	An integrated approach to Sustainable Energy Development
	Magdalena AK Muir, Associate Professor, Aarhus University
	mamuir@ucalgary.ca
Content	Sustainable energy development can assist in mitigating and adapting to climate change, especially with pursuing an integrated approach to the development of renewable energy in synergy with heat and water and waste treatment. The integration of renewable energy, heat and water are quite advanced across the Norden region, though there are variations in policies and legal frameworks, policies and projects. The focus in the following is how policies and legal frameworks can support an integrated approach to renewable energy in synergy with heat and water and waste. The projects in the Norden region could inspire communities in Alaska, Canada and Russia, and small and remote communities worldwide, and a set of illustrative examples are included.
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	1. Norden– not only Nordic – and circum-Arctic countries
The Nordic countries	The Nordic countries (Denmark, Iceland, Finland, Norway and Sweden), and the self governing regions of the Faroe Islands and Greenland (Denmark), and Aland (Finland), are collectively known as the Norden region. These are all countries which have many similarities in policies and frameworks. In the following, a circum-Arctic approach will be taken in order to include experiences from Canada and the Arctic countries. The purpose is to highlight some of the common issues of climate extremes, remoteness and access to renewable energy resources. Furthermore a circum-Arctic approach is important to ensure mutual learnings from projects between regions. Looking at the broader political context, the cooperation on sustainable energy development could be a focus area for the Arctic Council, to be led by the Norden governments and supported by Norden businesses.
Circum-Arctic countries	Sustainable energy projects have multiple benefits for all circum-Arctic countries, many of which rely on local and imported hydrocarbons for electricity, heating infrastructure and water supplies.
Wastewater	All northern communities share common difficulties with treating wastewater due to the cold long winters. There is regional variation in temperature given access to air and marine currents. However, the general pattern is for long cold winters with extremes of minus 40 to 60 degrees Celsius in northern regions of the circum-Arctic countries, and short cool summers.
	2. Differences in policy and legal frameworks in Europe and North America

Reliance on private sector business	Europe and North America have different approaches to development of sustainable energy in synergy with heat, water and waste treatment. Generally speaking, there is reliance on private sector business and investment in North America (i.e. United States and Canada) for sustainable energy development, but without consistent overarching regulation for carbon and environmental costs that could support these significant and long term investments.
Absence of national regulatory frameworks	This absence of national regulatory frameworks in North America discourages investment and creates a patchwork effect at a state and provincial level. As a result, sustainable energy development may be most promising in US states or Canadian provinces with a more developed regulatory framework (such as California and British Columbia), or northern or remote locations where the high costs for energy, water and waste treatment may justify investment.
Policy and legal framework elements	Elements in policies and legal frameworks which can encourage an integrated approach to sustainable energy development in North America are those elements that are already present in Europe and the Norden region. These elements include: • National regulation that provides requirements for increased renewable energy participation and carbon reductions, and creates mechanisms and structures for these requirements to be operationalized. • National regulation that provides consistent and implemented environmental standards for water quality and waste water treatment. • Academic and government funding for research and pilot projects for renewable technologies and wastewater treatment. • Innovative government and private sector financing for sustainable energy projects. North America experiences difficulties in proceeding with these types of integrated projects in the absence of this consistent coherent framework.
EU policies	The Norden region is subject to European Union directives and policies, and the evolving regulatory framework for renewable energy, energy efficiency, water, and climate adaptation and mitigation. Examples of the European regulatory framework include: the Energy Roadmap 2050, the 2020 Energy Strategy, the Renewable Energy Directive, the proposal for Energy Efficiency Directive, the Water Framework Directive, and the 2009 White Paper: Adapting to Climate Change : Towards a European Framework for Action.
Implementation in national legislation	Each Norden country implements these European requirements into the national legislation in ways most appropriate for that country. Even within a country, there can be significant variation. For example, Denmark, Faroe Islands and Greenland each have different renewable energy, heat and water emphasis in their national legislation given geography, climate, population and industries. However, as European policies and the framework for sustainable energy are quite developed,

