ARCTIC RENEWABLE ENERGY ATLAS PROJECT

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ARCTIC COUNCIL

Sustainable Development Working Group

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Energy Studies Institute
29 Heng Mui Keng Terrace
Block A, #10-01
Singapore 119620
Singapore
www.esi.nus.edu.sg

Editorial correspondence should be addressed to Ms Jan Lui (jan.lui@nus.edu.sg)

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INTRODUCTION

From 29–31 August 2018, the Energy Studies Institute (ESI), National University of Singapore hosted the Arctic Renewable Energy Atlas (AREA) Project workshop participants in Singapore. Initiated by the Arctic Council's Sustainable Development Working Group (SDWG), AREA integrates a range of resources from maps and data to research activities and storytelling, thereby enhancing knowledge of best practices and local action on renewable energy within the Arctic region.

The three-day event — which consisted of the AREA Project workshop, meetings and a field trip — was supported by the Ministry of Foreign Affairs of Singapore. There were over 20 workshop participants with representatives from Canada, Finland, Iceland, Norway, Sweden, Russia, the United States, as well as Southeast Asian participants from the Philippines, Myanmar and experts based in Singapore.

The objective of the workshop is to facilitate the discussion of AREA Project topics by the Arctic participants, focusing on renewable energy resource potential, data management and visualisation, as well as highlight Arctic country energy profiles. In addition, the event provided an opportunity for participants from the Arctic and Southeast Asia to share best practices and exchange knowledge on sustainable energy initiatives and projects, with a focus on energy transition challenges surrounding remote and "islanded" communities in both regions. In this regard, the non-Arctic participants shared the Southeast Asian experience on renewable energy developments, with speakers covering topics ranging from energy access in remote communities in Myanmar and the Philippines, the deployment of solar energy in the region, low carbon energy finance and institutional governance.

This event was jointly convened by Gail Mosey (AREA Project Lead) and Christopher Len (ESI Senior Research Fellow). Elena Reshetova, Hema Nadarajah and Mary Ann Quirapas served as rapporteurs for this event and contributed to the preparation of this report.

Convenor
Gail Mosey
Project Leader, Arctic Renewable Energy Atlas (AREA) Project;
Project Lead and Senior Energy Analyst,
National Renewable Energy Laboratory (NREL)

Singapore Co-convenor
Christopher Len, PhD
Senior Research Fellow
Energy Studies Institute
National University of Singapore

WORKSHOP SESSIONS
Day 1 | 29 August 2018

SESSION 1: Setting the Renewable Energy Landscapes in the Arctic and Southeast Asia — Overview and Problem Statement

Christopher Len, the moderator of the first session, made introductory remarks and spoke about the goals of the workshop. He pointed out that this gathering is significant given that it is the first time an Arctic Council Sustainable Development Working Group (SDWG) project event is taking place in Singapore. He then explained that the purpose of this opening session is to provide a basic introduction of the energy landscape of both the Arctic and Southeast Asia to the participants, given that the level of awareness of the other's region is low.

Len briefly spoke about the importance of energy access as a global development theme. According to the United Nations Sustainable Development Goals (SDG), energy is "central to nearly every major challenge and opportunity the world faces today". Goal 7 of the UN SGD is to "ensure access to affordable, reliable, sustainable and modern energy for all". The energy challenges faced by local communities in the Arctic are similar on many levels to those faced by remote and rural communities in other parts of the world, including Southeast Asia. The workshop aims at creating a community of experts who can work together to address these issues by learning from one another.

Mikhail POGODAEV
Executive Director, Secretariat of the Northern Forum, Republic of Sakha (Yakutia), Russia;
Chair of the Association of World Reindeer Herders

Mikhail Pogodaev provided the general introduction to the Arctic energy landscape. He started off with the discussion of the Northern Forum, the organisation he represents as an Executive Director. The Northern Forum is an international organisation uniting 14 subnational governments across the Arctic. It attained Observer status in the Arctic Council in 1998 and provides regional and local input to the work of the Council. Priority areas of the Northern Forum's projects include climate change and environmental protection, health, education and research, infrastructure development and innovation, indigenous people, cultures and tourism, and sustainable development.

Infrastructure development is one of the key areas of interest because it is important for improving the quality of life in the north. Projects that fall under this category include affordable energy in remote and isolated settlements, accessible transport, broadband and telecommunication, housing and social infrastructure.

The main drivers of change in the Arctic are climate change, natural resource development (e.g., oil and gas, mining), shipping, fisheries, tourism and governance. The Arctic is warming twice as fast as other places in the world. As the ice is melting, the interest in the region's natural resources is growing. As the Arctic is becoming more accessible, new shipping routes are attracting new government and business players, have an impact on fisheries and increase tourism. Therefore, governance of the Arctic is a pressing issue. The region needs active local communities, responsible corporations and best available knowledge on how to adapt to changes.

According to the speaker, two-thirds of greenhouse gas (GHG) emissions originate from the energy sector. According to experts, renewable energy sources have the potential to cut these emissions in

half. In the Arctic, there are many ongoing efforts to develop renewables. In Europe, the Arctic states are among the leaders in renewable energy integration. For example, Iceland is Europe's green energy leader and has a goal of 100 per cent final energy consumption based on renewable energy.

However, at least two million of the Arctic inhabitants are dependent on off-grid energy solutions, mainly relying on diesel for power generation. They face a number of challenges. The first is the changes to the land, which many indigenous people leading a traditional way of life rely on. On the one hand, they have no access to energy. On the other, there are conflicts of interest when it comes to traditional land use such as reindeer husbandry and newly introduced oil and gas extraction and pipeline construction.

Another challenge is the reliability of technology and energy storage in harsh weather conditions. For example, the republic of Sakha in Russia, where people live permanently, is known as the coldest region in the world. Low temperatures and heavy snow are an issue for renewable energy technologies there. The equipment has to be reliable and robust, and storage areas need to be kept warm for the equipment to function properly.

Weather conditions and long distances also interfere with the delivery of energy resources. In Sakha Republic, almost 90 per cent of power stations are dependent on diesel, which is delivered by river and there are some deliveries that can take up to 2.5 years to arrive. Long distances are also the cause of significant power losses in the electricity distribution networks.

Finally, financial issues are problematic as well. Many small remote Arctic communities find access to capital and credit for fuel delivery challenging.

Gautam JINDAL
Research Fellow, Energy Studies Institute (ESI), National University of Singapore (NUS), Singapore

Gautam Jindal presented the general introduction to the Southeast Asian energy landscape. The Association of the Southeast Asian Nations (ASEAN) comprises ten countries and is one of the fastest growing regions in the world. It has experienced significant economic growth and attracted a lot of global foreign direct investment. By 2030, ASEAN's labour force is estimated to grow by 70 million people. Strong economic growth, at about 6.2 per cent in 2013–35, is expected to result in increased energy consumption in the region.

The ASEAN Centre for Energy (ACE), which is an independent intergovernmental organisation within ASEAN, analysed projections of total final energy consumption until 2040 based on three scenarios: business as usual, member states' targets and accelerated targets. In all three scenarios, energy consumption is dominated by the industry and transportation sectors. ASEAN member states are pursuing national and regional energy efficiency and renewable energy targets. At the regional level, they are more ambitious than national goals and follow the ASEAN Plan of Action for Energy Cooperation (APAEC) 2016–2025.

ASEAN's energy growth will be dominated by growth in electricity consumption. In 2016, 10 per cent of the region's population did not have access to electricity. Around 40 per cent of the population relied on traditional use of biomass for their energy needs. According to ACE's analysis, significant increase in the power generation capacity is expected. It will amount to as much as three times the current level of capacity, and the growth will be dominated either by renewables or coal, depending

on the implemented scenario. As a result, there is tremendous potential for energy investment in the region.

The major challenge of integrating renewables is their intermittent nature, which affects power system stability. According to the International Renewable Energy Agency (IRENA), some countries (e.g., Cambodia and Myanmar) may have high penetration of renewables by 2025, while others (e.g., Laos and Malaysia) may not.

There are some initiatives to address the challenges of renewable energy sources integration. One of them is the ASEAN Power Grid, which is supposed to unite member states' electricity grids and increase efficient use of energy resources. Other initiatives include the energy storage test bed pilot project in Singapore and the first utility-scale solar project combined with battery energy storage in the Philippines.

Finally, there is a lot of potential for microgrids. As of 2016, a large share of the population in several ASEAN member states did not have access to electricity. Even those who do lack good quality supply resulting in frequent power outages.

DISCUSSION

During the discussion that followed the workshop, participants compared the challenges faced by the Arctic and Southeast Asia. A wide range of topics were brought up, including nomadic communities and the effect of climate change on traditional ways of life, politicisation of energy issues, problems introducing renewable energy, regional efforts to encourage energy transitions and the role of the government and private sector. Overall, it was noted that the challenges appear outwardly different on the map, but are similar in many ways despite climatic differences and different distances.

Nomadic Communities and Traditional Way of Life Challenged by Climate Change

One of the Southeast Asian participants wondered if nomadic communities were representative of the Arctic region. The representatives from the Arctic countries shared their knowledge and experience on the issue. In the Arctic, reindeer herders always have to migrate following the reindeer and need to use portable devices for energy supply. In different countries, there is a common approach of using solar panels backed up by diesel generators. There are also settlements which use biomass and diesel for heating and fuel. Some regions have more developed infrastructure than others. In Russia, northwestern regions are more developed due to their proximity to Europe. The Yamal Peninsula has indigenous gas resources, but they are exported instead of being utilised locally. Liquefied Natural Gas (LNG) could potentially be used in this region, but it requires a lot of investment. In Canada, there are no nomadic communities, but there are isolated remote limited-access communities. In Alaska, not a lot of communities are nomadic, but people are thinking of moving their settlements because of climate change. This is because animal and fish migration patterns have been affected, so the communities relying on these for food have to move.

The workshop participants also noted that climate change is a challenge to the traditional way of life of some communities in the Arctic as well as Southeast Asia. In southeastern Myanmar, there has been significantly more flooding in the last two years. Climate change also affects fishing communities as river banks are receding. Rice farmers are suffering because of the nutrient turnover in the soil. Climate vulnerability and adaptation are common themes between the Arctic and Southeast Asia.

Politics of Energy and Multilevel Governance

On the issue of the politics of energy, representatives of Canada, the United States (US) and the Russia Federation shared their opinions. In Canada, there are federal and territorial level strategies for utility companies that are crown corporations; these are government-owned and regulated corporations that operate at arm's length from the government.

At the federal level, there is Paris Agreement commitment to reduce GHG, and a lot of funding associated with that target goes to northern communities because they are diesel based. About 60 per cent of money coming to the Northwest Territories is going to energy projects. Federal level strategy cascades down to the territorial level. Linkages between the two are important because in the north, renewable energy projects are not merely a business case, but also a policy case.

