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Sustainable Development

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Oceans Solutions Report

SDSN
Northern Europe

Get inspired to act

This report is created to inspire you to act – act to reach Sustainable Development Goal No. 14: *Life Below Water – Conserve and sustainably use the oceans, seas and marine resources for sustainable development.* The report showcases some examples of solutions from Northern Europe to show that a sustainable use of our oceans is possible. *Enjoy!*

Oceans Solutions Report
May 2017, Gothenburg, Sweden
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Introduction

Our oceans are key to well-being and social and economic development worldwide. At present, as much as 40% of our oceans are heavily affected by human activities. They are polluted, overfished and contaminated with plastics. Now, let us join forces to figure out how to reverse the current in a sustainable direction!

Key facts about oceans

Three is the magic number for oceans:

- Three quarters of Earth's surface is covered by oceans.
- Three billion people depend on marine and coastal biodiversity for their livelihoods.
- Three billion people depend on the oceans as their primary source of protein, making oceans the world's largest source of protein.
- Thirty percent of the CO_2 produced by humans is absorbed by oceans, buffering the impacts of global warming.

Oceans are the key driver of global systems that make Earth a comfortable place to live.

The UN Ocean Conference

The timing of this report is of course no coincidence. Sweden and Fiji are co-hosting the high-level United Nations Ocean Conference in New York 5–9 June 2017, aiming to reverse the decline in the health of our oceans, for the sake of people, the planet, and prosperity. The UN Ocean Conference will be solution-focused with engagement from different stakeholders. This report contributes to the preparation of solutions to save our oceans.

Together for sustainable solutions – who are we?

The Sustainable Development Solutions Network (SDSN) Northern Europe is an action-oriented network focusing on mobilizing Nordic scientific and technological expertise to solve problems and create a more sustainable society.

The Maritime Cluster of West Sweden is a network for collaboration on innovation- and knowledge-based blue growth for the maritime sector in western Sweden.

Together, we are joining forces to promote innovative solutions to meet the challenges of our oceans. We do this by creating this report and getting together at the Solution Initiative Forum (SIF) Oceans on May 16, 2017 in Gothenburg, Sweden.

SIF Oceans is an action-oriented event where entrepreneurs, industry, investors, researchers, and decision makers come together to identify and promote solutions to challenges connected to our oceans. At this event, this report is handed over to the Swedish Minister for International Development Cooperation and Climate and Deputy Prime Minister Isabella Lövin, as part of the preparatory work for the UN Ocean Conference.

Advisory Panel

All the solutions comprised in this report have gone through a self-evaluation of their impact in relation to the Sustainable Development Goals (SDGs) – a so-called SDG Impact Assessment. The Advisory Panel took part in the review of submissions and gave feedback to the solution owners regarding their replies in the self-evaluation. The focus has been on the learning process of going through an SDG Impact Assessment, especially to learn to reflect holistically about potential effects of the solutions on the SDGs. The Advisory Panel consisted of the following members:

Anna Nordén
PhD in Environmental and Behavioral Economics and program manager of SDSN Northern Europe with many years of experience in sustainable development research. Anna has special expertise on different aspects of environmental policy instruments and their relation to human behavior and decision making. She has led projects on policy design for national parks and the Payment for Ecosystem Services (PES) program in Costa Rica as well as an evaluation of forest certification schemes in Sweden.

Rebecka H. Jorquera
Master of Science in International Administration and Global Governance from the University of Gothenburg and project manager at the Centre for Environment and Sustainability. Rebecka has studied in Tanzania and Italy and has completed internships at the Swedish Ministry for Foreign Affairs in Stockholm, UN ESCAP in Bangkok, as well as at UN DESA in New York, where she followed negotiations for Agenda 2030.

Jessica Hjerpe Olausson
MSc in Marine Science from the University of Otago, New Zealand and senior maritime expert, Region Västra Götaland, Sweden. Jessica has worked with various aspects of management in the marine environment such as fisheries management in West Africa and co-management of fisheries in Sweden. She has participated in HELCOM and ICES working groups and has also worked with R&D in shipping. Currently, she is heading the Maritime Cluster of West Sweden as an employee of Region Västra Götaland, with a special responsibility for regional development in the maritime sector.

Martin Eriksson
PhD in Environmental Science from the University of Gothenburg in Sweden and researcher at the Department of Mechanics and Maritime Sciences, Chalmers University of Technology. Martin has been involved in various research projects assessing effects and risks of pollution and chemical contamination of marine ecosystems. He also teaches about marine ecosystems and environmental effects of contamination.

Pierre Ingmarsson
MSc in Mechanical Engineering from Luleå Technical University. Pierre gained extensive experience from the automotive industry before entering the ocean energy sector where he has worked in areas ranging from a mechanical engineer to a project manager. Today Pierre works at the Research Institute of Sweden (RISE) and is contributing to building a new industrial sector via strategic and technical research projects.

Claes Eskilsson
Senior researcher in marine hydrodynamics at Chalmers University of Technology. Claes has worked in the field of computational hydrodynamics since 1999, mainly with applications for wave propagation and transformation. In the last 5 years, he has focused on marine renewables. Claes is currently involved in several national and international projects on modeling of floating wave energy converters and serves on the technical committee of the European Wave and Tidal Energy Conference.

Susanne Lindegarth
PhD in Zoophysiology with a specialization in marine aquaculture. Susanne works as project coordinator at the Centre for Sea and Society at the University of Gothenburg, where she shares her time between the Swedish Mariculture Research Centre (SWEMARC) and the Maritime Cluster in West Sweden.

Bethanie Carney Almroth
PhD in Ecotoxicology. Bethanie works as a lecturer and researcher at the Department of Biological and Environmental Sciences, University of Gothenburg. Her teaching focus is in the area of zoophysiology, while her research focuses on the effects of environmental pollution on marine and aquatic fish species. Bethanie has studied a wide range of environmental problems, including oils spills, sewage effluent, endocrine-disrupting compounds, global warming, and ocean acidification. Her current research projects aim to understand the release, spread, and fate of microplastics in the environment and include studies of the physiological effects of microplastics and associated environmental chemicals in fish.

Solutions

This report contains some of the available solutions from Northern Europe, focusing on four ocean-related challenges. The aim is not to be comprehensive but rather to reflect the wide spectrum of solutions that are available. The solutions show that a sustainable use of our oceans is possible.

Challenges

- *Marine Litter* – Solutions focusing on collecting, recycling, and replacing plastic with other materials.
- *Smart and Clean Energy for All* – Solutions focusing on marine renewable energy such as sea current, wave, and tidal energies, as well as reducing greenhouse emissions from shipping. Off-shore wind, specifically floating wind, is not represented in this report, even though this sector has effects on our oceans.
- *Finding Sustainable Protein Sources* – Solutions focusing on production of marine food for humans and livestock.
- *Marine Pollution* – Solutions focusing on reducing emissions of environmental pollutants.

Which selection criteria have been used?

Solutions have been selected based on seven criteria. The solutions should:

1. Be linked to one (or more) of the four challenges at SIF Oceans.
2. Together highlight a broad range of examples of innovative solutions from Northern Europe. The aim is not to be comprehensive but rather to reflect the wide spectrum of solutions that are available.
3. Be readily available and have overcome initial barriers.
4. Be borne by a small company in terms of turnover and staff.
5. Be transformative: the solutions should have the potential to move society towards sustainability.
6. Be holistic: the solutions should take all the SDGs into consideration in an SDG Impact Assessment.
7. Be scalable: the solutions and the company must have the potential to perform well after expanding in scope, size, and/or geographically.

SDG Impact Assessment

As part of a learning process, the solution owners have been invited to go through a self-evaluation of the impact of their solutions on the Sustainable Development Goals (SDGs), i.e., an SDG Impact Assessment. In a next step, the Advisory Panel has provided feedback on the submitted self-evaluations. The sections in this report that concern solutions are based on the replies received from the solution owners in the self-evaluation.

The solutions relate to the SDGs in different ways, depending on approach. In this report, each solution is dealt with in a separate section where all impacts are presented in table form while the four main impacts are explained in more detail. However, what the solutions do have in common is their impact on SDG 14: *Life Below Water – Conserve and sustainably use the oceans, seas and marine resources for sustainable development,* although in different ways.

Chapter 1: Marine Litter

Marine Litter

This section presents solutions focusing on collection and recycling of marine litter as well as replacing plastic with other materials. Let us start with a look at the challenge of marine litter and the potential effects on people, the planet and prosperity.

What is the challenge?

Marine littering is a global problem affecting both industrial and developing nations, and a majority of the waste is made up of plastics. Marine plastic pollution originates from both land-based and marine sources and is generally divided into two categories: macroplastics and microplastics (less than 5 mm in size). Macroplastics stem from a wide range of products used in society, including building materials, fishing equipment, packaging materials, and various consumer items. Microplastics are in turn divided into two subgroups: primary microplastics, which are small in size at the time of production and use, and secondary microplastics, which are derived from the weathering and fragmentation of larger plastic debris. Sources of primary microplastics include plastic pellets from industrial production, abrasives, particles in cosmetics, dust emissions from roads and tires, and fibers from synthetic textiles. Once it enters the marine environment, plastic litter can travel great distances, where lighter, less dense materials accumulate in ocean gyres or on beaches and heavier pieces sink to the ocean floor.

What are the potential effects on people, the planet, and prosperity if we do not solve this challenge?

Macroplastics have severe and well documented effects on the marine environment. Numerous studies have documented deaths of approximately 700 species of marine animals resulting from ingestion of plastics including plastic bags, ropes, bottle caps, and lighters. Lost or discarded fishing equipment will continue to indeterminately kill animals via entanglement, trapping, and drowning. Microplastics have been found to be taken up by numerous organisms ranging from zooplankton and shellfish to large predatory fish species. Observed effects include changes in metabolism and fat storage, inflammatory responses, reproductive effects and behavioral changes.

The main exposure routes in humans for plastics-associated chemicals are likely a result of ubiquitous use of plastics in daily life. There is an increasing concern regarding the importance of microplastics as vectors for chemicals in the marine food web. The extent of this problem from a human health perspective remains unknown.

Quantifying the challenge

An estimated 80% of marine litter consists of plastic materials, in line with increases in plastic production from less than 2 million metric tons in 1950 to 322 million metric tons in 2015. While it is difficult to know how much plastic reaches the marine environment, a recent report places estimates at 12.2 million tons per year. The economic impacts of the litter

80%

An estimated 80% of marine litter consists of plastic materials, in line with increases in plastic production from less than 2 million metric tons in 1950 to 322 million metric tons in 2015.

are also difficult to isolate and quantify, yet some estimates are indeed available. The impacts are generally discussed in terms of shipping, tourism, fisheries, and human health, and the costs are usually calculated based on the expenses associated with removing debris (e.g., from boat propellers, beaches, etc.) and repairing damages caused by the litter. In Asia-Pacific regions, plastic debris is estimated to cost marine industries €1 billion annually. The UNEP, however, calculated that the costs of pollutions to marine ecosystems from the current use of plastic in consumer goods reaching approximately €12.1 billion. As mentioned above, plastics cause a large number of deaths of marine organisms every year, with often unknown effects on the ecosystem. The number of deaths is difficult to quantify (numbers around 1,000,000 are often cited) and the value of these lives has never been estimated. Lost revenues in the recreation and tourism sector due to marine plastic litter have been estimated, though mainly based on the cost of beach cleanup and not lost revenue. Marine litter also impacts aquaculture industries, including both finfish and shellfish farming, and the cost of the damage has been estimated to €156,000 per year in Scotland.

There are also potential costs of marine plastic pollution to human health, though these concerns are mainly associated with plastic additives. Many plastics-associated chemicals are known endocrine disruptors and may as such give rise to numerous diseases. The total cost of diseases caused by endocrine-disrupting chemicals, a grouping which comprises many plastics chemicals, is estimated to be 1% of the gross domestic product in the EU and 2.33% in the U.S. (or $340 billion).

Solutions to the challenge

The many challenges in mitigating these problems span across international boundaries and require action from a multitude of actors and sectors in society, including initiatives from legislative bodies, improved industrial practices, changes in consumer behavior, and individual efforts. We also need to reduce the input of waste, improve the waste disposal and recycling practices, and intensify the environmental remediation.

Reused Remade

Founder: Pia Walter and Josephine Alhanko Ljungberg
Place of implementation: We are a Swedish start-up company with a focus on turning discarded hotel linen into carry bags. At present, Sweden is our main market. However, our aim is to export our business idea.
Partners involved: Rikstvätt AB, supplier of the material. "Project Konfektion 4.0", Marketplace Borås, development of an automated production process. SleepWell, member of the advisory board.
Contact: Pia Walter, pia.walter@reusedremade.com
Find out more at: www.reusedremade.com

Solution

Reused Remade is an innovative Swedish company with a patent-pending method of turning linen into carry bags in order to:

1. Reduce the need and use of plastic bags.
2. Increase resource efficiency by prolonging the lifecycle of existing textiles.
3. Decrease the need for production of new textiles.
4. Develop an international business model that combines economies of scales in the production, marketing, and sales with local procurement and labor.

Our aim is to develop a cost-efficient production that, in combination with marketing and local, national, and global SDGs (Agenda 2030) as well as with a growing consumer consciousness, will allow us to develop a competitive product with a capacity to compete with plastic bags.

Next steps

1. Find the financial resources to develop an automated production process in order to find the most cost-efficient solution.
2. Develop a recycling system for the bags.
3. Find cooperation with large general retailers in order to develop volumes.

Sustainable Development Goals

Reused Remade will contribute to SDG 6: *Clean Water and Sanitation.* By reusing existing textiles, our solution reduces the need for cotton, which saves water and reduces the need for pesticides. The hotel linen is often mixed with polyester (50/50), a material made from crude oil.

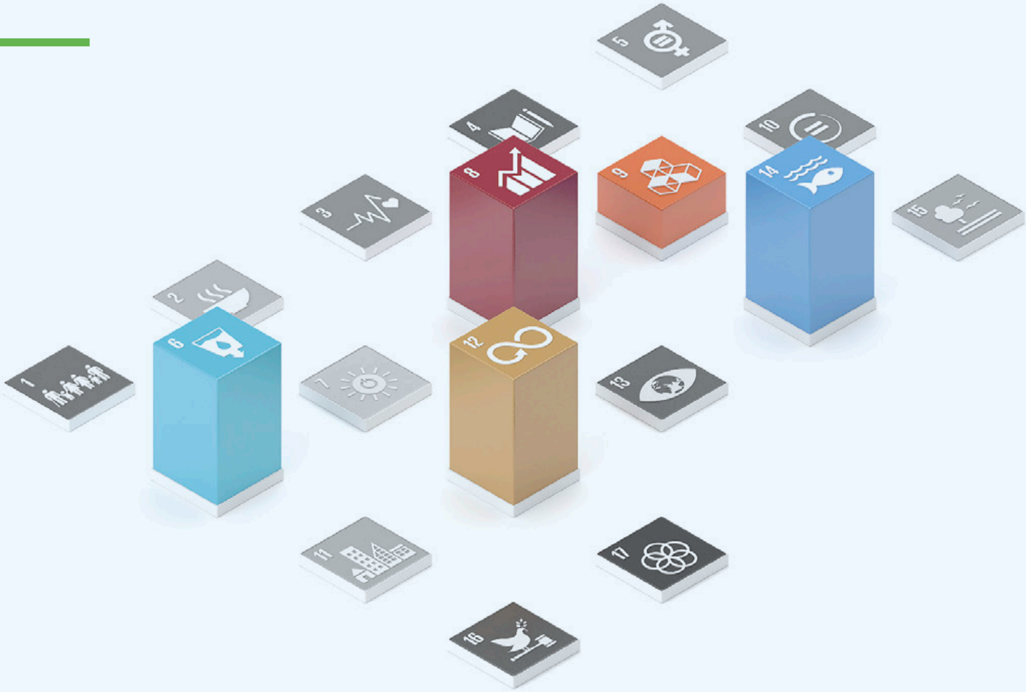
Estimated yearly hotel linen waste in Sweden is 200,000 kg, which is equivalent to:

1. 1,200 million–3,600 million liters of fresh water.
2. Up to 120,000 kg of pesticides used in conventional cotton production.
3. 32,000 liters of crude oil.

