The Food-Energy-Water (FEW) Nexus in Islanded Communities and High Latitudes: Issues, Pathways, and Implications (NSF CBET-1622408)

Final Report

July 2018
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1. Executive Summary

This report describes three events held at the University of Alaska Fairbanks (UAF) that focused on the food-energy-water (FEW) nexus in high-latitude environments. The goal of the events was to identify issues, needs, challenges and opportunities in FEW research in islanded high-latitude communities – communities isolated from the electric grid and from easy access to food imports. Such communities face unique and significant challenges to FEW production and acquisition, such as extreme swings in weather and daylight hours and high transport costs for food, fuel and other daily needs.

The first event was entitled “The Food-Energy-Water (FEW) Nexus in Islanded Communities and High Latitudes: Issues, Pathways, and Implications,” or **HLFEW 2016** for short. Held in September 2016, the workshop drew 45 people, who took part in breakout sessions and rich discussions that helped to identify the major issues, gaps in research, and research priorities for achieving a sustainable FEW nexus in high-latitude and islanded communities. The workshop was organized around three focus areas:

- **Infrastructure Engineering** includes topics such as efficient greenhouses; improved equipment to store and manage intermittent energy loads from renewables; and infrastructure to affordably provide clean drinking water and proper sewage disposal.

- **Environmental Engineering** includes topics such as bioaccumulated toxins in subsistence foods, and the high energy levels needed to provide clean water in islanded communities.

- **Society and Economy** includes topics such as the cost of food imports, the rising energy requirements (and hence prices) of subsistence practices, and the need for improved security of water sources.
The workshop had six concrete outcomes: identification of new FEW challenges and priorities, as described above; new collaborations; identification of FEW “grand challenges,” pinpointing of energy as the largest FEW challenge for high-latitude islanded communities; solidification of follow-up plans; and outreach materials, including a poster and website.

As part of small-group activities, attendees developed a list of “grand challenge” questions (see appendix b, page 32) to guide future research of the FEW nexus at high latitudes, then voted to rank the questions in order of importance. The three largest vote-getters were:

1. How do we design resilient communities with FEW systems as designed by communities?
2. What are the impacts of climate change on social and cultural practices related to FEW security?
3. How is a changing climate affecting the distribution and access of FEW resources?

Another key conclusion reached by attendees was to rank energy as the most significant of the three challenges. Some participants convincingly argued that low-cost energy production and distribution in high-latitude islanded communities would provide the necessary tools to address both food and water needs.

The second event was a June 2017 training and networking session for participants in the Arctic Remote Energy Networks Academy (ARENA), a yearlong program through which 17 individuals from communities in the U.S., Canada, and Greenland learned about rural energy systems through technical instruction, site visits, individual mentoring, and community case study projects. FEW funding provided travel support for 13 people for the event, at which attendees visited renewable energy facilities; attended classroom presentations on microgrid analysis, technologies, and operation; and took part in roundtable discussions with community leaders and project developers. Outputs of the program included energy projects in each participant’s community, as well as professional networks established as a result of the program.

The final event was an April 2018 kickoff meeting of MicroFEWs, a National Science Foundation-funded project that had its origins in discussions at HLFEW 2016. MicroFEWs has the ultimate goal of developing a process through which researchers and community members together characterize how renewable energy infrastructure might impact the FEW nexus in isolated northern communities. To address these questions, MicroFEWS researchers are focusing on three rural communities in Southcentral, Interior and Southwest Alaska. The meeting brought together researchers and community stakeholders to discuss the project, to advance a common understanding of current FEW systems in Alaska, and to develop goals for future activities. The event was essential for integrating the FEW needs of the three communities into the project and for establishing “next steps” for research and outreach.
2. Introduction

**Overview.** In 2016–18 researchers at the University of Alaska Fairbanks (UAF) held three events focused on the food-energy-water (FEW) nexus in high-latitude environments. The goal of the events was to identify issues, needs, challenges and opportunities in FEW research in *islanded* high-latitude communities – communities isolated from the electric grid and from the road system (and thus from easy access to food imports.) Such communities face unique and significant challenges to FEW production and acquisition, including extreme swings in weather and daylight hours and isolation from the main transport network and electrical grid.

In 2015, a group of researchers at the University of Alaska Fairbanks (UAF) submitted a proposal to the National Science Foundation to fund a workshop “to bring together a group of interdisciplinary researchers and community members to share and prioritize their top concerns, to examine the connections among availability and use of FEW resources, and to determine the best approaches to sustainably meet the FEW needs of isolated/islanded communities, especially those at high latitudes.” The workshop, HLFEW 2016, took place in September 2016 on the UAF campus and was attended by a diverse group representing academia, agencies, communities, organizations, and industry. The agenda emphasized active participation to facilitate discussion and progress.

Following HLFEW 2016, two further events were held in Fairbanks that focused on health and sustainability of Arctic communities. In June 2017, the Arctic Remote Energy Networks Academy (ARENA), a program sponsored by the Sustainable Development Working Group of the international Arctic Council, hosted training and networking sessions and site visits. In April 2018, a kickoff meeting and workshop was held for the NSF-funded MicroFEWs project, which focuses on the impact of renewable energy on FEW in rural Alaska.
HLFEW 2016. The September 2016 workshop drew 45 people, who took part in breakout sessions and rich discussions that helped to identify the major issues, gaps in research, and research priorities for achieving a sustainable FEW nexus in high-latitude and islanded communities. The workshop was organized around three focus areas:

• **Infrastructure Engineering** includes topics such as efficient greenhouses; improved equipment to store and manage intermittent energy loads from renewables; and infrastructure to affordably provide clean drinking water and proper sewage disposal.

• **Environmental Engineering** includes topics such as bioaccumulated toxins in subsistence foods, and the high energy levels needed to provide clean water in islanded communities.

• **Society and Economy** includes topics such as the cost of food imports, the rising energy requirements (and hence prices) of subsistence practices, and the need for improved security of water sources.

**ARENA.** The ARENA program gathered 17 participants from three Arctic nations who visited facilities and communities, received individual mentoring, and worked on community case study projects in order to gain experience in microgrid energy systems. The June 2017 event in Fairbanks, which also included visits to Nome and Kotzebue, was one of three events at which participants received instruction, networked, and visited microgrid sites. FEW funds supported travel by 13 of the participants.

**MicroFEWs.** The MicroFEWs project, which grew from discussions at HLFEW 2016, has the ultimate goal of developing a process through which researchers and community members together characterize how renewable energy infrastructure might impact the FEW nexus in isolated northern communities. To address these questions, MicroFEWS researchers are focusing on three rural communities in Southcentral, Interior and Southwest Alaska. MicroFEWs held its kickoff meeting in April 2018, bringing together researchers and community stakeholders to share in a conversation about the project, to advance a common understanding of current FEW systems in Alaska, and to develop goals for future activities.
3. HLFEW 2016 Workshop

The 2016 High-Latitude Food-Energy-Water workshop (HLFEW 2016) took place September 8-9, 2016 on the UAF campus in Fairbanks, Alaska. The event had multiple goals, including:

- To provide a forum for researchers, federal and state agency workers, Alaska Native leaders, and local residents to discuss current issues and emerging challenges and opportunities for achieving a sustainable FEW nexus, especially in islanded communities.
- To identify major FEW knowledge gaps in the context of infrastructure engineering, environmental engineering, and socio-economic structure in relation to islanded communities.
- To explore ideas and potential solutions to meet the FEW needs of islanded communities, especially those at high latitudes.
- To recommend next steps for research and actions on the FEW nexus for islanded communities in high-latitude and other environments, which can be used by federal, state, and local agencies to set funding priorities.

a. Activities

Prior to the workshop, all attendees were given “homework,” where they were asked to write down their most pressing concerns about FEW and brainstorm ways to a solution. On the first day, attendees heard a panel discussion focused on the ways food, water and energy intersect within three thematic areas, as well as a session on the state of current knowledge for each thematic area (see Table 1, below.) Interactive sessions (described below) called for attendees to map out connections between the themes and to identify knowledge gaps.

All sessions on the second day of the two-day workshop were geared toward knowledge production. These included two synthesis activities, the first centered on data and models and the second on scenarios, decisions and sustainable solutions. The workshop concluded with a group writing activity, through which attendees constructed a road map for future activities related to the three themes.

A key workshop activity was identifying challenges and priorities in each of the FEW areas. To this end, two sets of breakout sessions were held on day one. For the first session, one
group discussed food, the second water, and the third energy, with each group discussing the state of current research, short- and long-term challenges in the field, and research priorities. For the second breakout session, attendees were divided into three groups that considered food, energy and water from a different and more comprehensive perspective. As shown in Table 1 (below), groups were organized around three cross-cutting themes:

**Table 1. Cross-cutting FEW themes.**

<table>
<thead>
<tr>
<th>Infrastructure Engineering</th>
<th>Food</th>
<th>Energy</th>
<th>Water</th>
<th>Shared</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greenhouses Storage</td>
<td>Optimization of: Renewables Thermal Mgmt</td>
<td>Distribution/ Collection Systems Maintenance</td>
<td>Data Integration Data Visualization Decision Support Modeling Scenarios Sustainability Resilience Security Human Health Policy</td>
<td></td>
</tr>
<tr>
<td>Subsistence Agriculture Affordability</td>
<td>Access Cost Failure Tolerance</td>
<td>Reuse Availability Usage</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Environmental Engineering</td>
<td>Pesticides Bioaccumulation</td>
<td>Pollution Mgmt Contaminant Removal</td>
<td>Treatment Reuse Disinfection</td>
<td></td>
</tr>
</tbody>
</table>

Infrastructure Engineering, Society/Economy, and Environmental Engineering. The Infrastructure group considered FEW security in terms of key material components and challenges of the built environment. The Society group considered the FEW nexus in terms of key social, cultural, and economic factors shaping food, energy and water security. The Environment group considered the FEW nexus in terms of northern ecological contexts. Each group was asked to consider their own theme in light of the topics of food, energy and water, and in the overall relation of the theme to the FEW nexus.