In the US, there is no overarching policy. There are different departments within the federal government funding various aspects that can be related to the energy sector, such as Indian nations, distressed communities and others. In Russia, energy policy is similar to the US and Canada. There are two levels: federal and local. In Russia's Sakha Republic, projects are mostly supported by the regional government and the federal energy company RAO UES. Energy security is important because access to fuel is essential, so there are government subsidies in place.

Problems with Renewable Energy Deployment

The challenges with installing renewable energy systems in the Arctic were discussed. Citing an example from Russia, Pogodaev pointed out that in the Sakha Republic, there are wind resources being developed, while in Chukotka, there is a lot of solar power to be utilised. In both regions, there are 2,000 hours of solar radiation per year. In general, wind energy is challenging because of extreme conditions such as icing and storms. Solar energy installations are threatened by large amounts of snow.

Regional Efforts for Energy Transitions

While there is a regional energy plan in Southeast Asia, namely APAEC 2016–2025, there is no overarching regional Arctic energy policy. In the Arctic, there are efforts to create space for the industry to develop communities. For example, is development of natural gas in Yamal a federal government or a local government responsibility? Is it better to move forward with renewables or indigenous resources? The situation is similar in the Philippines and Indonesia.

Barriers to Private Sector Participation

Government involvement is declining in Southeast Asia and the private sector is encouraged to step in. Malaysia's national oil company, Petronas, is thinking about developing renewable energy driven by economies of scale. In the Arctic, there is a lot of federal government support. In Canada, at this point in time, there are interested third parties, but they are not actively involved. They will not get involved if they do not see viable financial returns within a five-year period. In the US, in the north, there are no economies of scale for investing in energy systems in small isolated communities.

Businesses are not going to get involved on the basis of pure economics because small communities are not bankable; but they will consider it if they have access to tax breaks. Moreover, policies can be translated into new business incentives if properly designed. Currently, in Southeast Asia, more companies are interested in investing because traditional energy is expensive. Also, there are tax privileges and subsidies for renewables.

The issue in the Arctic is that the communities are of such a small scale that they are not considered viable for businesses. Companies also have limited experience working in the north. The biggest challenge with the money that is being deployed is to find technology that will work without increasing electricity rates. This is not just about energy, but also about economic sustainability. One potential solution to the challenge of small communities is to develop cohesive integrated initiatives that can serve as regional development blueprints. This can, in turn, incentivise companies to form structure partnerships to provide in a variety of services as a consortium.

SESSION 2: Arctic Renewable Energy Atlas (AREA) — Regional Contributions of Renewable Energy Resource Potential

Gail MOSEY

Project Leader, Arctic Renewable Energy Atlas (AREA) Project;
Project Lead and Senior Energy Analyst, National Renewable Energy Laboratory (NREL), USA

Gail Mosey discussed the Arctic Renewable Energy Atlas (AREA) initiative, its objectives and current status. What prompted AREA is the wealth of renewable energy resources in the Arctic and a need to create a clearinghouse for data and information. AREA has a potential for expanding the reach of renewable energy and inspiring further innovation. It could also contribute to sustainable development and healthy, resilient communities. Finally, it could serve as a portal to easily access critical information for communities, academics, policymakers and developers.

AREA is an endorsed project of the Arctic Council's Sustainable Development Working Group (SDWG). It will compile and condense information about renewable energy use, renewable energy resource potential and energy efficiency. AREA will be an easy-to-use platform to learn the state of renewable energy and to better understand where opportunities exist in all Arctic nations.

The problem is not that there is too little information; it is that there is actually a wealth of information which has not been consolidated for the Arctic. Today, there are many sources of information: International Renewable Energy Agency (IRENA), Renewable Energy Atlas Alaska, the United States Department of Energy (US DOE) National Renewable Energy Lab (NREL), the US Energy Information Administration (US EIA), Natural Resources Canada (NRCan) and many others. AREA plans to consolidate and maintain information from a variety of sources in a judicious, critical manner.

AREA enhances knowledge of the best practices and local adoption of renewable energy within the Arctic region via four components. First, the renewable energy atlas includes data on wind, hydro, solar thermal, geothermal, biomass and tidal energy resources. Second, it maintains a community energy production, consumption and efficiency database. Third, it includes a best-practices guide for remote community renewable energy integration and efficiency. Fourth, it shares community energy stories discussing successes and challenges found in developing clean energy projects.

There are numerous interested and involved parties contributing funding, data and other resources to the success of AREA, including US DOE. The project is divided into two phases. During Phase I (2016–17), the website was developed, data visualisation tools were established, initial data was presented and the first community energy stories were shared. During Phase II (2017–19), data collection and integration is ongoing, the community energy use survey and identification of other data sources are underway, community energy stories are being collected, and a best-practice resource centre is being established.

Finally, Mosey shared a short video of a community story from Kodiak, Alaska, which is part of the community energy stories being compiled by AREA.

DISCUSSION

After Mosey's introduction to the AREA initiative, workshop participants had a chance to ask questions, discuss potential points of collaboration and share Southeast Asia's experience that might be of value in addressing the challenges AREA is facing.

AREA administrators are currently collecting best practices. They are looking for examples, and everyone is welcome to contribute to it. They are open to suggestions and ideas where any interested party could provide examples and even anecdotal information. This include examples of what has not worked and lessons learnt.

All information on the AREA portal is free of charge and publicly available. They are working on enhancing the quality of deliverables. Community energy stories were developed through funding associated with the AREA project. The dedicated team decides if the videos submitted by others fit the project's objectives. For data quality, there are teams of experts to make sure that the quality is acceptable. They are working on harmonising the data because it is usually presented in different formats.

AREA is also meant to provide a resource platform to learn about available technology and find out if they have been successfully deployed. This is because companies come to communities, and the latter buy into the proposed solutions. Technically, these are not feasible and technology may not be viable. In a worst case scenario, companies may try to make money off communities by taking advantage of their lack of knowledge.

As a resource portal, AREA could also host policy papers and recommendations as downloadable fact sheets or PDFs. It was also suggested that the Arctic regions can help by producing assessment reports and policy recommendations. Additionally, AREA has issues that are cross-cutting with other working groups of the Arctic Council, and this should be mentioned at the meetings to spread awareness. Different collaboration spaces could be created: on technology, local communities and others.

With regard to data collection, AREA includes whatever data is available and depends on what countries come forward with. They take into account mapping of resources and land areas, flora, fauna and local characteristics. However, different countries have different regulations. For example, environmental impact assessment guidelines and standards are different, and this complicates data integration.

Arctic countries have a lot of informal collaboration efforts unlike Southeast Asia, which is dependent on formal organisations. In Southeast Asia, there is the ASEAN Centre for Energy (ACE), which is a regional organisation for cooperation in the sector. ACE creates data uniformity, but data access from different governments remains a challenge. As for the country experiences relevant to AREA, a Southeast Asian participant pointed out that in Myanmar, there is the Myanmar Information Management Unit (MIMU). MIMU maintains a common data and information repository with data from various sources on all sectors, countrywide, at the lowest administrative unit for which it is available. It includes information about projects in the country and companies doing business there. MIMU also engages stakeholders to share information instead of simply providing access to it.

SESSION 3: Data Management and Visualisation — Challenges and Gaps

Gail MOSEY

Project Leader, Arctic Renewable Energy Atlas (AREA) Project;
Project Lead and Senior Energy Analyst, National Renewable Energy Laboratory (NREL), USA

Gail Mosey began by showing the Arctic Renewable Energy Atlas (AREA) website, which is currently hosted on the Arctic Portal. She explained that what prompted the creation of AREA was the need to consolidate the wealth of information about renewable energy sources in the Arctic region within an easily accessible website.

Aside from access and data visualisation, AREA would also like to raise awareness and inspire innovative energy efficiency solutions and renewable energy technologies for the development of sustainable and resilient communities in the Arctic region. It can benefit different end-users and actors that might have a stake in developing renewable energy, including local communities, academics, policymakers, technology developers, landowners and others. The AREA project was endorsed by the Sustainable Development Working Group (SDWG) of the Arctic Council, which shows the importance and seriousness of such an endeavour.

AREA requires the following computing capabilities for optimal functionality:

- Team of geospatial data science experts and energy data experts;
- Powerful server to host and process display and computation of big data;
- Top of the line geospatial platform such as OpenCarto for visualising spatial data; and
- Suite of analytical tools and interactives that can be utilised for querying and performing specific scenario-based and techno-economic analyses within the browser.

To make AREA more robust, Mosey mentioned the need for the following data from each Arctic nation:

- Renewable energy source availability (solar, wind, hydro, geothermal, tidal, biomass, etc);
- Local energy demand, which includes information on electricity consumption and community generating capacity; and
- Available infrastructure (roads, transmission lines, permafrost) and current power landscape which includes cost of electricity and sources of generation.

Currently, a few main sources of AREA's data include the International Renewable Energy Agency (IRENA), National Renewable Energy Lab (NREL), Natural Resources Canada (NRCan) and the Arctic Fulbright among others.

Aside from data requirements, some of the major challenges in maintaining AREA are the integration of different data layers for semi-seamless visualisation and the overlay of existing energy generation capabilities to allow easy visualisation of localised supply and demand information. In addition, there is also a need to scope and create additional technical committees for the inclusion of other nations in AREA. Gaps in the data and its sensitivity are also key issues that need to be addressed.

DISCUSSION

During the discussion, there were important points raised for improving AREA. Yngve Birkelund from UiT The Arctic University of Norway suggested that information should be provided on how to utilise

the data provided by the maps. The users can maximise the website's utility depending on their actual needs. In relation to this, Alvin Culaba from De La Salle University in the Philippines mentioned the possibility of using an artificial intelligence-based platform where the data gathered for the website can be stored and analysed. For example, this can be relevant for remote sensing or satellite data that can be stored on the cloud for easier and more intelligent storage.

Another suggestion was to map out the human resource capability of the region. In other words, who does what and which companies or communities provide these types of services. This can benefit the communities as well as potential project and technology developers who might be interested in working closely with the local stakeholders. The community-level data can also be aggregated in a form of community energy survey, which can be made available on the website for facilitating faster knowledge and best-practices sharing.

In summary, by combining detailed maps, resource data and storytelling into a single comprehensive tool, the AREA project can enhance knowledge of best practices and local adaptation actions on renewable energy and energy efficiency within the Arctic region. Data gathering and collection is a continuous challenge of the project, but these could be addressed through collaboration and cooperation among nation states, local communities and international organisations with the focus on and interest in the Arctic region.

SESSION 4: Regional Contributions of Renewable Energy Resource Potential and Best Practices

This session, moderated by Gail Mosey, included contributions on the respective renewable energy resource challenges and potentials from the Arctic countries. In the first part of the session, representatives from Canada, the United States and the Russian Federation shared their countries' experiences. In the second part, representatives of Finland, Iceland, Norway and Sweden discussed their countries' plans and current practices with regard to renewable energy.