Note: Our calculations are based on statistics from Statistics Sweden regarding number and average use of beds as well as information from laundry service companies about the lifespan of bed linens.

Reused Remade will also contribute to SDG 8: *Decent Work and Economic Growth.* Our aim is to develop a business model based on the company's core values of sustainability and equality that can be implemented globally in areas with a significant tourism and visitors industry. Some of these areas are located in developing countries or in developed

Goals



Postive impact on:
Goal 6: Clean Water and Sanitation
Goal 8: Decent Work and Economic Growth
Goal 9: Industry, Innovation and Infrastructure
Goal 12: Responsible Consumption and Production
Goal 14: Life Below Water

countries with regions struggling with high unemployment rates.

By creating new job opportunities and increasing resource efficiency by extending the life cycle of existing textiles, our solution contributes to sustainable economic development.

Reused Remade will contribute to SDG 12: *Responsible Consumption and Production,* because the solution:

1. Reduces the need for and use of plastic bags.
2. Increases resource efficiency by extending the life cycle of existing textiles.
3. Decreases the need for production of new textiles.

We also contribute to more responsible consumption by educating the consumer through our products and communication.

Reused Remade will furthermore contribute to SDG 14: *Life Below Water,* by:

1. Developing efficient production processes in a local market by producing carry bags of discarded hotel bed linen as a substitute for plastic bags.
2. Reducing plastic bags in our environment, which will decrease the risk of the plastic bags polluting our oceans.
3. Reusing already produced textiles, which reduces the need for new textiles. This in turn will reduce both the use of fresh water and pollution of water resources due to the use of pesticides in conventional cotton cultivation.
4. Reducing the need for crude oil in polyester production.

Nofir

Founder: Øistein Aleksandersen (CEO of Nofir)
Place of implementation: We focus our activity in Europe. From 2011 to 2016 we collected around 26,000 tons of discarded equipment from 4 continents: Asia, Africa, America, and Europe.
Partners involved: Healthy Seas–NGO founded by ECNC Group, Aquafil Group, and Star Sock. Fishing For Litter Initiative–in 2015 Nofir became part of Fishing for Litter in Norway. Nofir is also an associate partner of Circular Ocean and collaborates with the Norwegian Directorate of Fisheries.
Contact: Martyna Zajder, martyna@nofir.no
Find out more at: www.nofir.no

Solution

Nofir is a leader in collecting discarded equipment from fishing and fish farming. We have a global presence: From 2011 to 2016, Nofir collected around 26,000 tons of material from around the world. The collection cycle begins with locating companies, fishermen, and fish farmers who need to dispose of fishing equipment. The equipment is then transported to a factory in Lithuania or Turkey, where it is dismantled and prepared for recycling. Nofir has teamed up with a large number of local recycling companies for processing of the collected material. This way, we not only keep fishing nets from being lost at sea but also help create new, valuable products like clothes, furniture, and carpets.

Nofir was the first Norwegian company to receive support through the EU Eco Innovation Initiative. In 2015, Nofir was mentioned as an example of successful Nordic Business in the publication Move towards Circular Economy.

Next steps

Our strategy is to penetrate new geographical markets such as North America and Australia and to continue developing our recycling solutions.

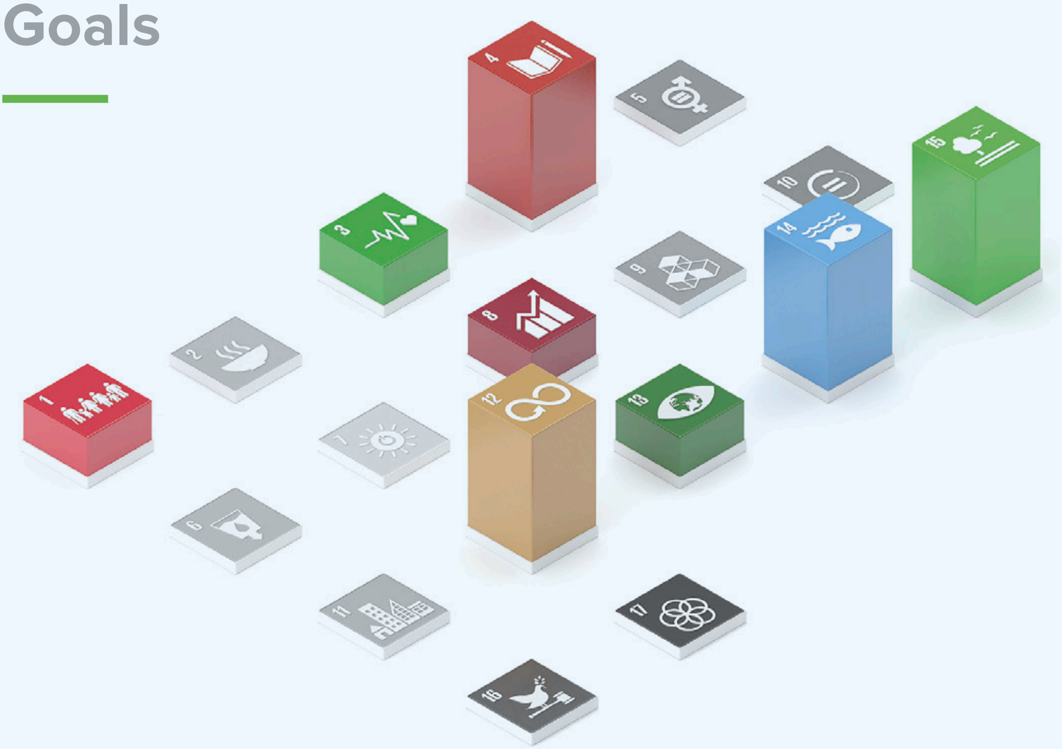
Sustainable Development Goals

Nofir will contribute to SDG 4: *Quality Education*, by educating people about marine litter and plastic pollution. We use both traditional education (talking to people, participating in panel discussions, conferences etc.) and modern education (using social media and marketing tools) to get our message out.

Nofir will also contribute to SDG 12: *Responsible Consumption and Production.* Our conversion of old equipment to new products has a positive environmental impact by:
- Reducing the consumption of new raw materials
- Reducing energy usage
- Reducing air pollution (from incineration) and water pollution (from landfilling)

We use life-cycle assessment (LCA) to calculate relevant environmental impacts of our collection and processing of equipment. The effects of Nofir's recycling include:
- Reduced use of non-renewable resources. For each kg of plastics recycled, 1.7 kg of oil is saved.
- Reducing the amount of fishing equip-

Goals



Postive impact on:
Goal 1: No Poverty
Goal 3: Good Health and Well-being
Goal 4: Quality Education
Goal 8: Decent Work and Economic Growth
Goal 12: Responsible Consumption and Production
Goal 13: Climate Action
Goal 14: Life Below Water
Goal 15: Life on Land

ment going into landfills, incineration, or ending at sea.

- Reduced carbon footprint by 3.6 kg CO_2 emission compared to producing new fishing equipment.

By collecting discarded equipment from fishermen and fish farmers, we keep nets from ending up as ghost nets in the sea, killing thousands of animals. We also cooperate with organizations such as Healthy Seas and Ghost Fishing, which specialize in recovering ghost nets from the bottom of the sea. Thus, Nofir will contribute to SDG14: *Life Below Water.*

Nofir will also contribute to SDG 15: *Life on Land.* The discarding of equipment used in fisheries and fish farming has long been identified as problematic. One example is the disposal of fishing nets. They often end up in landfills or may even be dumped at sea or burned, with negative environmental consequences. By collecting discarded fishing equipment, Nofir helps reduce the amount of plastics that go to landfill and incineration plants.

Much of the collected equipment is sent to Aquafil, a recycling plant in Slovenia. At Aquafil, old fishing nets become ECONYL® yarn, a high-quality fiber used in the production of for example socks, carpets, swimwear and clothes. According to company data, 1 ton of recycled fishing equipment can be converted to around 26,000 pairs of socks or 1,000 m^2 of new carpet.

FF Norden Smögen

Founder: FF Norden/Sixten Soederberg
Place of implementation: Coastal fishing with trawlers and recycling of fishing gears.
Partners involved: Swedish Agency for Marine and Water Management/Swedish University of Agricultural Sciences (SLU). Sveriges Fiskares Riksförbund (SFR; Swedish national association of fishermen). Region Västra Götaland. Sotenäs municipality. WWF Sweden.
Contact: Thord Görling or Sixten Söderberg, thord.gorling@hotmail.com or info@ffnorden.se
Find out more at: www.ffnorden.se

Solution

FF Norden, an association owned by fishermen on the island of Smögen, serves as a center for the development of selective gear, primarily for coastal fisheries, and reception of discarded fishing equipment, plastic waste, and abandoned nets found at sea.

We develop and produce selective trawls with an aim to increase compliance with the new rules surrounding the EU discard ban. Trawl bindery is a unique craft with an overall goal of catching the biggest fish possible while letting smaller fish pass through the mesh and back into the sea to grow. The new trawls refine the selectivity even further.

As for the collection and recycling of used equipment, FF Norden wants to further develop the collection system to be able to offer a service that is both efficient and attractive to fishermen.

Next steps

Financing, partnerships, and information/education will be important in order to scale up our project.

Sustainable Development Goals

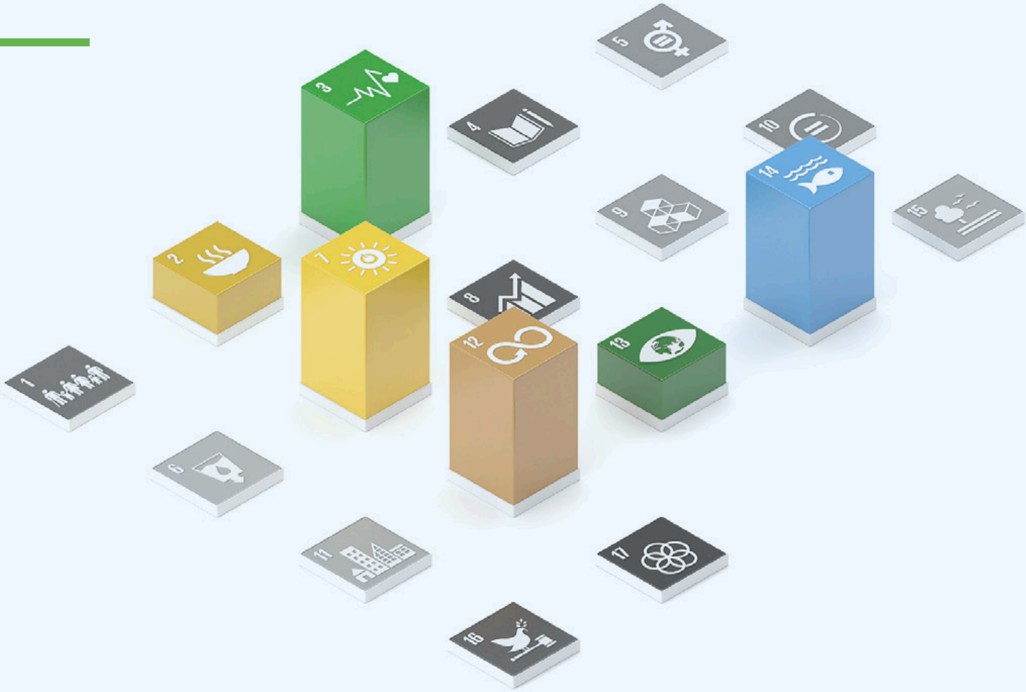
FF Norden Smögen will contribute to SDG 3: *Good Health and Well-being*. Less plastic material in the water means less harmful pollution in the form of hazardous microplastics.

The trawls we develop require less energy, and the recycling of material also saves energy, contributing to SDG 7: *Affordable and Clean Energy*.

Recycling of plastics reduces the amount of new materials produced, and sustainable fishing with our trawls save the small fish resources for future use. The activities will therefore contribute to SDG 12: *Responsible Consumption and Production*.

FF Norden Smögen will also have a positive impact in relation to SDG 14: *Life Below Water*, as its selective trawls reduce over-fishing. The removal of ghost nets reduces both unnecessary fish deaths and leads to less plastic waste in the oceans.

Goals



Postive impact on:
Goal 2: Zero Hunger
Goal 3: Good Health and Well-being
Goal 7: Affordable and Clean Energy
Goal 12: Responsible Consumption and Pro-duction
Goal 13: Climate Action
Goal 14: Life Below Water

Ren och Attraktiv Kust / Clean and Attractive Coast

Founder: Ulrika Marklund, Elsie Hellström, Anna Skrapste
Place of implementation: Along the Swedish west coast 11 municipalities (starting from north at the Norwegian border): Strömstad, Tanum, Sotenäs, Lysekil, Orust, Uddevalla, Tjörn, Stenungsund, Öckerö, Kungälv, and Gothenburg.
Partners involved: University of Gothenburg. County Administrative Board of Västra Götaland. Swedish Agency for Marine and Water Management. Clean Coastline (Interreg project) (Ren Kustlinje). Keep Sweden Tidy (Håll Sverige Rent) Clean Up Sweden (Städa Sverige).
Contact: Ulrika Marklund,
ulrika.marklund@vastkuststiftelsen.se
Find out more at: www.renkust.se

Solution

Clean and Attractive Coast's project aims to reduce the amount of marine debris through information and effective beach cleaning solutions. It focuses on communication between the municipalities to raise awareness and put marine debris on the agenda. An important part of the project is also to encourage and support the public and involved volunteers.

Public awareness is raised for example through campaign sailing, article writing, and presence in social media. The project has also launched a campaign called Don't Tell the Children, *www.donttellthechildren.com*

We decrease the amount of marine litter on beaches and, as a result, the amount of microplastics in the marine environment.

Our project includes an interactive map to make it easier for volunteers to take part in beach cleaning. We also support the municipalities in their work to organize the removal of marine litter.

Next steps

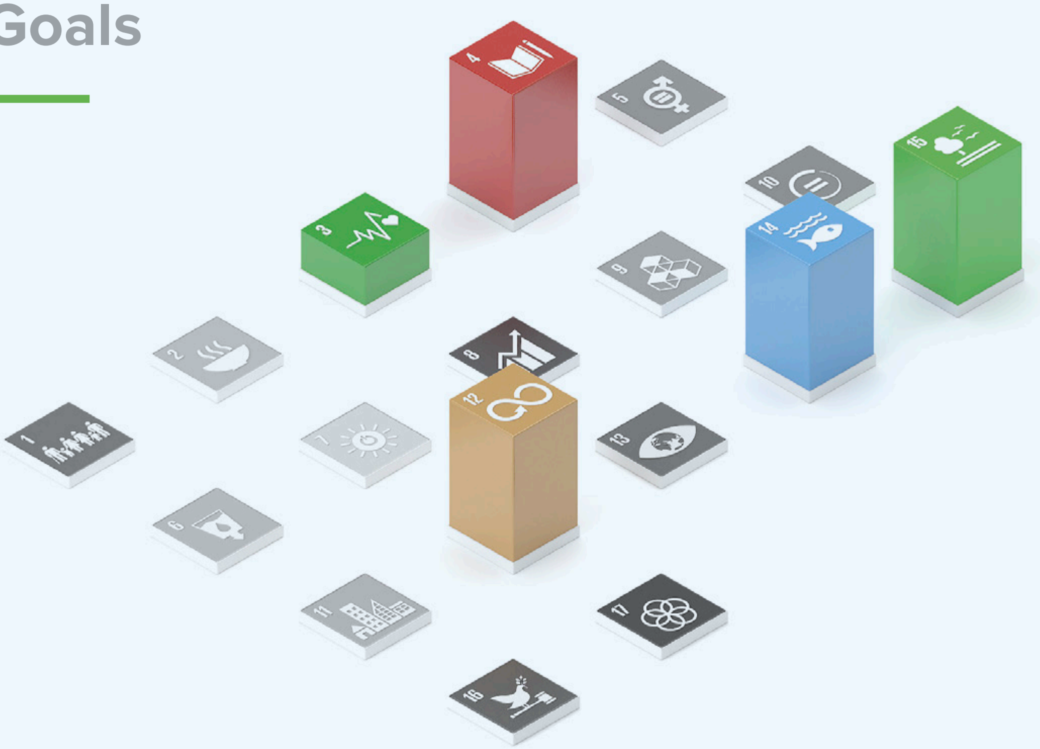
Our focus will be on cooperating with Baltic and other European countries to reduce the amount of plastics that start out on land and end up in the oceans.

