DTU

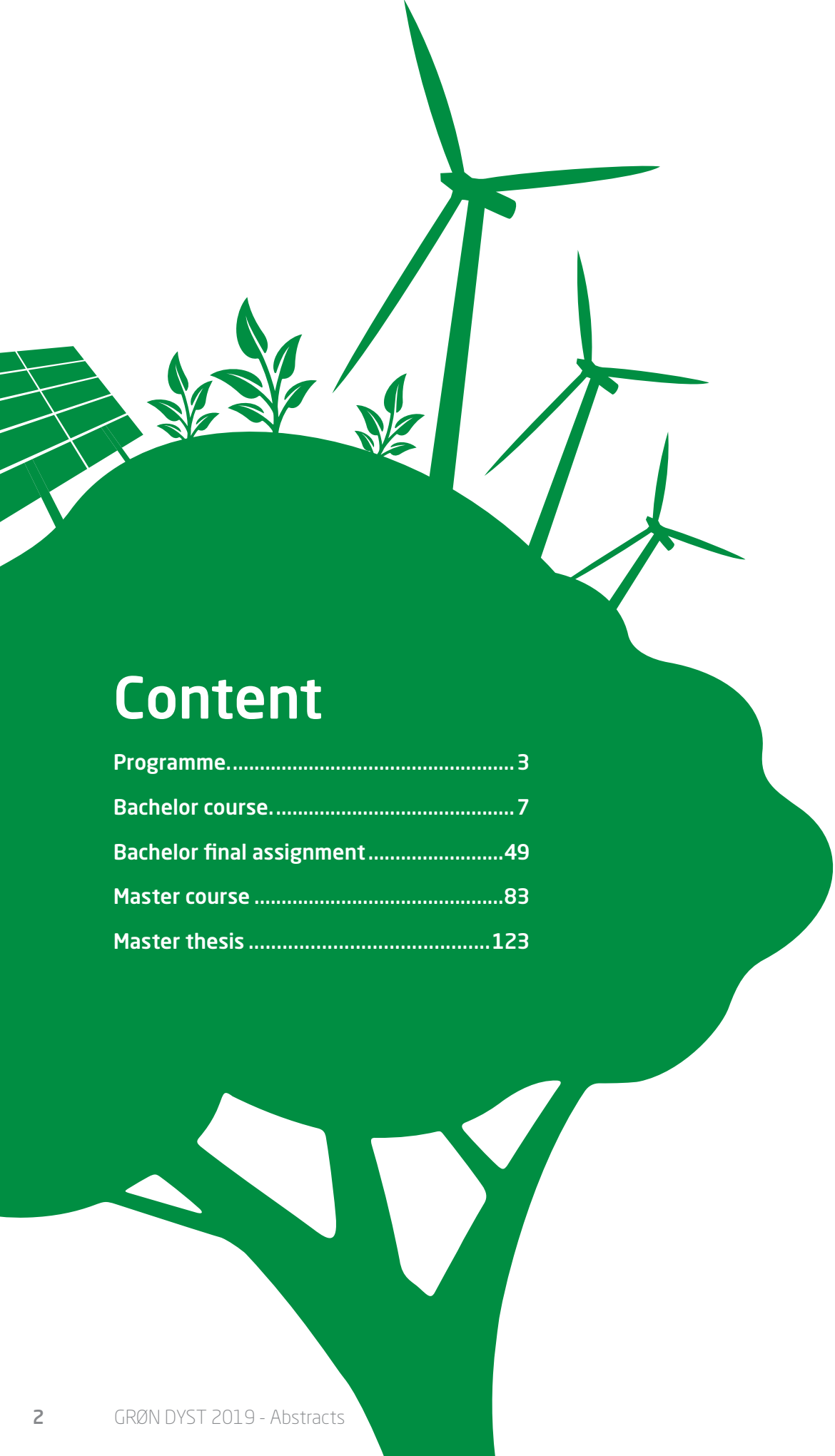
Technical University of Denmark

2019

GRØN DYST™

Green Challenge

Student conference on sustainability, the environment and climate technology.



Content

PROGRAMME

9.30 - 10.00:
Registration

10.00:
Welcome by the minister of higher education and science

10.45:
Judging the projects

12.35:
Lunch

13.35:
Judging the projects

15.20:
Deliberation of the projects

15.45:
Entertainment by comedian and script writer, Brian Mørk

16.15:
Award ceremony by Marianne Thellersen, Senior Vice President Innovation and Entrepreneurship assisted by Brian Mørk

17.30:
BBQ and Jazz concert in Grønnegården

Sustainable Development Goals

Engineers play an essential role in ensuring sustainable development. Engineers can and must continue contributing towards developing technological solutions and address global challenges.

United Nation has on September 25th 2015 adopted 17 goals to end poverty, protect the planet, and ensure prosperity for all as

part of a new global and sustainable development agenda. Each goal has specific targets to be achieved over the next 15 years.