Jay GREWAL
President and CEO, Northwest Territories Power Corporation, Canada

Jay Grewal provided an overview of renewable energy development in the Northwest Territories (NWTs), Canada. The NWTs is a region with a total population of 44,000 residents of which 50 per cent are indigenous peoples living in communities of varying sizes. The 33 communities found across the NWTs each have populations ranging from 84 to 22,000 people. About half of these communities can be accessed only at certain times of the year.

The NWTs generate 9 per cent of greenhouse gas (GHG) emissions. Almost 80 per cent of these emissions originate from the mining and transportation sectors. Transportation is one of the largest contributors because roads are almost non-existent resulting in the widespread use of large trucks, planes and barges.

Key challenges in providing energy in the NWTs arise mostly from unreliable weather, the cost of power and logistical issues. Communities are powered primarily by three energy sources: hydro (75 per cent), oil and gas (24 per cent) and to a much lesser extent, solar PV (less than 1 per cent). Hydropower use is being expanded with the target of doubling current production levels to 200 MW. Liquefied Natural Gas (LNG) is more preferable than diesel because it would lead to a 30 per cent reduction in GHG emissions, but getting LNG to consumers is problematic. Integration of intermittent renewables like solar is limited because a larger capacity of renewables would mean a larger base load and backup. Once renewables have a large share in electricity generation, balancing the system becomes a challenge. Thus, the true cost of renewables is not the capital cost, but the life cycle cost including maintenance and the cost of backup.

Grewal then explained the role of the Northwest Territories Power Corporation (NTPC). NTPC, a Crown Corporation, is the NWT's utility provider. Crown corporations in Canada are government-owned and regulated corporations that operate at arm's length from the government. They provide public services that cannot be provided by private companies for economic viability reasons. Challenges faced by NTPC include low economies of scale, small scale and unintegrated systems, as well as those arising from the use of ageing plants that are close to their decommissioning dates. She reiterated that renewables were not feasible without federal funding, where 75 cents on the dollar from the government allows the NTWs to generate energy using renewable sources.

Finally, Grewal highlighted the lessons learnt at NTPC. They included the need to understand northern conditions, training residents to maintain and operate plants and the lack of proven technology on intermittent renewables suitable for northern communities.

Janet REISER

Executive Director, Alaska Energy Authority, USA

Janet Reiser spoke about Alaska's energy needs as well as the challenges faced by the Alaska Energy Authority (AEA) in providing renewable energy to the state. There are over 200 microgrids across Alaska. The state can be divided into three regions: the Railbelt, the Southeast and the rest which includes rural Alaska.

The Railbelt is home to 72 per cent of the state's population. It is the only region connected to the grid and uses 76 per cent of the energy in the state. It is also home to the largest hydropower plant and the cheapest energy in the state at USD 0.05 per kWh. The Southeast is where the state's capital Juno is located, and the region consumes 13 per cent of the state's energy. Finally, the rest of the state is home to 18 per cent of the population and consumes 11 per cent of the total energy. There are two hundred rural communities of 20–200 people each. Although energy use is very efficient, households spend half of their income on power.

Diesel constitutes 90 per cent of the primary power used in rural Alaska. It is a reliable energy source, and the first priority is to get diesel systems more efficient rather than to get rid of them all together. Part of the challenge is building technical and commercial capacity in communities.

As a result, utilities like the AEA do not come up with the money. Instead, financing is provided by the state government. It used to be 100 per cent based on grants, but the government and utilities companies learnt that if the local community does not have buy-in, issues of longevity of equipment and proper exploitation become widespread.

The AEA has been integrating resources into communities using biomass, wind, hydro, geothermal, coal as well as oil and gas. For example, 15 biomass projects have been implemented successfully. However, wind and geothermal projects often do not make sense because there is not enough population in the areas where these renewable resources are widely available. Reiser emphasised that the challenges in providing renewables were both technical and commercial in nature and that what works elsewhere would not necessarily work in Alaska.

Mikhail POGODAEV

Executive Director, Secretariat of the Northern Forum, Republic of Sakha (Yakutia), Russia;
Chair of the Association of World Reindeer Herders

Mikhail Pogodaev introduced the electricity grid and renewable energy issues in the Russian Arctic, which spans eight regions from Murmansk in the north-west to Chukotka in the north-east. In these regions, electricity prices typically range from USD 0.50 to USD 2.70 — with prices as high as USD 10 in some communities due to delivery challenges — and these are heavily subsidised by the federal government, bringing the average price down to USD 0.05 to USD 0.10 per kWh. The key challenges throughout all the regions have been the delivery of energy resources as well as access to affordable energy for nomadic communities.

The speaker then provided overviews of key northern regions in Russia. The northwestern part is connected to the centralised grid, and half of the population of the northern regions resides there. Almost all population has access to the grid, and the region is not focusing on developing renewables with the exception of tidal energy. A tidal power plant was built in the Murmansk region in 1968. The

region also has surplus electricity capacity, which is exported to Norway and Finland. The Arkhangelsk region has small wind and solar energy potential but it does have some wind generation as well as energy produced from biomass. The Nenets autonomous region relies on oil and gas extraction and small wind-powered stations in the north. Yamal, which has a significant share of nomadic population, is self-sufficient in energy production as the region is the main natural gas producing region of Russia. Krasnoyarsk Kray is a major mining region, and renewables are not well developed there with the exception of hydropower. In Chukotka, solar energy potential is being explored.

Finally, in the Sakha Republic, there are three isolated energy systems. In the west, there is hydropower connected to diamond mining and more recently, oil and gas exploration. The central part is where the region's capital Yakutsk is located. The southern energy system is dependent on metal and coal mining. Other parts of the Sakha Republic are sparsely populated and do not have connection to the main grid. However, the region is home to 18 renewable energy plants and a number of solar stations. The Sakha Republic has a leading position among Arctic regions in the development of renewable energy. It also has the cheapest electricity prices at USD 0.10 per kWh.

Johannes VALLIVAARA

CEO and Cluster Manager, Arctic Smart Rural Communities, ProAgria Lapland, Finland

Before Johannes Vallivaara introduced the Arctic Smart Rural Community project, he provided an overview of Lapland. About 91 per cent of the region is powered by renewable energy, primarily hydropower. Peat is barely used as an energy source. Each municipality has a central utility, which has traditionally used wood chips. Biomass, wind and solar are frequently used by businesses. The key question in Lapland has been on how to transform rich natural resources into viable businesses for resource owners.

The Arctic Smart Rural Community began as a need to connect actors at a regional level. Vallivaara showed the case study of Saija village, which demonstrated how an investment could become profitable in three years when using a hybrid energy production model. The speaker also highlighted two challenges involved in the project. The first was the lack of capital within Lapland. Hence, businesses would have to collaborate with regional actors in Norway and Sweden. Second, there was a need for knowledge development via projects and international operations.

Sunna GUÐMUNDSDÓTTIR

Project Manager, Norðurorka, Iceland

Sunna Guðmundsdóttir introduced Iceland's renewable energy resources. About 81 per cent of Iceland's energy is from geothermal sources. The bulk of geothermal energy is being used for space heating and electricity generation. Iceland currently uses about 1 per cent of the geothermal energy available. The speaker highlighted that given the resource potential, it is eight times more expensive to heat greenhouses in the Netherlands than it is in Iceland.

Guðmundsdóttir compared the two Icelandic communities of Akureyri and Grímsey in terms of their energy sources. Akureyri aims to be a carbon neutral community. Collaboration with its inhabitants has been key in achieving this goal. The Grímsey community is isolated from the main electricity grid and has all of its electrical needs powered by diesel, which is subsidised by the government.

Yngve BIRKELUND

Head of Department of Engineering and Safety and Associate Professor, Arctic Centre for Sustainable Energy, UiT The Arctic University of Norway, Norway

Yngve Birkelund spoke about Norway's renewable energy sources and its future projects. Norway's primary electricity sources comprise of hydro, gas and wind. At the same time, Norway is one of the biggest producers of oil and gas. However, more than 90 per cent of Norway's fossil fuels are exported. Subsea cables are used in the export and import of electricity from Norway to Denmark, the United Kingdom, Germany and the Netherlands. Norway tends to export power during the day and import it at night when it is cheaper.

Norway's energy is sourced primarily from hydro, wind and other renewables including solar energy, geothermal energy and wind. Hydro has been touted as the "green battery of Europe". Wind, due to its intermittency, is balanced with hydro. It has generally been used in northern Norway with the key challenge being winterisation. Renewables have nevertheless been a successful source in Norway. Most of the country's renewable energy potential lies in wind power. Its usage ranges from electric cars and hybrid buses to planes.

Helena REITBERGER

Counsellor and Deputy Head of Mission, Embassy of Sweden, Singapore

Helena Reitberger presented an overview of Sweden's renewable energy sources and plans. By 2040, Sweden aims to be completely powered by renewable energy sources. Currently, 20 per cent of its energy comes from oil and the rest is from renewable energy sources. The key takeaway from Sweden's energy policy is that when it comes to the Arctic, the wants and needs of the indigenous communities are a priority.

DISCUSSION

The discussion started with the exploration of application options for biomass in electricity generation. There was a question on why biomass is not used on a larger scale as it appears to be a feasible and inexpensive option for small northern communities located close to large forest areas. An Arctic participant explained that not all wood is suitable for biomass production. Furthermore, getting the resource to the biomass plant is often a logistical challenge, and the slow growth of trees is another issue.

It was also suggested that energy projects could be coupled with other infrastructure projects such as road and pipeline construction. Integration of various development projects would be ideal, but in reality, there are many obstacles. In the United States, different agencies are responsible for different infrastructure aspects and funding does not come at the same time. In Canada, the same challenges exist, but there is an intention to create an entity where energy and water projects come under the same organisation. Integrated, or hybrid, projects require long-term thinking, which is complicated given various regulations and governance issues. In addition, hybridisation plays a role in energy efficiency, which is important in the Arctic context. The Finnish initiative on energy efficient buildings that will soon be presented at the Arctic Council's meeting was highlighted as one example.

The recurring themes throughout the discussion were project financing and costs associated with integrating new technology, as well as ambiguity around renewable resources. Even when financing is immediately available, there were concerns that not all renewable energy technologies commercially available could automatically be used in the Arctic context, given the region's local conditions, including climate, terrain and community profiles.

Workshop participants noted the differences between the Nordic and North American experience with electrification and renewable energy. Annual per capita electricity consumption varies significantly from about 5,000 kWh in Alaska to 25,000 kWh in Norway, and 20,000–40,000 kWh in Lapland, Finland.

The Nordic countries are much less dependent on non-renewable energy resources, such as fossil fuels. Places like Iceland, which is already using a lot of geothermal resources in its energy mix, are considering further diversification and integration of more renewable energy such as the combination of wind and hydropower to minimise the negative effects of wind's intermittency.

SESSION 5: The Southeast Asian Experience

Alvin CULABA

University Fellow and Professor, Mechanical Engineering Department, Gokongwei College of Engineering, De La Salle University, Manila, Philippines

Alvin Culaba shared the experience of the Philippines in sustainable energy development. The Philippines is made up of 7,500 islands with the population of 107 million people. The weather in the country is hot and humid, and it experiences about 20 typhoons annually between June and November.