Summaries of discussion at each of these six breakout sessions are presented below.

### 1. Food Breakout Session

**Summary of Current Research.** Food breakout group participants included academic researchers, agency representatives, farmers and food suppliers. The discussion began with several participants wanting to be sure that the group fairly considered nexus issues for subsistence and for market foods. Next, the group reflected upon the current state of research on food security, particularly in terms of access to healthy and nutritious foods. What, they asked, is the availability of healthy and nutritious food in local stores and online?
How healthy is subsistence food? What are people’s personal food choices and what factors delimit choices for what is good to eat?

The group agreed that there are important differences to consider, especially in terms of food choice and the rights of people for access to their preferred foods. Researchers, planning groups and policymakers alike should balance a desire for people to access healthy and nutritious foods alongside the realities of leaving the choice of what to consume up to the people themselves. Education about nutrition and health is important, but people still have the right to consume preferred foods, even those deemed to be better or worse for one’s health. This isn’t just an issue for communities in Alaska, but in every community. After all, food is part of culture and as such, different groups will have different aesthetics for taste and meanings associated with foods.

For individuals and families who depend on local stores for food, issues of price, availability and quality are intricately tied to the challenges of high fuel costs and transport and distribution of food from the lower 48 to Alaska. For example, the group considered a recent study by Jennifer Schmidt of the Institute for Social and Economic Research at the University of Alaska Anchorage, which asked residents of four rural Alaskan communities, “What do you do if you can’t get food at the local store?” The majority of respondents across all four villages said they would order from outside the community. Many said they would substitute or look in the freezer. Only a small percentage indicated they might travel to another community to buy food. Respondents from only two of the villages reported being able to get food from a relative or friend. The study also provided evidence that in some communities, people do engage in more subsistence practices due to the high cost of store-bought foods.

The group also discussed research into food refrigeration and processing, as well as the role of water in agriculture and as a habitat for marine animals. Group members also discussed socioeconomic factors that delimit food choices, such as income, education, percentage of elders within a community, and community social dynamics, as well as current elder subsistence programs incorporating food sharing, social support, and storytelling. Also discussed were links between food sources, cultural identity, and cultural resilience.
Short-Term Challenges

- Socioeconomic factors and food security. For example, the high cost of market foods, which is directly related to the high cost of fuel needed to transport food over long distances.
- The diminished quality of perishable market foods, which is also tied to shipping food from the lower 48 states instead of growing it in Alaska. Investment in local food production could overcome many challenges of food cost, quality, and access.
- Changes in governance and administration and how these changes impact building, implementing, and monitoring effective food policies for the state.
- Fair compensation for agricultural producers and farm workers. Without fair compensation, there is no sustainable income incentive for farming within the state.

Long-Term Challenges

- Climate change impacts on food security. For example, diminishing sources of freshwater affect fish, caribou and moose; less shorefast ice means diminished access to subsistence hunting on the ice; and warming trends in salmon streams make fish increasingly vulnerable to pollution, predation and disease.
- The relationship between culture and food preferences. These will have differential impacts on people depending on whether or not their preferred foods become scarce or harder to access.
- Generating interest in local food hubs for food production through strategies like farmer education, fair compensation for producers, transportation, storage, etc. This requires cross-cutting community and statewide investments in agriculture education and farmer training programs.

Priorities for Future Research

- Ways to increase community engagement with local food hubs to eliminate dependence on shipping food from the lower 48 states.
- Research into culture and food preferences alongside studies of market factors and food prices. For example: How do people adapt to increasing food prices in local stores and online markets? Will individuals seek out wage labor to obtain cash to buy food? Are there other types of trade occurring to offset cash demands? When and how do people change their subsistence activities in response to food prices? What about individuals who are primarily subsistence-based? If they become sick or unable to fish, hunt, or gather foods, how do they survive?
- Research into ethnography and community input on defining food security.
- Studies of food quality and nutrition, and the health impacts of different diets over time.
• Comparative research on governance policies that promote food security. What are evidence-based best practices? What is working in other rural, islanded communities and will those practices translate successfully to Alaska?
• Funding sources for these research priorities.
• Current data sources available to assist researchers in these efforts.

**ii. Energy Breakout Session**

**Summary of Current Research.** Energy breakout group participants included academic researchers and representatives from various state and university-affiliated research entities. Group members noted that one major gap in current energy research in high latitudes is a lack of baseline usage data. Current energy needs and use patterns are not known at a granular level, nor is there a roadmap to obtaining such data. Electrical usage data is relatively easy to obtain through existing “smart” meters. However, space heating is one of the highest energy loads in high latitudes (constituting up to 80% of energy use; source), but there is at present no cohesive data set describing community heat loads. Knowing and understanding usage patterns will help with development of affordable and stable heat sources. It will also help optimize use of intermittent renewable energy like wind or solar, since space heating may be used as a “dispatchable” load, helping to shift peak load times.

There exists a need for disparate research groups to work together to develop technologies and strategies to reduce the cost of energy and to effectively integrate renewable energy. “Learning networks” and “knowledge networks” were both suggested as ways to share experiences and lessons learned. Also mentioned was a need to develop a state energy policy that would help with funding for data collection and projects and create a centralized knowledge base.

There exist at present two known databases that could serve as such a platform. One is the [Alaska Energy Data Gateway](https://www.aedg.alaska.edu/), which is maintained by the Alaska Center for Energy and Power and funded by the Alaska Energy Authority (AEA) as well as the U.S. Department of Energy’s EPSCoR program and its Grid Modernization Initiative. The other is the [Alaska Energy Data Inventory](https://www.energydata.alaska.gov/), which is maintained by the AEA, the Geographical Information Network of Alaska, and the Alaska Department of Natural Resources’ Division of Geological & Geophysical Surveys. These entities have also contributed to an [Alaska Affordable Energy Model](https://www.aedg.alaska.edu/models/affordable-energy-model/). Another goal of the centralized knowledge base is to place a value on different types of energy generation, when social and holistic views are taken into consideration. For example, biomass energy leads to job creation. Solar energy leads to price stability. A way to assign numerical values to these qualitative factors would be useful.

It is known that governance and policy have historically had heavy influence on energy
production. For example, Germany leads the world in solar penetration despite their modest solar resource, due entirely to government tariffs. Similarly, government and policy can heavily influence energy development in high-latitude communities. This influence is especially critical in the face of changing resources and a changing environment, since future energy solutions may be different from the ones employed today. For example, thawing permafrost and changing weather patterns will alter the distribution and availability of different renewable energy sources such as solar and wind.

The suggestion was made that in smaller communities, federal entities often lack understanding of local issues, and state, community, or tribal-level governance may have a stronger influence. Smaller communities also offer more individual empowerment, as more people or entities have opportunities for leadership roles in decentralized systems.

Economic models must also be upgraded to include ecosystem services, which are the benefits that humans gain from the natural environment and healthy ecosystems.

Although discussions focused on energy generation, it was noted that increasing efficiency of usage is generally the first step in implementing an energy plan, whether at a community or household level. A given amount of money usually goes further when spent on efficiency measures than when spent on generation technology or management.

The desire to move away from fossil fuel dependency and decarbonize energy production must be realized in a systematic way that is technically realistic, fair, and culturally appropriate. Alongside increased usage of renewables, traditional fossil fuels have an important role, and perhaps diversifying among them might be a useful strategic step. For example, locally-obtained coal might be considered as a heating or power source.

Social issues must also be considered. Some communities value sustainability for its own sake, because they want to support their local well-being, or because they view themselves as citizens of a larger world, or because they take the long view of ensuring energy security. Other communities place the most value on immediate dollars saved. For example, when the price of heating fuel goes down, they will be more likely to switch from their sustainable heat source back to heating fuel. System designers and policymakers also struggle with valuing local input and adding it to economic models.
Short-Term Challenges

• High and/or unstable energy costs.
• Limited local resources, limited transmission range, and high costs of building transmission infrastructure.
• Dependence on outside delivery of fuel oil.
• Technical and political challenges associated with integrating privately produced energy into a utility grid.

Long-Term Challenges

• A paradigm shift from demand-driven to supply-driven energy economies.
• Development of resources, such as oil extraction or hydroelectric power, that can compromise other components of healthy life by (for example) causing pollution, releasing carbon, impacting fish migration and health, and damaging ecosystems.
• Low availability of cash in rural communities, and the fact that almost all cash leaves the community instead of being redistributed locally.