The 17 Sustainable Development Goals are now incorporated in the framework of Green Challenge, because Green Challenge needs to address global Challenges. Read about each of the 17 SDGs on United Nations website: www.un.org

Abstracts
Bachelor course

Bachelor course
Project no. 101

A PSS to eliminate single-use platic cups

J. Tryel, N.Z. Jelle, R.E. Eriksen, J.B. Søndergren, and M.H. Vang

DTU Process and innovation, Technical University of Denmark

THE PROBLEM

Single-use plastic is made from fossil fuels, has a huge carbon footprint, takes hundreds of years to decay, is rarely recycled, leaches toxins into food and drinks and causes hormonal disruptions to humans. Yet single-use plastic is to be found all around us, causing an environmental problem of such magnitude, that the EU is now banning several single-use plastic product such as straws, cutlery etc. as of 2021.

However the plastic cup is not amongst these banned items simply because a viable substitute is lacking. We've identified closed of systems and events, where massive amounts of these cups are used, places such hospitals in DK which consumes more than 28 mio. cups yearly, or here at DTU, where a fraction of the bars accounts for more than 100,000 cups yearly.

Figure 1 Single-use cups from production to disposal

THE SOLUTION

We offer a product service system (PSS), in which we pick-up, wash and deliver reusable (pp)plastic cups on a weekly basis to universities. The cups only has to be reused 1.6 times in order to make a positive enviromental impact, this includes added manufactering cost, washing of the cups and a 10km transport. The quality of the cup means that it can be washed and re-used between 3-5 thousand times, substituting one single-use cup with every use.
We belive in order to truly implement greener solutions, you need to involve the companies and provide them with a benefit. We realised by exposing the cups to specific consumers (such as students) over and over again, we've added a value to the cup, making them an atractive platform for companies to brand themselves, via a logo. We can provide consistent exposure on a sustainable platform, so effectively that companies are willing to sponsor the purchase of the reusable cups, thus totally eliminating the expense of having to buy cups. This puts us in a position where we can price our service, so that it is competetive with the price of single-use plastic cup.

Figure 2 Reusable cups from production to end of life

Bachelor course
Project no. 102

TigiTaka: digitalizing the way to recycle valuables in Kenya

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[2]DTU Civil Engineering, Technical University of Denmark

INTRODUCTION

Kisumu, the third largest city in Kenya, is plagued with both sanitation and waste safety. There is over 67% waste disposal of fecal matter combined with 80% of total waste which is improperly disposed of. There is roughly 400 tons of waste produced per day. This hampers the growth of the city – not only health wise but also economically. The aim of this project is to address SDG 11: Sustainable Cities and Communities to address the current scenario of waste disposal in not only Kisumu, Kenya but for the rest of Kenya. Our solution is to use a phone-based application, to target the 90% of citizens which have access to a cellular phone and most of them own a smartphone. The premise of our solution is to create an integrated phone platform which enables the citizens and local government to have direct communication regarding waste management and regulates a fair trade of recyclables within Kenya.

THEORY

Within Kenya, there is value for certain kinds of waste: plastics, paper, metal, etc. The people who collect these are called *scavengers*. Scavengers often collect this trash and bring to people here called as *middlemen*, who will pay for this valuable trash, and trade it further up the line for money. There is often fluctuation in price for valuables and carrying these heavy bags to the next middleman is not feasible. These scavengers face the problem that they don't know how much they will get payed for the waste that they gathered due to the supply and demand from the middlemen.
Due to the lack of communication between the government and the people the waste management sector has also suffered, which has led to majority of trash improperly disposed of. When it is correctly disposed of, scavengers tend to scour hazardous dumpsites in order to find valuables, leading them susceptible to diseases and injuries

SOLUTION

We want to provide a solution for both proper disposal of trash along with safe/stable conditions for the scavengers. TigiTaka is an app to properly dispose of waste. It will enable citizens to find common waste collection points by using our interactive map feature. When the collection point is full you can report the status to the app. The data is sent to the government to optimize a route to retrieve the waste. The live status will be beneficial for scavengers to collect valuables efficiently. Meaning less waste in Kisumu and more material for the waste pickers. By using our marketplace feature middlemen can create a demand for certain materials and scavengers can find middlemen with the best price and lock it in.

Figure 1 Logo

Bachelor course
Project no. 103

Efficiency model of converters with MPPT for PV-to-battery applications

L. Kluge and K.L. Pedersen

DTU Electro, Technical University of Denmark

Background

Up until recent times, photovoltaics (PVs) and batteries have mainly been used together for low power applications. However, new developments in photovoltaic and battery technology have made it feasible to also store electricity from higher power photovoltaic systems in batteries. The increased power means that it makes sense to use a more advanced electricity transfer method, namely voltage level conversion with Max Power Point Tracking (MPPT). Inverters for photovoltaics in energy grid supply applications already use this method and models exist for their efficiency. This project seeks to create a model for the efficiency of converters with MPPT by adjusting the existing inverter models.