Sustainable Development Goals

The solution will contribute to SDG 4: *Quality Education.* The project has co-arranged an international exhibit titled Out to Sea. In addition, we have created educational material for both children and adults, co-produced a movie (Strömmar av plast), and arranged a number of activities for both big and small groups.

The awareness of where the plastic debris originates has increased. In fact, 85% of a large number of people interviewed

Goals



Postive impact on:
Goal 3: Good Health and Well-being
Goal 4: Quality Education
Goal 12: Responsible Consumption and Production
Goal 14: Life Below Water
Goal 15: Life on Land

know that it comes from waste thrown on land and in rivers and streams. We want to increase the awareness among people in our region about what they can do to reduce the amount of plastic debris. Educating people about the importance of the problems plastics in the wrong environment can cause is of utmost importance.

Convincing people to choose more environmentally friendly products and use less plastics will also contribute to SDG 12: *Responsible Consumption and Production.*

The solution will also have an impact with respect to SDG 14: *Life Below Water,* for example by spreading awareness of how washing fleece emits microplastic particles into the oceans and how less plastic debris on our beaches means less microplastics in the oceans. When plastics are exposed to sunlight, wind, and water, they are broken down into microplastics and then mistaken for food by marine creatures (and as a result, they may end up on our dinner plate).

Similarly, less plastic littering on our beaches will also contribute to SDG 15: *Life on Land.* Less plastic material on the beaches keeps birds and marine mammals from eating plastics or getting trapped, saving them from devastating harm.


SOMMARØYBUEN
BM

Chapter 2: Smart and Clean Energy for All

Smart and Clean Energy for All

This section presents solutions focusing on marine renewable energy such as sea current, wave, and tidal energies, as well as reducing greenhouse emissions from shipping. Off-shore wind, specifically floating wind, is not represented in this report, even though this sector has effects on our oceans. Let us start with a look at the challenge of smart and clean energy for all and the potential effects on people, the planet and prosperity.

What is the challenge?

Ocean energy technologies can contribute to the world's future sustainable energy supply and reduce the dependence on fossil fuels, thereby lowering CO2 emissions. The challenges facing ocean energy harvesting are similar to those associated with offshore wind power: high costs relative to energy production methods and difficulties related to grid connections, engagement of a dedicated supply chain, and labor and operations in hostile marine environments. Estimation of capital costs (CAPEX) and operating costs (OPEX) remains cumbersome due to the plethora of diverse technologies, most of which are still immature and have not been implemented large-scale or for a sufficiently long time. Consequently, investors and technology developers have to extrapolate data from other industries to predict future cost trends, including technology readiness levels and learning curves. More reliable cost information can be derived from studying the likely maturation pathways of currently immature technologies to commercial availability.

What could the potential effects on people, the planet, and prosperity be if we do not solve this challenge?

Ocean energy is complementary to other forms of renewable energy generation, such as wind and solar, as the electricity can be generated at different times. If the clean energy sector, of which ocean energy is a part, is not able to tackle the challenges, we will most likely not reach the 2-degree target and its potential. Ocean resources have to be tapped locally, which means that ocean energy farms and power plants have to be deployed in coastal areas, some of which have suffered economic downturn in recent years. The development of ocean energy production will breathe new life into existing port and marine infrastructure and complement Europe's regional growth agenda. After wind and solar, a new generation of renewables must be developed to reach the full decarbonization potential. Installation of 300GW capacity worldwide would secure the energy supply and reduce CO_2 emissions by 500 million tons by decreasing the need for fossil fuel. Globally, the ocean energy market is estimated to reach €53 billion in annual value by 2050. It is also predicted to generate 680,000 jobs along coastlines and in remote areas. From a Nordic standpoint, a high level of renewables already in the system and only minor resources needed for deployment make this an innovation and export opportunity just like many other technologies coming out of the Nordic countries.

200

The European Marine Energy Center lists over 200 wave energy and almost 100 tidal power developers. Of these, 46 wave and 39 tidal power developers have reached open-water testing.

Quantifying the challenge

Ocean energy production is still in its infancy and is characterized by a wide range of devices based on widely different technologies. The European Marine Energy Center lists over 200 wave energy and almost 100 tidal power developers. Of these, 46 wave and 39 tidal power developers have reached open-water testing. For wave energy, the devices range from small point absorbers deployed in large arrays to multi-body attenuators and large-scale overtopping terminators, all with different methods for energy harvesting. The lack of design consensus hampers the short-term development. As pointed out earlier, the challenges facing ocean energy harvesting are similar to those for offshore wind power. Another key challenge is to ensure reliability and longevity of the energy converters.

Solutions to the challenge

Environment – The development and deployment of demonstration and pre-commercial devices, arrays, and plants will provide a key opportunity to validate predicted environmental impacts. From the developer's perspective, a standardized structure for project monitoring should be established, focusing on likely environmental impacts and seeking to advance projects by means of a risk-based approach. Enhancing knowledge of the marine environment is crucial to better inform plans and achieve more efficient licensing. To enhance knowledge regarding environmental impact there is a need for a standardized framework for data collection that would be adaptable to meet differing regulatory needs and legislative requirements in different nations and regions. Furthermore, mechanisms for funding research across international boundaries to ensure that the most efficient studies are carried out in the most appropriate locations with the complement of experienced researchers. To provide monitoring guidance and/or elucidate interactions sufficiently to reduce monitoring requirements a clear indication of additional strategic research is needed. Finally, reasonable costs estimates for routine monitoring and methods and pathways for further efficiencies and cost reductions in the future also need more attention.

Technology – To reach the stage where ocean energy technologies can be rolled out industrially and to truly reap the rewards of Europe's early investments, the technologies need to transition from R&D and prototypes to demonstration and a pre-commercial phase. Technology demonstration and validation is fundamental to the sector's development as commercial lenders and financiers are often reluctant to invest in unproven or little understood technologies.

Financial risk handling – For ocean energy development to move forward in a sustainable manner, the current practices in the areas of consenting and licensing, planning, and research and monitoring must be reviewed and enhanced. Creation of an Investment Support Fund for ocean energy farms: The EU and national authorities should create an investment support fund for the provision of flexible capital and to enable further leveraging of private capital.

W4P Waves4Power

Founder: Gunnar Fredrikson and Anders Noren
Place of implementation: Runde in Norway. Full scale test and demonstration device. Not a commercial device.
Partners involved: Chalmers University of Technology, Runde Environmental Center, Siemens, Parker, Petronas, nkt cables, Olympic Shipping and RISE.
Contact: Ulf Lindelöf, ulf.lindelof@waves4power.com
Find out more at: www.waves4power.com

Solution

We are building a new European energy industry that is totally fossil-free and renewable: wave energy production. The green marine energy industry is expected to be the future in energy production for Europe and the rest of the world.

The WaveEL grid-connected demonstration project for wave power at Runde in Norway was launched in February 2016 with the installation of the WaveEL buoy on site. The ocean's waves harbor tremendous amounts of raw energy and currently represent the single largest untapped source of renewable energy. Converted to electricity – by means of a wave energy converter (WEC), wave energy could potentially satisfy up to one tenth of the current global power demand.

Future targets for Europe (European Commission figures):
2050 = 15% from Marine Energy
2080 = 50% from Marine Energy

Next steps

The next generation of wave power devices will be built in new materials and reduce the costs and environmental impacts of production.

Green Power EcoSystem will be a complete solution for fish farms and remote islands, providing the products needed in a closed system.

Sustainable Development Goals

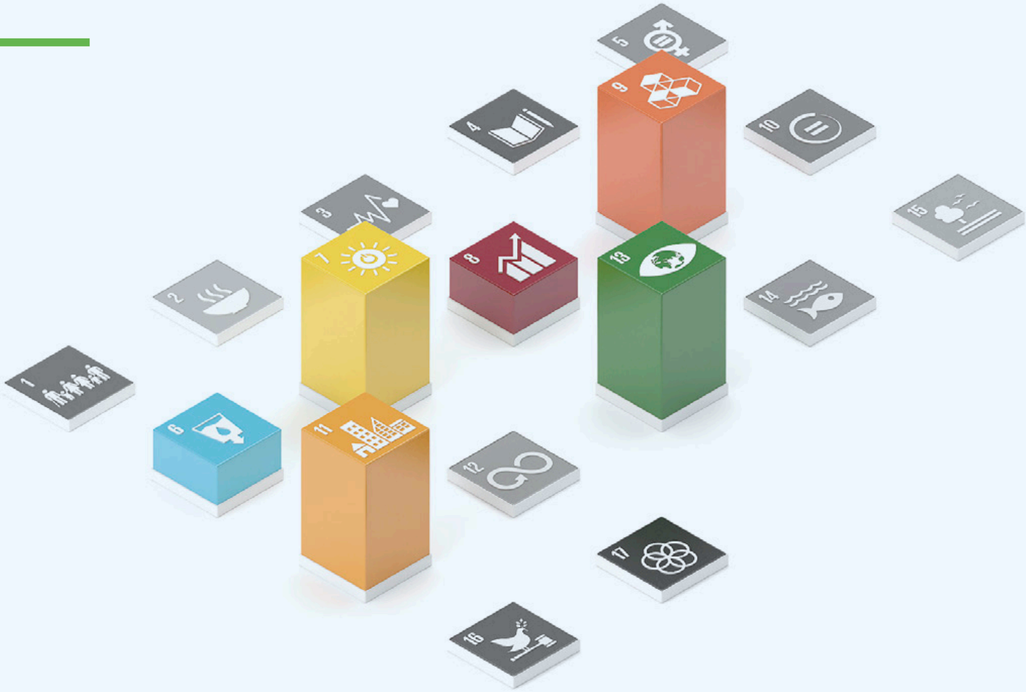
SDG 7: *Affordable and Clean Energy*, is our primary objective. Wave energy is eternal and can be developed in huge areas around the globe. At W4P, we believe that wave energy will become cheaper than land-based wind energy within the next 10 years, and the potential wave energy production is virtually limitless due to the sheer size of our oceans.

Wave power production will require local development of industry and will therefore contribute to SDG 9: *Industry, Innovation and Infrastructure.*

In the future, a growing share of the energy mix will come from wave energy, implying a contribution to SDG 13: *Climate Action.* W4P is working on a hydrogen-fueled vessel with hydrogen from wave energy.

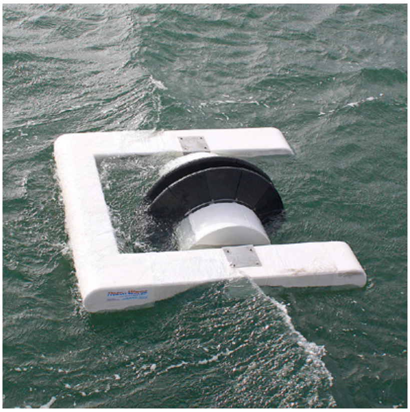
W4P also have the potential to contributes to SDG 11: *Sustainable Cities and Communities*, by providing a source of energy for many cities around the world.

Goals



Postive impact on:
Goal 6: Clean Water and Sanitation
Goal 7: Affordable and Clean Energy
Goal 8: Decent Work and Economic Growth
Goal 9: Industry, Innovation and Infrastructure
Goal 11: Sustainable Cities and Communities
Goal 13: Climate Action

Resen Waves



Founder: Per Resen Steenstrup
Place of implementation: In Denmark, Helligsø.
Partners involved: Resen Waves, as a private company, has been the driving force in developing this new technology based on many years of practical experience in wave energy.
Contact: Per Resen Steenstrup, prs@resenwaves.com
Find out more at: www.ResenWaves.com

Solution

Resen Waves is the first company in the world to provide continuous power and real-time data connectivity to autonomous instruments and machinery in the oceans and replace diesel generation in coastal areas and on islands by means of a plug-and-play buoy solution.

It is now possible to use smart phones or a web application to access instruments that monitor global warming and the health of the oceans in real time, no matter where the instruments are located in the big oceans. Power is no longer a limitation. In addition, the buoys have a great future potential to replace diesel generation, which is very costly to island populations due to the high transportation costs of diesel fuel.

Until now, instruments and machinery in the oceans have been powered by batteries or photo-voltaic (PV) or diesel generators, which require regular ship operation to replace batteries or diesel fuel and to maintain diesel generators. This is costly and sometimes not even possible due to difficult weather conditions. The buoys are like small modules that are low weight and can be installed from small local vessels, which is essential in the oceans and remote areas.

Next steps

We will follow the same path in wave energy as that for small wind turbines, by starting with small commercial wave energy buoys and over time advance to bigger buoys and eventually megawatt systems.

The impact is small in the early years, but it is necessary to go through this period in order to reach a greater impact in the future. The evolution cannot be rushed. This applies to all new production of renewable energy.

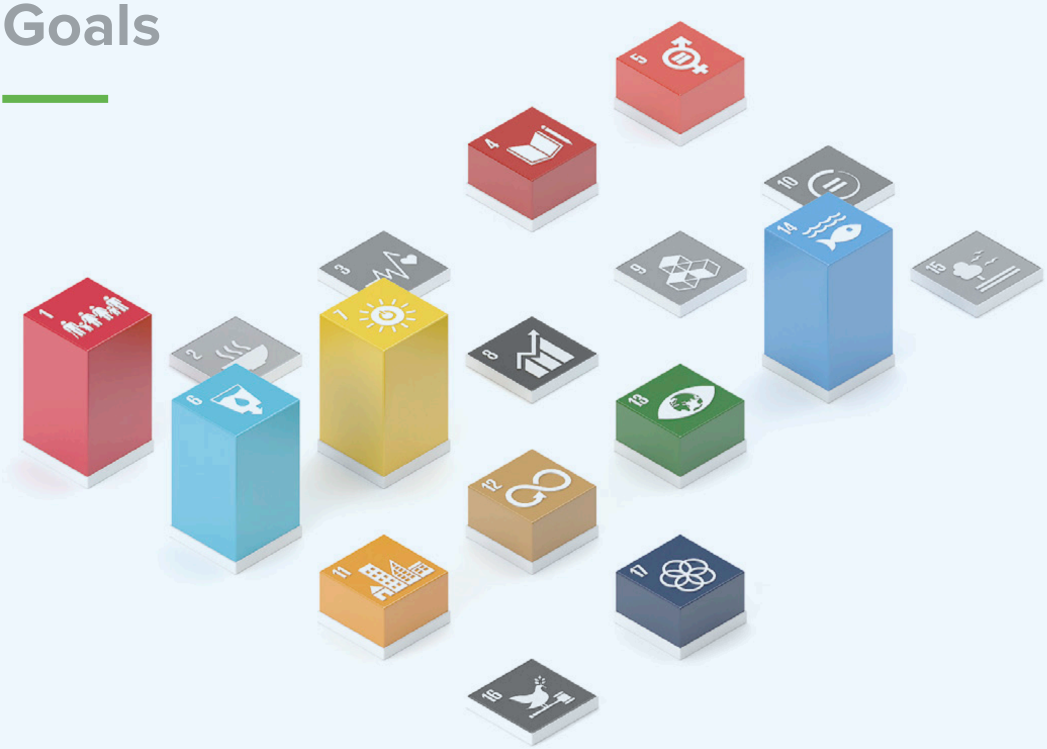
There are no quick fixes or fast tracks to success, but only hard work in small incremental steps.

Planned development phases:

1. Small-scale systems in the 100W–100kW range
2. Medium-scale systems in the 100kW–1MW range
3. Large-scale systems in the 1MW–20MW range

Over the next 10 years, Resen Waves will only deal with the small- and medium-size systems with the main aim being to replace diesel generated power in coastal areas and on islands worldwide.