The Philippine Department of Energy is mandated to foster the low carbon future, strengthen partnerships and manage the entire energy sector. While the previous administration was moving towards renewable energy, the current administration is energy neutral. It believes that people should exercise the power of choice among the available energy options, including conventional and renewable sources. The goal is to bring down the cost of energy. As a result, the administration is looking at cheaper sources like coal, which have environmental problems associated with them.

In Southeast Asia, the Philippines is a country with one of the highest shares of renewable energy in the national energy mix (32 per cent). Domestic natural gas resources will be depleted in about six years and more imports will be needed. The share of coal is relatively high (35 per cent). Hydro, wind and biomass are less popular right now and the generation of renewable energy varies from island to island. In the south, it is mainly hydro. In central Philippines, it is geothermal energy. In the north, it is a combination of geothermal and hydro energy. The challenges for the employment of renewable energy are the cost of electricity, transmission cost and a mismatch between the location of key industries and renewable resources.

According to the Power Development Plan for 2016–2040, the Philippines will need 43,765 MW of additional capacity by 2040. While this capacity will come from different energy sources, development of renewables is beneficial for several reasons. Renewable energy could insulate the economy from fuel price fluctuation, accelerate electrification in off-grid areas, promote sustainable growth and improve the country's energy security. The government claims that 99 per cent of the country is electrified. However, over one million people still lack access to electricity. Rural electrification is over 90 per cent, but this statistic does not include places that are not considered barangay, which are the smallest administrative units in the country. Barangay contain fewer than 100 households.

Key factors facilitating growth in renewable energy are renewable resources, policy support, tight local resources supply and attractive tariffs. There are different options to promote renewable energy: renewable portfolio standard, green energy option and net metering. The target is to increase the current share of renewable energy in power generation from 25 per cent to 35 per cent. Renewable energy policy aims to provide quality, reliable, affordable and secure supply.

The Feed-in Tariff (FIT) programme accelerated the solar PV development in the Philippines. This is one of the most attractive renewable energy sources due to a high number of sunshine hours, an average of over 1,825 hours. CEPALCO 950 kW Centralized PV Plant, has already been built and is the largest grid-connected PV plant in any developing country. Currently, solar energy is promoted for residential use, and off-grid hybrid systems will become even more significant in the future. The benefits of solar PV are increased investment, job creation, greater energy security and reduced greenhouse gas emissions.

The potential for wind energy is about 700 MW, mainly in the northern part of the Philippines and along coastal areas. The Philippines is home to the first wind farm in Southeast Asia — 25 MW NorthWind Farm in Bangui, Ilocos Norte. However, there are not many industries in the north, even though the electricity capacity is there.

The key strategies currently being implemented are the pursuit of a low carbon economy and legislative support. A low carbon economy can be achieved through public buy-in, enabling the market environment, the implementation of an energy efficiency road map and renewable energy capacity development. Legislative support includes advocating for the passage of policy options, building partnerships among government agencies and harmonising national and international policies and programmes. The Energy Investment Coordinating Council has recently been created to serve as a one-stop shop for projects.

Natasha ALLEN

Founder and Executive Director, Mee Panyar, Myanmar

Natasha Allen provided a description of the renewable energy landscape and off-grid electrification in Myanmar. The country is at a critical point, emerging from a 50-year military government. Two primary goals are maintaining peace and developing energy. As of 2017, the population of over 50 million people consumed 5,260 MW of power. Hydropower and natural gas provide almost 100 per cent of energy. Myanmar has one of the lowest electrification rates in Asia and the world. Electrification rate is at 33–40 per cent according to different sources, and only 16 per cent of the rural population has access to electricity. That is 37 million people without access to modern, reliable energy services.

Roughly 70 per cent of Myanmar's labour force practises farming. They spend 15 per cent of their income on candles and kerosene, lose 1,000 productive hours each year due to the inaccessibility of electricity, and lose 50 per cent of revenue because of the inability to process agricultural goods.

The government of Myanmar has developed three main energy plans by different ministries and partners. The first, Energy Master Plan, has been put forward by the Asian Development Bank (ADB) and Myanmar's Ministry of Energy. The second plan, Electricity Master Plan, was proposed by the Japan International Cooperation Agency (JICA) and the Ministry of Electric Power. Finally, the National Electrification Plan was drafted by the World Bank, Ministry of Electric Power and the Department of Rural Development. What is important is that different plans have different focus areas, influenced by different local and international actors.

The third plan — the National Electrification Plan — is being implemented to meet electrification targets, in accordance with United Nations Sustainable Development Goal #7. It has the goal of attaining universal electrification by 2030 and focuses on grid extension as well as off- and mini-grid solutions. The plan is funded by a loan from the World Bank.

Roughly about 13,000 villages across the country are considered non-electrified and are using self-made mini-grids. These mini-grids provide them with four hours of electricity a day at a price of USD 0.61 per kWh. These systems have been in place for 20 years and arose from necessity. Since the government did not provide access to the grid, the villagers had to make their own grids. In other words, it was a service to the community, not a money-making business.

In these rural households, technical capacity is home-grown. Power system operators need access to finance to upgrade their systems, but at the same time generators are too small to serve all households. Thus, since technical foundation is there in the community and people are willing to build from that, there are opportunities to transform diesel generation using solar hybridisation. Possible outcomes of hybridisation include uninterrupted access to electricity at USD 0.30 per kWh.

Communities are increasingly demanding access to clean, sustainable energy. As a result of protests, there have been closures of coal-fired power plants, and the government is focusing on regulations to support decentralised energy developments (i.e. mini- and off-grid projects), as well as renewable energy integration. Since the government's institutional capacity is low, there are a lot of proposals, but implementation is lacking. More coordination is also seen between private sector and the government in data aggregation efforts.

Community voices have to be prioritised, all existing local capacity has to be accounted for and ways of integrating it thought through. The government needs help in implementing energy solutions, accessing private financing and accessing data. Finally, there should be more public-private sector coordination and streamlining of processes.

Oktoviano GANDHI

PhD Candidate, Solar Energy System, Solar Energy Research Institute of Singapore (SERIS), National University of Singapore (NUS), Singapore

Oktoviano Gandhi talked about the work of the Solar Energy Research Institute of Singapore (SERIS), its research and projects in Southeast Asia. SERIS was founded in 2008 as part of the National University of Singapore. The institute focuses on applied solar energy research and provides professional services for the PV industry. The Solar Energy System Cluster of SERIS has four research groups: Solar Potential and Energy Meteorology Group, Urban Solar Group, PV System Technology Group and Asia PV Quality Assurance Group. Some of the key projects SERIS is involved in are SolarNova, the Singapore government's initiative to accelerate solar energy deployment, the world's largest floating PV test bed in Singapore, and TruePower Alliance.

SolarNova is an initiative led by Singapore's Economic Development Board and Housing Development Board to accelerate deployment of solar PV in Singapore. The target is to achieve 350 MWp by 2020, and 220 MWp of this target has already been tendered.

Another project SERIS is involved in is the National Solar Repository (NSR) where one can find relevant information about the solar PV scene in Singapore, including systems descriptions, meteorological information, solar industry contracts and others.

Singapore is also home to the world's largest floating PV (FPV) test bed. Its main benefits are a cooling effect from the waterbody, saved land space and a hydropower plant that can complement PV variability. The test bed provides side-by-side comparison of major commercial FPV technologies. The system's performance ratio is up to 15 per cent higher than typical rooftop PV systems in Singapore.

There are also plans for an offshore floating PV. There is no demonstrative case that has been built, but it is a potential direction for the development of solar energy because a lot of the world's population lives in coastal areas.

TruePower Alliance is a consortium that works to discover the true power of different PV technologies throughout their lifetime in real conditions as opposed to test conditions. Technologies are being tested in various climates including tropical (Singapore), desert (Alice Springs, Australia) and temperate (Friedenshall, Germany). More locations are expected to join the project in the near future, including some in colder climatic conditions.

Economic viability of PV in Southeast Asia is questionable. The biggest disadvantage for solar is the ongoing fossil fuel subsidies offered in some countries. Solar is currently viable only in the Philippines, Laos and Cambodia.

LEOW Foon-Lee

Adjunct Principal Research Fellow, Energy Studies Institute (ESI), National University of Singapore (NUS), Singapore

Leow Foon-Lee discussed low carbon energy finance in Southeast Asia. He started by identifying some commonalities and differences between Southeast Asia and the Arctic. Both regions have many remote communities, experience extreme weather conditions, and share issues related to ageing infrastructure. But their resources endowment is different with Southeast Asia relying on imports, the population of the Arctic countries being much smaller, the government support in the Arctic being much more significant than in Southeast Asian countries and the latter receiving more help from multilateral agencies like the Asian Development Bank (ADB), the World Bank, Japan International Cooperation Agency (JICA) and the Asian Infrastructure Investment Bank (AIIB).

ASEAN has committed to increasing the share of renewables in its energy mix to 23 per cent by 2025. In the region, demand for additional low carbon investment is on the rise, totalling USD 3 trillion between 2016 and 2030. Four key sectors that need to receive this investment are infrastructure, renewable energy, energy efficiency and food, agriculture and land use projects. Currently, annual flow of low carbon finance amounts to USD 40 billion, which is well below the average annual demand of USD 200 billion. About 75 per cent of current flows are from public finance and only 25 per cent is from private finance, largely in the form of commercial loans.

There are barriers to scaling up low carbon finance. First, accessing finance is an issue because banks would rather get involved in bigger projects. Second, structural features of ASEAN's financial system create maturity mismatches, where short-term bank financing and small investment pools are dominant. Third, there is insufficient environmental disclosure and limited information sharing, which makes it difficult to identify new opportunities or prices and manage environmental risk. Fourth, there is exchange rate volatility between ASEAN member states' currencies. Fifth, national environmental and broader sustainability objectives are not translated into coherent financial policy frameworks due to the lack of incentives for capital and financial services providers.

Proposed solutions to increase low carbon investments include, but are not limited to, the following. First, the development of green investment platforms in order to unite the diverse ecosystem of financial institutions, stakeholders, academia and non-governmental organisations is important. Second, insurance companies or pension funds could lend directly to green projects with long-term investment needs. Third, initiatives to develop voluntary, consistent environment-related financial risk disclosures should be put forward. Generally, projects have to be made bankable in order to be implemented and replicated.

DISCUSSION

Following the presentations on the state of renewable energy in the Philippines, Myanmar and Singapore, research on renewable energy sources and financing trends in Southeast Asia, workshop participants had a brief discussion. The topic that garnered a lot of interest was green finance and whether it required open markets or if bankable projects are a sufficient condition. Participants agreed that, at the moment, projects are not even bankable, so it is too early to talk about the role of open markets even though the funds are available. However, open markets could be advantageous for attracting investors as they would likely lead to the increase in electricity tariffs, and prices would reflect market fundamentals instead of being set and adjusted by governments.