The case

The case that motivated this project is the collaboration of Nordic Firefly and Living Energy to create a stand-alone photovoltaic lamp (SPVL). The SPVL is storing energy created by PVs in the daytime in a battery for use in LEDs during the night. For this it uses a converter with MPPT. Our model will help to determine how the converter with MPPT influences the overall system performance under different operating conditions. The SPVL will eventually improve traffic safety in developing countries and therefore contribute to SDG 9, Industry, Innovation and Infrastructure, while doing so with small CO_2 impact and thus also contribute to SDG 11, Sustainable Cities and Communities.

Project outline

This project will evaluate different inverter models to find the one best suited for describing converters in PV-to-Battery systems. It will then be proposed how this model can be adjusted to fit the new purpose. This includes changing the measurement procedure such that it takes the battery charge cycles into account and revising the equations that are fitted to the measurements in order to obtain the physical properties of the converter with MPPT.

Implementation

The proposed model will be applied to the converter that is used in the SPVL prototype and implemented in matlab for use in a model of the complete system.

Bachelor course
Project no. 104

Optimizing hand-washing by the use of ultra violet light

N.A. Sauer, P.F. Svendsen, J. Jensen, F.S. Holm, W.T Madsen, and C. Foss

DTU Diplom, Technical University of Denmark

INTRODUCTION

Every year 37.000 dies from hospital infections in Europe and 99.000 in US. Many of those infections could have been prevented with better hand hygiene. Unfortunately, handwash still leaves about 10% of bacteria and viruses on your hands even after a thorough handwash. This forces hospitals to use other methods like alcohol disinfection to remove as many bacteria and viruses as possible, but test results shows that the bacteria and viruses get more and more resistant against alcohol.

SOLUTION

One way to eliminate the last 10% of virus and bacteria as well as the multi-drug resistant microorganisms is to implement UV-LED in the hand hygiene procedure. UV-light, at a specific wavelength holds the ability to target the DNA of virus and bacteria and make them incapable of reproduction. UV-light also holds the key in fighting the problem with multi-drug resistant microorganisms as the method also kills them.

PRODUCT

We want to combine the aerator on a tap and a UV-LED, in a way that makes it compatible with most taps in Denmark. The UV-LED will be emitting a wavelength of 295nm, and we want to divide the exposure to the light so it matches that of 10 min of direct sunlight on a sunny summer day, over approximately 30 hand washes. The new aerator will have a dynamo that with the power from the water drives the UV-LED.

Our product has got a huge potential since the bacteria and viruses cannot build resistant against ultra violet light. Furthermore the aerator with integrated UV-led will reduce the use of water on hospitals since it is not necessary to wash hands for as long due to the effective removal of bacteria and viruses.

With this solution implemented on hospitals we expect to be capable of reducing hospital infections significantly and thus to safe lives.

Bachelor course
Project no. 105

Harvesting excess heat using magnets

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Harvesting energy from waste water

Water with intermediate temperature and low flowrates is a common byproduct of industrial processes. Either in the form of used coolant or condensed water from steam turbines. The relatively low temperature and flowrate mean that you cannot harvest the energy using conventional means like a turbine.

In this project the viability of using a magnetic based generator to harvest the energy from the byproduct. This has been simulated using a numerical model.

Simulating the harvester

The concept behind the magnetic generator, is that you have a magnetic material that is free to move in relation to a fixed permanent magnet. Heating the magnetic material with a flow of hot water reduces the attraction to the permanent magnet and allows it to be pulled away. Cooling the material with another flow of cold water, when it is away from the magnet, makes it more magnetic and attracts it back towards the permanent magnet.

This allows for a rotation of the magnetic material in between the two flows of water, which can be used to generate electricity.

The simulation looked at the energy balance in the magnetic material as it is respectively heated and cooled, and how it changes with the application of a magnetic field. This is then used to estimate the amount of energy that can be harvested. The simulations were done on beds of packed spheres of magnetic material where the temperature was changed by two different flows of water.

The results

The simulations were done for many different parameters as divided into two groups, parameters related to the operation of the harvester, and the parameters related to the design of the harvester.

The investigation showed that the most important operating parameter was the temperature of the hot water used to heat the material. A large change in generated energy was found when the temperature difference was right around the Curie temperature, the temperature for which the material changes between being ferromagnetic and paramagnetic, giving a large change in its magnetization. Additionally, it was found that the optimal amount of water that should flow through the harvester was closely related to the size of the harvester.

Viability of the harvester

In conclusion, it was found that it is possible to generate energy using a magnetic harvester. The most important parameter is to ensure that the hot water temperature was above the Curie temperature while the cold water was below it. Additionally, the amount of water must be optimized to the size of the generator to optimize the effect gained contra the cost of the generator.

Bachelor course
Project no. 106

How hyperlocal farming can ease the climate costs

J. Brandt, M. Andersen, M. Hansen, J. Skydsgaard, and A. Bergmann

DTU Process & Innovation, Technical University of Denmark

INTRODUCTION

The human population is at steady growth, and towards the year 2050 an estimated 68 % of the earth population will be living in major cities (UN DESA, 2018), which will put an increasing pressure on the agriculture. The transport, packaging, and food waste will only increase due to the constant increase in demand of food crops. In Denmark the average citizen creates approximately 59 kg of food waste (Stop Spild Af Mad) and 105 kg of retail sales packaging pr. year (DAKOFA, 2018). Therefore, there is a need for bringing the production of food crops to a local state, where the agriculture is based more locally than we see today. By doing this we also contribute to FN Sustainable Development Goal no. 12: Responsible Production and Consumption.

