REAL ICE

ARCTIC SEA ICE RESTORATION

GROWING ICE USING RENEWABLE ENERGY SOURCES

INTRODUCTION

June 2023

Why refreeze the arctic?

"I don't believe it is a fairytale but i don't know what the alternative is, what we are saying is 'we have to reduce emissions far more rapidly than we are today, we have to leave fossil fuels in the ground, we have to remove the excess greenhouse gases that we have already put into the atmosphere that are creating this crisis today and into the future and then to buy time while we manage those processes we will also need to refreeze the Arctic"
- Professor Sir David King, 28th July 2021

Professor Sir David King: He held the 1920 Chair of Physical Chemistry at the University of Cambridge from 1988 to 2006, and was Master of Downing College, Cambridge, from 1995 to 2000: he is now Emeritus Professor. Sir David was Chief Scientific Adviser to the UK Government and Head of the Government Office for Science from 2000 to 2007

Taken from: https://www.channel4.com/news/refreeze-the-arctic-to-tackle-climate-change-says-sir-david-king

Mission

Our mission is to answer the questions:

- **Is it technically viable to restore & preserve Arctic sea ice using only renewable energy?**
- **Can we develop an economic model that makes it attractive to execute at the scale necessary to restore arctic ice to pre-industrial levels and help slow warming of the planet due to climate change?**
- **Can we inspire at-scale partners including large industrial companies and governments to take our work and deploy it across the Arctic?**

Overview

At **Real Ice**, we are targeting direct action on climate change in the High Arctic, where global warming is occurring at a faster rate than elsewhere on Earth. We aim to achieve this by selecting key locations to restore and preserve Arctic sea ice using an ‘Aqua Freezing’ technique with systems designed to utilise renewable energy sources such as wind and tide to grow ice. These systems will be maintained and operated in collaboration with the indigenous people of the High Arctic regions.

“BY DEMONSTRATING THAT ARCTIC SEA ICE RESTORATION & PRESERVATION IS POSSIBLE WE HOPE TO ENCOURAGE OTHERS TO JOIN THIS ESSENTIAL INITIATIVE”

CIAN SHERWIN: CEO REAL ICE

Challenges of restoring sea ice?

Balancing; ***ecological considerations***, ***community needs*** & ***sustainable economic models*** is essential to a successful deployment of any restoration project

It is especially important in the Arctic, where it takes careful execution to build trust, ensure minimum footprint and incentivize capital investment

How will it benefit the wider public?

Biodiversity Conservation

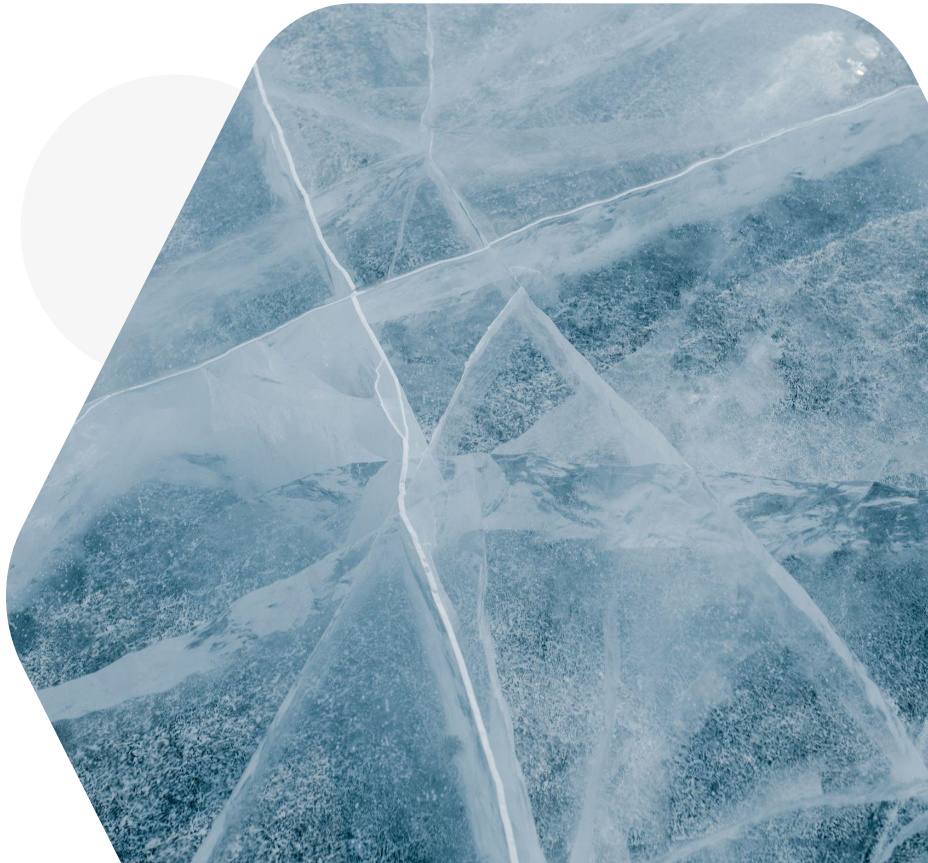
Sustainable Resource Management

Climate Stabilization

Advancing Solar Radiation Science

INSPIRE PEOPLE:

INDIVIDUALS CAN MAKE A DIFFERENCE



Who are your targeted beneficiaries?