Goals



Postive impact on:
Goal 1: No Poverty
Goal 4: Quality Education
Goal 5: Gender Equality
Goal 6: Clean Water and Sanitation
Goal 7: Affordable and Clean Energy
Goal 11: Sustainable Cities and Communities
Goal 12: Responsible Consumption and Production
Goal 13: Climate Action
Goal 14: Life Below Water
Goal 17: Partnerships for the Goals

The reduced expenditures on diesel oil will pay for the buoys and reduce emissions of greenhouse gases accordingly.

The small-scale systems represent a market of €50–100 million/year and will save 100,000–200,000 tons of diesel fuel annually. The relatively high figures include the fuel required for ship operation to replace batteries and fuel.

Sustainable Development Goals

According to the World Bank, some households on islands spend up to 30% of their income on importing diesel oil for generators, which keeps them in poverty. If a similar figure applied to the wealthy part of the world, it would throw the world economy into a deep recession. Resen Waves will hence contribute to SDG 1: *No Poverty.*

Low-cost electricity is essential for desalination in remote coastal areas. We will reduce the cost of desalination in these areas to roughly €.70/m^3. This will contribute to SDG 6: *Clean Water and Sanitation.*

Clean affordable energy is essential for all societies, including in remote areas. This is why we will have a positive impact in relation to SDG 7: *Affordable and Clean Energy.* The price of electricity, at this early stage, will be roughly €.35/kWh.

Resen Waves also works with real time monitoring of the oceans, which is essential to support natural life in the oceans, and will therefore contribute to SDG 14: *Life Below Water.* The buoys also provide the power needed for real-time transmission.

Norsepower Oy Ltd

Founder: Tuomas Riski (with co-founders)
Place of implementation: Europe
Partners involved: Norsepower Oy Ltd with several investors, partners, suppliers, and government organizations.
Contact: Tuomas Riski, tuomas.riski@norsepower.com
Find out more at: www.norsepower.com

Solution

The Norsepower rotor sail solution is a modernized version of the Flettner rotor – a spinning cylinder that uses the Magnus effect to harness wind power to propel a ship. When the wind conditions are favorable, Norsepower rotor sails allow the main engines to be throttled back, saving fuel and reducing emissions while providing the power needed to maintain speed and voyage time. Rotor sails can be used with new vessels or retrofitted to existing ships.

Two small Norsepower Rotor Sails have already been installed on the 9,700 DWT Ro-Ro carrier Estraden, and a third-party analysis by NAPA, the leading maritime data analysis, software, and services provider, has recorded a 6.1% reduction in fuel consumption, reducing annual CO_2 emissions by 1,200 tons. Based on these results, we forecast an up to 20% average reduction in fuel consumption for slow-steaming ships, such as tankers, fitted with several large rotor sails and sailing on routes with favorable wind conditions.

Next steps

The commercialization of Norsepower's technology will be ongoing. Two more delivery projects have been recently launched with the leading players of the global maritime industry. Please see www.norsepower.com/news for more details.

Sustainable Development Goals

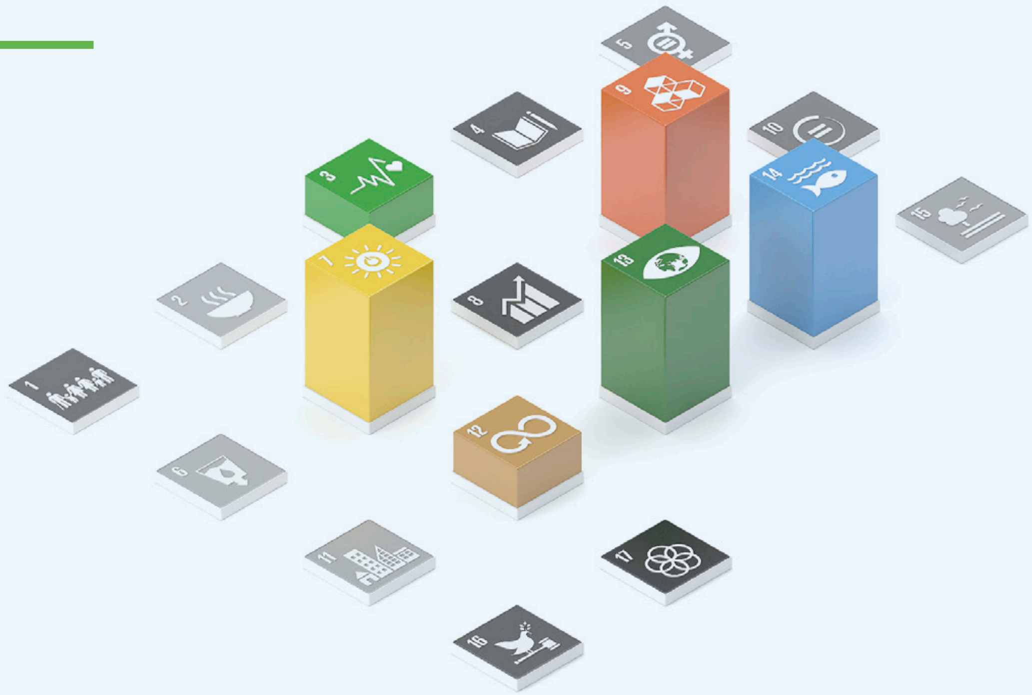
The solution enables ships to replace part of their propulsion power with renewable wind energy, which decreases the use of fossil fuels in shipping. The decrease in fuel consumption is typically 5–20%, meaning 400 to 1,600 tons of fuel per year. It will therefore have a positive impact on SDG 7: *Affordable and Clean Energy.*

We are developing the shipping technology by bringing an alternative, new, and renewable energy source (auxiliary wind propulsion) to the market, contributing to SDG 9: *Industry, Innovation and Infrastructure.*

Norsepower Oy Ltd will also have a positive impact in relation to SDG 13: *Climate Action.* Our solution reduces all emissions from shipping, increases energy efficiency of shipping, and enables the shipping of goods and passengers with a smaller environmental impact. The estimated decrease in fuel consumption corresponds to a reduction of CO_2 emissions by 1,200 – 5,000 tons per ship and year.

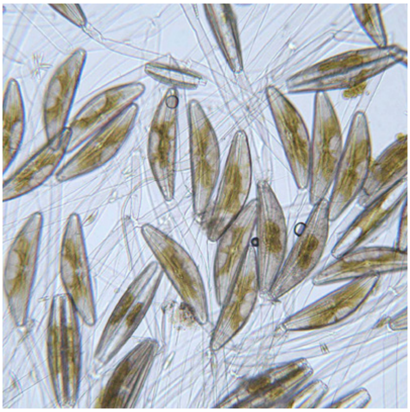
The solution furthermore reduces water pollution by decreasing the fuel consumption of ships and therefore contributes to SDG 14: Life Below Water.

Goals



Postive impact on:
Goal 3: Good Health and Well-being
Goal 7: Affordable and Clean Energy
Goal 9: Industry, Innovation and Infrastructure
Goal 12: Responsible Consumption and Production
Goal 13: Climate Action
Goal 14: Life Below Water

Swedish Algae Factory



Founder: Sofie Allert and Angela Wulff
Place of implementation: Sweden
Partners involved: University of Gothenburg
Contact: Sofie Allert, sofie@swedishalgaefactory.com
Find out more at: www.swedishalgaefactory.com

Solution

Swedish Algae Factory cultivates a unique diatom-type of algae and extracts the nanomaterial that constitutes its shell. When cultivating in the Nordic climates, we use algae that thrive in cold and dark climates on the bottom of the sea, but we also have a databank of various species for other climate conditions. For temperature control, we couple ourselves with fish farms which have a constant temperature of their water which is optimal also for our algae species.

The nanoporous shell of the algae is naturally designed to trap light in an extremely efficient way in order to secure its survival, which naturally inhabits ocean floors. We have shown that this material could be utilized to enhance the efficiency of standard silicon solar panels by at least 4% when added as a film on top of the solar panel glass. In tests scheduled for late spring 2017, we expect to achieve an even higher efficiency gain, possibly by 20%. The first tests of a new solar panel technology (dye sensitized solar cells) indicate an efficiency increase by 60% when incorporating this material. Moreover, the algae-based nanomaterial is produced in an extremely environmentally friendly way. The material is presently produced while we treat nitrogen- and phosphorus-rich wastewater from a land-based fish farm pilot in the Swedish community of Kungshamn. In this process, CO_2 is naturally absorbed and a nutrient- and oil-rich organic biomass is produced. This organic biomass can be utilized to produce more sustainable food, feed, fertilizers, and fuel.

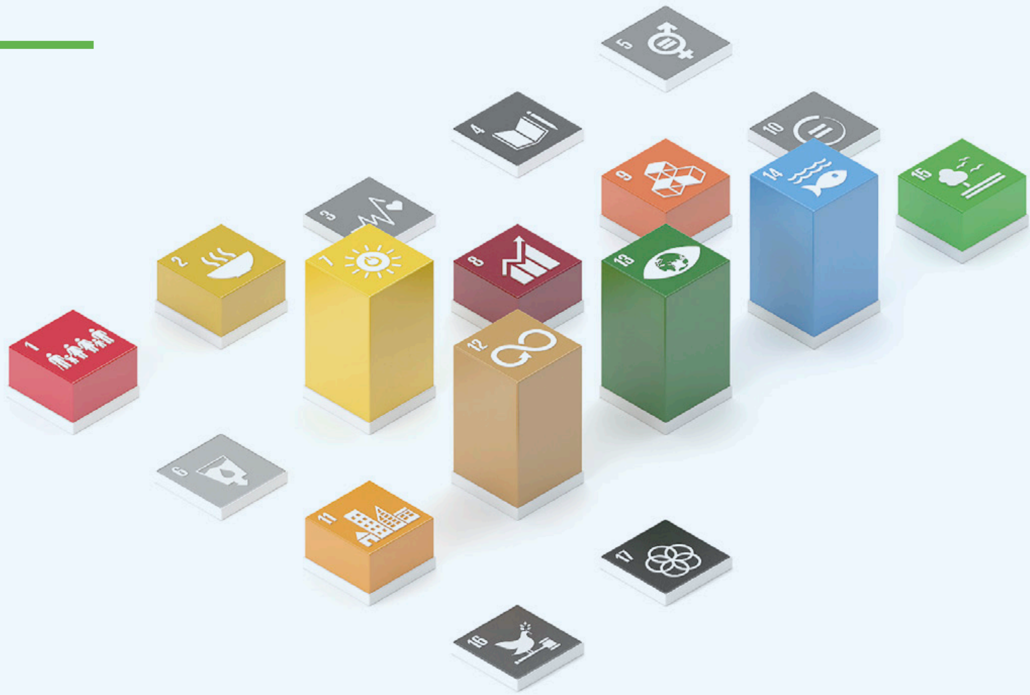
Next steps

We are aiming for more technological and market verification that shows that our technology works in a commercial setting, as well as financing for the building of a larger algae cultivation scale that can produce our products from the algae at a profitable scale.

Sustainable Development Goals

Swedish Algae Factory will contribute to SDG 7: *Affordable and Clean Energy*. Extracting the material from algae is cheap and the efficiency enhancement will thereby make the solar panel investment more profitable by decreasing the payback period of a solar panel investment. The cost of our material is expected to be only €0.4 per m^2 of solar panel for an efficiency gain of at least 4%. Some coating costs will be added to this figure, but not over a price that will increase the payback period of the solar panel. The 4% efficiency gain we have seen in externally validated tests (by SP, now RISE – Research Institutes of Sweden) was achieved under suboptimal condi-

Goals



Postive impact on:
Goal 1: No Poverty
Goal 2: Zero Hunger
Goal 7: Affordable and Clean Energy
Goal 8: Decent Work and Economic Growth
Goal 9: Industry, Innovation and Infrastructure
Goal 11: Sustainable Cities and Communities
Goal 12: Responsible Consumption and Production
Goal 13: Climate Action
Goal 14: Life Below Water
Goal 15: Life on Land

tions, i.e., there were problems with the particle distribution of particles and the concentration of the particles was too low. Moreover, these tests were only performed with perpendicular light, whereas internal tests have shown that non-perpendicular light is preferable in term of increased efficiency. The reason for this is that the nanoporous material has a three layer funnel-like structure that traps light from different angles and then makes it perpendicular.

In May 2017, the Dutch Research Institute (ECN) will perform tests with more optimal light and particle conditions.

Swedish Algae Factory, with its circular business model, will also contribute to SDG 12: *Responsible Consumption and Production.* We contribute to both increased energy efficiency, by improving the efficiency of solar panels, and increased resource efficiency, by recycling the nutrients phosphorus and nitrogen from wastewater to sustainably produced food, feed, and fertilizers.

The solution will furthermore contribute to SDG 13: *Climate Action*, as the algae naturally absorb CO_2 during growth (2 kg CO_2 per kg algae). In addition, recycling nutrients in this way reduces the demand for conventionally produced, CO_2-intensive synthetic fertilizers. Moreover, the algae contribute to more electricity being produced per m2 of solar panel, enabling more energy to be derived from a climate-neutral energy source.

Finally, by clearing wastewater from nitrogen and phosphorus, we reduce eutrophication and hence the solution will contribute to SDG 14: *Life Below Water.*

Orust E-boats

Founder: Arne Lindström, Lars Carlsson, Thomas Ivarsson, Elisabet Staf, Lennart Hesser, Ocke & Ted Mannerfelt
Place of implementation: Orust, Sweden
Partners involved: Design by Mannerfelt Design Team, Production Vindö Marin Orust, Technical Manager Lars Carlsson (Orustengineering), Solid works Mats Hjortberg, Pilot study with Swedish Energy Agency, C-Marine with Fredrik Åkerman, Msc. Naval Architec and Johan Edvardsson, Msc. Naval Architect.
Contact: Arne Lindström, arne.lindstrom@email.com
Find out more at: www.orusteboats.se

Solution

Our solution consists of a lightweight ferry powered by batteries and/or a fuel cell system. Our sustainable mode of waterway transportation can increase net welfare gains from economic activities by reducing pollution and energy use along the whole lifecycle, while increasing quality of life.

The public sector will need to set a clear direction. Monitoring frameworks, regulations, and incentive structures must be retooled to attract investments and stimulate sustainable development. National oversight mechanisms such as supreme audit institutions and oversight functions by legislatures should be strengthened.

Next steps

To manufacture various scalable vessels that suits a sustainable society.

Sustainable Development Goals

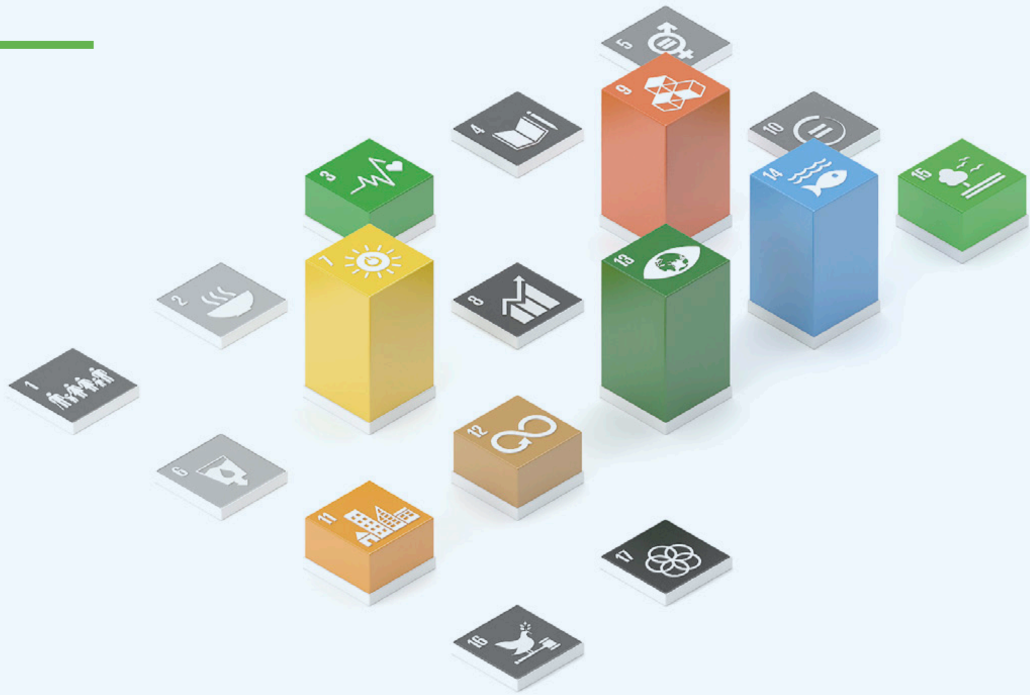
The energy used by the ferry comes from renewable energy sources such as solar, wind, hydro, and wave power, addressing SDG 7: *Affordable and Clean Energy.*

Orust e-boats will also contribute to SDG 9: *Industry, Innovation and Infrastructure,* through investment in waterway infrastructure. Our sustainable water transport development facilitates income generation, rapid and sustained increases in people's quality of life, and technological solutions for environmentally sound industrialization.