CONCEPT

Lettuce Grow Green is based on module size grow boxes, which lets the consumer build their own individual sized grow wall, that can be used indoor as well as outdoor, making it possible for growing crops vertically within a minimal spaced area.

The grow system is based on a technique called fog-phonics, which is a soilless growing method used to optimize the growing process with a reduced use of water.

With this technique it will be possible for everyone to grow their plants without the worry of watering too much or too little, keeping the maintenance to a minimum. Combining this with flexible plant-subscriptions, where the consumer gets pre-sprouted plants delivered straight to the doorstep. The solution will on that behalf be able to hit a broad mainstream market with segments ranging from the non-typical grower to the busy family, joining the trend and growing their own crops in their apartments.

OUR VISION

By moving parts of the production to the private consumer we eliminate some of the transportation and offer fresh commodities that lasts longer. It will also be beneficial for the amount of food wasted, which is also on the rise, due to the fact that they will be able to only pick the amount of food to be consumed leaving the crop to continue its growth. Finally, when no packaging of the crop is needed, the ease of packaging used, is also a benefit when using this principal.

If citizens can produce their own crops where they live, hyperlocal, each citizen could give their own contribution to ease the pressure on the increasing demand.

References

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Bachelor course
Project no. 107

The new standard – a cone for everyone

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INTRODUCTION

In Denmark during the summer months ice cream is a necessity. What better way to cool down on a hot and sunny day? And the most traditional ice cream is the old fashioned ice cream, which is an ice cream cone filled with the most delicious sorbets and ice creams.

During the past couple of years vegetarian, vegan and allergy friendly products have started to become more normal in stores. Consumers have also become more aware of where everything comes from and more people prefer locally produced food products. Because of this trend, many ice cream stores have had to focus on producing more products that would live up to these requirements. It has resulted in many different vegan and lactose free ice creams. But what about the rest of the experience?

THE PRODUCT

Together with Bornholms Ismejeri, an ice cream company based on the island of Bornholm, a vegan and gluten free ice cream cone has been developed. The focus has been to create a new standard cone for the stores, so they do not have to have a vegan, a gluten free and the traditional cone. It is made from products found on Bornholm, and it lives up to the following criteria for a good ice cream cone:

- It does not go soft easily
- It has a good crunch, and it does not crumble when you break a piece off
- It looks like a traditional ice cream cone
- It costs the same as the traditional cone
- And most importantly it has to be delicious

The new cone lives up to these requirements, and it is even cheaper than the traditional cone.

Bachelor course
Project no. 108

Prosperity energy game

J. Brittain, P. Løjmand, and A. Gleerup

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INTRODUCTION

Prosperity is a cooperative multiplayer game to be played primarily by students in middle school on multiple tablets, but also the general public and anyone interested. The game simulates the energy production and consumption in a city. By controlling the means of production and consumption, each player can influence the system. The goal is to cooperatively sustain the city with minimal pollution and maximum quality of life for its citizen. By playing and improving, the students should teach themselves how to implement a sustainable energy network and get a deeper understanding of the underlying issues.

THE GOAL

The aim is to motivate students to learn about sustainable energy in a fun way where optimal play leads to great sustainable models and a high score. Our goal is to connect their sense of accomplishment to active learning, thereby sparking interest in sustainable sciences and research. If our simulation is accurate and expanded enough, entire new sustainable models could arise from optimal play. The primary goal of the project is to educate young people and increase awareness of sustainable energy production, and the challenges it involves.

THE CONCEPT

The basic concept is a distributed cooperative game that models the energy balance of a city. Each player controls part of the system, contributing to either energy production, consumption or storage. Using local weather data, the players need to adapt to shifting weather conditions which affect the output of various energy sources as well as the consumption necessary for adequate heating. The goal is to maintain a positive energy balance while minimizing pollution. Since each player only controls part of the system, this can only be achieved through cooperation, which makes the game suitable for a classroom environment. The target platform is android tablets.

CHALLENGES

The main challenge is finding the right balance for the game. We realize its success depends on a combination of accuracy of simulation and fun gameplay mechanics. If the game is too complex or overwhelming, then the students may not find it intuitive or engaging. However, if the game is too simple then the simulation may be misinformative and lack depth. Our solution is to keep our models simple, but at a point where they still make sense in their respective context and combine them with other engaging mechanics encourages cooperation and exploration.

Bachelor course
Project no. 109

Minimizing the carbon footprint of Danish production by connecting companies and visualizing the availability of slack resources with database creation

N. Mustafi, P. Fergus, M. Salihu, U. Siddiqi, and A. Clemmensen

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INTRODUCTION

In Denmark 60% of all plastic waste ends up being incinerated, which means we have to produce even more plastic. Most production companies have some kind of waste product that ends up in the scrapyard. A lot of these materials are the same as what is being mined from the earth.