	this results in a more integrated approach to carbon reduction, energy, water and heat for sustainable energy projects across all Norden countries.
Long term funding	Long term European, regional and national funding is available for research and implementation of sustainable energy projects at a European, regional and national level, which encourages the development and implementation of pilot and full scale projects.
Nordic Council of Ministers	The Nordic Council of Ministers sponsors analysis and encourages the implementation of joint approaches for energy, heat and water across Nordic countries, such as the Action Programme for Nordic Cooperation on Energy Policy for 2010 to 2013.
Nordic Investment Bank	The Nordic Investment Bank's mandate includes sustainable energy and climate. The Bank has invested extensively in sustainable energy projects in the Norden regions including: offshore wind development, hydroelectric projects that substitute for diesel generation, projects to increase energy efficiency, and combined power, heat and water projects. This funding has led to successful implementation and operation of projects, which encourages other projects.
Lack of continental and national policies in US and Canada	Considering Canada and United States, there are no continental and national policies, and no integrated approaches for the development of renewable energy in synergy with heat and water and waste treatment. There are particular benefits in implementing sustainable energy projects in northern areas of the continent. For Canada, northern regions include the Northwest, Nunavut and Yukon Territories and northern areas of some provinces (Alberta, British Columbia, Manitoba, Ontario, Quebec and Saskatchewan). Alaska is the only northern region of the United States
Northern Canada: ¾ of energy consumption is imported hydrocarbons	In northern Canada, almost three-quarters of energy consumption is imported hydrocarbons: fuel oil or propane which is used for heating, and diesel which is used for transport and power generation. Despite many natural gas reserves, gas used only in the communities of Inuvik and Norman Wells of the Northwest Territories. Many communities are not connected to or part of an extensive electricity grid.
Mines	Electricity generation, heat and water in northern Canada may be supported by industrial developments such as mines. Water resources are used for dams and run-of-river hydroelectric projects. The use of district heat is restricted in Canada, but an innovative use of warm mining wastewater has been proposed to heat the community of Yellowknife, Northwest Territories. Remote mining projects in Canada's territories usually generate their own electricity and treat significant volumes of waste water.
Difficult to obtain long term funding	Financing is difficult in northern Canada for sustainable energy projects. For example, the absence of long term funding and funding restrictions has impeded the development of hydro impoundment and run-of-river projects in Iqualuit of the Nunavut Territories, despite the favourable economics of displacing imported hydrocarbons.

	3. Illustrative examples of the Norden Experience
Innovative and inspiring projects	Sustainable energy development projects in the Norden region which illustrate an integrated approach to renewable energy in synergy with heat and water and waste treatment are briefly examined here. These are all examples chosen for their innovation. All represent national implementation of European policies on climate, energy, environment and water. These illustrative examples are all local and national implementation of climate adaptation and mitigation measures.
A unique pattern	Energy uses in the northern Europe differs from southern Europe, given the colder climate, remote northern communities, and the occasional absence of electricity grids. Climate, geography, and small populations contribute to unique patterns of energy, heat and water uses in the Norden region.
	The Norden region is far along on the path to sustainable energy development. Even remote areas like the Faroe Islands and Greenland have innovative projects, though each country has differences which are examined below.
Requirements for energy, heat and water	Within the region, requirements for energy, heat and water are driven by small and large communities, and furthermore by military and research stations, as well as energy, forestry, mining, and other industrial developments. The high cost of importing hydrocarbons for electricity generation and heat in some areas encourages the use of renewable energy, with hydro development being the most prevalent.
Bio-gas	European renewable energy targets for 2020 support the use of biogas for electricity, heat production, transportation, and within natural gas networks, as well as encouraging the re-use of solid and liquid wastes for biogas production.
	Biogas use differs substantially among the two largest producers, Denmark and Sweden. Denmark uses biogas in combined heat and power plants, while Sweden uses upgraded biogas as a vehicle fuel. More than half of Danish production is based on manure, in combination with organic wastes from food and meat processing plants, while the rest is from sewage and landfill gas.
	In Finland, landfill gas is the main source of biogas, and nearly all biogas is used for heat and electricity production. Finland has a natural gas network which could also use bio-methane.
District heat and energy efficiency	District heating is important throughout the Norden region, with high participation in most countries. Norway has the lowest participation in district heating, but now leads in annual growth of district heating scope. Due to the emphasis on district heating, much of the Norden region excels at energy efficiencies.