Day 2 | 30 August 2018

SESSION 6: Key Takeaways: Participants' Impressions of Energy Developments in the Arctic and Southeast Asia

Before discussing key impressions, Philip Andrews-Speed, the moderator of this session, asked the presenters from Myanmar and the Philippines to elaborate on their discussions of energy access issues in their respective rural and remote communities. This is so that the Arctic participants could have a better understanding of the energy access challenges and solutions in these locations.

Natasha ALLEN

Founder and Executive Director, Mee Panyar, Myanmar

Natasha Allen explained that in Myanmar, a typical village has around 250 households. A self-made mini-grid with a 50 kW capacity costs about USD 3,000 to install, including a generator, electricity poles and labour. They are generally more than a decade old and set up by a single person. The person is the primary operator and owns the grid. As it is usually the older person — the average age is 60 years old — it is common to hire younger people to help and transfer the knowledge and skills.

It costs about USD 10 for a household to get access to the grid, which is 10 per cent of their monthly income. A flat fee is charged on a monthly basis. When people choose to install meters, they tend to be more mindful about consumption. But the cost is not necessarily an issue; some households might not even see the grid connection as valuable.

In addition to skills transfer and awareness of electricity benefits, safety of such grids is a concern. The system is often set up without any concerns for safety. For example, it is common for the wires to be exposed and within easy reach of young children. Also, one of the common reasons for the system failure is people plugging in extra devices. While households lack basic understanding of the energy system, energy efficient appliances are not widely available either.

Power theft is another challenge. Although there is some accountability at the community level, households and villages rarely keep logs of their monthly energy use. This is important because issuing receipts, for example, could increase the customers' willingness to pay for electricity services.

All of the above challenges call for community-based management models. Allen is the founder and executive director of Mee Panyar, based in Myanmar, which is advocating these models. The company is participating in diesel rehabilitation programmes with five villages. It offers a revenue sharing scheme, whereby education is provided in exchange for a percentage of revenues. The objective is to introduce solar PV in the near future and use diesel generators as backup.

Following Allen's presentation, participants discussed the goals of Mee Panyar in more detail. The company currently is predominantly funded by grants. This allows for flexibility to experiment and test ideas. At the end of the day, it still needs profits and returns. In the longer term, expected payback period for rehabilitation projects is one year with return-on-investment at 59 per cent. Right now, the company is supported by a grant from the University College London (UCL) and is seeking more funding. Locally, there are not many grant opportunities available.

The company's objective is to increase electricity generation capacity and extend hours of service. The long-term objective is hybridisation, because electricity needs to be sustainable. At the policy level,

grid extension is a priority, so it is unclear how long these community-based systems will be independent for. The local operators' jobs might be gone as soon as the grid arrives. However, there is no set plan within the government now. The government pays for access to the grid down to the township level, not the village level. Village households cannot afford to pay USD 800 to get connected to the grid.

Electrification needs to go hand in hand with other developments, including infrastructure. Infrastructure development is needed, such as the construction of larger roads. Access to electricity could also develop industries. For example, rubber farming is widespread, and rubber production could be mechanised to save people's time and increase efficiency.

Alvin CULABA

University Fellow and Professor, Mechanical Engineering Department, Gokongwei College of Engineering, De La Salle University, Manila, Philippines

Alvin Culaba discussed rural electrification in the Philippines in 42,000 of the smallest administrative units called barangay. Talking about barangay is important because although the government claims that almost 100 per cent of the population has access to electricity, people in remote isolated communities are not accounted for in terms of the socio-political unit. So in reality, over one million people do not have access to electricity.

In remote and isolated barangay, the only viable options are solar PV or micro hydro. Solar PV provides 5–10 kW per household, while hydro provides 10–30 kW on average and not more than 100 kW. Hence, solar PV is a good option for households, and hydro, which provides bigger capacity, is a better option for the community. The challenge with hydro is that water resources might be located where there are no potential customers.

Not only people in remote villages are hard to access due to the location and weather conditions, they are also not always happy to receive help or accept energy projects from the government. Big investors are not interested in such small projects. As a result, the only potential providers of energy services are universities and non-governmental organisations (NGOs). Village dwellers have to be trained to run power systems in order to understand that it belongs to them and is there for their benefit.

Once access to electricity is provided to barangay residents and the quality of life improves, new challenges will arise. For instance, installed capacity of 10–30 kW will no longer be sufficient and power systems will not be able to cope with demand. From this perspective, solar PV installations are easier to deal with as stand-alone systems as opposed to hydropower projects that require more maintenance.

The government of the Philippines would like everyone to have electricity, but it is not achievable realistically. Politicians tend to focus on success stories while there is a lack of attention for areas that lack energy access.

Culaba stressed the importance for locals to have a stake in the project and in having the social licence to operate within the community. There are examples when a microgrid is installed, but cables disappear a year later. According to the locals, it is easier for them to sell the equipment than wait for returns from the benefits of electricity. Another issue is that electric cooperatives responsible for

electrification of barangay become more politicised as they grow. Thus, building trust and understanding the needs of communities is important.

DISCUSSION

The Arctic and Southeast Asia: Differences and Similarities

Prior to the general discussion, Philip Andrews-Speed, the moderator of the session, provided general comments on the similarities and differences between the Arctic and Southeast Asia. The differences he listed include long distances, low population density and small community size which add to the cost and commerciality issues in the Arctic. In Southeast Asia, communities can be isolated, but distances are much shorter and population density is high. In the Arctic region, state capacity is higher and financial resources are more readily available than in Southeast Asia. Although there are formal cooperation efforts in the latter, informal cooperation (e.g., Track II, expert collaboration) in the Arctic might be more effective.

The two regions have different climates, but both face extreme weather conditions, which require deployment of robust technology. Other similar challenges include marginalised communities that are small in size and require low-cost solutions. Both regions are vulnerable to climate change, which causes displacement of resources and people. They also have diverse cultures and geography, and as a result require tailored solutions with community participation. Finally, data access is problematic; accurate information is needed for strategic planning and attracting investment.

Challenges faced by the Arctic and Southeast Asia demonstrate the resource nexus and the need to think in terms of a circular economy. Every country has a different governance system, but coordination is key for making things happen on the ground, for ensuring that financing and implementation take place. The question is who is going to coordinate to bring all the components together at the village and community level.

The discussion that followed addressed the issues of funding, links between industrial and energy development, the role of local communities as co-investors in the energy projects and the social aspects of providing access to energy.

Multilateral Funding Opportunities

Multilateral funding agencies are more prevalent in Southeast Asia. In the Arctic, federal intervention and support are more significant, and commitment at the government level is stronger. In Southeast Asia, the problem is too huge for individual governments to address single-handedly, while the problem with multilateral agencies is that small communities tend to be outside their scope of support.

Bringing Industries to Remote Locations to Encourage Energy Investment

The experience of other sectors can be applied to energy issues. In Southeast Asia, for example, telecommunication towers are often located in rural areas, and so are manufacturing and textile facilities. Industries serve as an anchor load. In the Arctic, fish processing can be an example of an anchor load. But this is applicable only to coastal areas as there is no commerce further inland.

Moreover, energy systems are where the industries are, such as mining, extractives and others. That is why energy systems are harder to create inland. In remote areas, there are no such arrangements.

In Russia, a large company, RusHydro, funds projects in northern remote areas. It takes them over 10 years to recoup their investment. The regional government of the Sakha Republic also established a local company responsible for remote isolated grids called SakhaEnergo, and RusHydro helps this company to finance projects. Also, in a company like RusHydro, the majority of employees are not locals, while smaller companies are interested in training and employing local people.

Government-Community-Private Sector Interaction

Workshop participants pointed out the importance of balancing the roles of the government and communities, based on accountability, trust, social buy-in and aspirations. For example, in Alaska, the funding structure is changing from being 100-per-cent provided by the government to one with a co-investment requirement; but people resist this change. In Canada's Northwest Territories, the challenge around power is that third parties are going in, talking to communities and creating high expectations without adequate understanding of local conditions.

It was also pointed out that in the Arctic, if it is something planned for the community, the community would need to have a vested interest, otherwise the initiative will not work. In other words, a top-down approach — even with the money available — is still difficult to implement. Overall, it is often not so much the lack of trust between the government and communities, but an over-reliance on the government. When something breaks and equipment wears off, people expect the government to fix it for free. There is a wide range of opinions — on the government and companies bringing in services — from being extremely supportive to those that are unfavourable. Another major issue is the local brain drain, as young people typically do not return to their communities after studying in the cities.

The challenges in Southeast Asia are similar. Governments need to communicate with communities and need to convince them that it is theirs, to involve them from the planning stage in order to demonstrate transparency. Otherwise, doubts will emerge regarding these outsiders' motivations and purpose. Academic institutions tend to be regarded more favourably as they are perceived to be facilitating a social public good rather than being driven by financial benefits or political agenda. University funds usually come from companies in the context of social corporate responsibility (CSR) programmes.

Societal Aspects of Energy Access

Workshop participants also discussed generational differences, and issues such as resistance to change and over-reliance on government support.

In Alaska, compared with the earlier generations of Alaskan natives who displayed a high level of self-reliance, the current generations have become more dependent on government support. So the challenge is to reinvigorate the culture of self-reliance and in building participation among the younger population.

In the Philippines, there are some indigenous communities that are not very interested in their children being sent to universities. That is why universities set up their own education programmes for these communities with government help. They want to preserve their culture and are not open to learning advanced things as they are worried that their children will not come back to the community after graduation if they become exposed to the outside world.

In Finland, the younger generation is moving to cities. Urban dwellers are more passive and tend to expect help. In the villages, people need to be motivated to stay. They should have a stake in projects rather than fully rely on outsourcing activities to private companies.

In Norway, even the most isolated communities have their own grids. The current challenge is not to provide electricity, but to figure out how to transform the society to use renewable energy.

In Canada, urbanisation is not a challenge because people choose to stay in their communities. Either communities own, maintain and operate energy systems, or the government will play the role. The next generation has to embrace their responsibility and take their own accountability instead of relying on the government.

SESSION 7: Key Takeaways: Consolidating Lessons for the Arctic Renewal Energy Atlas (AREA) Project

The final session was moderated by Gail Mosey and Christopher Len. The aim was to discuss participants' general observations, consolidate key takeaways, and to receive feedback on the Arctic Renewal Energy Atlas (AREA) project.

Gail Mosey opened the session by highlighting lessons for AREA. She emphasised that moving forward, the focus should be on indigenous communities and technology that would work in Arctic conditions. The key challenges are the large volume of information that needs to be integrated under the AREA umbrella and keeping up-to-date with relevant events in order to provide timely updates. Instruments that could be used in spreading the word about AREA are webinars, newsletters and efforts to encourage nation-states to contribute to the project. In order to make sure that AREA is a useful resource for all interested parties, it is important to identify points of common interest, which would also be helpful for getting funding in the future. Information that many countries and communities would find valuable would include information on technology assessment, profiles of companies and their track record, and the energy-water-food nexus.