The preservation and restoration of Arctic sea ice benefits everyone:

Planetary: Arctic sea ice plays a vital role in regulating global climate patterns. Its reflective surface helps to cool the planet by reflecting sunlight back into space. Preserving and restoring sea ice can mitigate climate change impacts, such as rising temperatures and sea level rise, benefiting people and ecosystems worldwide.

Locally in the Arctic: Indigenous communities and local populations in the Arctic region heavily rely on sea ice for their traditional livelihoods, including hunting, fishing, and transportation. The preservation and restoration of sea ice can help sustain their cultural practices, improve food security, and enhance their overall well-being.

Biodiversity: Arctic sea ice is home to diverse marine species, including polar bears, seals, walruses, and numerous fish species. Preserving and restoring sea ice habitats can contribute to the protection of these species and help maintain the delicate Arctic ecosystem.

AHDR: Arctic Human Development Report, four million people live inside this border.

AMAP: Arctic Monitoring and Assessment Programme Working Group

CAFF: Conservation of Arctic Flora and Fauna

How will you reach your beneficiaries?

Collaboration and Partnerships: Engaging with local communities, indigenous organizations, environmental NGOs, and research institutions can ensure a participatory and inclusive approach, leveraging their expertise and local knowledge.

Advocacy and Policy Influence: Working closely with policymakers, government agencies, and international organizations can help advocate for policies and regulations that prioritize the preservation and restoration of Arctic sea ice.

Education and Awareness: Conducting awareness campaigns, workshops, and educational programs can help inform and engage the broader public, raising awareness about the importance of Arctic sea ice preservation and restoration.

Research and Innovation: Supporting scientific research and innovation can lead to technological advancements and new approaches for sea ice preservation and restoration, benefiting both the scientific community and the broader public.

Leadership Team

Andrew Woods

Chief Engineer

34 years designing and deploying some of the most complex water processing systems internationally and in the UK including at the Spallation Neutron Source at the Rutherford Appleton Laboratory.

Cían Sherwin

Founder & CO-CEO

Bangor University MSC, 2 years leading Real Ice from a wholly volunteer and N.Wales organisation through initial fundraising and on to recruiting a world class team to support the company's development.

Andrea Ceccolini

CO-CEO

An expert on data science and machine learning with a keen interest in scientific innovation for the environment, clean energy health and new materials.

Simon Woods

Co-Founder & Executive Chairman

A seasoned company builder & business development leader from the world of technology, Simon is supporting strategy and regulatory efforts for the leadership team.

Steve Hall

COO

With over 30 years experience in ocean science, policy and technology including serving as CEO of the Society for Underwater Technology, heading the International Office at the UK's National Oceanography Centre, and as Vice Chair of UNESCO's Intergovernmental Oceanographic Commission.

Christine Woodhouse

Investor & Documentary Filmmaker

Stanford educated general counsel, fund manager, investor & documentary film producer. Christine produced the influential One Vote documentary featuring Warren Buffet and is currently involved with films in production in the French Pyrenees and Nigeria. Christine leads the effort to document the Real Ice journey on film.

Keith Grehan

CFO

Helping Companies grow and refocus for over twenty years as an executive (Chief Executive Officer, Managing Director, and Chief Financial Officer), investor (Private Equity, Venture Capital and debt provider) and non-executive (Director and Advisor).

Advisory Board

World leaders in Polar science, policy & climate regulation are advising Real Ice.

Prof. Peter Wadhams

Chairperson

Peter Wadhams ScD, is Emeritus Professor of Ocean Physics, and Head of the Polar Ocean Physics Group in the Department of Applied Mathematics and Theoretical Physics, University of Cambridge. He is best known for his work on sea ice. He is credited with alerting the world to the full extent of sea ice melt, being the first to measure the ice from beneath aboard British Navy submarines in the 1970's. Until the end of 2012, Professor Wadhams was on the Scientific Committee of the European Environment Agency. In 1990 he received the Italgas Prize for Environmental Sciences and had also been awarded the Polar Medal (UK) and the W. S. Bruce Prize of the Royal Society of Edinburgh. He is a Visiting Professor at the Università Politecnica delle Marche, Ancona, and a member of the Finnish Academy.

Alice Rogoff

Alice Rogoff is Publisher and Owner of ArcticToday.com. From 1985 to 1997, she was Chief Financial Officer of US News and World Report. She served at The Washington Post Co. as assistant to publisher Donald Graham, and she was the creator of the Post's National Weekly Edition. Earlier in her career, she served in President Jimmy Carter's administration as special assistant to the Director of the US Office of Management and Budget. Alice is also the founder of Arctic Circle (https://en.wikipedia.org/wiki/Arctic_Circle_(organization) established in 2013 together with the former President of Iceland and the former premier of Greenland. In addition Alice is a founder of the Arctic Imperative, a lecture series dedicated to raising awareness of circumpolar north issues. She is the former publisher and owner of Alaska Dispatch, and co-founder of a number of other organisations, including the Alaska Native Arts Foundation.