If there was a way to reuse the waste materials, there would be no need for mining new resources from the earth.

THE PROBLEMS

1. The first problem is that not every kind of waste can be recycled and it is therefore sent to the landfill. This is a problem because it harms the environment and our planet only has a finite amount of resources, which we can use.
2. The second problem is that the process of recycling materials costs a lot of energy. It is also an expensive process, which leads to higher prices of these recycled materials.
3. The final problem is that buying recycled materials reduces profits for firms, and this makes it harder for them to invest in an environmentally-friendly future.

SOLUTION

Our solution to this problem is an online platform where companies can upload information about the material that they are planning to throw out. Companies can also use this platform to look for materials for their project, which they can buy. The incentive for companies to use this site is to save money. The seller earns money by selling their materials, which would otherwise have been sent to a landfill. The buyers save money by buying materials at a discount. The prices of these materials are lower than usual because the sellers have to get rid of said materials. Furthermore, our platform should be a place for companies to create bonds with each other, so that they in the future hopefully can replace raw materials in their production line with reused materials from other companies.

OUR VISION

Our plan for the future is to help all companies work together with each other to create a closed loop and hereby preventing any resources of being wasted. If every company starts to buy resources from each other, we would no longer have to mine new resources from the earth. This way we can eliminate the threat of the earth being depleted by its resources.

Bachelor course
Project no. 110

Regenerative braking system for improving the fuel consumption of vehicles with internal combustion engines

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INTRODUCTION

29% of the world's greenhouse gas emissions comes from internal combustion vessels, such as cars and trucks. In the meantime, an increasing level of complex electronics are added to modern vehicles, which results in increased electrical power requirements. Usually, a simple belt driven generator delivers electrical energy to the vehicles' battery powering the electronics. However, constantly having the internal combustion engine of the vehicle drive a generator results in higher fuel consumptions. We are developing a system capable of powering the electronics of a vehicle without increasing the fuel consumption on the vehicle. If such a system can be implemented in a large number of vehicles, thus decreasing the fuel consumption of each vehicle, it will have a significant positive impact on total greenhouse gas emissions.

METHODS

When a vehicle brakes, a portion of its kinetic energy is converted into heat in the braking system. This energy can instead be collected as electrical energy to be used for powering the electronics of the vehicle, potentially replacing the traditional engine driven generator. The goal is to develop an efficient, compact and lightweight regenerative braking system to be implemented on DTU Roadrunners' Ecocar. The system must be capable of braking the car whilst charging the battery powering the electrical systems in the car. During the international competition, Shell Eco-Marathon, where the Ecocar competes with other highly fuel-efficient cars, the total fuel consumption of the Ecocar is measured when driving in a simulated urban environment. The energy consumed by the electronics in the car is converted into litres of fuel consumed, which adds to the total fuel consumption. By implementing a regenerative braking system, generated electrical energy is subtracted from electrical energy consumed, thereby lowering the total fuel consumption of the Ecocar.

SOLUTION

The regenerative brake can be made efficient as well as compact and lightweight by taking advantage of the already existing gearbox in the car, as it can be used to drive a custom electrical induction generator at very high rotational speeds. Furthermore, electronics for converting the induced electrical energy for charging the battery of the car must be designed. The overall concept is proven if such as system can be successfully implemented on DTU Roadrunners' Ecocar to reduce the total fuel consumption of the car (including energy consumed by electronics). If the system performs well enough for the highly specialised Ecocar, a similar system can be implemented on traditional cars, thus eliminating the need for an engine driven generator.

REFERENCES

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Bachelor course
Project no. 112

Reducing unnecessary power usage by indirectly applying Mesh-Networking to consumer electronics

C.K. Andersen, M.S. Galsgaard, M. Kousholt, P. Ravnsbæk, V. Schwartzbach, and F.M.V. Voss

DTU Process & Innovation, Technical University of Denmark

Introduction

The world is annually increasing its usage of electricity, currently with a rate of over 25.000 TWh per year. Parts of this increased usage arises from households where an increased amount of consumer electronics takes up power being in idle mode - Also known as standby.

Studies shows that households within developed countries tend to spend towards 10-15% of their total electricity usage on standby-power a year. Electricity that could've been saved or used elsewhere.

Solution

Our solution for the problem stated above? Meet StandBye.

With StandBye, we seek out to say goodbye – hence the name, to almost all standby power. Our way of doing so, is by developing and producing a low powered power socket which with built-in mesh-networking technology lets the user wirelessly control and keep track of his or hers ordinary power appliances in a 'smart' way.

Theory

The theory behind our solution is based on studies showing that people are becoming more open-minded towards products / solutions that will have a positive environmental impact. A change that's in correlation to our growing awareness for the climate – If we don't act now, planet earth will.