We will also contribute to SDG 13: *Climate Action.* Our solution does not generate any climate-altering exhaust emissions such as CO_2 and NO_x as the ferry's electrical propulsion is powered with renewable energy.

We will have a very positive impact in relation to SDG 14: *Life Below Water,* as we do not have any harmful emission such as CO_2, polyaromatic hydrocarbon and NO_x as we rely on electric propulsion fueled with renewable energy from solar, wind, and water.

Goals



Postive impact on:
Goal 3: Good Health and Well-being
Goal 7: Affordable and Clean Energy
Goal 9: Industry, Innovation and Infrastructure
Goal 11: Sustainable Cities and Communities
Goal 12: Responsible Consumption and Production
Goal 13: Climate Action
Goal 14: Life Below Water
Goal 15: Life on Land

Chapter 3:
Finding Sustainable Protein Sources

Finding Sustainable Protein Sources

This section presents solutions focusing on production of marine food for humans and livestock. Let us start with a look at the challenge of finding sustainable protein sources and the potential effects on people, the planet and prosperity.

What is the challenge?

Increasing food production to meet the needs of a growing world population while at the same time reducing the ecological footprint of food production, protecting natural resources and ecosystems, and advancing rural development is one of the greatest challenges of our time.

Hunger and malnutrition is rampant in the world. More than 800 million people are believed to suffer from chronic malnourishment due to low protein intake, and fish is a vital and sometimes exclusive source of protein in many poor and developing countries.

As it is widely recognized that wild fish stocks are no longer able to support world seafood demand, the demand for seafood is increasingly met by aquaculture. The sector is already providing about 50% of all fish and shellfish consumed globally, but it is nevertheless expected to more than double in capacity by 2050. However, the current production systems, particularly those relying on feed, may have some negative impacts on ecosystems and society that need to be addressed. Finding solutions to promote sustainable aquaculture systems for food production is therefore essential.

What could the potential effects on people, the planet, and prosperity be if we do not solve this challenge?

Fish and shellfish are a major food resource for a large number of people but also provide critical ecosystem services. Consequently, viable fish populations need to be maintained to promote both human well-being and ocean health. Over-fishing has severe consequences as it changes the structures and functions of the ecosystems and has dramatic impacts on socio-economic development. Thus, there is an urgent need to protect and restore wild fish populations through responsible governance of fish and fisheries. The aquaculture sector plays an important role in providing fish and other seafood products yet is facing some major challenges. We need to find solutions that minimize the environmental impacts of released organic and inorganic waste as well as the unsustainable use of wild marine species for the supply of juveniles and feeds. Expansion of the sector must include a shift toward innovative aquaculture systems and feed production that does not negatively impact wild populations.

20 kg

Global fish consumption has increased from 10 kg to nearly 20 kg per person over the last fifty years. This has been driven by a combination of population growth, rising incomes, and urbanization.

Quantifying the challenge

Global fish consumption has increased from 10 kg to nearly 20 kg per person over the last fifty years. This has been driven by a combination of population growth, rising incomes, and urbanization. The global catch of wild fish in the last 30 years has been stable at around 100 million tons per year, of which 80% is caught in marine waters. Over the same period, aquaculture production expanded from just a few million tons to levels similar to those for wild fish. Freshwater aquaculture is currently the predominant form of production (>60%). However, fresh water is a limited global resource and the major expansion is predicted to take place in the oceans. A majority of cultured organisms are food fish (66%) with the remainder comprising invertebrates (oysters, mussels, prawns etc.) and seaweed.

In the Nordic countries, Norway is a giant in aquaculture and one of the world-leading producers of Atlantic salmon. Approximately 1.3 million tons of salmon was produced and sold in 2015. Grow-out of salmon is done in open net-pen cages, a production system that provides significant amounts of high-value marine protein but also creates negative environmental effects such as excessive nutrient release and genetic, pathological, and parasitic interactions with wild populations. The Swedish aquaculture production of fish and shellfish is by comparison very low (~12,000 tons in 2015) and the sector has not grown in recent decades, partly due to strict environmental regulations. However, novel and environmentally friendly aquaculture technologies for land and sea use are continuously being developed and tested also in the Nordic countries, which will allow for expansion of the industry.

Solutions to the challenge

Sustainable aquaculture production of food for a growing population has a huge potential to grow in the near future. Innovative systems that address the negative environmental impacts of traditional open-cage fish farming include land-based recirculating systems (RAS), which are closed systems with limited (or no) release of waste material, infectious agents, and animal interaction with wild populations. Fish farming in semi-enclosed systems at sea significantly reduces organic pollution, efficiently limits infections by sea lice and other pathogens, and increases growth and survival. Moreover, it is possible to boost resource-efficient seafood production by means of integrated multitrophic aquaculture (IMTA). In IMTA, fed species (e.g., fish) are co-cultured with extractive species such as mussels, sea squirts, seaweed, or microalgae, which grow using the nutrients released from the fish. Finding sustainable feed resource alternatives to fish meal and fish oil from wild capture is a priority. Low-trophic level organisms of marine origin, potentially produced in IMTA systems, could provide new raw materials for feed, as could by-products from agriculture and the seafood-processing industries.

To ensure continued growth of the aquaculture industry, the present regulatory frameworks need to be modernized and adapted to the novel technologies in order to drive the implementation of sustainable farming systems with minimal environmental impact.

Processum

Founder: Processum
Place of implementation: Not implemented yet.
Partners involved: Processum, Matis, Domsjö fabriker, Swedish University of Agricultural Sciences (SLU), RISE Research Institutes of Sweden, Danish Technological Institute (DTI), Technical University of Denmark (DTU), Viur.
Contact: Björn Alriksson, bjorn.alriksson@processum.se
Find out more at: www.processum.se

Solution

The world's population is projected to reach 9 billion by 2050, which will increase the demand for food accordingly. The production of fish must increase significantly in order to meet this rise in demand. As about 80% of the fish stocks of the oceans are currently fully exploited, overexploited, or depleted, intensifying the fishing even further does not appear to be a possible solution. Instead, the contribution from aquaculture needs to increase from its current share of 50% of the fish supply for human consumption. However, fishmeal derived from wild fish is currently the preferred protein for many aquaculture species, to the detriment of wild fish stocks. It is therefore important that the increased aquaculture production will not increase the demand for fishmeal-based feed.

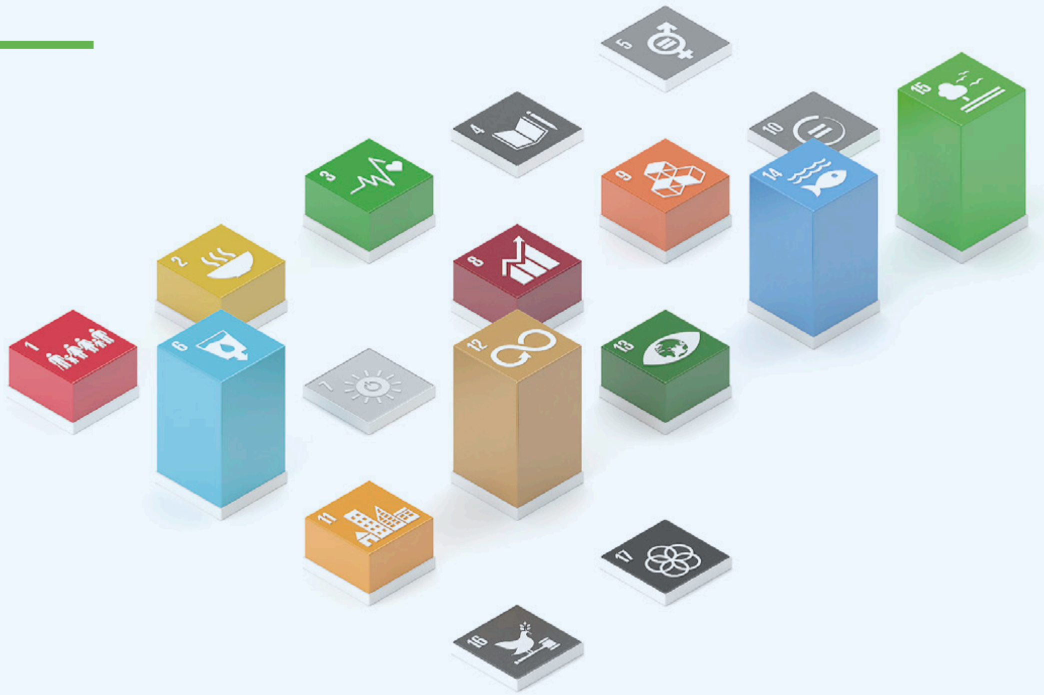
The fishmeal production has been fairly stable at around 5–7 million tons per year over the last 40 years while the aquaculture production has grown by an average of about 8% annually since the 1970s. This has led to a large increase in fishmeal prices in recent years. The increased demand for fishmeal for fish feed production and the high price has caused a need for alternative protein sources. However, most available protein sources are of plant origin and can generally only be used in limited amounts due to a different amino acid composition compared with fishmeal protein and the presence of anti-nutritional substances that can be detrimental to the fish. The sustainability of today's production of plant protein for feed, such as soy protein, can also be questioned. An interesting alternative is single cell protein (SCP).

SCP consists of microorganisms such as yeast, bacteria, algae, and filamentous fungi. Many species have high protein content and some have amino acid profiles that are very similar to that of fishmeal. In addition, SCP can be produced using residuals from the forest industry. This offers an attractive concept of turning forest raw material into a protein-rich component of fish feed.
In conclusion, the wild fish stocks are shrinking and the demand for fish is increasing. The described concept is therefore needed in order to meet the increased need for sustainable fish feed in the fast-growing aquaculture industry. In addition, there is a great need for new profitable bio-refinery products for the European forest and bio-refinery industry.

Next steps

The next step will be to build production facilities for single cell protein and continued R&D.

Goals



Postive impact on:
Goal 1: No Poverty
Goal 2: Zero Hunger
Goal 3: Good Health and Well-being
Goal 6: Clean Water and Sanitation
Goal 8: Decent Work and Economic Growth
Goal 9: Industry, Innovation and Infrastructure
Goal 11: Sustainable Cities and Communities
Goal 12: Responsible Consumption and Production
Goal 13: Climate Action
Goal 14: Life Below Water
Goal 15: Life on Land

Sustainable Development Goals

Processum is expected to have a large impact with respect to SDG 6: *Clean Water and Sanitation,* because the production of single cell protein does not require as much water as the production of many plant-based protein sources (e.g., soy protein). In addition, the import of nutrients from other ecosystems (e.g., soy from South America) can be decreased and lead to less eutrophication where the fish is produced. Furthermore, the production of single cell protein can work as a wastewater treatment system to decrease COD and BOD levels from industrial effluents. Processum is also expected to contribute to SDG 12: *Responsible Consumption and Production,* as it can facilitate the development of more eco-friendly food.

Improving the fish stocks of the oceans will contribute to SDG 14: *Life Below Water.*

Our solution can also contribute to less deforestation in countries that produce plant protein (e.g., soy protein), implying a positive impact in relation to SDG 15: *Life on Land.*

Marin Biogas

Founder: Fredrik Norén
Place of implementation: Sweden
Partners involved: Swedish Environmental Institute (IVL), E.ON (full-scale fermentation plant), Scanfjord AB (Sweden's largest mussel farming company), Danish Technical University – DTU Aqua, Swedish University of Agricultural Sciences (SLU), Lantmännen, Raisio Agro.
Contact: Olle Stenberg, olle@marinbiogas.se
Find out more at: www.marinbiogas.se

Solution

Marin Biogas has developed a new innovative concept for large-scale cultivation and harvesting of Ciona. A demonstration project is currently underway to produce Ciona biomass. The main purpose of the project is to show the positive environmental effects in the sea and the usage of Ciona biomass as a substrate for biogas production in full-scale trials.

The inner parts of the Ciona organism are very high in protein and have a favorable protein composition. This fraction may be used as a feed ingredient, and the potential is large. A Ciona cultivation area of 6x6 km could supply all the protein needed in the Norwegian fish farming industry.

Next steps

1. Verify large-scale feed ingredient application
2. Generate a sustainable business model

Sustainable Development Goals

Marin Biogas will contribute to SDG 7: *Affordable and Clean Energy*, because renewable energy in the form of biogas is produced by fermentation of the biomass.

By having a circular business model, the solution will have a positive impact with respect to SDG 12: *Responsible Consumption and Production*. It will enable production of fossil-free products based on renewable raw material.

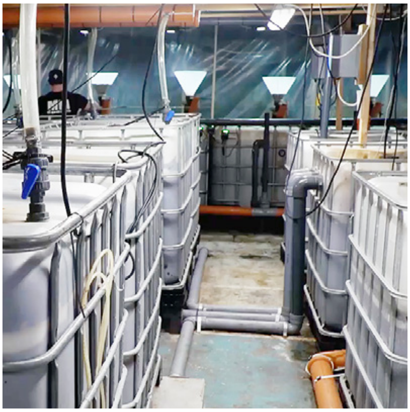
By increasing the amount of fossil-free fuel (biogas) and decreasing the need for ammonia production used for fertilizers, the solution will contribute to SDG 13: *Climate Action*.

The solution will have a very strong positive impact on the marine environment, i.e., SDG 14: *Life Below Water*, by actually filtering large amounts of water and harvesting the accumulated biomass. The net effect will be recirculation of nitrogen and phosphorus to the farmlands, resulting in a decreased demand for fertilizer production (ammonia and phosphor mineral).

Goals

Postive impact on:
Goal 2: Zero Hunger
Goal 7: Affordable and Clean Energy
Goal 8: Decent Work and Economic Growth
Goal 9: Industry, Innovation and Infrastructure
Goal 11: Sustainable Cities and Communities
Goal 12: Responsible Consumption and Production
Goal 13: Climate Action
Goal 14: Life Below Water

Lantfisk



Founder: Diana Olsson Waage, Andreas Olsson Waage, Valter Eklund, and Lars Forsberg
Place of implementation: Gothenburg, Ale municipality
Partners involved: Chalmers Food and Nutrition Science & Gothenburg University Department of Biological and Environmental Sciences & Kajodlingen in Gothenburg.
Contact: Diana Olsson Waage, diana@lantfisk.se
Find out more at: www.lantfisk.se

Solution

Lantfisk provide the market with first class quality tropical fresh fish, that is locally and sustainable farmed with care for animal welfare, the environment and human health.

Lantfisk farm tropical freshwater species that can feed on vegetable feed and thrive in dense environments in recirculated aquaculture systems (RAS) with no pollution or adding of toxicants.

We are develop¬ing a feed that excludes fishmeal and is based on locally and sustainably grown crops and sustainable marine resources that benefit the water quality. Our sludge water is used by the Kajodlingen vege¬table farm as a source of nutrients and soil improvement.

We build circular systems of supporting the city with sustainable and locally produced healthy foods with optimal resource usage and no pollution of, or contamination from the sur-rounding environment.

This protected environment excludes the fish and the consumers from unwanted contamina-tion of medication, pollution, parasites or stress hormones.