Dr. Dwayne Menezes

Dr Dwayne Ryan Menezes is the Founder and Managing Director of Polar Research and Policy Initiative. Dr Menezes has long pursued a career at the intersection of academia, policy, social entrepreneurship and the arts. His many senior policy roles include serving as Consultant to the Secretary-General of the Commonwealth. He is Vice-President of Arctic Today, the world's foremost media outlet covering the circumpolar North. In addition to his other roles, Dr. Menezes currently serves on the All-Party-Parliamentary Group for Greenland at the UK parliament.

Scientific Background

First proposed by **Flannery** et al in **1971**, researchers such as Professor **Steven Desch**, proposed 'Arctic Ice Management' as a method of Solar Radiation Management (SLR).

Bitz & Pauling, 2021 first looked at the principles behind flooding the sea ice to show that flooding snow on sea ice early in the sea ice growth season. For this biomimicry scheme to be most effective, the pumps must be deployed almost immediately

Real Ice have been working for on an engineering solution for coastal ice preservation & restoration, utilising renewable energy powered pumping machines.

Real Ice is developing an automated, modular system that can target remote, large scale sea ice restoration & preservation.

A prototype Hydrogen fuelled pump will be trialed in the Canadian High Arctic Research Station (CHARS) in Canada in November 2023 and Nome, Alaska in February 2024.

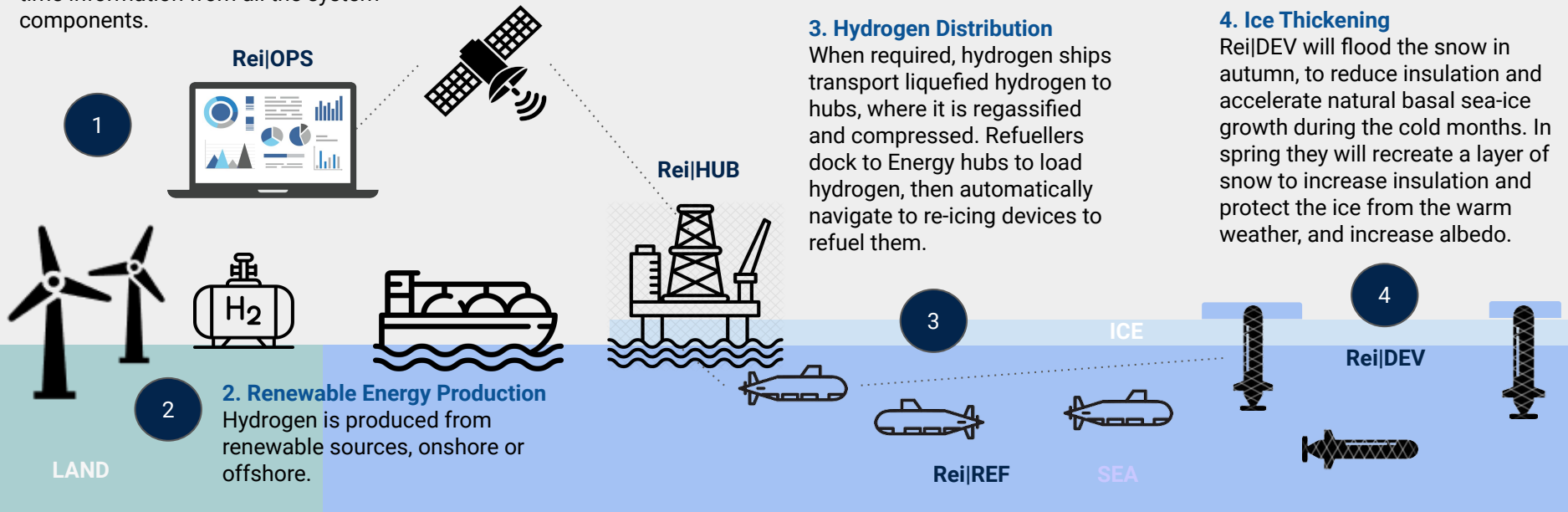
[1] Flannery, B. P., H. Kheshgi, G. Marland, and M. C. MacCracken (1997), Geoengineering climate, in Engineering Response to Global Climate Change: Planning a Research and Development Agenda

System Components

Legend
Rei|OPS: Operation centre for monitoring and planning
Rei|HUB: Energy Hubs storing and providing hydrogen
Rei|REF: Fuel Cell AUV Refuellers distributing hydrogen
Rei|DEV: Fuel Cell AUV Water Pumps - ice and snowmaking

As sea ice breaks and drifts. Components can move with it, and navigate to the required destinations taking into account the dynamic nature of sea ice.

1. Ops and Comms
Distributed operations, located in key regions and in energy hubs, monitor progress, maintain components and optimise global re-icing by receiving real time information from all the system components.



2. Renewable Energy Production
Hydrogen is produced from renewable sources, onshore or offshore.

3. Hydrogen Distribution
When required, hydrogen ships transport liquefied hydrogen to hubs, where it is regassified and compressed. Refuellers dock to Energy hubs to load hydrogen, then automatically navigate to re-icing devices to refuel them.

4. Ice Thickening
Rei|DEV will flood the snow in autumn, to reduce insulation and accelerate natural basal sea-ice growth during the cold months. In spring they will recreate a layer of snow to increase insulation and protect the ice from the warm weather, and increase albedo.