Priorities for Future Research

• Collection and collation of baseline energy usage data, including heat data, at a granular level.
• Connecting disparate groups that are researching similar topics so they can link efforts.
• Pursuing a state energy policy outlining parameters for data collection and analysis and establishing a knowledge sharing mechanism.
• Engaging social scientists in technical endeavors to help determine criteria for project success.

iii. Water Breakout Session

Summary of Current Research. Participants in the Water breakout group included academic researchers and state and tribal agency representatives. Discussion within the water group was broadly divided into two themes: water resource issues concerning hydrology, snow, and precipitation, and water supply and quality issues such as contaminants and treatment.

Participants noted that water is essential for any society or community, and a strong determinant of human and public health. Disinfection of drinking water has been one of the great success stories in the twentieth century, and one of the main reasons for the drastic reduction in mortality from water-borne illnesses. However, in remote areas such as the Arctic villages in Alaska, water-quality standard practices elsewhere in the United States have yet to be achieved. Several documented studies have shown the spread of pathogenic microorganisms and associated health impacts in rural Alaska due to lack of hygiene stemming from unclean water.
However, the field of environmental engineering (previously known as sanitary engineering) has come a long way in the last 150-odd years. We now know that unclean water is a cause of diseases and have the technological know-how to efficiently treat and even reuse water. For rural Alaska, thus, it is not about lack of technology but rather lack of resources and skilled manpower that stand in the way of supplying clean water. The State of Alaska has invested since the 1960s in improving rural sanitation by constructing conventional, community-wide piped and truck haul systems for drinking water supply and wastewater disposal. This has tremendously improved public health in these communities. However, over 3,300 year-round occupied homes in rural Alaska still lack running water and a flush toilet. And state funding to develop, maintain and operate community-level centralized systems is on a sharp decline. Thus, the state Department of Environmental Conservation (DEC) is realizing the need to decentralize the water and wastewater treatment systems in the communities, and simultaneously to make them socially and economically sustainable. To that end, DEC has initiated a pilot research program, the Alaska Water and Sewer Challenge, which aims to answer some of these questions.

Finally, climate change in the Arctic is expected to significantly impact water quality, owing both to increased temperatures - which encourage microbial and pathogenic activity - and to the release of organic matter and other contaminants from thawing permafrost into lakes and streams. Climate change effects are also expected to significantly impact hydrological resources in the Arctic. Thus, there is a twofold challenge facing water resources in rural Alaska: declining funding at the state level combined with climate impacts to water quality and supply. There is a need to understand the challenges and research priorities facing this unique hydrological system to not only maintain the progress of the last 50 years but also to take it to the next step.

**Short-Term and Long-Term Challenges**

- **Socio-economic issues.** In rural communities, socio-economic issues strongly govern the implementation of any solution to local problems. We must take into account the social aspects and implications of any proposed approach through continued community engagement.
- **Perception of water.** While research has repeatedly shown that a simple per capita increase in daily (clean) water use positively correlates with improved health, just
increasing the amount of water available to a community may not help. Effectively increasing water use and good hygiene may require educational intervention. Similarly, new approaches such as reuse of water may require changes in perception.

• Maintenance of water and wastewater systems. The remoteness of these communities dictates that systems be maintained by local personnel, but there is frequently a lack of skilled labor. Also, extremely cold temperatures as well as the fact that some communities almost completely empty out at times (e.g., during the whaling season) require that solutions be simple to operate, maintain and troubleshoot. Appropriate training and inculcating a sense of ownership of the system is a must to make solutions viable and sustainable.

• Affordability of clean water. Water treatment solutions will need to be affordable if communities will be expected to self-fund their installation, operation and maintenance.

**Priorities for Future Research**

• Economic impact of water-related health issues. There is a close link between water and health, but there is no clear analysis of the economic impact of water-caused illnesses. This could help identify an important economic link justifying allocation of resources for ensuring safe water supplies.

• Identification of culturally, socially and technologically appropriate systems for water treatment. In part, the Alaska Water and Sewer Challenge tries to address this question. How much water is used, and what can communities afford?

• Parameters jeopardizing water quality in communities. Understanding threats to water quality and creating short- and long-term projections of water quality could help direct water treatment efforts. For example, planners could evaluate expected water quality changes due to permafrost thaw.

• Collection of data on water usage in different communities, and development of a single comprehensive database. Only partial, decentralized data is currently available.

• Review of water quality standards for rural Alaska. The question to be addressed is, do we really need to adhere to the highest possible standards? This is a sensitive issue because on one hand even small improvements in water quality can lead to significant
health benefits. On the other hand, environmental justice concerns inhibit adopting a lower water quality standard.

- Exploration of simple, novel technologies for low-cost, energy-efficient water treatment and reuse. This should include social and environmental considerations, such as water use habits, low-skilled workers, and freezing environments. An affordable and accessible method for testing water quality in remote areas is also needed.
- Enhancing the ability to harvest freshwater from the sea.

### iv. Infrastructure Breakout Session

Important infrastructure components supporting the FEW nexus in northern latitudes include farms, food storage, land, water infrastructure, and energy production and distribution infrastructure. In each of these areas, there exist shining examples of local people optimizing the resources at hand. However, there are also strong bureaucratic impediments.

**Infrastructure and Food.** Participants first considered what infrastructure is required to ensure food security in high latitudes. Bethel farmer Tim Meyer pointed out that one large need is attracting younger generations to farming, and incentivizing production of staple crops such as potatoes, cabbages, and carrots. Meyer noted that food needs could be met if more people were incentivized to mass-produce staples instead of crops such as tomatoes that do not produce sufficient yield at high latitudes to feed a community. Meyer also noted that even the biggest greenhouses are insufficient in size to feed a community; therefore, producers need to focus on cold-tolerant crops with high nutritive value. Five acres, he estimated, could produce 10,000 – 100,000 pounds of food per year. He also noted that it is bureaucratically difficult to obtain secure land for farming, and that rates of vandalism were high in his community.

In order to drive development of local, effective agriculture, Meyer said land access needs to be simplified, and development needs to be incentivized. For example, he faced an 8-year process through the Bureau of Indian Affairs to buy land. However, he observed that land could be leased for 10 generations with relative ease.

The need for food storage infrastructure was also mentioned. High latitudes have a short growing season and high cost of energy, so traditional food storage that uses passive temperature control (such as root cellars) plays an important role.

**Infrastructure and Energy.** Participants discussed what infrastructure is required to support reliable and affordable energy at high latitudes. One unique factor on islanded grids is that maintenance is a much bigger challenge than in high population-density areas. This is because in small communities, there may be only one technically proficient person who can maintain the grid. Moreover, people in small communities often fill multiple roles, so if (for example) a power plant operator must travel to fulfill another task, no one is available to maintain the power plant. Therefore, it’s important to train several people in each community in the skills of maintaining energy infrastructure. Education and workforce
development were therefore both mentioned as important components of technology deployment. Education also involves keeping local people informed and playing active roles as infrastructure is built. That way, residents feel vested in the projects and will teach their children the benefits of having structures like wind turbines and solar panels in their communities.

Regulations and policies can also affect behavior. Energy subsidies often disincentivize conservation. Cultural views may also impact behaviors and acceptance or rejection of new technology. For example, wind farms are often located on high peaks, which may have cultural significance that is denigrated by construction on top of them. Balancing energy optimization with cultural pressures can impact how energy is valued within a community. Just as innovative, decentralized solutions in water and sewage treatment hold promise, so, too, can such solutions address challenges of renewable energy integration into microgrids. This jibes with the larger worldwide trend of moving from large, centralized power to distributed energy generation that integrates renewables with redundancy and storage.

**Infrastructure and Water.** Some of the most pressing needs of Arctic communities relate to the limited availability of clean water and sanitation. Over 4,500 rural Alaska homes lack running water and a flush toilet ([source](#)), which leads to poor hygiene and elevated rates of skin diseases and respiratory ailments.

The Alaska Water and Sewer Challenge is a great first step toward driving innovative solutions to the problem of sewage treatment in Alaska. One innovation introduced via the Challenge was installing sewage systems in individual rural homes, rather than in a centralized facility. Decentralized sewage treatment may turn out to be a solution, just as decentralized power production is becoming a solution to expensive and unstable energy.

**Infrastructure and the FEW Nexus.** One commonality that infrastructural challenges share across all three parts of the FEW nexus is the need for human capital. Many problems have existing technical solutions, but they cannot be realized with insufficient or improperly trained human capital. We require culturally sensitive design and long-term, holistic
planning that account for local needs and future conditions in the face of climate change. The village of Tanana has a 100-year plan; more tribes need to adopt this mentality.

In the long term, there needs to be more cooperation among different agencies, so (for example) one could utilize the waste from another as feedstock. One excellent example is the **Holistic Approach to Sustainable Northern Communities** collaboration, which aims to utilize local people’s knowledge and observations to inform government decision-making and the creation of infrastructure. Federal, state, local, and nonprofit partners have been assembled in “roundtable” discussions to develop a more collaborative approach to projects in rural Alaska. The village of Oscarville was chosen as a pilot, due to its aging infrastructure, housing shortage, and high energy costs.

Planners must account for climate change. For example, structures built on permafrost will shift and collapse if the permafrost melts. Seasonal use of waterways may change if the ice cover is not as thick and stable, or if seasonal freeze-up and breakup patterns change from their historic behavior.