Furthermore it is within our belief that by using a technology like mesh-networking, which essentially is a lot like Wi-Fi, just more stable and secure in terms of operating and controlling systems, we'll differentiate ourselves from the current market, adding additionally value to our product solution. We want the average consumer to think they do not only want our product, but they *need* it.

Conclusion

By using our mesh-network power socket, we can provide the consumer with a bigger economical profit on their electricity bill after 1 year and 2 months (generally speaking) as well as lower their CO_2 print on the planet, here as in power saved from general electric appliances.

Bachelor course
Project no. 113

4 QUALITY EDUCATION

OmTange - seaweed in the classroom

T. Kappel, S. Morgenstjerne, K. Zinck-Madsen, C.Terp, and M. Larsson

DTU Process & Innovation, Technical University of Denmark

INTRODUCTION

We at OmTange know that the future is the children of today. We therefore have developed an educational kit for kids in primary school, classes 3rd to 6th, to enlighten them about the fantastic potential in seaweed.

THE PROBLEM

70% of our planet is covered by water. The potential for aquaculture is huge, yet not exploited much in the western hemisphere. As we run out of land to farm, we need solutions to ensure future sustainable foods, and feed. This could be addressed by growing the ocean's seaweed, as this is a sustainable key resource. As we have spoken to several seaweed farmers, nationally and internationally, we discovered that the demand for western seaweed products is limited, which leads to high manufacturing costs. The prices cannot decrease until demand will increase. The big question is: how do we change that?

CONCEPT

We have developed an educational kit including the material needed to grow the seaweed species Ulva, for kids in primary school. The kit will be used as an experiment in science class to teach the kids how to cultivate seaweed. As an important part of the teaching we believe the kids should be taught about the biological needs seaweed demands in order to grow, as well as its uses among others, such as food, feed, plastic and medicine. The kids will in addition to this learn about the positive environmental impact seaweed has.

OUR VISION

Our vision is to plant a seed in the children that will change the current western cultures view on seaweed. We believe that by enlightening children about seaweed they will learn to see it as a multipurpose resource and so help promote the use and knowledge about seaweed, hence creating the demand that can propel the development of local, sustainable seaweed productions. Potentially, if every school in Denmark is supplied with seaweed kits for one class, we could averagely teach 64.439 kids about seaweed every year.

Figure 1 Logo

Bachelor course
Project no. 114

CASA - design and build a sustainable social housing home to revolutionize the Dutch housing market

E.C. Kinsella and K. Vaitkute

Eindhoven University of Technology

We are 23 ambitious students across 9 nationalities, who have worked throughout the last two years to design and engineer all aspects of our home. We have gathered 43 partners from the academic and business worlds to work alongside us to provide sustainable materials, newest technologies and expertise; together we will build a remarkable home, which is a comfortable affordable and sustainable alternative for the current way houses and neighborhoods are being built.

Our first house has been sold to social housing corporation WoonBedrijf, even before the first hole has been dug in the ground. The first CASA will be built in October 2019 and we have the honor of being the first house in the Netherland's smartest new neighborhood in Brandevoort, Helmond.

HOW DOES OUR DESIGN REVOLUTIONIZE THE CONSTRUCTION INDUSTRY?

CASA will be completely circular. All materials are chosen for their longevity, materials that are less durable are biodegradable to further reduce waste and the ecological footprint of the house. The house is full of cutting edge sustainable technologies to keep it energy efficient. Our energy roof generates electricity and heat from the sun, and the energy will be converted to heat that will be put under the ground in our Seasonal Thermal Energy Storage.

Our steel construction will carry all the weight of the building so that our wooden facades do not support anything. This means that future renovations will be easy and cheap. Maintenance will be affordable and efficient due to the accessible service core running through the centre of the house, housing all the components and appliances. The way of building is also much more time efficient than currently is the case; as we prefabricate every part of the house, the construction will be on site will only take a few days.

Our energy roof generates electricity and heat from the sun, and the energy will be converted to heat that will be stored under the ground in our Seasonal Thermal Energy Storage: STES in short. This is a water tank with 104 cubic meters of water, which will reach a temperature of 80 degrees in the summer. The heat will be used in the rest of the year to make sure it is never cold at home, therefore, we do not need any gas to heat our house.

The house will run on a combined AC/DC grid, combining them will reduce energy loss through conversion. Rain water will be collected through a specially designed sloping roof that converges towards the centre. This will create a significant reduction in the water consumption demand of the house. The house runs on a demand-driven ventilation system based on measurements of CO2 and humidity levels in the house, the ventilation system decides where and how much to ventilate. Since the ventilated air still contains thermal energy, this energy can be 'won back' by the heat pump.

Once the first house is built, research will be carried out in collaboration with Eindhoven University of Technology and CASA. Through this, we can continue to analyse our building and users and continue to innovate and optimize the design so that the concept in suitable for social housing in the future. We will also use insights from this research to work on our next project CASA 2 which will be a circular education building on the TU/e campus, built using parts from an existing, demolished building.