	For example, almost all of Helsinki's buildings are served by district heating, with heat from electricity generation by coal and natural gas. This results in energy conversion efficiency as high as ninety percent in the winter due to the strong demand for heating. Helsinki is now extending the district network to increase cogeneration in the summer, with heat being converted to cooling. Helsinki's reduction and recycling of wastes results in wastes that can be used for electricity and heat generation, with greenhouse gas emissions comparable to biomass.
	Industrial and commercial businesses also produce heat which can be captured and used. An example is the city of Aalborg in Denmark. Heat from Aalborg Portland, a local cement plant, is delivered through the city's district heating system, satisfying a quarter of the city's heat demand.
	In Iceland, geothermal energy provides one third of overall electricity, but the main use of geothermal energy is for heating. Hot water and heat are distributed through extensive district heating systems for residential and institutional heat and also to support agricultural and business processes.
	Qaanaaq illustrates district heating and energy efficiency in a remote Greenlandic location. In the northwestern community, the above-ground pipes combine multiple energy and water services, while diesel engines and district heating provide highly efficient fuel use. The overall efficiency of hydrocarbon generation for the electricity and heating in Qaanaaq is around eightyfive percent.
	If the Qaanaaq system was supplemented by a thermal storage, efficient integration of wind could also occur. Biogas derived from wastes could also be used to generate electricity and heat.
Hydro	It is projected that the Norden region will have more hydro resources under future climate regimes, supporting more hydro development, and greater electricity interconnections and transfers outside the region. Hydro resources are used throughout the region, including remote locations and smaller communities. For example, all electricity in Iceland is renewable with seven tenths being hydro, and the remainder being geothermal.
	Greenland has the most similar environment and populations to other Arctic regions like Alaska, the Nunavut Territory and Siberia, offering insights for hydro development. Where hydro resources are available, Greenland is switching from hydrocarbons to hydro for electricity generation.
	Funding for hydro facilities is provided by the Nordic Investment Bank, and national and private entities. Interestingly, there are also significantly lower hydro construction costs in Greenland than the Nunavut Territory. This has resulted in proposals that hydro businesses from Greenland consider operating in Nunavut.
Hydrogen	Hydrogen technologies are being explored throughout the Norden region for energy conversion

	and storage. In Nuuk, Greenland, a hydrogen plant uses hydro electricity to electrolyze water into hydrogen and oxygen.
	The hydrogen is stored for conversion into later electricity, and on-demand heat in a fuel cell. Excess heat from hydrogen production and fuel cells heats Nuuk, while the electricity goes to the grid or buildings.
	In the future, compression and distribution systems in Nuuk could enable storing of the hydrogen under pressure in distributable bulks, where it can be used for local energy production, and hydrogen refueling station could allow the use of hydrogen as fuel for transport.
Smart Grid Development	Managing fluctuating power source and meeting growing electricity needs may require smart grids in combination with energy storage. While hydro resources have been developed, abundant wind has not been extensively used in the Faroe Islands due to concerns about de-stabilizing the small electricity grid.
	Smart grids, hydrogen storage and fuel cells are being explored in the Faroe Islands to address grid stability concern. In the future, smart grids and offshore grid development could enable the Faroe Islands to become a net exporter of electricity.
	Electricity from terrestrial wind farms and ocean current turbines in the Faroe Islands could be transferred to other countries by high voltage transmission lines on the seabed. Proposals have also been made to transfer renewable electricity from Iceland to the United Kingdom, and from Norway to Germany and the United Kingdom using high voltage transmission lines, also known as interconnectors. These interconnectors will also support the future integration of offshore wind, wave and tidal resources from the North and Baltic Seas into Europe electricity systems.
Water sanitation and treatment	Water sanitation and treatment can be complex in the remote and northern communities. Constructed wetlands can used to remediate wastewater, but winter freezing may require significant volumes of wastewater to be stored till summer. Further, treated and untreated waste water may be discharged from the coast into marine waters.
	Sustainable energy approaches can assist in water sanitation and treatment, the removal of heat from liquid and solid wastes, and conversion of wastes to biogas even in the coldest climates. Qaanaaq in northwestern Greenland is considering decentralized wastewater treatment, and technologies like dry toilets, due to costs of centralized systems and environmental impacts of disposing of untreated wastewater.
	4. Creating a good business and social acceptance
National successes	Norden countries have developed successful sustainable energy businesses that are prominent internationally. For example, Danish business leadership in wind energy is known globally