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**v. Society Breakout Session**

**Society and Food.** Many of the themes identified during this part of the group discussion were consistent with themes raised during the earlier discussion during the Food breakout group, while several new themes also emerged.

Group members asked how climate change impacts subsistence practices over time, and how changes in subsistence practices affect the sharing of cultural knowledge and traditions from one generation to the next. Cultural knowledge discussed included locations of food sources, ways to identify and select food sources, food processing techniques, and hunting, fishing and gathering techniques. The group also discussed the “graying of the fleet,” and what happens when fishing captains retire without having the time or opportunity to transfer their wealth of detailed knowledge to the next generation.

Other topics included effective methods of Alaska farmer training and retention, and how available technology can be used to produce local and regional food. The group discussed culturally preferred foods and food sources, and the factors that predict individual and community decisions regarding what to buy and consume versus what to hunt, fish or grow.

One major new theme that emerged was food contaminants. Group members asked about
the current state of evidence regarding contaminants and subsistence food consumption. One topic was how messages about contaminants are communicated, and how these messages affect actual consumption of subsistence foods. For example, policies about appropriate risk levels of mercury contamination for fish consumption vary and the levels required for warnings in Alaska are often higher than elsewhere due to what some researchers call “Alaskan exceptionalism.” Is this an acceptable way to determine public health policy around contaminants in subsistence foods?

Group members also asked about the ripple effects on communities if school meals are reduced. They also asked general questions about data: What data is available to researchers and communities now, what data do we need, and how can we improve measures and open access? Can we create an open access data portal for social, cultural, and economic data to improve research and practical problem-solving for food security?

**Society and Energy.** The group asked about the current availability of baseline data, including rates of energy usage, and how group data can be shared for modeling and forecasting.

They asked about the role of society in developing a state energy policy, and about community perceptions and current capacities for community energy needs. They discussed the level of “community readiness” to move away from fuel dependency, whether it is realistic or fair, and what energy alternatives local communities are willing to consider. They inquired about the impact of more people sharing housing as heating prices go up, and whether coal is a “dirty word.”

They also discussed society’s role and responsibility regarding affordability, efficiency, and reliability of energy in rural, islanded communities, and how to determine a fair balance of affordable and stable heat sources.

**Society and Water.** Participants discussed how remote communities can afford operations and maintenance for water and wastewater systems without subsidies and with declining state funds. They asked about the value of water availability or use within communities, what social mechanisms promote or hinder alternative approaches to water access in rural
Alaska, and how one can best change behaviors related to water conservation and use.

Another topic was which communities have functioning water systems, and why. Group members also discussed federal regulations, and asked about how realistic it is to change regulations as they pertain to water quality, access and use in Alaskan rural villages. Along the same lines, they discussed the standard for defining “clean” water: Who determines the standard, and is it fair and just? What are the acceptable tradeoffs?

**Society and the FEW Nexus.** Participants raised a number of questions. They asked how one increases community capacity at the local level to achieve FEW security, while respecting sociocultural traditions, knowledge, attitudes, and values. At the same time, they inquired about local attitudes towards sustainability: Is it valued? If it is not valued by everyone, what is that best way forward? How do we prioritize issues and who gets to prioritize the issues?

A related topic was how to communicate about FEW with rural residents in a common language. Communities are tired of short-term “quick fixes” that come from outsiders, group members noted, and strategies that rely on top-down “experts” alone will not solve these problems. Problem solving that involves community members and local knowledge from start to finish is a model that works and is sustainable over the long term.

Group members also asked how cultural identity is connected to land, streams, rivers, and oceans, and how one can build a community’s capacity to maintain a FEW system from one generation to the next. Another topic was the mental health impacts of FEW insecurity, and how one can increase local capacity to address these challenges over time. On the positive side, group members also discussed how to create employment and business opportunities through innovation around FEW challenges.
Data needs were another topic. Members asked about current data sources and current and future data needs, and asked how to create an open access data portal for FEW nexus data. How can we improve measures and the acquisition of baseline data, they asked, and how can we better provide data to decision-makers?

Decision-makers were a final point of discussion, with members asking what role local governments play in FEW issues, and what scale of governance or policy most influences FEW issues for rural Alaska. For example, they noted, we know that dietary preferences differ from place to place; how can we develop practical FEW strategies in light of these differences? Also, which regions of the state are better able to cope with FEW setbacks and why, and can these be used as case studies to improve FEW challenges in other communities?

vi. Environment Breakout Session

**Environment and Food.** The group considered issues such as ocean acidification, soil loss, mercury contamination and other climate change impacts. Ocean acidification is endangering water quality and seafood resources such as shellfish. Water quality is directly tied to health and food sources. In this regard, mercury contamination and bioaccumulation are also impacting marine and seafood sources that relate to trophic-level effects and food web effects of consumption. Climate change is also significantly increasing the growing season, which leads to potential opportunities for future agriculture development in high-latitude regions.

**Environment and Energy.** Water sanitation and supply are significant energy consumers. Specifically, water treatment and distribution in islanded communities are very energy-intensive, and a significant portion of their costs go toward energy and heating of water. Access to clean water is connected to the cost of fossil fuel. Very high energy costs for water and wastewater treatment lead to unaffordable water bills, sometimes leading to closure...
of utilities. Related to this, there is a prevalence of low water usage in rural high-latitude communities, impacting community health and wellness. There is concern that thawing permafrost could release ancient carbon and additional microbial loads into the lakes and rivers that are common water sources in the Arctic. The ways energy demands for water treatment might change in the future needs to be investigated.

There is also a growing trend of renewable energy use in high-latitude communities, and there is a need to assess the impact of using renewables for water treatment on water quality and cost. Other issues include how exploration for offshore oil and gas, or coal exploration, can threaten water quality in sensitive coastal and riverine locations. Terrestrial and marine fuel spills pose environmental threats, an increasing concern as the Northwest Passage opens. Gas hydrates also create environmental issues.

**Environment and Water.** The warming Arctic will trigger several anticipated changes to water quality and availability. There is currently limited information on Arctic water storage and flows, and knowledge must be drawn from local residents in addition to scientific studies. Permafrost thaw poses several threats to water quality including increased natural organic matter, higher formation of disinfection byproducts, and even lake drainage. Also, the warming Arctic increases the risk of migration of Giardia and other microbial pathogens further north. Pollution from pharmaceutical and personal care products and distantly transported contaminants may also be on the rise in the Arctic region.

Given the lack of sanitation and piped facilities in northern remote communities, there is also a concern regarding increased microbial risks (with rising temperatures) from handling untreated sewage. There is also potential for climate-change induced impacts on salt-water intrusion in drinking water supply systems of coastal communities, and river-derived surface water sources are also threatened by sea level rise. Rapid glacial melt in Southeast Alaska could negatively affect water quality or quantity in salmon streams. Changes in water resources could also impact and transform water transportation prevalent in many northern high-latitude communities.

**Environment and the FEW Nexus.** There is a marked uncertainty around climate change and the future landscape as many communities are being forced to shift and move. This leads to the advent of new communities, underscoring the need for optimal community planning as well as adaptable community systems. There is also a need for regional or subregional analysis to minimize social and FEW impacts of such changes. In this regard, what does a flexible and adaptable system look like as a disaster management strategy?
b. Outcomes of HLFEW 2016

The workshop had six concrete outcomes: identification of new FEW challenges and priorities, as described above; new collaborations; identification of FEW “grand challenges,” pinpointing of energy as the largest local FEW challenge; solidification of follow-up plans; and outreach materials, including a poster and website.

New Collaborations. A diverse group of researchers and community members attended the meeting, including multiple faculty and students from the UAF and the University of Alaska Anchorage, as well as attendees from the University of Calgary, University of Minnesota, Texas A&M University, the Alaska Energy Authority, the U.S. Arctic Research Commission, the City of Tanana (an islanded Alaska Native village), and two local farms. Rich discussion among these attendees was key to identifying ‘knowledge gaps’ and needs in the FEW nexus, especially in islanded communities.

Grand Challenge Questions. As described, HLFEW16 participants were organized into three interdisciplinary teams of infrastructure, society, and environment. Part of the charge of each team was to generate “grand challenge” questions that reflect the most critical elements still required to understand the FEW nexus at high latitudes.

These questions were then compiled and printed on individual sheets for display at the final session of the workshop. During this session, each participant was asked to identify the three most important questions by placing stickers beside each one. The total numbers of stickers were tallied and the final list of questions was compiled for the final group discussion.
The top three vote-getters were:

1. How do we design resilient communities with FEW systems as designed by communities?
2. What are the impacts of climate change on social and cultural practices related to FEW security?
3. How is a changing climate affecting the distribution and access of FEW resources?

The full list of “grand challenge” questions considered is listed in the appendices.

**Energy as the most significant challenge.** One key point of consensus among attendees was that of the three points in the nexus, providing affordable and reliable energy presents the largest challenges for high-latitude islanded communities. Some participants convincingly argued that low-cost energy production and distribution in these communities would provide the necessary tools to address both food and water needs. To this effect the participants voiced the need for a follow-up workshop focused on energy needs and solutions in rural, high-latitude and islanded communities.