In addition to the above points, the discussion centred around the following key issues: (1) the role of AREA in the Arctic Council; (2) AREA deliverables; (3) harmonised holistic approach to the Arctic; and (4) AREA's value to the Arctic countries.

First, the Arctic Council's Sustainable Development Working Group (SDWG) currently has two sustainable energy focused projects — the Arctic Remote Energy Networks Academy (ARENA) and AREA. The latter is supported by the various Arctic Council member states as well as the Gwich'in Council International. Also, there is the issue of energy cuts across many sectors. In this regard, the Arctic Council can facilitate the discussion of cross-cutting issues — such as energy — among different Working Groups so that issues can be discussed in a more holistic context.

Second, the four deliverables for AREA would constitute a best practices guide, a map to the extent that it is developed, community energy stories and relevant data. These deliverables are due two months before the next Ministerial Meeting of the Arctic Council scheduled for 2019.

Third, it was mentioned that in Southeast Asia, effort is made to harmonise policy and to enable energy market integration. In the Arctic, harmonisation of energy information and data collection can be facilitated through AREA. With global warming and trade routes opening up, harmonisation of policies could lead to other information that AREA could collect. It could also be useful to tap into the Arctic Council's Agreement on Enhancing International Scientific Cooperation to increase collaboration on data exchange, equipment and scientists.

Fourth, participants also discussed the potential value of AREA for the Arctic countries. It could add information on solar panel, wind turbine, biomass and marine hydrokinetic installation and how practical technical issues are solved in various communities. Off-grid sustainability practices would also be helpful because communities are used to getting electricity from the grid. Also, the target user of the AREA website needs to be clarified, whether it is a first-stop information portal for the general public or a technical platform for experts seeking detailed information on the deployment of energy systems. It would also be beneficial to have Arctic-specific data as opposed to country-wide data. Finally, case studies shared through the AREA portal and at AREA workshops could be more consistent so that it is easier to draw comparisons across different regions. In this regard, for future workshop

presentations, it might be useful to include a standard template that summarises basic information for reporting. This set approach will help to consolidate information from different case studies, which can then be shared via the AREA portal.

In the closing remarks, Mikhail Pogodaev thanked Christopher Len and the Energy Studies Institute for the invitation. He mentioned that it was interesting to learn about renewable energy from the perspective of two different regions — the Arctic and Southeast Asia.

In reference to previous discussions on funding, Pogodaev highlighted Guggenheim Partners' estimate that approximately USD 1 trillion dollars is needed to develop Arctic infrastructure and that there is a discussion on the need of an Arctic investment protocol to provide guidelines for responsible investments in the region.

He also highlighted the importance of building capacity and investing in training, and how both the AREA and ARENA projects could find means to connect with each other. He also mentioned the need to engage with local communities to find mutually beneficial solutions. In harmonising policies, the Arctic countries still have a lot of room to learn from one other and for collaboration.

Mosey agreed, saying that the key to success for the AREA project would depend on sustained engagement by stakeholders and interaction with relevant energy experts, both within and outside the Arctic region. Len added that AREA is a project with long-term potential, given that the issue of facilitating sustainable, reliable and affordable energy access for remote communities through the deployment of renewable and hybrid mini-grid and off-grid projects is gaining momentum worldwide.

AGENDA

Gail Mosey (AREA Project Lead): Gail.Mosey@nrel.gov
Christopher Len (Singapore Convenor): esiclhl@nus.edu.sg

WORKSHOP: ESI Conference Room **Day 1 (29 August 2018)**	
9.30 am	**Registration**
10.00 am	**Welcome Remarks** Christopher Len and Gail Mosey (Co-convenors) (Self introduction by participants and house rules)
10.30 am	**Session 1: Setting the Renewable Energy Landscapes in the Arctic and Southeast Asia — Overview and Problem Statement** In this session the speakers will provide a basic overview of the two regions to set the context. Moderator: Christopher Len *Introduction to the Arctic Energy Landscape* (10 min) Mikhail Pogodaev *Introduction to the Southeast Asian Energy Landscape (*10 min) Gautam Jindal *Discussion*
11.00 am	**Coffee Break (and Group Photo)**
11.30 am	**Session 2: Arctic Renewable Energy Atlas (AREA) — Regional Contributions of Renewable Energy Resource Potential** In this session, the AREA Project Leader will introduce the objectives of the AREA Project and provide a status update. *AREA Project Update* Gail Mosey *Discussion*
12.00 pm	**Session 3: Data Management and Visualisation — Challenges and Gaps** In this session, the AREA Project Leader will provide a status update on the AREA Project which will include issues relating to metadata agreement, national contributions, subnational resources, as well as the overall coordination and management of data and visualisation. *AREA Project Update* Gail Mosey *Discussion*

12.30 pm	**Lunch**
1.45 pm	**Session 4: Regional Contributions of Renewable Energy Resource Potential and Best Practices (up to 15 mins each)** The country representatives in this session will cover the following topics: • Overview of the current and future energy landscape; • Renewable energy resource potential; • Community and energy challenges and opportunities; • Best practices and success stories toward renewable energy deployment. Moderator: Gail Mosey **North America and Russian contributions** • Canada (Jay Grewal) • USA (Janet Reiser) • Russia (Mikhail Pogodaev)
	Coffee Break (15 mins)
	Nordic contributions • Denmark (TBD) • Finland (Johannes Vallivaara) • Iceland (Sunna Guðmundsdóttir) • Norway (Yngve Birkelund) • Sweden (Helena Reitberger) *Discussion*
4.30 pm	**Break**
4.45 pm	**Session 5: The Southeast Asian Experience** (up to 12 mins each) In this session, the speakers will share their views on renewable energy developments in Southeast Asia. Moderator: Liu Yang *Renewable Energy Landscape of the Philippines* Alvin Culaba *Renewable Energy Landscape of Myanmar* Natasha Allen *Solar Energy Research Institute (SERIS): Research and Projects in Southeast Asia* Oktoviano Gandhi *Low Carbon Energy Developments in Southeast Asia — Transfer and Finance* Leow Foon Lee *Discussion*
6.00 pm	**Closing for Day 1 by Gail Mosey and Christopher Len**

6.30 pm	**Welcome Dinner**

WORKSHOP: ESI Conference Room Day 2 (Thursday 30 August 2018)	
9.30 am	**Session 6: Key Takeaways: Participants' Impressions of Energy Developments in the Arctic and Southeast Asia** Free flow discussion with participants invited to share their impressions on what they learnt from the day before. The discussion will be structured as follows: • Impressions on the Arctic energy landscape; • Impressions on the Southeast Asian energy landscape; • Comparing the two regions (similarities and differences); • Aspirations — Obstacles — Path forward. Moderator: Gail Mosey and Philip Andrews-Speed
11.00 am	**Coffee Break**
11.15 am	**Session 7: Key Takeaways: Consolidating Lessons for the Arctic Renewable Energy Atlas (AREA) Project** This last session aims to bring the discussion back to the objectives of the AREA Project. It will be a free flow discussion to consolidate lessons for the AREA Project and provide input for the report. It will focus on: • Review of outcomes; • Potential challenges or barriers to development; • Opportunities for collaboration. Moderator: Gail Mosey and Christopher Len
12.15 pm	**Closing Remarks by Mikhail Pogodaev** Vote of Thanks by Gail Mosey and Christopher Len
12.30 pm	**Lunch**
1.15 pm	**[Arctic Participants and ESI Convenor]** **Session 8: AREA Project Meeting: Inputs on Workshop** • Discussion on the 2018 Arctic Circle Assembly • Arctic Participants will provide feedback and inputs on the event
2.45 pm	**Return to Hotel**
6.00 pm	**Dinner for Overseas Participants**

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FIELD TRIP + MEETING **Day 3 (Friday 31 August 2018)**	
10.00 am	**Field Trip to Marina Barrage**
2.30 pm	**AREA Project Meeting — Planning the Next Steps** Convener: Gail Mosey

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GROUP PHOTO

Participants of the AREA Project Singapore Workshop. Photo by ESI staff.

Arctic participants with the Singapore co-convenor. Photo courtesy of Gail Mosey.

LIST OF PARTICIPANTS

#	Name	Affiliation
Arctic Participants		
1	Yngve BIRKELUND, PhD	*Head of Department of Engineering and Safety and Associate Professor* *Arctic Center for Sustainable Energy, UiT The Arctic University of Norway, Norway*
2	Jay K. GREWAL	*President and CEO* *Northwest Territories Power Corporation, Canada*
3	Sunna GUÐMUNDSDÓTTIR	*Project Manager* *Norðurorka, Iceland*
4	Gail MOSEY (Convenor)	*Project Lead and Senior Energy Analyst* *National Renewable Energy Laboratory, USA*
5	Mikhail POGODAEV, PhD	*Executive Director, Secretariat of the Northern Forum, Republic of Sakha (Yakutia), Russia;* *Chair of the Association of World Reindeer Herders*
6	Janet REISER	*Executive Director* *Alaska Energy Authority, USA*
7	Helena REITBERGER	*Counsellor and Deputy Head of Mission* *Embassy of Sweden, Singapore*
8	Johannes VALLIVAARA	*CEO and Cluster Manager, Arctic Smart Rural Communities* *ProAgria Lapland, Finland*
Singapore and Southeast Asia Participants		
9	Natasha ALLEN	*Founder and Executive Director* *Mee Panyar, Myanmar*
10	Philip ANDREWS-SPEED, PhD	*Senior Principal Research Fellow and Division Head* *Energy Studies Institute (ESI), National University of Singapore (NUS), Singapore*
11	Alvin B. CULABA, PhD	*University Fellow and Professor,* *Mechanical Engineering Department* *Gokongwei College of Engineering, De La Salle University, Manila, Philippines*
12	Oktoviano GANDHI	*PhD Candidate, Solar Energy System* *Solar Energy Research Institute of Singapore (SERIS), National University of Singapore (NUS), Singapore*
13	Peter GODFREY	*Managing Director, Asia Pacific* *The Energy Institute (EI), Singapore*
14	GOH Shu Hui Gina	*Nanyang Technological University (NTU);* *Co-founder and Singapore Representative to the Arctic Youth Network (AYN)*
15	HO Juay Choy, PhD	*Associate Professorial Fellow* *Energy Studies Institute (ESI), National University of Singapore (NUS), Singapore*
16	Gautam JINDAL	*Research Fellow* *Energy Studies Institute (ESI), National University of Singapore (NUS), Singapore*
17	Christopher LEN, PhD (Convenor)	*Senior Research Fellow* *Energy Studies Institute (ESI), National University of Singapore (NUS), Singapore*

18	LEOW Foon-Lee	*Adjunct Principal Research Fellow* *Energy Studies Institute (ESI), National University of Singapore (NUS), Singapore*
19	LIU Yang, PhD	*Senior Research Fellow* *Energy Studies Institute (ESI), National University of Singapore (NUS), Singapore*
20	MOCK Yuan Ning	*Undergraduate Student, Environmental Earth Systems Science* *Nanyang Technological University (NTU)*
21	Hema NADARAJAH	*PhD Candidate, Department of Political Science* *University of British Columbia, Canada*
22	Mary Ann QUIRAPAS	*PhD Research Scholar, Political Science Department* *National University of Singapore (NUS), Singapore*
23	Elena RESHETOVA, PhD	*Research Fellow* *Energy Studies Institute (ESI), National University of Singapore (NUS), Singapore*

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ARCTIC PARTICIPANTS

Yngve BIRKELUND, PhD

Head of Department of Engineering and Safety and Associate Professor
Arctic Center for Sustainable Energy, UiT The Arctic University of Norway, Norway

Yngve Birkelund has been working at UiT The Arctic University of Norway for almost 20 years, the last seven years within the field of renewable energy. He is currently Head of the Department of Engineering and Safety and holds an associate professor position in renewable energy at the Department of Physics and Technology. He finished his master's degree in applied physics in 1998, and a PhD in science in 2003, both at UiT The Arctic University of Norway. Birkelund has a long and broad research background, working with statistical signal processing, non-linear systems, biomedical technology and microwave engineering. He has been a visiting researcher at the University of Texas at Austin, Texas, and at Duke University, North Carolina, and he spent the spring of 2018 at the National Center of Atmospheric Research in Boulder, Colorado, working with wind power prediction and numerical weather modelling. Birkelund led the development of the scientific plan of the Arctic Center for Renewable Energy, established at the UiT in 2017, and is currently on the scientific board of this centre.