Large Scale Re-icing

The Purpose:

We must protect sea-ice from melting completely during the summer months.

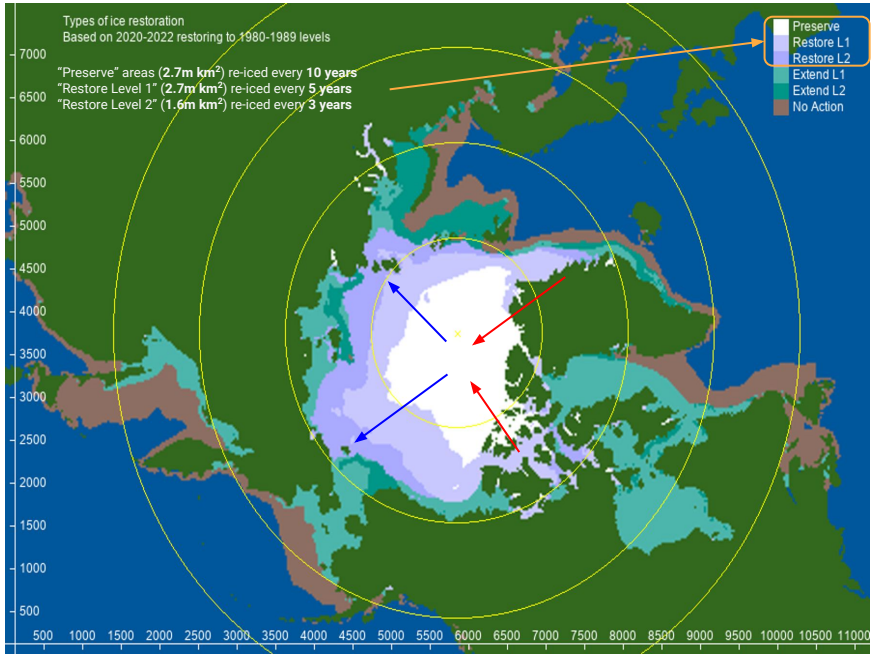
REAL ICE is designing a high-autonomy, modular system that, will be accelerating natural processes, can thicken-up sea-ice in large areas, help it survive the summer months, and use only renewable energy to power the devices.

The Benefits of large scale re-icing:

Time to fight Climate Change
Saving sea-ice will give us more time in the battle against climate change thanks to its cooling effect, and the slowing of permafrost thawing and glacier melting

Preserve Arctic Ecosystems
The Arctic is known as 'Earth's refrigerator', responsible for keeping our planet from warming but if we lose this vital coolant we are on a course set to surpass tipping points for environmental catastrophe.

Every year we would target around **1.38m km²** for re-icing



Snow flooding (Sep-Dec)
Progression from colder to warmer areas

Snow making (Mar-May)
Progression from warmer to colder areas

Climate Impact: ‘AquaFreezing’ Approach

Long-Term Cycles:

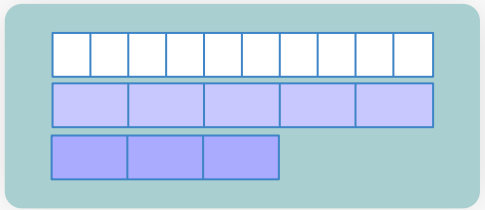
We focus on areas where we can preserve or restore full-year sea-ice (white and purple): a total of **7 million km2.**

“**Preserve**” areas (2.7m km2) re-iced every 10 years

“**Restore Level 1**” (2.7m km2) re-iced every 5 years

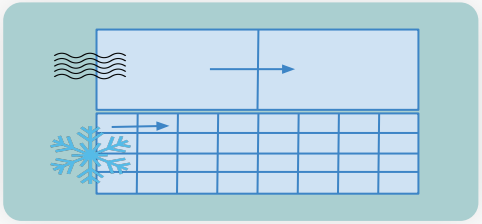
“**Restore Level 2**” (1.6m km2) re-iced every 3 years

Every year we would target around 1.38m km2 for re-icing.



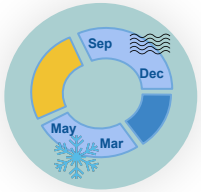
Short Term Cycles:

Rei|DEV split their allocated area like a matrix, and relocate across cells once they complete one to the required ice or snow thickness. Snowmaking will cover smaller cells from a single spot, relocating more frequently.

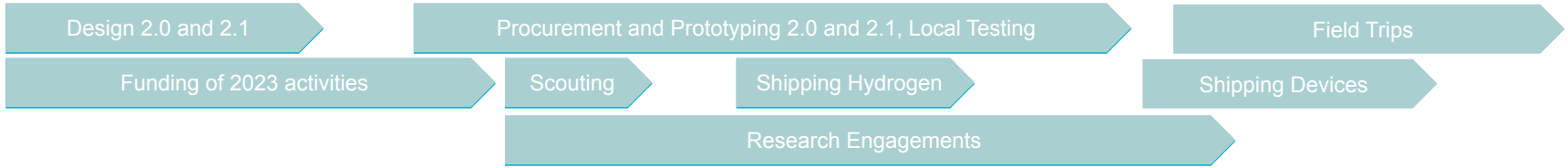


Yearly Cycles:

Sep-Dec (17 w): Flood 20 cm of snow with 15 cm of water
Mar-May (13 w): Create 20 cm of snow with 8 cm of water



12-month Timeline



April
Target Locations Preliminary Decision
Preliminary selection of target locations
Design 2.0

May
Funding effort
Release of short doc
Roadshow
Design 2.1

June
Survey Trip(s)
Visit target location(s) and final decision
Procurement of 2.0 and 2.1 equipment

July
Local Testing
Local testing of 2.0
Initial engagements for AUV

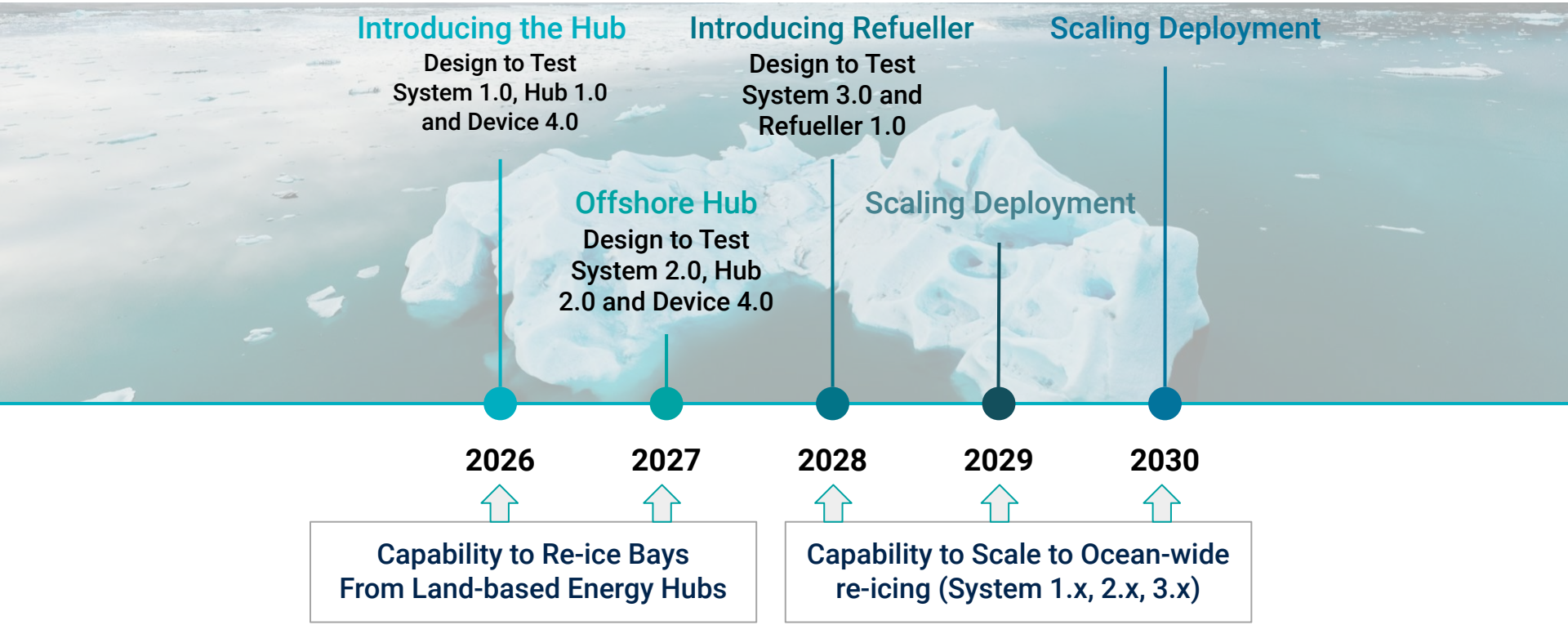
August
Shipping H2 Deadline
Sea Freight H2 to destinations for Q4 23 and Q1 24 field trips

September
Local Testing
Local testing of 2.1 device

Q4 23
Field Trip 1
Air Freight devices to target location
Field Trip 1

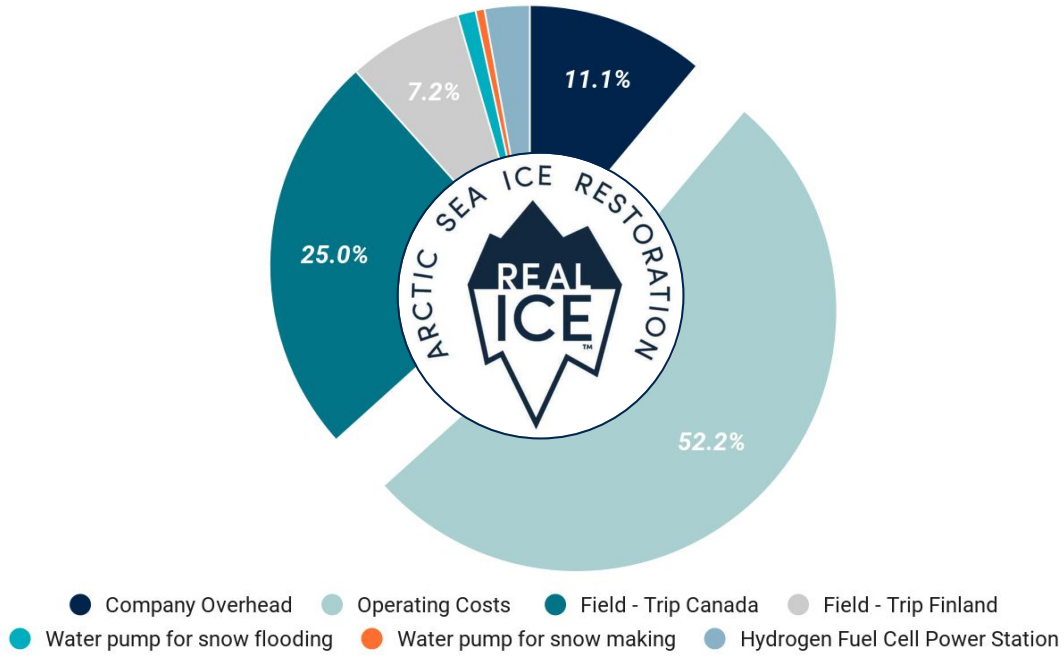
Q1 24
Field Trip 2
Air Freight devices to target location
Field Trip 2