Our production model of fish farming build on environmental technology that is scalable and adaptable to other food production models for nutrition, soil improvement and efficient use of resources. The systems are robust, easy to build and support, and very cost efficient.

Next steps

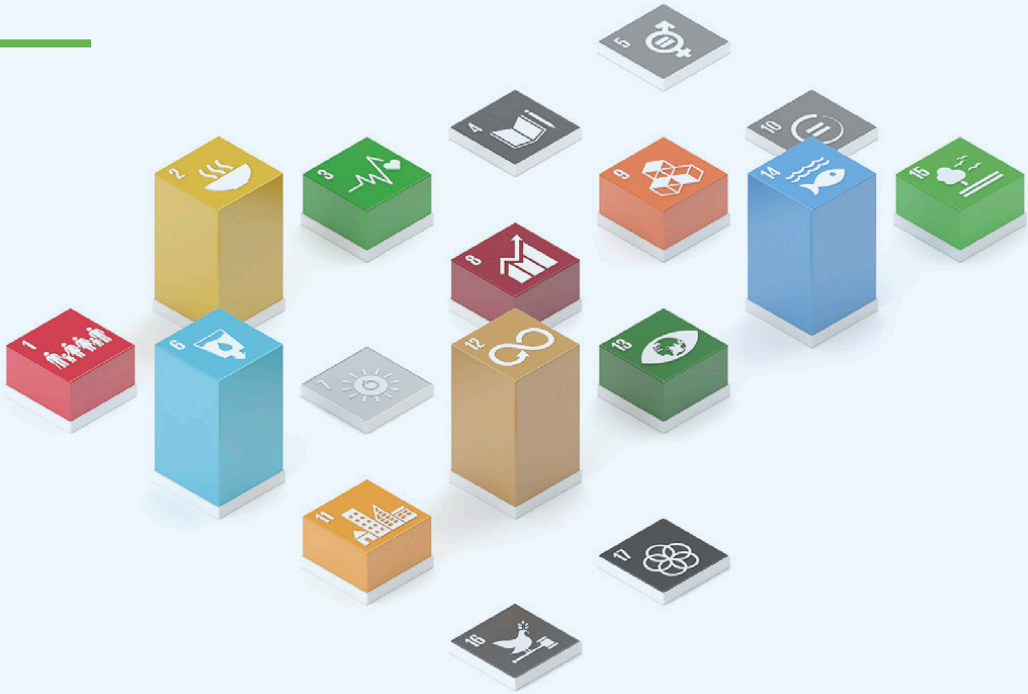
Enter the market, developing of products and brands in partnership with food industry, expand, research our new feed, develop partnerships with sustainable food production systems, scale up pro¬duction, enter partnerships with institutions that can implement our model in developing countries, and obtain proper certification for sustainable RAS-grown fish.

Sustainable Development Goals

Our circular production model of growing fish can provide phosphorus, nitrogen, and other valuable resources for growing vegetables and other crops, increasing yields, improving soil, thus contributing to SDG 2: *Zero Hunger.*

Lantfisk can also contribute positively to SDG 6: *Clean Water and Sanitation.* Grow¬ing fish in closed recirculating systems does not result in pollution or significant wasting of water. Our system can be recir¬culated up till 99%. Clean water is a main argument for Lantfisk. Lantfisk offer ethical fish products by taking responsibility for fish health and the environment. We use our water to

Goals



Postive impact on:
Goal 1: No Poverty
Goal 2: Zero Hunger
Goal 3: Good Health and Well-being
Goal 6: Clean Water and Sanitation
Goal 8: Decent Work and Economic Growth
Goal 9: Industry, Innovation and Infrastructure
Goal 11: Sustainable Cities and Communities
Goal 12: Responsible Consumption and Production
Goal 13: Climate Action
Goal 14: Life Below Water
Goal 15: Life on Land

grow vegetables together with Kajodlingen. We are currently developing a feed with the University of Gothenburg and Chalmers University of Technology to exclude already low levels of fish protein in our feed (max. 10%). We are showing consumers that we can grow happy fish in local settings without polluting or emp-tying the oceans, contributing to SDG 12: *Responsible Consumption and Production.*

We do not pollute the sea or raise the levels of phosphorus and nitrogen in the oceans. Nor do we empty the sea of fish for our feed. Our new feed aim to improve water quality by absorbing excess nutrients from water and seabed's. Thus, Lantfisk will have a positive impact in relation to SDG 14: *Life Below Water.*

Musselfeed AB

Founder: Dr. Odd Lindahl,
Royal Swedish Academy of Science
Place of implementation: West coast of Sweden
Partners involved: Mussel farmers, Customers within food production, Customers within feed production, Eco-farmers, Universities, and Research institutes
Potential end users. Country and municipality.
Contact: Sofia Kocher, sofia@musselfeed.com
Find out more at: www.musselfeed.com

Solution

Musselfeed brings climate-smart foods and feed from mussels to the market. Most food production harms the ecosystem, but it does not have to be this way. Mussel farming not only produces healthy seafood but also helps regenerate the ecosystem by recirculating nutrients back to land.

But there is a limited demand for fresh mussels. Therefore, Musselfeed has developed an industrial scale process that separates the mussels into two parts: high-protein meal of mussel meat and calcium-rich fragments of dried shells.

Traditional foods in a new form open up for new business opportunities: The sustainable mussel protein is used in sports nutrition products, delicacy foods, and feed. It has a 10 times lower climate impact than whey and a 160 times lower climate impact than Swedish beef. It effectively replaces unsustainable protein sources, such as fish and soy.

Musselfeed AB was founded by Dr. Odd Lindahl, Royal Swedish Academy of Science. Lindahl is one of Sweden's most experienced experts on the marine environment and has focused his research on improving the quality of water. Musselfeed started as a research project and became a company in 2013. The product has attracted vast interest, implying a great business opportunity. To lead the business development, Sofia Kocher was recruited to the team. She has over 12 years of experience from commercializing research in the processing industry.

Next steps

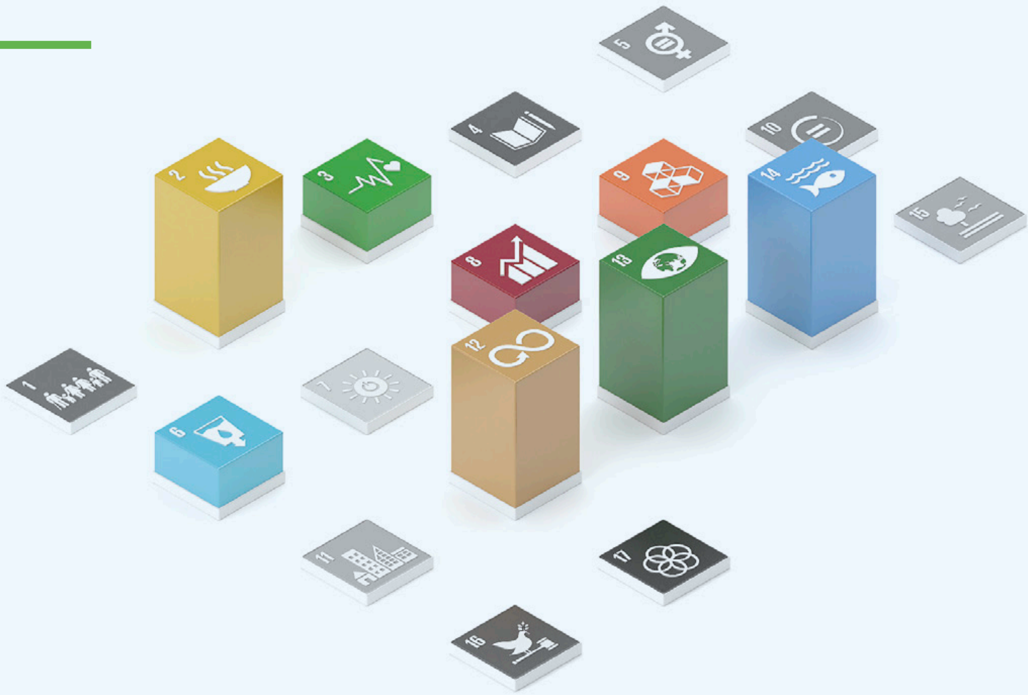
Attract funding, both public and private. Regulations for mussel farming need to change so that blue catch crops get the same status and become subject to the same rules as green catch crops.

Work with social responsibility, where customers take responsibility for buying more food from more sustainable resources.

Sustainable Development Goals

Musselfeed has a potential to take an active regenerative role in relation to the ecosystems in which we produce nutritious food. This will contribute to both SDG 2: *Zero Hunger*, and SDG 12: *Responsible Consumption and Production.*

Goals



Postive impact on:
Goal 2: Zero Hunger
Goal 3: Good Health and Well-being
Goal 6: Clean Water and Sanitation
Goal 8: Decent Work and Economic Growth
Goal 9: Industry, Innovation and Infrastructure
Goal 12: Responsible Consumption and Production
Goal 13: Climate Action
Goal 14: Life Below Water

The much lower climate impact of mussels than other common protein sources implies a potential to become the world's most climate-smart large-scale source of animal protein, positively affecting SDG 13: *Climate Action.* Mussels have 160 times lower climate impact than beef, 30 times lower impact than pork, and 10 times lower impact than whey.

Musselfeed can also contribute positively to SDG 14: *Life Below Water.* Mussel farming recirculates nutrients and helps reduce the negative effects of eutrophication. It regenerates the ecosystem and creates healthier oceans. Products can replace unsustainable fish meal in feed applications. Farming 15,000 tons of mussels means recirculating 150 tons of nitrogen and 15 tons of phosphorus.

Stadsjord/Pond

Founder: Niklas Wennberg
Place of implementation: Gothenburg, Sweden
Partners involved: Vinnova is funding Stadsjord/Pond in a program supporting innovative solutions for industrial symbiosis. Chalmers Architecture: Master's Program in Urban Sustainability. Chalmers Nutrition: Master's Program. SSEC – Swedish Surplus Energy Collaboration. Vuxenskolan Education. RCE – Regional Center of Expertise (UN Initiative).
Contact: Niklas Wennberg, niklas@hylapond.se
Find out more at: www.stadsjord.se

Solution

Aquaculture has been the world's fastest growing food sector since 1974. Vast capacity building is needed in this sector to meet the growing demand for aquatic protein without degrading marine ecosystems. We need to focus on cultivating omnivores and herbivores, or "water pigs" and plant eaters. Moving down in trophic levels means that we present good food at a lower price to the consumers and at a lower cost to the oceans and the overall environment.

Stadsjord/Pond uses urban voids for aquaculture. We produce fish and vegetables in empty factories and old and new apartment buildings. The fish are fed excellent food – called waste – from the neighborhood instead of feed from diminishing wild fish stocks. We save the sea with fish farms on land, in urban and rural voids. Fifty square meters is all it takes to make a 200-resident building self-supporting with fish, or even turn the building into a "plus protein" dwelling and at the same time help save the oceans.

We are currently discussing introducing aquaponics as a clever way to provide the world's largest refugee camp (in Kenya) with protein produced from waste using very small amounts of energy, water, and space. Vertical farming connected to aquaculture uses 1/5 of the ordinary space needed for farming and 1/10 of the water volume. We intend to make the camps self-supporting with protein and greens and also provide people in the camps with essential skills that can be practiced almost anywhere.

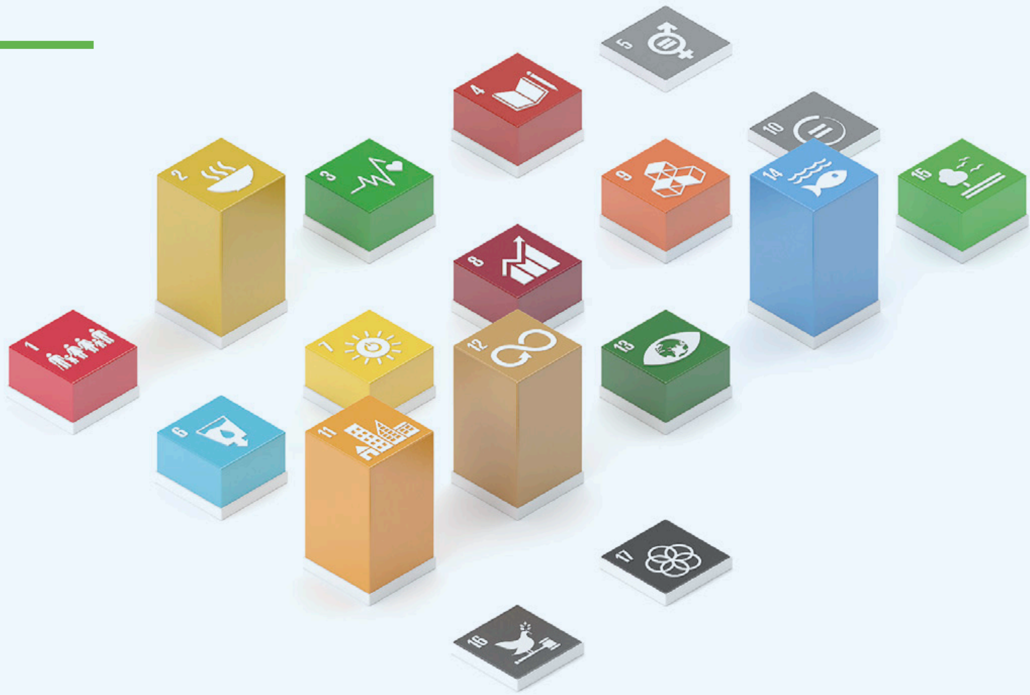
Next steps

In 2017 and 2018, we want to install five more of our modular and mobile fish farms in Nordic cities. We also want to deepen our cooperation with actors in East Africa and Southeast Asia and try to implement our aquaponics models in fast growing cities where the Western food culture is threatening local traditions that offer a better potential to provide good and affordable food without degrading sea or land ecosystems.

Sustainable Development Goals

Stadsjord/Pond will contribute to SDG 2: *Zero Hunger*. Providing people with good protein from circular sustainable production systems is a global challenge. Urban areas around the world are displaying a growing and promising interest in engaging in the production of food in a climate-smart and responsible way. This movement is very important in order to understand and embrace sustainable food production and distribution. Urban agriculture is a way to link cities and the countryside, rich and poor, educated and not educated, young and old. Knowledge about and commitment to producing good food is necessary for the will to support strong food systems all over the world.

Goals



Postive impact on:
Goal 1: No Poverty
Goal 2: Zero Hunger
Goal 3: Good Health and Well-being
Goal 4: Quality Education
Goal 6: Clean Water and Sanitation
Goal 7: Affordable and Clean Energy
Goal 8: Decent Work and Economic Growth
Goal 9: Industry, Innovation and Infrastructure
Goal 11: Sustainable Cities and Communities
Goal 12: Responsible Consumption and Production
Goal 13: Climate Action
Goal 14: Life Below Water
Goal 15: Life on Land

The solution will also contribute to SDG 11: *Sustainable Cities and Communities.* According to the UN Food and Agriculture Organization (FAO), around 1 billion people in the world depend on urban agriculture for their livelihood. They also point out that urban agriculture is 10–15 times more efficient than so-called rational agriculture characterized by large volume monoculture agriculture with huge dependence on oil- and fossil-based fertilizers. Urban agriculture, including Stadsjord/Pond's aquaponic model, generates incomes, food security, good nutritional status, reduced negative environmental impacts, an alternative to scarce marine protein, well-being, and lovely green cities.

SDG 12: *Responsible Consumption and Production.* Some would say that environmental and climate performance in fish production is ensured by international sustainability organizations such as the Marine Stewardship Council (MSC). While MSC is great in many ways, its labeling does not address climate issues at all. For instance, the first Norwegian lobster fishery that was MSC labeled was trawl-based which generates 3–4 times more CO_2 than fishing with pot traps. Stadsjord/Pond can present a fish produced in the city with a climate impact 10 times smaller than that of MSC-labelled Norwegian lobster.

By combating overfishing, Stadsjord/Pond will obviously also contribute to SDG 14: *Life Below Water.*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200
150

Chapter 4:
Marine Pollution

Marine Pollution

This section presents solutions focusing on reducing emissions of environmental pollutants. Let us start with a look at the challenge of marine pollution and the potential effects on people, the planet and prosperity.