Jay K. GREWAL

President and CEO
Northwest Territories Power Corporation, Canada

Jay K. Grewal has a strong background focused on strategic planning, corporate development and financial strategies. As the current President and CEO of the Northwest Territories Power Corporation, she has led the development and implementation of a 20-Year Strategic Plan focused on economic and environmental sustainability and revenue growth. Prior to this, Grewal was Senior Vice President of Strategy and Corporate Development with Capstone Mining. She was responsible for leading strategic planning, enterprise risk management, business effectiveness, stakeholder engagement and sustainability. Previously, she was Managing Director for Accenture Inc.'s B.C. Practice and held a number of executive positions at BC Hydro including acting CFO. She also has extensive experience within the investment banking and finance sector. Grewal is a graduate of the University of British Columbia, Canada with a BA (Hon), and also holds an MBA in finance from the University of Western Ontario. She is an active United Way NWT Board Member, and a past member of the B.C. Business Council, United Way Campaign Cabinet, Board of Governors, University of British Columbia (where she chaired the Finance Committee), and past Chair, Energy Division of the B.C. Children's Hospital Miracle Network.

Sunna GUÐMUNDSDÓTTIR

Project Manager
Norðurorka, Iceland

Sunna Guðmundsdóttir is an engineer. She holds a BSc in mechatronics engineering from Reykjavik University and a MSc in sustainable energy systems from the University of Edinburgh. Since graduating in 2016, Sunna has taught mathematics at college level and worked as a project manager for three energy companies in Akureyri, Iceland. The companies she works for are various and so are the projects she works on. She buys and sells electricity to both homes and businesses and handles correlating planning and management of power stations run by Fallorka. Sunna also works for EIMUR, a partnership in the field of energy, increased utilisation of geothermal resources and innovation. The third company she works for is Norðurorka, which services homes and businesses with processing and the distribution of hot water and drinking water, as well as the distribution of electricity and sewer operations. She has worked on risk management and process analysis for Norðurorka. As well as working in the energy sector in Iceland, Sunna likes outdoor activities like hiking, running and camping.

Gail MOSEY
Project Lead and Senior Energy Analyst
National Renewable Energy Laboratory, USA
Gail Mosey has worked at the National Renewable Energy Laboratory (NREL) as a Project Lead and Senior Energy Analyst for 14 years. She has a master's degree in economics from the Colorado School of Mines and a bachelor's degree in finance from the University of Colorado. Gail is NREL's transnational Arctic lead and works on strategic aspects related to the Arctic and is developing an expertise in energy solutions in remote communities to improve resilience, energy security and in aspects related to the energy-water-food nexus. A primary area of Gail's expertise is working with the United States Environmental Protection Agency (US EPA), siting renewable energy on environmentally compromised lands including economic and technical analysis of the viability of renewable energy on these sites and any related community impact. Another area of her expertise is working with tribes and villages through the US Department of Energy (US DOE) on strategic energy planning that includes energy efficiency and renewable energy solutions to meet tribal energy requirements and improve resilience.

Mikhail POGODAEV, PhD
Executive Director, Secretariat of the Northern Forum, Republic of Sakha (Yakutia), Russia;
Chair of the Association of World Reindeer Herders
Mikhail Pogodaev is Executive Director of the Northern Forum, a non-profit, international organisation composed of subnational or regional governments from eight northern countries. He is also Executive Chair of the Association of World Reindeer Herders, an NGO that unites more than 20 different indigenous peoples from 10 countries across the Circumpolar North. Pogodaev is also the President of the University of the Arctic Institute for Circumpolar Reindeer Husbandry. He was born in 1978, in a reindeer herding village Topolinoe in the Tomponsky district of the Sakha Republic (Yakutia). He graduated from the Saint Petersburg State University of Economics and Finance and has a PhD in economics.

Janet REISER
Executive Director
Alaska Energy Authority, USA
Janet Reiser joined the Alaska Energy Authority as its Executive Director in January 2018. Prior to that she served on the Chugach Electric Board of Directors for nine and a half years serving as Board Chair for six and a half of those years. She has served as a Director on the Alaska Railbelt Cooperative Transmission & Electric Company (ARCTEC) since its inception in 2011. She continues to serve on the Board of Directors of the Cooperative Leadership Network, an organisation dedicated to helping rural electric cooperative directors explore and share successes in the consumer-centric utility model for cooperatives. Janet has been in Alaska for over 30 years, serving in technical and executive management roles in the telecom, construction and engineering industries. She holds a BSc in chemical engineering from the University of Colorado, Boulder, USA.

Helena REITBERGER
Counsellor and Deputy Head of Mission
Embassy of Sweden, Singapore
Helena Reitberger has been the Counsellor and Deputy Head of Mission at the Swedish Embassy in Singapore since 2015. Her previous assignments include postings in London and Beijing as well as various positions at the Department for Asia and the Pacific at the Swedish Ministry of Foreign Affairs. Helena has an MA in East Asian studies with minors in business administration and journalism.

Johannes VALLIVAARA

CEO and Cluster Manager, Arctic Smart Rural Communities

ProAgria Lapland, Finland

Johannes Vallivaara is CEO and Cluster Manager of ProAgria Lapland, Finland. This organisation consists of a team of 23 specialists tasked with developing rural businesses and coordinating a network of food and energy sector companies and developers. He is constantly looking for ideas to keep sparsely populated areas alive and to help the local Arctic communities where he is based develop new business initiatives. Johannes lives in Rovaniemi, which is located in Finland's northernmost region, Lapland. It is a small city with 62,000 inhabitants and known worldwide as the hometown of Santa Claus. He studied management and accounting at the University of Lapland. He has also researched the use of natural raw materials as a food and for healing purposes, and has a small garage studio where he is developing new products in this area. Johannes is also a partner in a small safari company based at the northernmost municipality of Lapland. He loves to spend time with his family in nature during his free time.

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SINGAPORE AND SOUTHEAST ASIA PARTICIPANTS

Natasha ALLEN
Founder and Executive Director
Mee Panyar, Myanmar
Natasha Allen is the Founder and Executive Director of Mee Panyar, a business pioneering a novel business model for the operations, maintenance and workforce training for rural mini-grids, starting in Myanmar. She has recognised expertise in developing training programmes for solar education and a strong technical background that she has employed in improved cook stoves monitoring and evaluation with potential energy as well as the servicing and maintenance strategy with We Care Solar. Natasha was awarded the prestigious Thomas J. Watson Fellowship for her research in best practices for building capacity and ensuring sustainability in energy access interventions. She holds a BSc in physics from Harvey Mudd College and is completing an MSc in engineering for international development at the University College London.

Philip ANDREWS-SPEED, PhD
Senior Principal Research Fellow and Division Head
Energy Studies Institute (ESI), National University of Singapore (NUS), Singapore
Philip Andrews-Speed is a Senior Principal Fellow at the Energy Studies Institute, National University of Singapore. He has 35 years in the field of energy and resources, starting his career as a mineral and oil exploration geologist before moving into the field of energy and resource governance. Until 2010, he was Professor of Energy Policy at the University of Dundee and Director of the Centre of Energy, Petroleum and Mineral Law and Policy. His main research interest is the political economy of energy and resource governance, at the national, regional and global levels. From 2010 to 2012, he led a major European Union Framework 7 Programme project, "Competition and Collaboration in Access to Oil, Gas and Mineral Resources". When he was a Fellow at the Transatlantic Academy of the German Marshall Fund of the United States, he co-authored a report entitled *The Global Resource Nexus: The Struggles for Land, Food, Water and Minerals*. Although Asia has been the focus of the last 25 years of his career, his previous interest was in the Arctic when he visited Greenland on four occasions.

Alvin B. CULABA, PhD
University Fellow and Professor, Mechanical Engineering Department
Gokongwei College of Engineering, De La Salle University, Manila, the Philippines
Alvin B. Culaba is an academician and focal person on energy and environment of the Philippine National Academy of Science and Technology. A multi-awarded scientist, academic, and administrator, he served as Philippine Energy Adviser and independent board member of the Philippine Electricity Market Corporation. As an expert panel member of the Philippine Joint Congressional Commission on Science, Technology, and Engineering, he assessed the S&T competitiveness of the energy sector. He was commissioned to undertake energy policy studies that led to the crafting of the country's energy twin-bill, the Biofuels Act of 2006 and the Renewable Energy Act of 2008. He had previously served as energy consultant for the Asian and Pacific Centre for Transfer of Technology of the United National Economic and Social Commission for Asia and the Pacific and as member of the Technical Working Group of ASEAN Energy Centre-Economic Research Institute for ASEAN and East Asia, among others. Currently, Culaba is a University Fellow and Professor of Mechanical Engineering at De La Salle University where he also served as its former Executive Vice President from 2010 to 2016.

Oktoviano GANDHI
PhD Candidate, Solar Energy System
Solar Energy Research Institute of Singapore (SERIS), National University of Singapore (NUS), Singapore
Oktoviano Gandhi received a Master of Physics degree from the University of Oxford, United Kingdom in 2015. He is currently working towards a PhD with the Solar Energy Research Institute of Singapore

(SERIS), National University of Singapore (NUS). On the research front, he has worked on the engineering aspects of solar cells and modules, all the way to analysing policies' impact on energy intensity. He is currently focusing on the integration of solar energy into power systems, especially in the fields of optimisation and reactive power dispatch. Oktoviano is passionate about implementing renewable energy solutions to solve problems in Indonesia, which prompted him to co-found Alva Energi, an organisation focusing on rural electrification and quality solar energy installations in Indonesia.