Roadmap: Large-Scale Re-icing System (Ocean scale)



Use of Funds (2023/24)

$500k / £420k raise: Q4’2023/Q1’2024



Giving Page

Why donate?

Your partnership will be acknowledged through prominent recognition in our communications, reports, and events, showcasing your commitment to environmental sustainability.

We firmly believe that with your support, we can drive meaningful progress in Arctic sea ice restoration and preservation. Together, we can protect our planet's fragile ecosystems and secure a sustainable future for generations to come.

Join us in this vital journey by helping us reach $500,000 given in donations today. Together, let's make a lasting difference in the fight against climate change and the preservation of Arctic sea ice.

Thank you for your consideration and support,

The Real Ice Team.

Contact: Cian@realice.eco for further inquiries or donations

REAL ICE

For additional information contact:

Cian@realice.eco

Appendix

Carbon & Albedo credits

Allison Wood:
Partner, McGuire Woods

“We believe that a multi-jurisdictional approach will be successful”

ALLISON WOOD
Advisor to Real Ice

Allison is nationally recognized in the United States as a leader in the area of climate change law. For more than two decades, many multi-national companies and nonprofits have turned to Allison for advice on climate change issues. Allison has represented clients before the Supreme Court and has testified multiple times before Congress on the legal issues surrounding climate change.

Leverage existing cap and trade mechanisms in the US to partner with industry to fund development of the necessary infrastructure in the Arctic to produce ice at massive scale

In Canada, carbon taxes coupled with cap and trade provide significant incentives for collaboration with both industry and government.

In Europe, where carbon cap and trade is no longer supported, we intend to work with regulators to consider approving reimbursement for initiatives such as Real Ice, that can provide verifiable first order cooling effects from increased surface reflectivity (increased albedo) in mitigation of climate change

Local Community Engagement

There are 40 different ethnic groups in the region and Indigenous peoples make up an estimated 10% of the area's inhabitants.

Indigenous groups include; the Saami in Finland, Sweden, Norway and Russia, Nenets, Khanty, Evenk and Chukchi in Russia, Aleut, Yupik and Inuit (Iñupiat) in Alaska, Inuit (Inuvialuit) in Canada and Inuit (Kalaallit) in Greenland. Real Ice will engage with the following Circum-Arctic & Regional Councils and Regional Non-Governmental Organisations. Members include the eight Arctic Nations: Canada, Denmark, Finland, Iceland, Norway, Russia, Sweden and United States.

Real Ice will engage with the following Circum-Arctic & Regional Councils and Regional Non-Governmental Organisations:

Arctic Council Members

- Inuit Circumpolar Council (ICC)
- Gwich'in Council International (GCI)
- Aleut International Association (AIA)
- Saami Council
- Arctic Athabaskan Council (AAC)
- Russian Association of Indigenous Peoples of the North (RAIPON)

Council Working Groups

- Arctic Monitoring & Assessment Programme (AMAP)
- Conservation of Arctic Flora & Fauna (CAFF)
- Emergency Prevention, Preparedness & Response (EPPR)
- Protection of the Arctic Marine Environment (PAME)
- Sustainable Development Working Group (SDWG)

NGOs & IGOs

- Greenpeace
- WWF
- National Oceanographic and Atmospheric Administration (NOAA)
- International Maritime Organisation (IMO)

In The News

"Could new technology help preserve and restore Arctic sea ice?"

WWF

"Existing approaches to mitigating climate change and Arctic ice melt are proceeding too slowly. Therefore, scientists and innovators are crafting creative, unconventional ways to preserve and restore Arctic ice — here are two wildly different approaches being tested."

SB

"The winners will receive support from the awards' pro bono community and £25,000 each to develop their ideas. To support any of the winners or to support the awards themselves please get in touch."

STEPHEN LLOYD AWARDS

"The rapid melting of Arctic sea ice has prompted some scientists to take climate action a step further; not just by cutting emissions, but also thinking of ways to reverse the damage."

