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## **SOLUTION:** **CLOSED LOOP** RESOURCE MANAGEMENT FOR **SUSTAINABLE PRODUCTION**

Effective management of resources the local scale will become an important economic factor for manufacturing companies.

Researchers at Aarhus University are working to develop a conceptual framework for eco-industrial realisation of policy goals within water, climate and nature policy sectors.

The field of Industrial Ecology advances designoriented, inter-industry strategies for resource conservation, minimising waste products. The goal is to develop more cyclical resource-use patterns within industries – analogous to those observed in natural ecosystems.

### **THE 'GREEN BUSINESS CALCULATOR'**

The 'Green business calculator' is a tool for local businesses and municipalities to calculate and optimise waste, resources and CO<sub>2</sub> emissions simultaneously.

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## **SOLUTION:** INNOVATIVE METHODS FOR **PHOSPHORUS RECYCLING**

Enhanced demands for food production will increase the global demand for fertilisers such as phosphorus. The global sources of phosphorus are limited, and the increased demand will result in rising market prices and a global fight for control over the limited reserves.

In such a market situation it will become increasingly important to recycle, upgrade and reuse surplus nutrients such as excess phosphorus leaked from agricultural land, causing eutrophication of freshwater ecosystems. Also sludge from household waste contains phosphorus that is not reused today. Manure and sludge may be upgraded for the production of an added value product compared to the commercial available product.

Researchers at Aarhus University are collaborating across disciplines to develop new concepts and methods for reuse of phosphorus from drainage water, animal waste and household sludge, turning a waste product into a marketable asset.

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## SELECTED PROJECTS

### RESOURCE FLOW AND RECYCLING

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#### **Sustainable recycling of phosphorus – innovative resource flows and technologies (2012)**

Ecoinnovation, DEPA. Comparative assessment of P extraction efficiencies, and positive externalities from innovative resource management and technology systems.

#### **The Macroalgae Biorefinery (MAB3) (2012-2015)**

Strategic Research Council. Ecoindustrial system analysis comprising multifunctional production chains from offshore cultivation, harvesting, preprocessing of macroalgae. (14 partners in DK and abroad)

#### **The Municipal CO<sub>2</sub>-Calculator (2010-)**

Climate and Energy Agency. Ad hoc improvement of a CO<sub>2</sub>-calculator for use in the nature and climate action plans at municipal level.

#### **Green Business Calculator (GBC) (2011-2012)**

Aarhus University. Model tool that is able to document companies' contribution to reducing the human footprint on natural systems. The tool supports increased recycling of resources (e.g. energy, materials, metals) from production processes, products and systems through identification of opportunities to close the circuit of resource flows; including utilization of residues such as manure and waste.

#### **Innovation network for Environmental technologies (2010-2014)**

Strategic Research Council. The network brings together stakeholders in the clean-tech areas of land, water, air and waste and is working to find new and innovative products and services across the four elements. AU is a partner contributing with systems thinking and modelling across sectors, monitoring, verification and reporting (MVR) of corporate contribution to climate mitigation and restoration of environmental quality, particularly through increased resource efficiency and collaborative networks across the clean-tech resource areas.

#### **Innovation network for shredder waste (2011-)**

Knowledge sharing network on market regulations and technologies

#### **Innovation network for phosphorus recycling (2011-)**

Knowledge sharing network on market regulations and technologies

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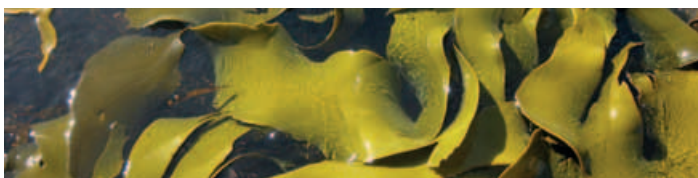


## **SOLUTION:** **MACROALGAE AS A NEW SOURCE OF BIO-BASED PRODUCTS**

The world's area of arable land is limited, and at the same time the need for biological products for food, feed and energy is increasing. This calls for alternative solutions – for instance growth of marine bio-based products.

Macroalgae represent a huge unexploited biological resource. They have many advantages making them a potential solution:

- **Macroalgae grow fast**
- **They can grow in all climatic zones**
- **They contain a high content of valuable carbohydrates, proteins and lipids**
- **They take up CO<sub>2</sub> and nutrients that are in excess in our coastal waters**



Researchers at Aarhus University are on the forefront of optimising macroalgae production and exploring new technologies for conversion of algae biomass into an energy source, simultaneously exploiting excess biomass, for instance as fish feed. Large scale macroalgae production can thus help alleviating the resource, energy and food challenges of the future, while at the same time improving the environment.



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## SELECTED PROJECTS

### MACROALGAE

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#### **The Macroalgae Biorefinery (MAB3) (2012-2015)**

Strategic Research Council. Cultivation and utilization of large brown algae in a biorefinery with focus on fuel and fishfeed (14 partners in DK and abroad)

#### **CO<sup>2</sup> capture and feeding to algae (2012-2014)**

The Foundation for Development of Technology in the Danish Water Sector. Recycling waste streams (CO<sup>2</sup> and nutrients) via algae production to biogas and soil enrichment (3 partners).