Peter GODFREY
Managing Director, Asia Pacific
The Energy Institute (EI), Singapore
Peter Godfrey is the chief representative of the prestigious UK Energy Institute (EI) in Singapore. In addition to his work with the EI, Godfrey provides customised executive advisory services through his own company Merlenergy Pte Ltd. He has gained an international reputation as a leading independent energy strategy and business development consultant with an executive-level international client-base that has included the world's leading national and international energy and mineral resource companies as well as a number of governments and regulatory agencies. Most of Peter's career has been spent in the oil and gas industry, mainly with BP. In Singapore, he was Head of Oil & Gas in Standard Chartered Bank's principal finance team and prior to that, he was a member of Arrow Energy's executive leadership team responsible for building Arrow's international coal-bed methane (CBM) business, based on the company's successful development of CBM reserves in Queensland, Australia.Peter's interests have now extended into renewable and alternative energy development and addressing issues related to industry transition towards a lower carbon, greener and cleaner energy future. Within this context, he has majored on promoting the relevance of "The Circular Economy" as a framework for the future development of energy systems worldwide.

GOH Shu Hui Gina
Nanyang Technological University (NTU);
Co-founder and Singapore Representative to the Arctic Youth Network (AYN)
Goh Shu Hui Gina is a final year Biological Sciences undergraduate at the Nanyang Technological University. She is the co-founder of and Singapore's youth representative to the global Arctic Youth Network (AYN). Being passionate about biodiversity conservation and climate change, she has been volunteering with the National Parks Board as a Conservation Volunteer in the hopes of raising greater conservation awareness on local wildlife. She is also an administrator of the "Campus Creatures" Facebook Page, a platform which allows people to share and learn about their wildlife encounters on various campuses in Singapore. In 2011, Gina was awarded the HSBC-NYAA Youth Environmental Award for her outstanding leadership and contributions in biodiversity and environmental conservation and was given the opportunity to participate in an Earthwatch research expedition to Churchill, Manitoba, in Canada, to study Climate Change at the Arctic's Edge in 2014. More recently in 2017, she was the first youth delegate to represent Singapore at the 5th Arctic Circle Assembly in Reykjavik, Iceland, where she gave a speech on "Biodiversity Conservation and Environmental Stewardship — Igniting the Arctic Youth Movement, Making the Move", and emphasised the need for multilateral cooperation among different countries in order to make conservation of biodiversity and environmental efforts more effective.

HO Juay Choy, PhD
Associate Professorial Fellow
Energy Studies Institute (ESI), National University of Singapore (NUS), Singapore
Ho Juay Choy is currently the chairman of the ASEAN Subcommittee on Sustainable Energy Research (SCSER). He represented the Energy Studies Institute (ESI) in the preparation of the Singapore Country Report for the study "The Economics of Climate Change in Southeast Asia: A Regional Review"

conducted by the Asian Development Bank. He was the project leader for ASEAN projects on Landfill Gas Development and Applications in ASEAN. He was also the Singapore focal point of an ASEAN project on "State of Science and Technology Development in ASEAN". At ESI, his activities include climate change, tracking implementation of the Paris Agreement and HFC emissions monitoring. He is the lead author of the Asia-Europe *Handbook for ASEAN Government Officials on Climate Change and SDGs*. Ho's experience covers industrial energy efficiency, natural gas and biomass cogeneration applications, compact heat exchanger design and applications, enhanced performance of absorbers in absorption refrigeration systems and design and application of energy efficient heat pump drying systems. He obtained his BSc in Engineering from the University of London and his Master's and PhD degrees from the University of Wisconsin.

Gautam JINDAL
Research Fellow
Energy Studies Institute (ESI), National University of Singapore (NUS), Singapore
Gautam Jindal is a Research Fellow at the Energy Studies Institute (ESI) of the National University of Singapore (NUS). He holds a Master's degree in Carbon Management from the University of Edinburgh, Scotland and a Bachelor's degree in Electrical and Electronics Engineering. Gautam has seven years of experience in energy and low carbon policy research, corporate GHG measurement and management and sustainability reporting. At ESI, his research areas include renewable energy integration, climate change negotiations and the management of HFCs under the Montreal Protocol.

Christopher LEN, PhD
Senior Research Fellow
Energy Studies Institute (ESI), National University of Singapore (NUS), Singapore
Christopher Len is a Senior Research Fellow at the Energy Studies Institute (ESI) of the National University of Singapore (NUS) and is in charge of the *Maritime Energy Futures Programme* at ESI. His research focuses on Asian energy and maritime security issues, regional infrastructure connectivity, as well as the growing political and economic linkages between the various Asian subregions. In recent years, he has also developed an interest in the Arctic region, focusing on energy policy-related issues in the Arctic which are also of relevance to the wider world — from the governance of sustainable energy transition, to energy access in remote locations, maritime infrastructures and shipping and issues related to innovation, resilience and capacity-building. He obtained his PhD from the Centre for Energy, Petroleum and Mineral Law and Policy (CEPMLP) at the University of Dundee in Scotland. He also has degrees from the University of Edinburgh, Scotland and Uppsala University, Sweden.

LEOW Foon-Lee
Adjunct Principal Research Fellow
Energy Studies Institute (ESI), National University of Singapore (NUS), Singapore
Leow Foon-Lee has been an Adjunct Principal Research Fellow at the Energy Studies Institute (ESI) of the National University of Singapore (NUS) since June 2017. He has more than 25 years of experience in the energy sector, having worked for some of the world's global US, European and Asian companies, including General Electric (for 20 years), Shell and others, with global assignments in New York, Singapore, Taiwan, Hong Kong, Beijing and Shanghai. His career portfolio encompasses, among others, leading Asia-Pacific regional operations, large gas power and liquefied natural gas (LNG) regasification terminal project developments, turbine technology transfers and coal gasification licensing as well as managing start-ups and the operation of equity joint ventures. He is also the founder and CEO of Enerpower, an energy investment advisory company focused on renewable energies and projects. In 2015, he was appointed as a technology expert by the Asian Development Bank under RETA 8105 for the Transfer of Low-Carbon Technologies to Asia and the Pacific. At ESI, he is developing an interest in the Arctic. Foon-Lee holds a Bachelor of Engineering (Mechanical) from NUS and an MBA from the Rensselaer Polytechnic Institute in New York. He is bilingual in English and Mandarin.

LIU Yang, PhD
Senior Research Fellow
Energy Studies Institute (ESI), National University of Singapore (NUS), Singapore
Yang Liu is a Senior Research Fellow at the Energy Studies Institute (ESI) of the National University of Singapore (NUS). His research interests include energy economics, smart energy systems and climate finance. His current research focuses on the integration of renewables and energy efficiency, and economic impacts of energy transition. Yang has a blend of operational and academic experience in clean energy, public policy and sustainability strategy. Over the last few years, he has published widely on the topics of energy efficiency, renewable energy and policy evaluation in well-recognised journals including *Energy Journal and Energy Economics*. He was previously an energy specialist at the International Energy Agency, where he co-authored the 2015 and 2016 *IEA Global Energy Efficiency Market Reports*, and provided technical assistance to the Chinese government and businesses to improve urban energy systems. He earned his PhD in Energy Economics from the Ecole Polytechnique of France.

MOCK Yuan Ning
Undergraduate Student, Environmental Earth Systems Science
Nanyang Technological University (NTU)
Mock Yuan Ning is a final-year Environmental Earth Systems Science undergraduate from the Nanyang Technological University (NTU). A Youth Environment Envoy with the National Environment Agency, she is passionate about sustainable business and sustainable finance. As a Sustainability Intern with DBS Bank, she is contributing to the development of a bank-wide sustainability strategy. Outside of her coursework in NTU, she attended the Enterprise and Environment Summer School at the University of Oxford as well as a semester exchange at the University of Hertfordshire. She also conducted research on coral reef restoration in Southeast Asia as part of the NTU URECA (Undergraduate Research Experience on Campus) Programme. Yuan Ning has also presented and engaged at international events such as the Arctic Frontiers Student Forum 2018 in Norway, the World Festival of Youth and Students 2017 in Russia, and UNLEASH 2018, a global innovation lab for the UN Sustainable Development Goals.

Hema NADARAJAH
PhD Candidate, Department of Political Science
University of British Columbia, Canada
Hema Nadarajah is a PhD candidate at the Department of Political Science, University of British Columbia. Her research interests concern studying the political processes of translating scientific knowledge into international policy and cooperative management, as well as the influence of legal instruments pertaining to science and technology on interstate relations, in frontier regions such as the Arctic and Outer Space. Hema holds a Master of Environment from the Australian National University where she specialised in Climate Change Policy and Economics, and a BSc from the University of Toronto where she majored in Geography and Geology. She used to work with the National Parks Board of Singapore.

Mary Ann QUIRAPAS
PhD Research Scholar, Political Science Department
National University of Singapore (NUS), Singapore
Mary Ann Quirapas was previously with the Energy Research Institute at Nanyang Technological University (ERI@N) as a Research Associate of the Wind and Marine Renewables Team. Concurrently, she was also the Lead Secretariat of the ASEAN Centre for Energy — Southeast Asia Collaboration for Ocean Renewable Energy (SEACORE) and ERI@N's Joint PhD-Industry Programme (JIP). She has been involved in different research projects funded by international universities and government agencies, at both local and regional levels. Currently, she is a PhD Research Scholar under the Political Science

Department of the National University of Singapore. She obtained her MSc in Asian studies from the S. Rajaratnam School of International Studies (RSIS), Nanyang Technological University. Her research focus is on community energy and Southeast Asia's regional energy security and policy studies on offshore-related renewable energy.

Elena RESHETOVA, PhD
Research Fellow
Energy Studies Institute (ESI), National University of Singapore (NUS), Singapore
Elena Reshetova is a Research Fellow at the Energy Studies Institute (ESI) of the National University of Singapore (NUS). She has several years of experience researching natural gas market developments in Asia and Europe, policymaking in the oil and gas industry in East Asia, ASEAN and North America and being involved the evolution of national energy security policies. She has, in the past, worked with government agencies, non-governmental organisations and research institutes in Russia, the United States (US) and Singapore. During her time in the US, Elena developed a keen interest in the Arctic when she started researching US strategic interests in the Arctic for her master's thesis. In 2016, she co-authored an ESI event report titled *Energy Transitions in a Globalised Arctic: The Role of Science, Technology and Governance*. She holds a PhD in public policy from the Lee Kuan Yew School of Public Policy, NUS, and an MA in International Affairs from Boston University.

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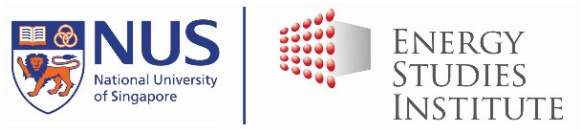
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