	through companies such as Vestas, while Norweigan businesses are known for hydroelectricity and Icelandic businesses are known for geothermal energy. Other Norden business sectors are equally well known. Due to long experience, the architectural and construction sector is known for energy efficient buildings and innovative heat and water applications.
Tax exemptions	Norden companies and countries have also pioneered social acceptance of sustainable energy. Community wind systems in Denmark provide tax exemptions for electricity generated in that community. These tax exemptions have resulted in the use of cooperatives for most wind generation, and broad social acceptance of the development of Danish wind resources.
Participatory governance	Similarly, hydroelectricity development in Norway is characterized by participatory governance approaches that result in social acceptance.
Public communication	Public communication plays a key role in social acceptance in the Norden region.
	Stockholm leads in public awareness, and communication on energy and climate strategy. Stockholm summarizes its strategies with simple brief statements, so all parties can understand and support the strategies on a long term basis. Messages communicated include investing in district heating and public transport, using technology to change to low carbon fuels and increase energy efficiency, managing urban planning to minimize car use in the city, and managing waste through reduction and alignment with the district heating needs.
	The Norden region provides interesting insights, policies and models for sustainable energy development across the circum-Arctic and globally. These insights, policies and models include innovative approaches and projects for biogas, carbon reduction, district heat and energy efficiency, hydro, hydrogen, smart grid development, water sanitation and treatment, sustainable business development, and social acceptance. The challenge will be to ensure knowledge sharing, policy development and technology transfer from Norden communities and projects to communities in Alaska, Canada and Russia, and small and remote communities worldwide. Further research will occur under NORD-STAR to meet this challenge, and to provide a bridge between all these communities.
Ms Muir	As Associate Professor at the University of Aarhus, Denmark, Ms Muir participates in the NORD-STAR project on Nordic strategic adaptation research with a focus on energy, water, coasts and oceans, and adaptation governance. Research discussed in this article is being implemented with the NORD-STAR Danish hub at Aarhus University, in cooperation with the Arctic Institute of North America (AINA). Ms Muir's other academic appointments include Research Associate with the AINA, a bi-national institute based in the University of Alaska Fairbanks and the University of Calgary; alternative Council member of the University of the Arctic on behalf of AINA; and Adjunct Professor at John Hopkins University in Washington DC, teaching in the Masters of Energy Policy and Climate Program. Ms Muir is an Advisory Board Member, Climate with the Coastal and Marine Union (EUCC) based in Leiden, Netherlands; and represents AINA at the Centre for the North Roundtable, Conference Board of

	Canada. Ms Muir has been engaged in circum-Arctic research and positions for over twenty years, including Executive Secretary of the Conservation of Arctic Flora and Fauna International Secretariat from 2002 to 2004, and contributing author and expert reviewer for the Arctic Climate Impact Assessment Scientific Report (2004) and the Intergovernmental Panel on Climate Change Fourth Assessment Report (2007).