Bachelor course
Project no. 115

Møn-proppen (The Møn Cork)

I.S.S. Christensen[1], K.W. Rasmussen[2], K.K.M. Jacobsen[2], T.N. From[3], and J. Lambrechtsen[3]

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[2]DTU Process & Innovation, Technical University of Denmark
[3]DTU Chemical Engineering, Technical University of Denmark

THE PROBLEM AT HAND

At the Danish island Møn and its surrounding waters it is a well-known fact that there are large occurrences of the special seaweed called eelgrass. Eelgrass is a plant that is often found in coastal areas and is important as a home or food to a wide variety of oceanic wildlife. It also helps stabilizing the ocean environment by absorbing heavy metals and storing CO_2, phosphor and nitrogen. The downside to this plant is that it washes onto beaches and accumulates in large piles. If the eelgrass is not removed straight away it flushes out again and interacts with algae resulting in decomposing when it washes onto shores again. The eelgrass then starts to smell, creating a problem for visiting tourists.

Besides this there is a problem with the way a lot of liquor bottle corks are made. These corks are a harm to the environment, since they are made from either plastic, metal or wood. According to Danmarks Statistik around 2 million T-type corks are produced every year. These corks are a harm to the environment and needs to be produced with a more environment friendly material.

SOLUTION

The solution for these problems is to create alternative corks. These new types of corks will be made of a material where eelgrass is mixed with a leftover material from a production (for instance junipers from gin production) and blend it with a biodegradable plastic.

The solution has already proven to be realizable with the first prototypes in place. These prototypes have been made by heating of the mixture of eelgrass, tailings and biodegradable plastic and thrust it with pressure into a mould. It is then put inside another mould where the bottom of the cork gets a layer of natural rubber. This ensures that there is no taste, air or smell that will be transferred to the liquid in the bottles.

By creating these new types of corks, it will result in a positive impact to the environment. By replacing only 50 % of the conventional corks made of metal we will be able to save 12 tons of metal each year.

On top of this, our new type of cork will accommodate four of the UN Sustainable Development Goals. These include number eight; Decent work and economic growth, number nine; Industry innovation and infrastructure, number twelve; Responsible consumption and production and lastly number seventeenth; Partnerships for the goals.

With this new type of cork, we want to create the foundation of a more sustainable future!

Bachelor course
Project no. 116

Re-Use.It

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INTRODUCTION

Our vision is to ensure that water is utilized efficiently and hereby turn wastewater into a valuable resource. The need to recycle our wastewater is crucial and urgent, as wastewater is becoming a worldwide issued due to the fact that water shortage has become evident in our lives. With the rising temperature, as a result of global heating, water is becoming a more and more needed resource. In 2016 the water stations experienced a rise in the usage of water, due to the high temperatures. It got so bad, that they had to turn down the pressure to compensate for the lack of water in the tanks. A change must be made to grant the future generations a sustainable and improved living. By developing a recycling system that will reduce the water usage in households, we strive to eliminate this concern. The aim is to have a positive impact on UN's 6th world goal ''Water and Sanitation''.

THE PROBLEM

According to the UN, half of the world's population will lack clean drinking water by 2030. The water shortage is greatest in developing countries and the Food and Agriculture Organization of The United Nations (FAO) estimates that every 5th country will experience permanent water shortage by the end of 2030. The lack of drinking water has a direct impact on the risk of being infected with diseases such as diarrhea, cholera, dysentery, typhoid and polio. Furthermore, water is also used to grow the crops we eat. Without enough water, it will almost be inevitable that we will experience food shortages.

THE SOLUTION

Re-Use.It will make sure that households reduce their harmful impact on the planet, by recycling and cleaning the water that is wasted on a daily basis. This will enable households to see a dramatic decrease in their water bills, as well as contribute to a more sustainable environment. The filter used in Re-Use.It will make sure that all particles and bacteria are removed from the water and thereby making it safe to consume.

Bachelor course
Project no. 117

Evolt: Electricity sharing community

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INTRODUCTION

The Danish government wants to invest in green solutions and become CO_2 neutral by the year of 2030. Therefore, they have come up with a climate plan to reduce carbon emission. However, this plan is not ambitious enough. As a result, we see a growing interest from the public to act even further. It is commonly known that our impact as a society, instead of an individual, makes a greater impact in general. It has been our motivation to work out a solution that gathers private households and give them the possibility to make a greater impact together and take control of the green transition. In order to understand the key factors in motivating the private householders, the focus has been on gathering information from the users themselves and the main thing that drives them to the decision of investing in green energy solutions. Previously the Danish government has rewarded Danish citizens economically when they invested in renewable energy. However, later on they removed this economic incitement to invest in these solutions and the tendency of private green investment was thus reduced. To give a new incitement to investing in green energy solutions, we have come up with the following concept.