**Follow-up plans.** The enthusiastic networks formed during the workshop coalesced into research partnerships which planned follow-up actions. Of particular note, one group took on the task of planning a follow-up workshop focused on energy needs and solutions, and another group formed to submit a proposal to the NSF Innovations at the Nexus of Food, Energy and Water Systems (InFEWs) program. The latter group received $2.4 million from the NSF in 2017 to fund their proposal, “Coupling infrastructure improvements to food-energy-water system dynamics in small cold region communities: MicroFEWs” (NSF CBET #1740075). For more information see “MicroFEWS meeting,” below.

**Products.** A dedicated [website](#) hosts all relevant information related to the workshop and its findings. This website is publicly accessible and staged on a stable server housed at the Geophysical Institute at the University of Alaska Fairbanks. A poster was also produced and displayed at the annual meeting of the Alaska NSF EPSCoR program and was provided to the workshop participants for broader distribution to their independent networks.
4. ARENA Session

The Arctic Remote Energy Networks Academy (ARENA) program is a capacity-building, knowledge-sharing, and network-building initiative focused on establishing sustainable energy solutions for remote communities in the Arctic and other regions of the world. The program, sponsored by the Sustainable Development Working Group of the international Arctic Council, launched in 2017 and brought together 17 individuals from communities and organizations from the U.S., Canada, and Greenland. Over an eleven-month period, they received technical instruction (in-person and via web), visited facilities and communities, received individual mentoring, and worked on community-focused case study projects.

The program was anchored by three on-site sessions, held in Yellowknife, Canada in March 2017; Fairbanks in June 2017; and Reykjavik, Iceland in November 2017. Each participant used the knowledge they gained to work on a sustainable energy project for their own community or region. FEW funding was used to support 13 of the 17 individuals to travel to the Fairbanks meeting.

a. Activities

The on-site program in Alaska was coordinated by the Alaska Center for Energy and Power (ACEP) at the UAF campus and by the Alaska Technical Center in Kotzebue. 17 ARENA participants attended the main program, nine also participated in a visit to Kotzebue and Nome, and one individual visited Kodiak for in-depth discussions with the utility there.

The program had an overarching theme of energy resource integration and holistic development. Participants visited three energy facilities demonstrating Alaskan experience in integrating energy from wind, solar, and hot springs resources, including aspects of storing both electrical and thermal energy. They also attended the 2017 Alaska Wind-Diesel Workshop, which provided an opportunity to network with approximately 50 attendees from across the U.S. and Canada. Participants attended classroom presentations on microgrid analysis, technologies, and operation, as well as a real-time demonstration of ACEP’s Power Systems Integration laboratory, which

ARENA participant Mogens Nielsen examines the geothermal power plant at Chena Hot Springs Resort outside Fairbanks.
provided insights into strategies to address aspects of generation such as varying loads and contingency events.

The program included roundtable discussions with community leaders and project developers, providing an opportunity to share practical experiences. In addition to the emphasis on energy, participants also visited organizations in Fairbanks, Kotzebue and Nome working on local food systems using a variety of greenhouse, shipping container and open field agriculture systems. Additionally, they met with organizations implementing multi-stakeholder sustainability projects in Alaska in areas like high-efficiency housing, sewage systems, and drinking water supplies.

### b. Outcomes

A panel session dedicated to ARENA was part of the agenda at the 2017 Arctic Energy Summit in Helsinki, Finland. Co-lead representatives and three of the participants worked together to provide an overview of the program. A [brief video](#) is also available, providing highlights of the site visits and testimonies from the participants regarding their experience.

Each nation with ARENA participants has community energy projects that directly benefited from the content, as well as professional networks established as a result of the 2017 pilot.
5. MicroFEWs Meeting

As noted above, a group of researchers at the HLFEW 2016 workshop agreed to partner on a proposal to the NSF’s Innovations at the Nexus of Food, Energy and Water Systems (INFEWS) program. Researchers Bill Schnabel, Daisy Huang, Erin Whitney, Rich Wies, and Srijan Aggarwal at UAF and Jen Schmidt and Aaron Dotson at UAA were awarded $2.4 million in 2017 for their project, “Coupling infrastructure improvements to food-energy-water system dynamics in small cold region communities: MicroFEWs” (NSF CBET #1740075).

The MicroFEWS project seeks to develop a process through which researchers and community members together characterize how renewable energy infrastructure might impact the FEW nexus in isolated northern communities. The research project continues to explore themes from the HLFEW 2016 workshop by addressing two key research questions: 1) “What are the direct and indirect linkages between renewable energy generation and local drivers of FEW security in Arctic and Subarctic communities?” and 2) “To what extent can combinations of renewable energy generation and FEW-related infrastructure energy loads be optimized to enhance FEW security in Arctic and subarctic communities?”

To address these questions, MicroFEWS researchers are focusing on three rural communities: Cordova, a fishing town on Prince William Sound in Southcentral Alaska; Kongiganak, a Native village on the Kongiganak River in Southwest Alaska; and Tanana, an Alaska Native village on the Yukon River in Interior Alaska. At the kickoff meeting they also agreed to incorporate another Southwest Alaska village, Igiugig. Researchers are engaging communities to develop place-based FEW metrics, and measuring existing FEW flows and feedbacks within the communities. They are then evaluating new technologies that can impact local FEW strategies, developing energy distribution models to optimize on-grid infrastructure components, and using the previously-defined metrics to evaluate those optimization scenarios.
a. Activities

The April 2018 kickoff meeting brought together UA researchers and representatives of partner communities and organizations to discuss processes and develop goals for future activities.

The three communities reported that they have all successfully established renewable energy projects and have learned many lessons along the way, which they said could be summarized and shared with other Alaska communities wishing to implement renewable energy projects. They all agreed building local capacity in a manner that provides useful knowledge, skills, and decision making should be an important part of this project.

Representatives from Cordova said their goal is to reduce losses in water and energy resulting from aging infrastructure. They also expressed interest in using renewable energy to help preserve food year-round; and to explore a proposed dam on nearby Crater Lake as a potential supply of both water and energy. Other areas of interest cited include cardboard biomass, shoulder and wintertime seafood processing, hydroponic vegetable gardens, local fertilizer production, and wood drying through use of renewable energy.

Kongiganak representatives reported that the community is looking for ways to reduce the cost of heating fuel and electricity. The community is making progress toward goals of providing running water for households and portable alternative sanitation, and they noted that integration of excess wind or heat energy or new solar power into this project would be beneficial. One example they cited could be to use the excess energy for a boiler, in combination with a battery.

All three communities noted that they support access to local foods either from subsistence, commercial fishing, gardening, or greenhouses. They suggested renewable energy could be used or optimized to grow local produce, or to reduce energy costs to free up more money to spend on subsistence and related activities. They voiced concerns about Alaska’s Power Cost Equalization subsidy formula and its effects on communities.
Participants from Tanana said the community hopes to study the economic feasibility of the wood harvest as well as its trickle-down effects in the community. This investigation would include looking into the use of the standing dead wood from a 2015 fire near the village. The community is also interested in solar power.

### b. Outcomes

Researchers agreed to continue to integrate the research needs of Cordova, Kongiganak, and Tanana into the objectives of the proposal. They also agreed to incorporate Igiugig, a Native community in Southwest Alaska, as an additional case study. Other next steps agreed upon at the meeting included:

- To use the current energy scenarios of Cordova, Kongiganak, and Tanana to examine the influence of renewable energy on the economy and power generation and to quantify the effects of current renewable energy infrastructure on stakeholder communities.

- To use generation and load data gathered from stakeholder communities to develop energy models to assess efficiency of current renewable energy and effects of future renewable energy infrastructure.

- In summer 2018, to begin data collection to build models, and begin collecting information on lessons learned by communities.

- To create a website and/or Facebook page hosting project updates and FEW contacts and information, as well as to produce video documentaries about Tanana, Cordova, and Igiugig renewable energy projects, similar to a video already produced about Kongiganak.

- To work with Cordova to develop a way to utilize excess cardboard for heat.

