including innovative applications in the Northstar Project in 1999, and recent initiatives to more systematically apply Traditional Knowledge as part of the North Slope Borough oil and gas plan. It will present suggestions for more effectively collecting, evaluating, and applying traditional



knowledge to resource development in the Arctic.

SUSTAINABLE-26

Impact and Benefits Agreement: A Russian-Canadian Comparison

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Impact and Benefits Agreements (IBAs) are arrangements negotiated between indigenous peoples and industry for resource development ventures. While indigenous people negotiate these agreements to secure short and long-term local benefits from resource developments, industry uses those to demonstrate corporate social responsibility and, in some cases, to fulfill regulatory requirements. Typically, agreements cover matters such as employment, training, economic development, business opportunities, social, cultural and community services, environmental protection, and cash payments. While information about Canadian IBAs is rapidly increasing, little is known in North America about the use and success of IBAs in Russia. This paper explores similarities and differences in the negotiation and implementation of IBAs by indigenous peoples in Canada (Yukon) and Russia (Nenets Autonomous Okrug). The paper will highlight questions such as: who is negotiating IBAs, what is the content of the agreements, how do differing legal land rights of indigenous peoples in Russia and Canada influence the negotiation and implementation of IBAs, how is industry approaching indigenous people in both countries, and what lessons can be learned from those experiences.

SUSTAINABLE-27

Arctic Soils Monitoring, Oil Spill Bioremediation, Remote Sensing Technologies

Heather Fernuik

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U.S.A.

Founded by U.S. Congress in 1995, the U.S. Civilian Research & Development Foundation focuses on addressing global challenges through international science collaboration and sustainable partnerships. While the range of research foci supported by CRDF varies widely, this presentation will provide a broad overview of arctic research jointly performed by U.S. and Russian teams in the areas of monitoring of greenhouse emissions from arctic soils; oil spill bioremediation in cold weather climates; and several important remote sensing technologies. The presentation will also include a concise summary of practical “how-to” tips for efficiently facilitating international research partnerships.





We have the opportunity to make a change in how the Arctic is viewed and to create a new energy vision of the North for the people of the North.

With vision, energy and action we can lead this change and make a difference.