What is the challenge?

Human activities result in the discharge of a multitude of pollutants into the marine environment. Apart from the direct discharges to the sea, for example from shipping, emissions from agriculture, sewage treatment plants, and land-based industries can reach the marine environment via rivers. Air-borne pollutants from land- and sea-based industries can also end up in the sea. Many human activities interfere with the natural turnover of nutrients or emit potentially toxic chemicals, and pollution is the flip side of many technological developments. Hence, marine pollution is a multi-faceted issue and its magnitude depends on geographical factors, type of industry in an area, population density, and regional environmental regulations.

What could the potential effects on people, the planet, and prosperity be if we do not solve this challenge?

The marine environment contains many ecosystem functions and services that humans depend on. Apart from providing fish and seafood for human consumption, it provides supporting and regulating services such as global nutrient turnover and climate regulation. When pollution reduces the marine biodiversity and marine ecosystem functions, these ecosystems are disturbed and their services are at risk. Pollution might thus result in a reduced production of marine goods, including food for human consumption. It might also result in marine food with elevated concentrations of toxic chemicals, making it unsuitable for human consumption. Restrictions in this regard are already in place. Fish from Swedish lakes and the Baltic Sea is one example. Reduced food production will inevitably have negative economic and social effects.

Quantifying the challenge

Eutrophication has increased in both Swedish waters and globally, resulting in so-called dead zones on sea floors. Such dead zones have no, or very few, animals due to low oxygen levels. Globally, the number of dead zones had doubled each decade since the 1960s. This problem has been well documented for example for the Baltic Sea, in which large areas of the

128

In 2017, the international CAS registry of chemicals contained 128 million organic and inorganic chemicals. Although not all of these chemicals reach the market and are used in large volumes, it has been estimated that over a million tons of around 100,000 different chemicals are produced per year.

bottom are classified as dead zones. A ten-fold increase in such dead zones has been observed over the last 115 years. As regards chemicals produced by humans, the chemical production has increased exponentially since the 1940s and the trend is expected to continue. Also the number of chemicals synthesized and sold in the market is increasing. In March 2017, the international CAS registry of chemicals contained 128 million organic and inorganic chemicals. Although not all of these chemicals reach the market and are used in large volumes, it has been estimated that over a million tons of around 100,000 different chemicals are produced per year. A very small fraction of these chemicals have been subject to environmental risk assessments. Hence, there is currently a large knowledge gap concerning their potential environmental effects.

Solutions to the challenge

Societies need to substantially reduce the emissions of pollutants into the marine environment. Until now, this problem has commonly been solved with so-called end-of-pipe solutions, meaning that the activity itself is not restricted but the emission is reduced by some kind of purification or waste handling. A more desirable approach would be to have a more circular system where the use of polluting agents and methods is minimized and recycling is employed. End-of-pipe solutions will likely still be used to minimize pollution, but it is important to ensure that such solutions are effective and do not produce downstream problems, such as problematic waste handling. There have been rapid technological advancements in areas such as purification, remediation, and energy production in recent years. In addition to minimizing the use of polluting agents and methods, such advancements are very important for reducing the pollution of the marine environment.

Again

Founder: PhD Zsofia Ganrot together with colleagues
Place of implementation: Gothenburg, Sweden
Partners involved: GU Venture, and technical partners and consultants.
Contact: Mikael Olsson, mikael.olsson@again.se
Find out more at: www.again.se

Solution

Again's solution is to recover nutrients from human urine in waste water. The company's patented and natural additive ZeoPeatTM precipitates most of the macronutrients from the urine. In this way, Again's solution can catch > 98% of phosphorus and up to 70% of nitrogen and potassium. The precipitate is dried and can be pelletized. This dry, complex fertilizer, ReturineTM, is an excellent nutrient source ("slow release fertilizer") for plants directly in private gardens or agriculture.

The solution reduces the amount of eutrophication-causing nutrients that reach lakes, streams, and the ocean and instead facilitates reuse for productive purposes. Phosphorous is predicted to become a scarce resource in the future and nitrogen (as a fertilizer) is expensive and requires a lot of electrical energy when produced.

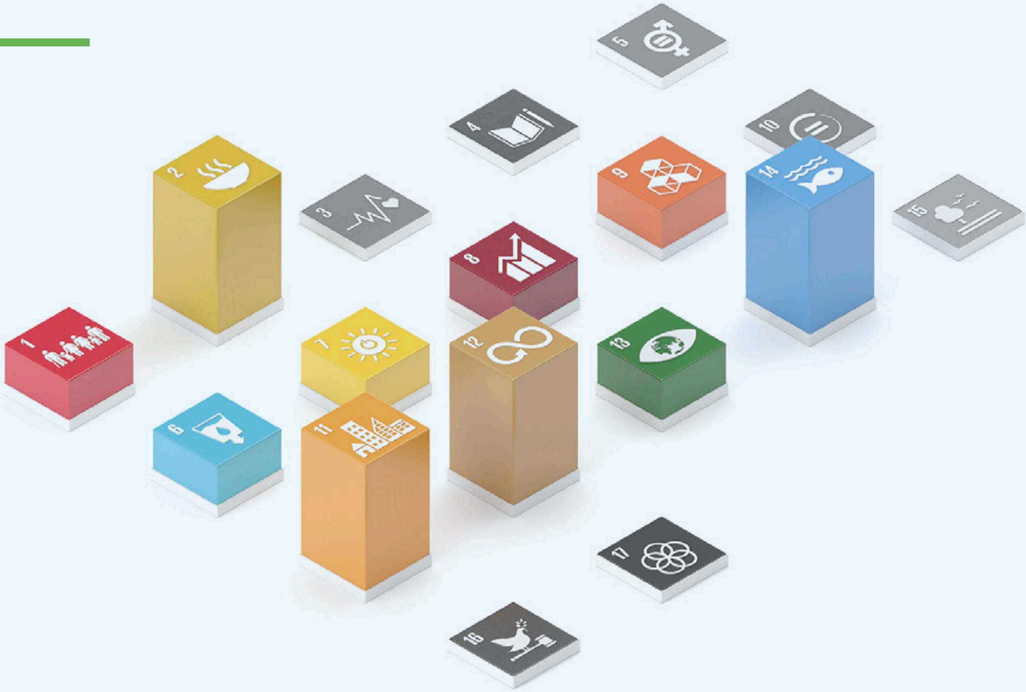
Next steps

We will need financial resources to develop commercial sewage plants for single family dwellings with flush toilet and simple dry toilet solutions.

Sustainable Development Goals

After capturing the nutrients with our technique, the water is nearly free from virus and bacteria due to the high pH in our reactor and can be used for irrigation. Nutrients are necessary for all agriculture. As fewer nutrients available equals a higher risk of hunger, Again's solution is expected to contribute to SDG 2: *Zero Hunger*. Re-using nutrients from thousands of water and dry toilets in cities will make it possible to establish "city farming" and maintain "green roofs" without importing expensive fertilizers, positively affecting SDG 11: *Sustainable Cities and Communities*. Similarly, our solution will contribute to SDG 12: *Responsible Consumption and Production*, by facilitating re-use of nutrients, less transport of expensive fertilizers, and less money spent on building and installing sewage pipes. It is also expected to have a large impact in relation to SDG 14: *Life Below Water*, since effective nutrient recovery will reduce eutrophication.

Goals



Postive impact on:
Goal 1: No Poverty
Goal 2: Zero Hunger
Goal 6: Clean Water and Sanitation
Goal 7: Affordable and Clean Energy
Goal 8: Decent Work and Economic Growth
Goal 9: Industry, Innovation and Infrastructure
Goal 11: Sustainable Cities and Communities
Goal 12: Responsible Consumption and Production
Goal 13: Climate Action
Goal 14: Life Below Water

Sansox Oy

Founder: Mikael Seppälä
Place of implementation: Finland and Vietnam
Partners involved: Three universities, two companies, and governmental support.
Contact: Mikael Seppälä, mikael.seppala@sansox.fi
Find out more at: www.sansox.fi

Solution

O_2 is needed to support most life on Earth, whether it is fish, plants, or algae. If the natural production of O_2 in a water bed is disturbed or the consumption exceeds the production, the O_2-based life in it is threatened (the Baltic Sea is a good example).

The Oxtube is a modular solution for dissolving air or any other gas into liquid. The product is made of stainless steel pipe and requires a pump for creating flow. Functions are:

- Vortex and ejector modules generate gas suction into the water flow.
- Efficient mixing of oxygen, air, or other gas in the water or other liquid.
- The impulse module creates a high-speed flush on the impulse energy walls, forcing extremely fast dissolving by diffusion.
- Finally, the micro bubbling module offers a resting area, to enhance diffusion area and time for perfect diffusion.

In this project we apply high O_2 water to a fish farm, thus enabling better and healthier growth of the fish. Our product can also be used in all types of rehabilitation of natural waters, such as waste and potable water treatment.

Sansox Oy has participated in three different studies at three different universities on diffusion of oxygen in water. In addition, after a Finnish governmental body identified the target area and company to whom we should introduce the project, the resulting know-how was implemented to increase production at a Vietnamese fish farm.

Next steps

Introduce the technology in new markets in Africa, Southeast Asia, and China. Find another site with an oxygen-poor water bed to apply our technology on.

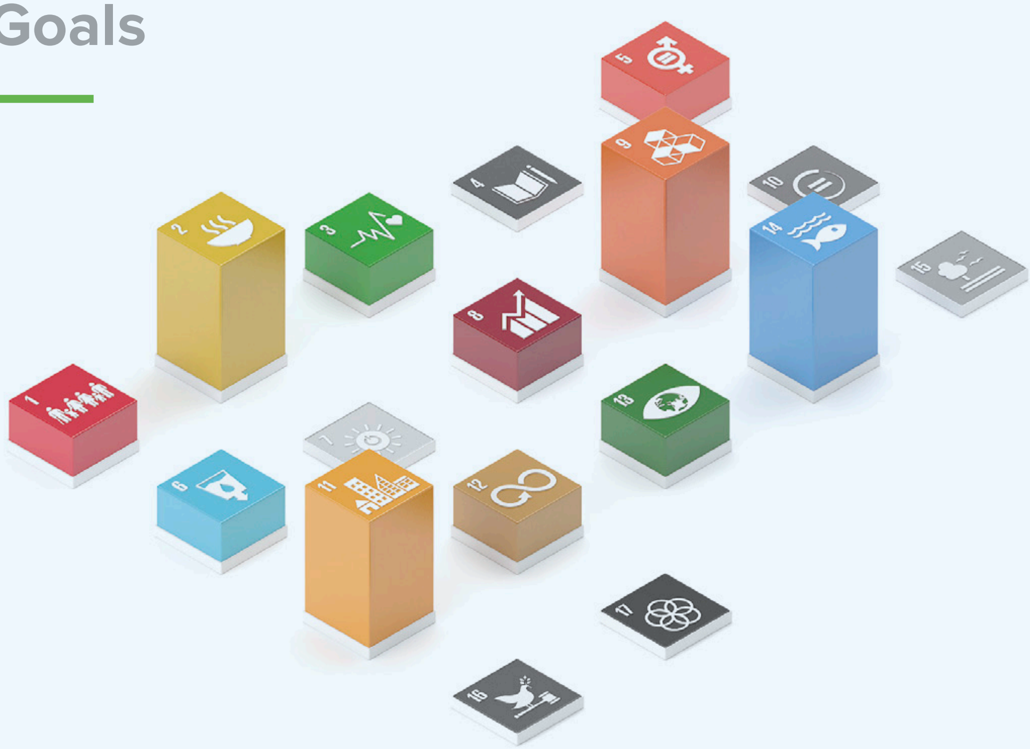
Sustainable Development Goals

According to FAO, the demand for fish will increase by 30% by 2030. As the harvesting of seas and oceans cannot be increased, fish farming will continue to grow. We can make aquaculture more sustainable and, thus, Sansox Oy can contribute to SDG 2: *Zero Hunger*.

The solution will also contribute to SDG 9: *Industry, Innovation and Infrastructure.* We also expect to contribute to SDG 11: *Sustainable Cities and Communities*, since recirculating fish farms enable the production to be increased and brought closer to cities. For RAS fish farming (Recirculated Aquaculture Systems) the enabling question is how to oxidize the water, which is the focus of Sansox Oy.

Our solution also helps increase marine sustainability by decreasing the harvesting of seas and, hence, will contribute to SDG 14: *Life Below Water.*

Goals



Postive impact on:
Goal 1: No Poverty
Goal 2: Zero Hunger
Goal 3: Good Health and Well-being
Goal 5: Gender Equality
Goal 6: Clean Water and Sanitation
Goal 8: Decent Work and Economic Growth
Goal 9: Industry, Innovation and Infrastructure
Goal 11: Sustainable Cities and Communities
Goal 12: Responsible Consumption and Production
Goal 13: Climate Action
Goal 14: Life Below Water

Scandinavian Water Technology SWATAB

Founder: Katarina Klöfverskjöld
Place of implementation: In laundry rooms, with installations in Denmark and the U.K. In the U.K., we have a sales agreement with SWF Ltd.
Partners involved: Swedish Energy Agency, Kristianstad municipality, MKB in Malmö, Sweden.
Contact: Per Hansson, per@swatab.com
Find out more at: www.swatab.com

Solution

DIRO® is a filter system that is placed in dwellings between the incoming cold water and a laundry machine, making detergents totally redundant. The system also works for commercial dishwashers. DIRO® has been tested by SWEREA IVF and has a proven cleaning effect according to the EU Ecolabel test for detergents. Laundry can be washed in cold water and completely without chemicals.

In cooperation with municipal property management company MKB in Malmö, Sweden, we have an installation in place where all laundry is washed in cold water. This installation is currently being energy measured in relation to conventional detergent-dependent laundry rooms and the results will be presented on our website in May 2017.

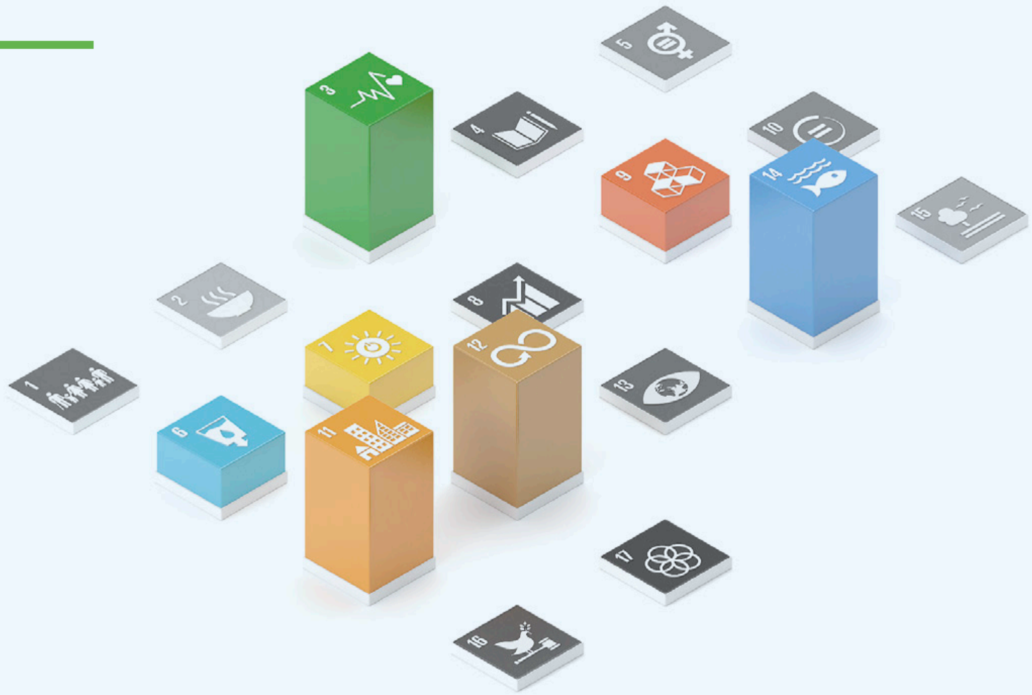
Next steps

Establish business contacts for production and sales of systems for both commercial and domestic use.