### 6. Acknowledgements

We gratefully acknowledge the support of Bill Cooper, director of the NSF Chemical, Bioengineering, Environmental and Transport Systems Division, for his invaluable contributions to the success of HLFEW 2016. We also wish to thank the Alaska NSF EPSCoR program and the Office of the Vice-Chancellor of Research at UAF for their help in coordination and reporting. We also thank all of the individuals who attended these events and shared their expertise in FEW fields.
Appendix a: Participant lists

HLFEW 2016

Srijan Aggarwal, UAF
Dayne Broderson, UAF
Martin Cenek, UAA
Elaine Drew, UAF
Cindy Fabbri, UAF
Craig Gerlach, University of Calgary
Jess Grunblatt, UAA
Jennifer Guerard, UAF
Birgit Hagedorn, UA
Eric Hanssen, Alaska Native Tribal Health Consortium
Jack Hebert, Cold Climate Housing Research Center
Elizabeth Hodges-Snyder, UAA
Gwen Holdmann, Alaska Center for Energy and Power
Daisy Huang, UAF
Barbara Johnson, UAF
Shaina Kilcoyne, Renewable Energy Alaska Project
Meagan Krupa, UAA
Anna Liljedahl, UAF
Bret Luick, UAF
Molly Mayo, Meridian Institute
Holly McQuinn, Alaska Design Forum
Tim Meyers, Meyers Farm
Nicole Misarti, UAF
Debasmita Misra, UAF
Art Nash, UAF
Devany Plentovich, Alaska Energy Authority

Anupma Prakash, UAF
Tom Ravens, UAA
Cheryl Rosa, US Arctic Research Consortium
Josephine-Mary (Josie) Sam, UAF
Jennifer Schmidt, UAA
Bill Schnabel, UAF
Shashi Shekhar, University of Minnesota
Julia Taylor, UAF
Anastasia (Ana) Thayer, Texas A&M University
Jamie Trammell, UAA
Pips Veazey, UAF
Caixia Wang, UAA
Jeff Weltzin, City of Tanana
Dan White, UAF
Erin Whitney, Alaska Center for Energy and Power
Sveta Yamin-Pasternak, UAF
Tom Zimmer, Calypso Farm

ARENA

Katharine Ballegooyen, Kluane First Nation (Canada)
Amanda Byrd, Alaska Center for Energy and Power (USA)
Keith Charlie, Native Village of Minto (USA)
Rob Cooke, Polar Knowledge Canada/Yukon College (Canada)
Shannon Erhart, Village of Tanana (USA)
Kecil Joseph, Town of Inuvik (Canada)
Tyler Kornelis, Kodiak Area Native Association (USA)
Felix Mercure, Northern Energy Consortium (Canada)
Mogens Nielsen, Nukissiorfiit (Greenland)
Henry Nielsen Jr., TDK Power (USA)
Jordan Peterson, Gwich’in’in Tribal Council/Gwich’in Council International (Canada)
Roderick Phillips, Chaninik Wind Group (Canada)
Chris Pike, Alaska Center for Energy and Power (USA)
Rhonda Pitka, Beaver Village Council (USA)
Danny Powers, Kasteler Consulting Inc. and Aerospective Imaging (USA)
Brad Reeve, Kotzebue Electric Association (USA)
George Roe, Alaska Center for Energy and Power (USA)
Anahma Shannon, Kawerak, Inc. (USA)
Eva Sheldon, NANA affiliate (USA)
Rolf Sloth, Nukissiorfiit (Greenland)
Oana Spinu, Carleton University (Canada)
Eryn Stewart, Lumos Energy (Canada)
Rich Stromberg, UAF (USA)
Erika Tizya-Tramm, Vuntut Gwitchin Government (Canada)
Bill Williams, Hamlet of Kugluktuk (Canada)

MicroFEWS
Srijan Aggarwal, UAF
Wes Alexander, Tanana Chiefs Conference
Kristin Carpenter, Copper River Watershed, Cordova

Malinda Chase, Alaska Climate Science Center
Andrew Crow, UAA
Ronald David, Power Plant Operator, Kongiganak
Arlo Davis, Cold Climate Housing Research Center, UAF
Aaron Dotson, UAA Craig Gerlach, University of Calgary
Tashina Duttle, Rural Energy Program Manager, ANTHC
Connie Fredenberg, Energy Advisor, Anchorage
Barbara George, City Clerk, Tanana
Gwen Holdmann, Alaska Center for Energy and Power
Daisy Huang, UAF
Henry Huntington, U.S. Arctic Research Consortium
Kelly James, UAF
Meriam Karlsson, UAF
Clay Koplin, Mayor, Cordova
Harry Penn, University of Calgary
Chris Pike, UAF
W. Roland Phillip, Tribe Manager, Kongiganak
Jennifer Schmidt, UAA
Bill Schnabel, UAF
Bekah Tsigonis, Lifewater Engineering
Pips Veazey, UAF
John Walsh, UAF
Jeff Weltzin, Tribe Manager, Tanana
Erin Whitney, UAF
Rich Wies, UAF
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<tr>
<th>Votes</th>
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<tr>
<td>19</td>
<td>How do we design resilient communities or systems of communities as defined by communities?</td>
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<td>13</td>
<td>What are the impacts of climate change on social and cultural practices related to food security?</td>
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<td>12</td>
<td>How is a changing climate affecting distribution and access of FEW resources?</td>
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<td>10</td>
<td>What can the world learn from FEW issues and solutions in islanded communities? How can the impacts of climate change in the FEW nexus experienced at high latitudes prepare the global community to anticipate and respond to similar changes?</td>
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<td>9</td>
<td>How do we increase production of food supply and reserves in Alaska?</td>
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<td>9</td>
<td>How do communities adapt when FEW environments are changing quickly?</td>
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<td>8</td>
<td>How do resource managers make decisions during a time of climate change and of changes in resource use in Alaska?</td>
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<td>7</td>
<td>How do we build FEW capacity through training, education and workforce development?</td>
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<td>6</td>
<td>What are the primary and secondary data gaps and limitations that must be overcome to understand FEW?</td>
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<td>6</td>
<td>What is the relationship between community-level socioeconomic conditions and vulnerability to food insecurity?</td>
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<td>6</td>
<td>How can efficiencies be achieved by taking an integrated approach to FEW systems?</td>
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<td>5</td>
<td>How do we identify, access and integrate datasets across FEW issues in high-latitude communities?</td>
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<td>4</td>
<td>What knowledge systems need to be transferred to ensure food security for future generations, and what are the best methods to accomplish this?</td>
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<td>2</td>
<td>What is the functionality of current and future landscapes?</td>
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<td>2</td>
<td>How will disconnected systems be connected in the future?</td>
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<td>2</td>
<td>What factors determine food preferences and consumption?</td>
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Appendix c. Agendas

i. HLFEW, September 8-9, 2016

The Food-Energy-Water Nexus in Islanded Communities and High Latitudes: Issues, Pathways and Implications

http://hifew16.alaska.edu

September 8-9, 2016
University of Alaska Fairbanks
Akasofu Building

Wednesday, September 7, 2016

6:30-8:00 pm Casual gathering in the bar at Pike’s Landing Restaurant, 4438 Airport Way

Thursday, September 8, 2016

7:30 am Shuttle departs from Pike’s Waterfront Lodge - please meet in the lobby by 7:25

8:00 Registration and Coffee (501 Akasofu)

8:30 Welcome Remarks
Larry Hinzman, Vice Chancellor for Research, University of Alaska Fairbanks

8:40 Introduction to the workshop and overview of agenda
Larry Hinzman and Anupma Prakash, Associate Dean, UAF College of Natural Science and Mathematics and Principal Investigator and Project Director, Alaska NSF Experimental Program to Stimulate Competitive Research (EPSCoR)

9:00 Session 1: FEW Foundation Panel
Presentations on the state of knowledge of food, energy and water research followed by short discussion
Moderator: Anupma Prakash
Panelists: Svetlana Yamin-Pasternak, Assistant Professor of Anthropology (food)
Gwen Holmmand, Director, Alaska Center for Energy & Power (energy)
Bill Schnabel, Director, UAF Institute of Northern Engineering (water)

10:00 Coffee Break

10:15 Participant introductions - 30 seconds per person
Facilitator: Pips Voezey, Associate Director, Alaska NSF EPSCoR
11:00  **Session 2: Breakout Groups**
Theme: High-latitude research needs and directions
*Session Lead: Anupma Prakash*

Food Breakout Group *(green; 501 Akasofu)*
*Facilitator: Elaine Drew, UAF Assistant Professor of Anthropology*
*Co-facilitator: Meagan Krupa, UAA Research Professional*

Energy Breakout Group *(yellow; 401 Akasofu)*
*Facilitator: Daisy Huang, Assistant Professor, Alaska Center for Energy and Power*
*Co-facilitator: Erin Whitney, Research Assistant Professor, AK Center for Energy and Power*

Water Breakout Group *(blue; 417 Akasofu)*
*Facilitator: Srijan Aggarwal, UAF Assistant Professor of Engineering*
*Co-facilitator: Jamie Trammell, UAA Assistant Professor of Environmental Studies*

Questions to consider:
What are the challenges and priorities for high-latitude research in your thematic area?
Where are the knowledge gaps?
What are the short- and long-term research priorities?

12:00  **Report back to plenary to recap, reflect and synthesize (501 Akasofu)**
*Moderator: Pips Veazey*

12:30  **Lunch (401 Akasofu)**

1:45   **Session 3: Flash talks (501 Akasofu)**
Theme: FEW in Society, Infrastructure and Environment in 7 minutes
*Moderator: Jennifer Guerard, Assistant Professor, UAF Chemistry Department*

**Presenters:**
Tom Zimmer, Co-founder and Ecology Center Director, Calypso Farm and Ecology Center
Shashi Shekhar, University of Minnesota, McKnight Distinguished Professor of Computer Science
Cheryl Rosa, Deputy Director, US Arctic Research Consortium
Devany Plentovich, Program Manager, Alaska Energy Authority
Jack Hebert, CEO and Founder, UAF Cold Climate Housing Research Center
Jen Schmidt, UAA Assistant Professor of Natural Resource Management

2:45  **Coffee Break**
HLFEW, September 8-9, 2016

3:00 Session 4: Breakout Groups
Theme: The FEW nexus in thematic areas: society, infrastructure, and environment
Session Lead: Anupma Prakash

Society Breakout Group (501 Akasofu)
Facilitator: Elaine Drew, UAF Assistant Professor of Anthropology
Co-facilitator: Meagan Krupa, UAA Research Professional

Infrastructure Breakout Group (401 Akasofu)
Facilitator: Daisy Huang, Assistant Professor, Alaska Center for Energy and Power
Co-facilitator: Erin Whitney, Research Assistant Professor, Alaska Center for Energy and Power

Environment Breakout Group (417 Akasofu)
Facilitator: Srijan Aggarwal, UAF Assistant Professor of Engineering
Co-facilitator: Jamie Trammell, UAA Assistant Professor of Environmental Studies

Questions to consider:
What are the challenges and priorities for high latitude research in your thematic area?
Where are the knowledge gaps?
What are the short- and long-term priorities for research?