CBC radio — The Current

'The melting of the ice caps is not just bad news for polar bears — losing reflective surfaces heats up the Earth for us all. Reversing it will require a bold vision and a fair bit of cash'

THE TIMES

"Hey presto. The melting of Arctic Ice-one of the most visible symptoms of climate change-is halted and reversed."

Forbes

"Real Ice pledges to help Indigenous people obtain re-icing machines that can increase ice thickness and restrict ice melt in Arctic regions."

( ) for Tomorrow

HYUNDAI × UNDP

"A North Wales company has invented a revolutionary ice-making machine powered by renewable energy"

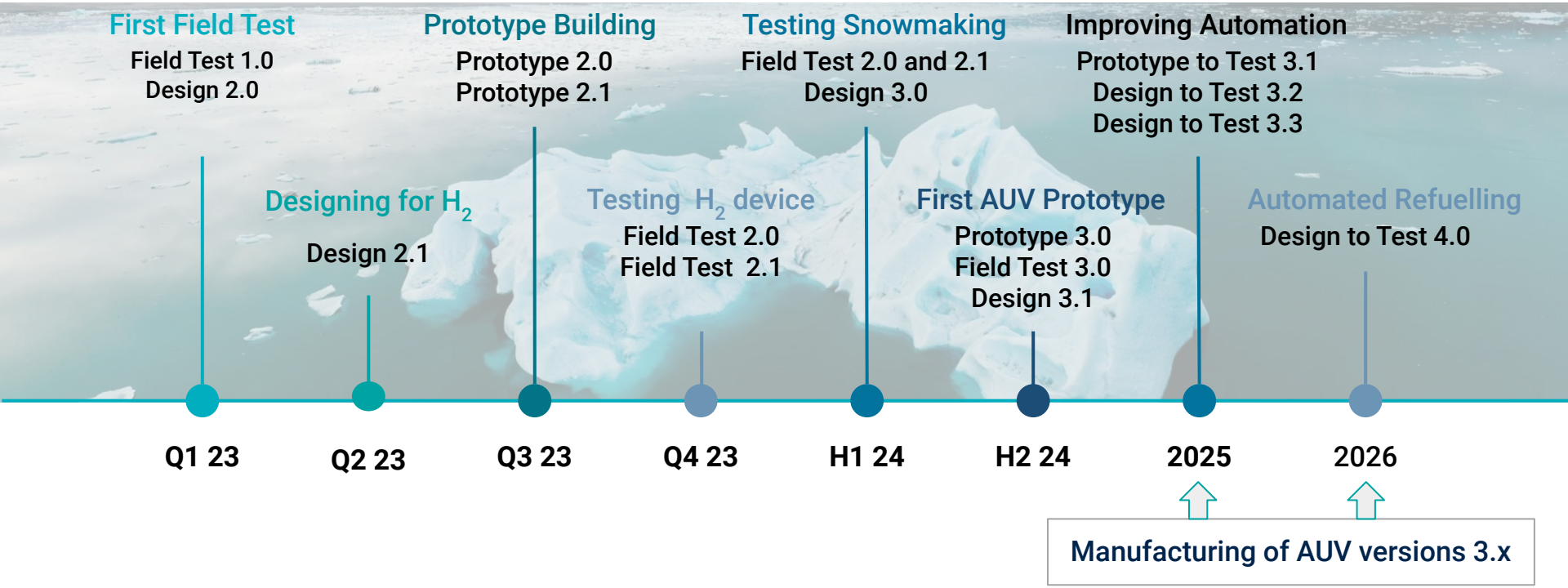
PRIFYSGOL BANGOR UNIVERSITY

"Students and graduates of Bangor University have an ambitious plan to re-ice the Arctic"

BBC NEWS

BBC RADIO

Roadmap: Re-icing Devices (Coastal & Bay Scale)



System Designs - *Real Ice Device*

A Real Ice Device is the terminal assembly, including a water pump and its required energy source to displace water and generate ice or snow. In its evolutions it can be operated manually or automatically, and have a number of increasingly “intelligent” automation functions

Device Version	Energy	Flood	Snow	Run-time	Type	Refuel	Automation	Restoration Type
1.0	Battery	✅	-	2h	Manual	Manual	-	Experiments
2.0	Fuel cell	✅	-	12h	Manual	Manual	-	Coastal
2.1	Fuel cell	✅	✅	12h	Manual	Manual	-	Coastal
3.0	Fuel cell (*)	✅	✅	24h	AUV	Manual	Pre-progr. navigation, work and return home, acoustic wave comms, positioning	Bay-scale
3.1	Fuel cell (*)	✅	✅	24h	AUV	Manual	+Obstacle avoidance, optimise destination	Bay-scale
3.2	Fuel cell (*)	✅	✅	24h	AUV	Manual	+Flexible objective, interactive planning	Bay-scale
3.3	Fuel cell (*)	✅	✅	24h	AUV	Manual	+Reading ice features, angle of flood/snow	Bay-scale
4.0	Fuel cell (*)	✅	✅	24h	AUV	Auto	+Auto refuelling	Ocean-scale

(*) AUV’s will require battery energy sufficient for navigation and drilling hole. Fuel cell energy generation will only be usable once the AUV resurfaces above ice (air input requirement)

Policies & Regulations Governing the Arctic

Defining soft dependencies (E.g. Awareness, Benefits (Positively affecting Arctic) & Image)