#### **Algae in modern agriculture (2012)**

Danish Agency for Science, Technology and Innovation. Theoretical scenario for incorporation of algae in modern agriculture (4 partners).

#### **Natural Ingredients and Green Energy (2011-2014)**

Danish Agency for Science, Technology and Innovation. Production of high value products and energy from waste products and algae (12 partners)

#### **Seaweed on the plate! (2011-2012)**

Danish Agency for Science, Technology and Innovation. Gastronomical voyage of discovery through Danish seaweed species - with focus on taste, visual appearance, health and potential for sustainable production (4 partners).

#### **Algae for biogas in the Central Jutland region (2010-2013)**

Region Midtjyllands Vækstforum. Production of biogas and fertiliser from marine seaweed (5 partners)

#### **BioWalk4Biofuels (2010-2014)**

EU FP7 project. Production of biogas from marine seaweed via bioremediation of waste water and flue gas (10 partners)

#### **Energy from marine biomass (Ulva lactuca) (2008-2011)**

Energinet.dk PSO project. Energy production based on the marine seaweed *Ulva lactuca* (4 partners)

#### **Bioethanol from Ulva lactuca (2008-2010)**

Villum Kann Rasmussen Fonden. Production of bioethanol from the marine seaweed *Ulva lactuca*.

#### **Potential for commercial cultivation of Chondrus crispus in Denmark (2008)**

DFFE project. Land- and seabased cultivation of Irish moss (*Chondrus crispus*) for food applications (3 partners).

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## **SOLUTION:**

### **INTEGRATED MANAGEMENT OF NATURAL CAPITAL: BIODIVERSITY AND ECOSYSTEM SERVICES**

Ecosystems and their natural capital of species are under pressure from multiple factors such as the increasing need for land for urbanization and food production, but also from direct stressors on the natural environment leading to ecosystem degradation and species depletion.

The concept of ecosystem services has been developed to aid our understanding of the human use and management of natural resources and to make it possible to consider the trade-offs between management for different types of services.

#### **Types of ecosystem services:**

- Supporting services: E.g. soil formation, photosynthesis, primary production and cycling of water and nutrients.
- Provisioning services: Products obtained from ecosystems e.g. food, fuel, pharmaceuticals and fresh water
- Regulating services: Includes air quality regulation, climate regulation, erosion regulation, water purification and pollination
- Cultural services: Non-material benefits such as spiritual enrichment, recreation and aesthetic experiences

#### **CASE: POLLINATORS UNDER PRESSURE**

Pollination is vital to the maintenance both of wild plant communities and agro-ecosystems. Beside the well-known, domesticated honey bee, pollinators include e.g. hover flies, butterflies, bumblebees and solitary bees. Pollinators have declined along with the intensification of agriculture.

Aarhus University investigates cause – effect relations involved in the decline of pollinators in order to assess the relative importance of different aspects of agricultural practice and land use. For instance, we investigate response patterns of wild pollinators to pesticides and develop indicators that quantify pesticide effects on flowering plants. Important challenges include interactions between man-made effects and environmental drivers such as climate change.

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## SELECTED PROJECTS

### ECOSYSTEM SERVICES

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**EcoFinders:** Ecological Function and Biodiversity Indicators in Europe-an Soils (2012-2015) European 7th Framework Programme. Identification and quantification of soil biodiversity throughout European soils and its importance for essential ecosystems functions and services (23 partners, coordinator INRA, France)

BESAFE Biodiversity and Ecosystem Services: Arguments for our Future Environment. EU-Framework Programme 7 (2011-2014) (15 European partners)

PRESS – Peer Research on EcoSystem Services, PEER-initiative, (Partnership for European Environmental Research), (2010-2012), Case studies are used to illustrate how to map and assess ecosystem services related to water purification, recreation and pollination. (6 European partners)

**UKNEA:** UK National Ecosystem Assessment (2009-2011), (500 experts on natural science, economics and the social sciences)

Sustainable pollination services for UK crops (4 UK partners). Insect Pollinator Initiative, Living with Environmental Change (LWEC) partnership.

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## SELECTED PROJECTS

### POLLINATION

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The importance of pesticides for the occurrence of wild bees and honeybees, Danish Environmental Protection Agency. A preliminary project that studies whether bees are exposed to pesticides in Danish agricultural landscapes, the likelihood of direct and indirect pesticide effects, and which methods should be applied to study this further.

**STEP:** Status and Trends of European Pollinators, European 7th Framework Programme, <http://step-project.net> Aims at assessing the current status and trends of pollinators in Europe, quantifying the relative importance of various drivers and impacts of changes, identifying rele-vant mitigation strategies and policy instruments, and disseminating this to a wide range of stakeholders.

**EcoServe:** Ecosystem Functions and Services of Biodiversity in Grasslands, Organic RDD Project, GUDP. The aim of the project is to design hay fields that sustain both nature and food production.

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