4:00 Report back to plenary to recap, reflect and synthesize (501 Akasofu)
Moderator: Pips Veazey

4:30 Keynote Speech - An NSF Perspective
Bill Cooper, Program Director, National Science Foundation Chemical, Bioengineering, Environmental and Transport Systems Division, Environmental Engineering Program

5:00 Summary and concluding comments for Day One
Anupma Prakash

5:15 Adjourn

5:30 Shuttle departs for Pike’s Lodge (organizing committee debrief in IARC 501)

Friday, September 9, 2016

7:30 am Shuttle departs from Pike’s Waterfront Lodge

8:00 Coffee (401 Akasofu - please note venue change)
8:30   Welcome  
Dan White, Vice President for Academic Affairs and Research, University of Alaska

8:40   Recap of Day One and Overview of Day Two Goals and Activities  
Anupma Prakash

9:00   Session 5: Breakout Groups by Theme  
Society/Grand Challenges: Decision Theater North, 010 West Ridge Research Building  
Infrastructure/Integration and Synthesis: 401 Akasofu  
Environment/Funding Opportunities: 417 Akasofu

9:45   Coffee Break (401 Akasofu)

10:00  Session 6: Breakout Groups by Theme  
Society/Integration and Synthesis: 401 Akasofu  
Infrastructure/Funding Opportunities: 417 Akasofu  
Environment/Grand Challenges: Decision Theater North, 010 West Ridge Research Building

10:45  Session 7: Breakout Groups by Theme  
Society/Funding Opportunities: 417 Akasofu  
Infrastructure/Grand Challenges: Decision Theater North, 010 West Ridge Research Building  
Environment/Integration and Synthesis: 401 Akasofu

11:30  Return to plenary and report out (401 Akasofu)  
Chairs: Anupma Prakash, Bill Schnabel and Pips Veazey

12:30  Lunch (401 Akasofu)

1:30   Session 8: Plenary  
Theme: Integrate, Synthesize, and Capture: Constructing a FEW Road-Map for High Latitudes  
Leads: Srijan Aggarwal (FEW diagram), Daisy Huang (ISE matrix) and Elaine Drew (ranking and writing activity)

2:15   Writing activity

2:45   Post-workshop evaluation

3:00   Concluding remarks and path forward  
Anupma Prakash and Larry Hinzman

3:15   Adjourn

3:30   Shuttle departs for Pike’s Lodge
ii. ARENA, June 17-24, 2017

AGENDA
ARCTIC RENEWABLE ENERGY NETWORKS ACADEMY (ARENA)
Alaska On-Site Program
Fairbanks & Kotzebue
June 17-24, 2017

Saturday June 17th 2017
University of Alaska - Fairbanks

Arrivals throughout the day / Check into Wickershaw Hall - UAF Campus
18:00 BBQ Dinner on roof of Lola Tilly Commons
22:00 Midnight Sun Run (Optional) – start is at Lola Tilly Commons

Sunday June 18th 2017
Lola Tilly Commons Large Conference Room
411 Tanana Loop East, UAF

08:30 Hot Breakfast
09:00 On-site Program Plan Highlights & Administrative Items
09:15 Participant Project Update Presentations – Progress since March (5 minutes each)
11:00 Chena Hot Springs Background – Gwen Holdmann, ACEP
       Pilgrim Hot Springs (Nome) Project Overview

Chena Hot Springs is the site of the world’s lowest temperature geothermal power plant, and uses the
local geothermal water to heat its buildings and greenhouse, and to chill its Ice Museum. The
geothermal resource at Pilgrim Hot Springs has been evaluated with respect to its potential to serve as a
power source for Nome and/or as the energy supply for a self-sustaining development at the site.

12:00 Depart for Chena Hot Springs Visit and Lunch Stop Enroute

13:30 Chena Hot Springs (CHS) Visit
13:30 CHS Power Plant & Facility Tour – Bernie Karl
15:00 Ice Museum Tour – Bernie Karl
15:45 Free Time - Soak ($15 fee), Hike, ...
17:00 Dinner at Chena’s Restaurant, featuring fresh ingredients grown on-site
18:30 Depart for Fairbanks and return to Wickershaw Hall
Monday June 19th 2017
Lola Tilly Commons Large Conference Room
411 Tanana Loop East, UAF

07:30  Light breakfast

08:30  Microgrids Overview – Dr. Marc Mueller-Stoffels, ACEP

Marc will provide an overview of the diesel-based power grids serving the remote communities of Alaska, including the integration of various renewable energy sources and energy storage. He will discuss layout of the ACEP Power Systems Integration Laboratory, and illustrate the manner in which it has been used to support communities, utilities, industry and researchers.

09:30  Power Systems Integration Lab Tour / Demonstration – Dr. Marc Mueller-Stoffels, ACEP

The PSI lab can be configured to represent, at full power, the Alaska rural community energy grids, including a mix of renewable energy sources (wind, solar, hydrokinetic are currently on display) integrated with diesel-generated power and electrical energy storage. The electrical load profile can be programmed to match the requirements of any specific application. Evaluation scenarios include both normal operating regimes and contingency events.

11:30  Lunch at Lola Tilly

12:30  Sustainable Southeast Partnership – Local & Regional Engagement- Shaina Kilcoyne

The Sustainable Southeast Partnership (http://sustainablesoutheast.net) is a diverse network of organizations and individuals working together to reach cultural, ecological and economic prosperity for their communities and region. Shaina will provide highlights from their experience so far, and guide discussion exploring possible applications of interest to ARENA participants.

13:30  Water Treatment Systems in Rural Alaska – Eric Hanssen

Key issues and approaches to provide safe drinking water and manage liquid waste throughout the year in rural communities will be reviewed, as background for the tours of Lifewater Engineering and the water treatment facilities in Kotzebue. In some communities, water treatment facilities can be a significant fraction of the total energy requirement.

14:00  Transit to Cold Climate Housing Research Center

14:30  Tour of Cold Climate Housing Research Center – Robbin Garber-Slaght
ARENA, June 17-24, 2017

The Cold Climate Housing Research Center (http://www.cchrc.org) is an industry-based nonprofit corporation created to facilitate the development, use, and testing of energy-efficient, durable, healthy, and cost-effective building technologies for people living in cold climates. Robbin will provide an overview of their work and provide ARENA participants with the opportunity to explore a range of solar energy, thermal energy storage, water treatment, and built-structure technologies.

16:00 Transit to Calypso Farm and Ecology Center
17:00 Tour of Calypso Farm and Ecology Center - Susan Willsrud

Calypso Farm (http://www.calypsofarm.org) is a non-profit, educational organic farm in Ester, Alaska offering hands-on education programs for all ages, and growing fresh food for the community through community-supported agriculture (CSA) and markets. It will be the first of several opportunities for ARENA participants to learn about local food initiatives in Alaska.

18:00 Dinner at Calypso Farm and Ecology Center
20:00 Transit to Wickersham Hall

A Project Endorsed by the Arctic Council’s Sustainable Development Working Group
ARENA, June 17-24, 2017

Tuesday June 20th 2017
Lola Tilly Commons Large Conference Room
411 Tanana Loop East, UAF

07:30 Light Breakfast & Golden Valley Electric Association Briefing – Dan Bishop

GVEA (http://www.gvea.com) is the electric power utility serving Fairbanks and the surrounding region. It has an inter-tie to the grids in Anchorage and the Kenai Peninsula. Dan Bishop will provide an overview of the Battery Energy Storage System we will be visiting.

Track I – HOMER Pro Training

08:15 Transit (walk) to Ernest Gruening Building (Room 408)

08:30 HOMER Pro Training – John Glassmire, Dr. Peter Lilienthal

HOMER Energy (http://www.homerenergy.com/index.html) will provide training in the use of the HOMER Pro software for analyzing microgrid energy system options, focusing on case studies relevant to ARENA, and provide individual support for development of models representing ARENA participant communities.

Track II – Community Leaders Panel

08:30 Community Leaders Panel – Shannon Erhart, Roderick Phillip, Connie Fredenberg (moderated by Amanda Byrd)

The panelists will share from their experience working in rural Alaska communities to achieve greater self-reliance in the implementation and operation of sustainable energy systems addressing local requirements and priorities.

11:30 Transit to Lunch at Lola Tilly

12:00 ‘Fireside Chat’ with Energy Project Developers – Jim St. George, Bill Thomson, Rob Bensin, David Messier (moderated by George Roe)

The panelists will share from their experience implementing energy infrastructure in a wide range of Alaska settings. Each individual will provide brief highlights of their work, offer key lessons they have learned from the experience, highlight key opportunities and challenges they see for the future, and interact with ARENA participants.