Sustainable Development Goals

Scandinavian Water Technology AB (SWATAB) offers a solution expected to contribute to SDG 3: *Good Health and Well-being*. Chemical residues remain on textiles after conventional washing, resulting in allergies, contact dermatitis, and aggravated eczema. Powder detergents contain zeolites, which appear as a fine dust with particles so small they can enter a person's lungs. Other chemicals in detergents include sodium lauryl sulfate (SLS), linear alkyl benzene sulfonates (LAS), petroleum distillates (also known as naphtha), and sodium hypochlorite (household bleach). Many of the chemicals have negative effects on humans, animals, and/or the environment, such as skin irritation, organ toxicity, liver and kidney damage, lung and mucous membrane damage, toxicity to fish, reproductive and developmental problems in animals, and excessive growth of marine plants, triggering unbalanced ecosystems. Fabric softeners also contain many hazardous chemicals, including chloroform, benzyl alcohol, ethanol, and linalool. Human skin is frequently exposed to some of these chemicals as they remain in fabric after washing.

Goals



Postive impact on:
Goal 3: Good Health and Well-being
Goal 6: Clean Water and Sanitation
Goal 7: Affordable and Clean Energy
Goal 9: Industry, Innovation and Infrastructure
Goal 11: Sustainable Cities and Communities
Goal 12: Responsible Consumption and Production
Goal 14: Life Below Water

Our solution is also expected to contribute to SDG 11: *Sustainable Cities and Communities,* by reducing the use of chemicals in society, decreasing the need for transportation, and cutting energy consumption by shortening drying times, lowering washing temperatures, and sending less polluted wastewater to sewage treatment plants. As for economic effects, it reduces service and maintenance costs, extends the service life of the machines, and lowers the cost per wash compared with conventional washing.

By reducing resource use, the solution will affect SDG 12: *Responsible Consumption and Production.* The holding tanks are rotation molded with reused plastic. Filters have been analyzed by SYSAV in Malmö and are classified as combustible waste. The production will be outsourced to countries strategically selected to minimize the environmental impact. Local household appliance service companies will install and service the systems.

The solution will also contribute to SDG 14: *Life Below Water.* Sewer plants and septic systems process large quantities of wastewater but do not always operate properly or remove enough nitrogen and phosphorus before discharging into waterways. Some detergents contain zeolites instead of phosphorus, and wastewater plants have problems removing these small particles from the water. Another issue is that detergents and softeners contain microplastics. Sweden also has over 700,000 private non-approved sewage systems where in many cases the greywater pollutants end up in the streams, lakes, and groundwater.

BoatWasher

Founder: Gustaf Otto Douglas
Place of implementation: Harbours in Sweden
Partners involved: Boat clubs, Municipals with leisure boat harbors, Leisure boat clubs/associations, Trade organizations representing the Recreational marine industry, Naval schools, Environmental organizations, Water authorities, Ministry of environment.
Contact: Odd Klofsten, odd.klofsten@boatwasher.se
Find out more at: www.boatwasher.se/english

Solution

BoatWasher is Green Antifouling.

Identifying the problems in Sweden:

- Approximately 500,000 tons of toxic paint is applied to the hulls of leisure boats every year. The paint is known to leak toxins into the marine environment.
- Every spring, boat owners spend uncountable hours scraping their boats and applying new toxic paint, implying health risks.
- The paint, materials, and tools are expensive
- An alternative is to let professionals do the job. However, this service is also expensive.

The problems in the rest of the world:

- The warmer and saltier the water, the more paint is used.
- A vast amount of hours of unhealthy work.
- The paint, materials and tools, or service are expensive.

BoatWasher eliminates/reduces the use of toxic bottom paint on leisure boats by convincing boat owners to mechanically wash the hull approximately once a month instead of applying toxic antifouling paint.

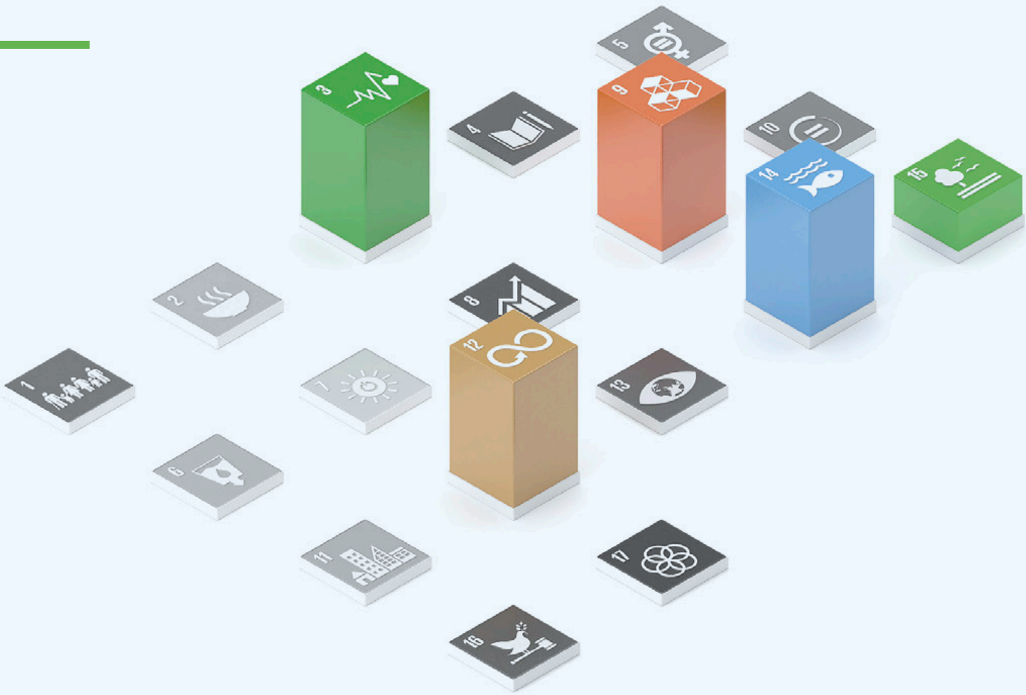
The tools for this behavioral change among boat owners are:

- Information
- Education
- Lobbying
- A machine, the BoatWasher, manufactured by BoatWasher Sweden AB, that mechanically, without any chemicals, scrubs the hull clean from fouling and collects the residue.
- A service concept for keeping the machine in good shape.
- A operational concept for running the BoatWasher stations.
- A customer service concept for bookings, payments, information, etc.
- A BoatWasher Ambassador concept for spreading the word.

Next steps

Liquidity/financing/money to start up more BoatWasher stations in Europe and the rest of the world. Our experience has taught us that putting up a new BoatWasher station is the most efficient way to convince boat owners to choose BoatWasher instead of toxic antifouling paint and to engage others in spreading the message.

Goals



Postive impact on:
Goal 3: Good Health and Well-being
Goal 9: Industry, Innovation and Infrastructure
Goal 12: Responsible Consumption and Production
Goal 14: Life Below Water
Goal 15: Life on Land

Sustainable Development Goals

Less toxins in the marine environment translates to healthier humans. The solution minimizes the risk of exposure to antifouling toxins, since no painting or removal of paint is needed. Hence, SDG 3: *Good Health and Well-being*, will be promoted.

The BoatWasher solution is an example of technological progress that facilitates environmentally sound industrialization and thus will contribute to SDG 9: *Industry, Innovation and Infrastructure*. The conversion from toxin-based antifouling to non-toxic/green antifouling makes boating more sustainable (cheaper, comfortable, healthy, and environmentally friendly)

BoatWasher will also contribute to SDG 12: *Responsible Consumption and Production*, as it reduces the production and consumption of material that is hazardous to the environment and human health. Thanks to our solution, boat owners can learn about and choose an environmentally friendly and efficient antifouling method. To make the necessary behavioral change among boat owners possible, it will be vital to continue spreading knowledge about the green antifouling method BoatWasher.

Moreover, the solution will have a positive impact in relation to SDG 14: *Life Below Water*, as fewer toxins in the water imply better life below the water.

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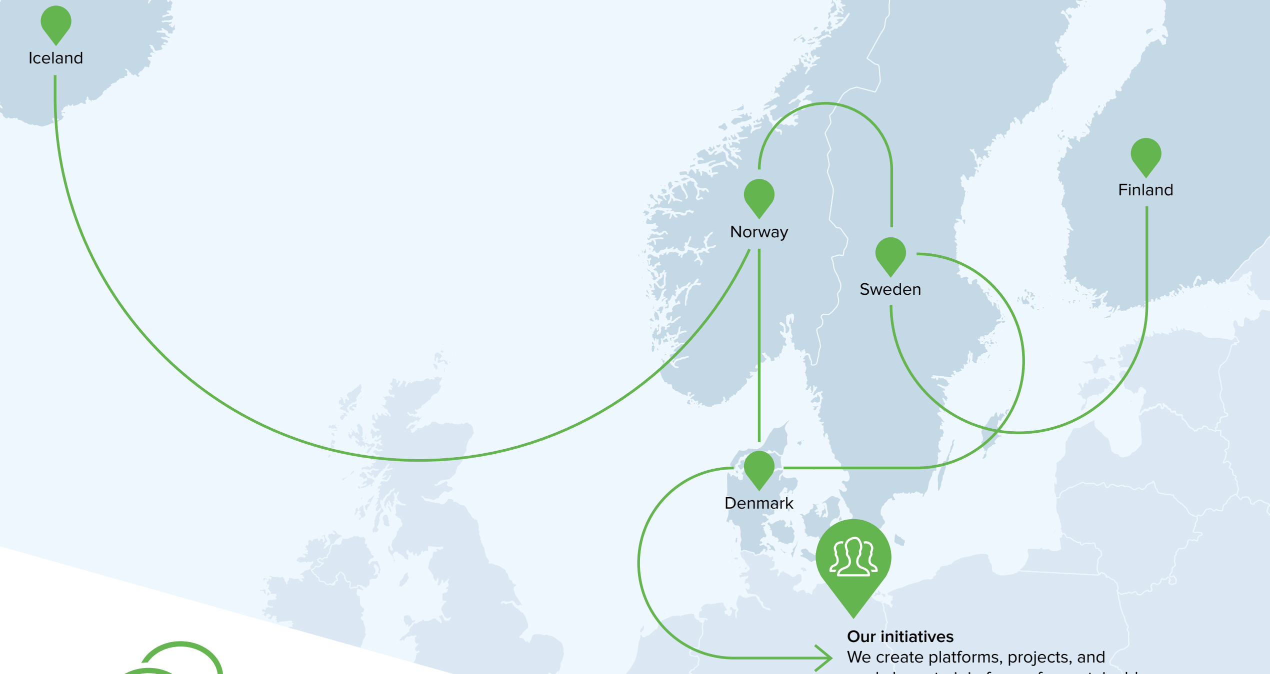
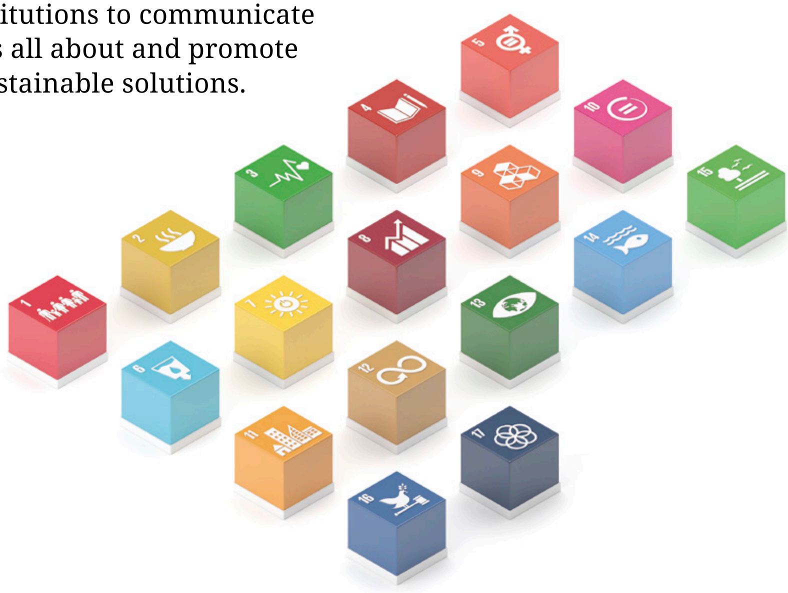
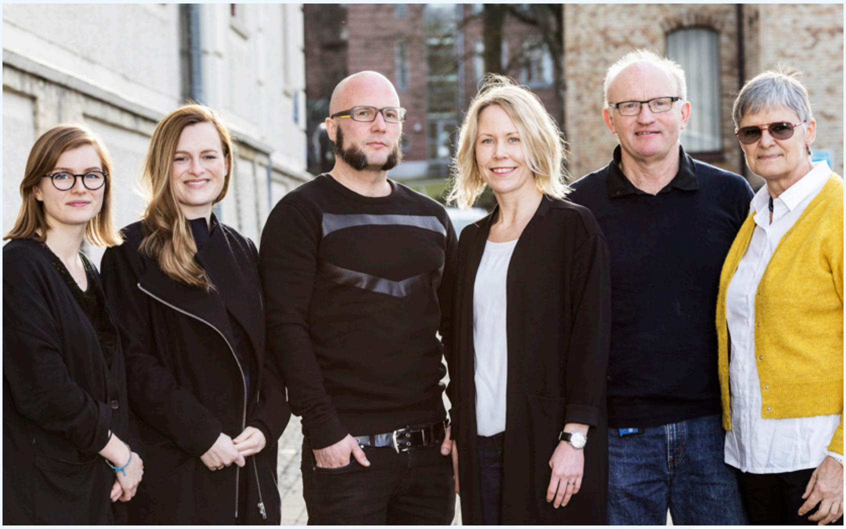


Our initiatives
We create platforms, projects, and workshops to join forces for sustainable solutions. Our initiatives are our way of contributing to reach the Sustainable Development Goals.

About SDSN NE

To reach a sustainable society we need change, and change is not possible without knowledge. SDSN Northern Europe connects Nordic academic institutions to communicate what sustainability is all about and promote joint learning and sustainable solutions.





From left: Linnéa Lundmark, Ida W. Brattström, Anders Ahlbäck, Anna Nordén, Dan Strömberg and Maria Svane.

The Sustainable Development Solution Network (SDSN) Northern Europe is an action-oriented network focusing on mobilizing Nordic scientific and technological expertise to solve problems and create a more sustainable society. The network links knowledge to action in order for society to achieve the UN Sustainable Development Goals (SDGs). For more information about the 17 SDGs, go to: *sustainabledevelopment.un.org/sdgs*

Each person matters in the work to achieve a sustainable society. Yet sustainability can be a complex and overwhelming task. Luckily, academia has the role of understanding the complexity of sustainability. For example, can you imagine all the interconnections among the 169 pre-targets of the Sustainable Development Goals (SDGs)? And sustainability is not just about understanding a complex structure of cause-and-effect relationships, but also about understanding and considering a long-term perspective. As an illustration of this seemingly simple concept, do you normally think of your grandchildren when you decide to take a flight to Paris? It feels good to know that academia does better in this respect than most people.

Where we come from

Despite a long tradition of research, education, and innovation for sustainable development, only a fraction of the results of these activities are utilized to steer society in a more sustainable direction. Therefore, the Sustainable Development Solutions Network (SDSN) was established in 2012 under the auspices of the former United Nations' Secretary-General Ban Ki-moon to mobilize global scientific and technological expertise to promote practical problem solving to reach the SDGs. SDSN Northern Europe was launched in February 2016, in Gothenburg, Sweden, as a national and regional network to support the realization of actions to achieve the SDGs.

Where we act

SDSN Northern Europe includes all SDSN member institutions from Denmark, Finland, Iceland, Norway, and Sweden. SDSN Northern Europe's secretariat is hosted by the Centre for Environment and Sustainability at Chalmers University of Technology and the University of Gothenburg. Visit us at: *www.unsdsn-ne.org*

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