Sustainable Energy challenges in the Arctic

Mikko Strahlendorff
Hydropower is often the Arctic export nr 3

- It can be the most important power source to balance the system that includes wind and solar as it can be regulated smoothly adapting to the production of the others.
- Challenges in changing snow cover and large rains that overwhelm dams.
- Biggest renewable that according to IEA for a carbon neutral world needs to grow 33% worldwide.

Energy plants by type on [https://resourcewatch.org](https://resourcewatch.org)
https://hops.fmi.fi for seasonal snow power prediction

Jaakko Ikonen
Cemal Tanis

• Biggest hydropower operator in Finland with many dams on the same river system
• Observations on snow and weather are visualized
• Model analysis on soil conditions and river flow as well
Seasonal forecasts

- Default time window is 20 days back and 10 forward based on NWP weather forecasts
- Clicking on river gauge stations the time window is expanded also to seasonal forecasts 3 months ahead based on ECMWF SEAS5
- Hindcasts are demonstrating how well the HOPS model has performed until now
- A very good new machine learning forecast is developing
Lake ice and river ice dams as challenges

- Tarkka service for lake ice
- Copernicus lake ice product using hi-res EO, surface temperatures and S-1 SAR

- Copernicus S-1 SAR VH analysis for river and lake pixels reveals icejams
Wind power is increasing in the Nordics

- A boom has started already in recent years
- Arctic is selling wind power to the south
- Indigenous interests like reindeer herding are challenging as reindeers seem to avoid turbine vicinities
  - Courts have made wind parks liable
- Permafrost is another challenge
  - Seasonal thawing goes deeper

Only little wind in N-American Arctic

Sámi culture
Permafrost change detection with EO

- Longyearbyen Svalbard
- Arctic Passion progress
  - Permafrost Share Arctic Variable
  - Practical application of permafrost monitoring
- Co-design with local communities including Canadian indigenous and Svalbard municipality
Arctic relies mostly on residential heat from wood burning

- Trees/Bioenergy is the prime source for heat and increasingly power in combined production
- Both residential and communal solutions are included, but industrial size production is connected to forestry-based biofactories for pulp, biofuels and lignin leading to non-fossil solutions: plastic, fibre,
- Cooking is used so surplus energy is an easy gain
- Tree material is also a source for biofuels and a lot of chemicals
https://HarvesterSeasons.com

• Trafficability conditions and forecasts from weather and seasonal predictions

• Seasonal forecasts are based on 90% of ensemble members over/under a threshold for soil wetness, soil temperature and snow depth

• Downscaling to 16m in Finland and soon 30m in Europe is based on TWI and soil information
  • Finnish analysis is also including air-borne laser-scanning of ditches and

• Additional information is available for fireweather, NDVI and tree cover density

• Finnish forest industry is using the app for sustainable forestry and ensuring logistics for biofactory supply chains
Solar power is used privately and being evaluated for larger production

• Solar is in the Arctic seasonally very variable with strong production in summer in even zero in winter
• Still residential solutions are using solar as a lot of housing is almost only used in summer
• Tilted panels are more productive, but snow removal needs solutions that don’t harm panels or their frames

(1. Winter; 2. Spring; 3; Summer; 4. Autumn)
Arctic wave and tidal energy is scarce

Especially scientific observation networks are looking for energy from the marine environment, but solutions are not simple especially in combination with sea-ice.


Seasonal wave power per unit crest length $J$ calculated using WAVEWATCH III model output. Data are averaged from June 2014 to May 2019. (A) Spring: March-May, (B) Summer: June-August, (C) Fall: September-November, and (D) Winter: December-February.

Maximum tidal velocity as calculated with the Tide Model Driver toolbox.
Pilot Service – Improving Safety for Shipping in the Polar Seas

Andrew Fleming BAS and many from Univ Calgary, Univ Ottawa, Met Norway, FMI, DTU, DMI, AWI

• The pilot service aims to reduce the risk of a shipping incident by improving application of the International Maritime Organisation’s (IMO) POLARIS risk assessment system.
• to improve understanding of POLARIS application and usefulness for all maritime operators in the Arctic.
• Developments are co-designed and developed with AC PAME, national ice services, ship owners and operators, insurers and marine safety organisations.

The pilot service comprises three components.
• Historical analysis of shipping risk in the Arctic by comparing a record of ship movements with concurrent POLARIS risk assessments.
• Improving the delivery of current sea ice information to ships by combining position data from satellite AIS information.
• Assessing the usefulness of POLARIS forecasts based on sea ice forecasts.

polarview.aq/arctic

BAS ship RRS Ernest Shackleton navigating through heavy sea ice

examples of POLARIS risk assessment from ice chart (left) and POLARIS forecast (right).
Conclusion

- Arctic is in Europe an energy exporter and the potential is comparable in many parts of the Arctic
- European projects Arctic Passion, e-shape, Destination Earth and national projects are developing concrete services for the challenges involved
- Forecasting renewables with ML and weather forecasts is highly successful, Helsinki solar and all wind power in Finland per hour
- Very good predictions of electricity price as well