13:30 Energy Efficiency and Conservation – Dr. Tom Marsik

A Project Endorsed by the Arctic Council’s Sustainable Development Working Group
Energy efficiency and conservation have been referred to as "the first fuel". With cost recovery timeframes sometimes measured in fractions of a year, these provisions and practices warrant careful consideration in the development of energy solutions for existing and future communities.

14:30  Transit to Lifewater Engineering

15:00  Tour of Lifewater Engineering – Bob Tsigonis

Lifewater Engineering (http://lifewaterengineering.com) provides artisuitable solutions to address wastewater management challenges, with system configurations that span the residence-community-industrial application space.

15:45  Transit to GVEA Battery Energy Storage System Facility

16:00  Tour of GVEA Battery Energy Storage System Facility – Dan Bishop

Completed in December 2003, the BESS is one of GVEA's initiatives to improve the reliability of service. The largest utility battery system in the world at the time it was constructed, the system can provide 27 megawatts of power for 15 minutes, avoiding the requirement for "just in case" active spinning reserve to protect against problems with the Intertie or power plants in Anchorage or Fairbanks.

16:45  Transit to Home of Fairbanks North Star Borough Mayor Karl Kassel

Enroute stop at Trans Alaska Pipeline viewing station and information display near Fox, Alaska.

17:30  Home Tour and Dinner – Mayor Karl Kassel

The Kassel residence one of the greenest homes in Alaska. Located near Fox, Alaska, it is completely off the grid – relying on local wind, solar and passive heat retention. Our visit will provide an opportunity to both hear the vision that motivated its development, and learn about the technologies that enable the vision to be achieved.

21:00  Transit to Wickersham Hall
ARENA, June 17-24, 2017

Wednesday June 21st 2017
Alaska Wind-Diesel Workshop (ARENA participants will attend all day)
Alyeska Pipeline Training Center

07:00  Transit from Wickersham Hall to Alyeska Pipeline Training Center

07:15  Registration and Hosted Breakfast

08:00  Wind-Diesel Workshop

ARENA participants will participate in all sessions of the workshop. (Details of the program content and speaker biographies are provided separately in hard copy format.)

17:30  Transit to Trail Breaker Kennel for Celebration Dinner

18:00  Celebration Dinner – Hosted by US Department of State

ARENA participants and stakeholders gather to celebrate highlights from the time in Fairbanks, learn about one of the most ancient forms of transportation in the Arctic, enjoy an Alaska Native dance performance by students in the Rural Alaska Honors Institute, and relax in a beautiful setting on the longest day of the year.

21:00  Transit to Wickersham Hall

21:30  Pack / Prepare for Checkout
Our visit to Kotzebue provides an opportunity to visit a community with much to offer from their experience with a wide variety of sustainable energy initiatives and among the smaller communities throughout the Northwest Arctic Borough.

06:00  Depart Wickersham Hall with sack breakfast for Ravn 922 to Kotzebue

07:35  Flight departs for Kotzebue with a stop in Anchorage

12:25  Arrive Kotzebue (Ravn 922)
       Transport from Airport to Alaska Technical Center (ATC)
       Check into ATC Dormitory

13:00  Lunch at ATC

14:00  Alaska Technical College Overview & Tour - Cheryl Edenshaw

14:30  Solar & Heat Pumps in NWAB - Ingemar Mathiasson (via Internet)

15:15  Advanced Technologies for Hydroponics & Local Food – Jeff Buchholz

15:45  Overview of Water & Waste Management in Kotzebue – City of Kotzebue

16:15  Walk from ATC to Water Plant

16:30  Water Plant Tour – City of Kotzebue

17:00  Visits to Containerized Hydroponic Greenhouse Systems (split into groups A & B)

17:00  Group A: Kikiktagruk Inupiat Corporation – Larry Daniels
       Group B: Northwest Arctic Borough- Jeff Buchholz

17:30  Group A: Northwest Arctic Borough- Jeff Buchholz
       Group B: Kikiktagruk Inupiat Corporation - Larry Daniels

18:00  Walk to Dinner at Nullagvik Hotel

20:00  Walk to ATC Dormitory
Friday June 23rd 2017
Kotzebue, Alaska

07:30   Breakfast at ATC
08:00   NANA Regional Corporation - Liz Cravalho
        City & Borough of Kotzebue – Patrick Savok, Mayor Gayle Ralston
09:00   Kotzebue Electric Association (KEA) Presentation – Brad Reeve, Matt Bergan
10:00   Transit from ATC to Power Plant
10:15   Tour of KEA Power Plant – Matt Bergan
12:00   Walk to Lunch at ATC
13:00   Transit to KEA Wind Turbine Site
13:15   Wind Turbine Site tour
14:15   Transit to Kotzebue
        Enroute Drop-in Visits to Landfill & Sewage Lagoon
15:15   Walking Tour of Kotzebue Highlighting Residential and Business Energy Installations
        Visit Sullianich Art Center & Sample
16:30   Return to ATC Dormitory / Checkout (for those leaving after dinner)
17:00   Dinner at Nullagvik Hotel
17:30   Transport to Airport (subset of group)
18:56   Flight to Nome / Anchorage (Alaska 153)
Saturday June 24th 2017
Kotzebue, Alaska

07:00 Transport to airport (subset of group)
08:32 Flight to Anchorage (Alaska 154)

08:30 Breakfast at ATC / Pick-up sack lunch

Recreation Day – local site-seeing / rest time
Fishing, National Park Service Visitor Center, Sulianich Art Center, Flightseeing, ...

16:30 Dinner at Nulagvik Hotel

17:30 Transport to Airport (remainder of group)
18:56 Flight to Nome / Anchorage (Alaska 153)
iii. MicroFEWs, April 9, 2018

Food-Energy-Water Dynamics in Alaska Rural Communities – Partnership Meeting

Location: University of Alaska Fairbanks Engineering Learning and Innovation Facility (ELIF)
BP Design Theater (4th Floor)

Monday, April 9, 2018  8:00am to 5:00pm

Map and directions at bottom. If you need assistance please call Jen Schmidt’s cell phone: 907-750-3750

Goals:

The overall purpose of this meeting will be to bring together university researchers and community stakeholders to share in a conversation about the MicroFEWS project, advance a common understanding of current food-energy-water (FEW) systems in Alaska, and develop goals for future activities.

Specifically, the group will address the following broad topics:

- Share knowledge and understandings of the FEW connections in the communities of Cordova, Kongiganak and Tanana.
- Identify connections and feedbacks among food, water and energy.
- Consider ways in which renewable energy systems may change life patterns and well-being.
- Identify FEW use, flows and trade-offs and the availability of previously or currently collected data sources to measure these variables.
- Discuss the idea of FEW security and address various means of measurement.
- Document existing and potential infrastructure components that influence FEW security within rural Alaska communities.

Agenda:

8:00am – 8:30  Coffee, breakfast snacks, and check-in
8:30 – 9:00  Welcome and introductions
9:00 – 9:30  What do we mean by a food-energy-water (FEW) nexus and what is FEW security?
9:30 – 10:00  Presentation of project structure and reflections from community visits.  How can this project be helpful for communities and stakeholders?  What outcomes are important for the group here today?
10:00 – 10:15  Refreshments break
10:15 – 11:00  Team mapping exercise … The team will work through a facilitated process to develop a FEW map that depicts a model system with common elements found in typical Alaskan rural communities.
11:00 – noon  Breakout groups

Breakout groups (by community) identify the major components of a FEW nexus map as well as the major connections among the various pieces.

Noon – 1:00pm  Lunch provided
1:00 – 1:45  Breakout community groups continue work to identify the impacts of introducing renewable energy. Specifics for this exercise will be provided by session lead.
1:45 – 2:30 Community groups reconvene and report back. Information might include what discoveries you made, what information was missing, what were the most important ideas that were generated, and what do you want to know more about from the research team?

2:30 – 3:00 Refreshments break and walk to the Power Systems Integration (PSI) Lab.

3:00 – 4:00 Tour of the PSI Lab to showcase the facility and talk about how elements of the project will be supported by PSI capabilities.

4:00 – 4:15 Walk back to ELIF building

4:15 – 4:45 Concluding discussion to cover topics such as:
   Is this a helpful way to look at these topics?
   What do you think about the exercise today?
   How can this project be helpful to your community and your work?

4:45 – 5:00 Concluding remarks and adjourn

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1810 Salcha St., Fairbanks, AK 99709 (address for Signers Hall. ELIF is too new for GPS/Google Maps)

Red Star: Engineering (ELIF) Building

Red Arrow: Direction of travel (University to College Road/Alumni Drive intersection, left on Alumni Drive, right on Chandalar Drive then right on Salcha St) to parking on right.

Park in any of the green shaded areas. There is a kiosk on the corner or pay from your phone at this link: https://pprpk.com/park/. If those are full you can use the additional parking location and a kiosk is near there.

Enter the Engineering building from the Cornerstone Plaza. You will enter a lobby area with a coffee shop. To the right of this area is a hallway that leads up into the ELIF (Engineering) building. There is an elevator halfway down this hallway. Take the elevator to the 4th floor. It will open directly in front of the BP Design Theater, which is where the event is being held.

Feel free to contact me if you need further direction.

Thank you!
Kelly James (907) 474-5457