Real Ice will need to prove the benefits of our technology to local governance & regulatory bodies in Arctic regions to effectively devise a strategy for deployment, this includes:

Multi-jurisdictional engagement roundtable sessions with political key stakeholders in;

- Arctic Coastal States (Canada, Denmark (via Greenland), Finland, Iceland, Norway, US, Sweden and (maybe in the future) Russia)
  - Annual events to facilitate conversations surrounding Arctic refreezing

Establishing credible research & development to demonstrate the benefits and to meet the standards set out by regulators in the regions

Building a positive relationship with local political & tribal leaders through meaningful engagement

Jurisdictions presiding over the Arctic

EEZ Map of Arctic w/ Shipping routes

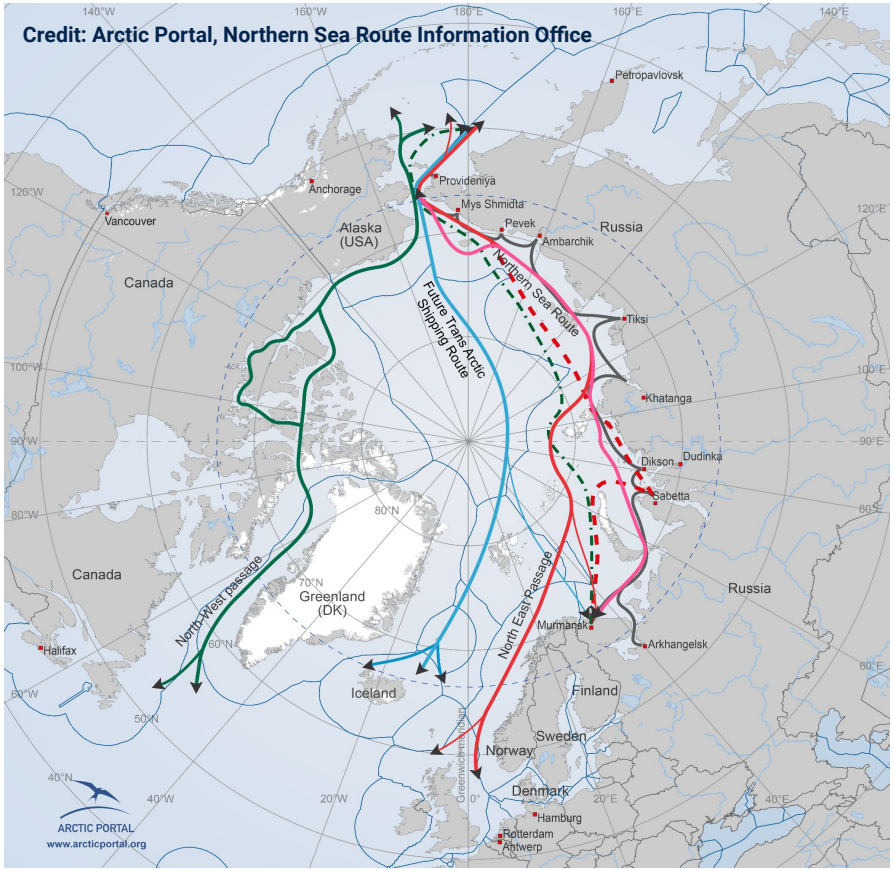
Real Ice will need a multi-jurisdictional approach dependent on the country operations take place within. Therefore, when considering deployment in the Arctic, Real Ice must consider the EEZ map and shipping routes that dissect the region. Similar to this, each region will require a tailored approach with additional layers of approval based on the distance from shores and settlements.

Considering regulatory and policy compliance precautions we can assume that;

Onshore Demonstrations = **Low** engagement(4-12 weeks)

>12nm / 22 km / 14 mi = **Medium** engagement (3-12 months)

<12nm / 22 km / 14 mi - 370 km; 230 mi = **High** engagement (1+ years)



Key - Engagement
High - International & National Authorities
Medium - National/State/Provincial Authorities
Low - Local Authorities

Regulatory & Policy Approach

Approval, Support & Guidance

- For deployment of Real Ice services
- Real Ice must perform the following process before developing an approach for conducting research or deployment;

- **Identify Key Stakeholders**

A planning authority will be consulted and permission obtained before deployment

- **Provide Impact Assessments**

The relevant assessments will be completed to mitigate risks to environment, wildlife, etc.

- **List Competencies & Assurances**

External groups will be hired to conduct the R&D and insurances will be given to perform the tasks as described in our proposals

Real Ice is committed to the Policies and Regulations set out by;

- The Arctic Coastal States
- Trade and export law (International/National in residing country (Dependence on Org. Structure)
- International Law of the Arctic Sea Treaty and the United Nations
- Indigenous Organisations & Advocacy groups

Hard Dependencies for Formal Approval to Act

Defining hard dependencies (E.g. Timescale, Engagement, Application Material, Permissions & Approval)

Real Ice will have to allow for the time taken to process applications and navigate bureaucratic barriers to deploy systems in Arctic regions with various levels of complexity exhibited from each country

Regulatory and Policy approach/Impact Assessments

Building a positive image with local political and tribal leaders through meaningful engagement from the outset of the initiative