Our Solution

Our solution is an electricity sharing community concept that revolves around the residential area of Trekroner in the city of Roskilde, which is an area that is commonly known to have policies and active opinions of caring about the environment. It is a relatively new residential area constructed after the government withdrew the economic benefits of green investment and therefore, the green energy solutions in the area are limited in terms of solar and wind turbines. The idea is to bring Trekroner residential area together in a community that produces and uses renewable energy to become self-sufficient. Trekroner as a community is "cut" from the public energy supply lines by a separation caused by a meter that prioritizes community power over public electricity to ensure minimal electricity tax, which currently accounts for 76% of the average electricity bill. It is made possible by placing a battery hub that acts as a storing device and distributes electricity produced by the community. This ensures that the energy produced during the day is stored to be used during the night. This enables house owners to use green energy at all times and avoid buying energy from the public grid in order to lower carbon emission and the cost of the electricity bill.

Results

Our investigations have shown that the public is interested in not only investing in green energy based on economic benefits but are also willing to invest further on their own to ensure a faster green transition if they are part of a community that together can make a bigger difference.

We can conclude that the concept is met with interest from the residential area of Trekroner who shares the common interest of becoming self-sufficient in terms of energy. As a bonus, the community model enhances the pricing of houses in the area based on dialogs with real estate agents based in the same area.

Bachelor course
Project no. 118

3 GOOD HEALTH AND WELL-BEING

Hand hygienical behavioral changing system for kids

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THEORY

In Denmark only 35-40% of the population wash their hands after visiting the toilet, which is often caused by forgetfulness. Due to the low rate of people washing hands, there is an increased rate of infections transmitted between people, especially between the staff and children in nursery schools. This correlation results in more frequent illness both among children and more absence for the staff as shown in studies compared to other professions. The consequences of this correlation is less money for nursery schools, which results in less staff per child and more cases of stress-related absence and in worst case temporary closure of the nursery school.

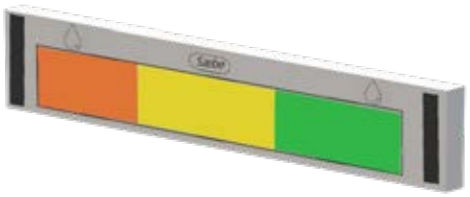

Figure 1 Sketch of pretotype

METHOD

By doing interviews with various professionals in this field consisting of doctors, nurses, psychologists, CFO of the company Saninugde, and alternately desk research about the hygiene, the correlation to illness, nudging and game theory in the formation of LEAN startup, we have found a solution.

RESULTS

We have developed a simple but effective feedback system for children based on nudging to increase social sustainability. By using sensors for each step in handwashing, a display with a loading bar gives feedback to that specific child. The child can then follow the progress, and in the end, a big mental reward in form of a visual will make the children remember to wash hands.

Bachelor course
Project no. 119

Development of process for trinity bio-waste types

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INTRODUCTION

Trinity bio-waste types are which cannot be recycled as animal feed however highly mis-considered as food waste; bones of chicken, pork, beef, egg shell, fibrous vegetal wastes. We introduce a systemic procedure to reuse these trinity wastes from household to various purposes; degrading fibrous vegetal wastes for making bio-ethanol, bones for making fertilizer, egg shell to neutralize both processes.

THEORY/METHOD

Generation of Bio-ethanol

Decomposing the cellulose into glucose includes two major steps, denaturation of structure with acids and anaerobic bacterial fermentation to generate ethanol. “The predominant technology for converting biomass to ethanol is fermentation followed by distillation. Fermentation is a bio-chemical conversion process in which the biomass is decomposed using micro-organisms. This technology can be used for various types of biomass feedstocks.” [1]

Nitrogen fixation fertilizer

The majority component of chicken bone is $Ca_3(PO_4)_2$. We can make $Ca(H_2PO_4)_2$ using mineral phosphates with sulfuric acid. It is employed as fertilizer for plant. Nitrogen fixation is a process that nitrogen in the air is converted into NH_3 or nitrogenous compounds. This reaction depends on microorganism such as Rhizobia so we can mix bacterial compounds into food waste fertilizer to support the effect of nitrogen fixation. [2]

PRODUCT

The product of this trinity food waste procedure is highly effectuated bone-based fertilizer with nitrogen fixation bacteria, and bio-ethanol generated from cellulose materials.

EXPECTATIONS/RESULT AND CONCLUSION

Although the policy of separate collection of food waste is various, each household should generate various amount of trinity food wastes unavoidably. And farms, livestock, butcher can also bring this waste into environment. By this procedure, we can elevate the effectiveness of fertilizer, biomass energy from household scale to industrial scale. And introducing this concept can generate other policy to delicately regulate the food waste costs.

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Bachelor course
Project no. 120

Team CORE, from waste to raw materials

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THE SOCIAL RELEVANCE

Team CORE focusses on a large societal, ecological, and economical issue with which our planet currently deals. Rare earth metals present in the earth crust are getting depleted. These metals are getting extracted from the earth in an environmentally hazardous manner. This mainly happens in China and African countries where there is minimal attention for the consequences of the mining process. Metals are often extracted from the earth crust by using acids in which stones dissolve. This is very effective regarding the mining process. However, the acids left behind in the natural environment, cause gigantic acid lakes. In these places, almost nothing is able to live and grow anymore. Animals extinct, plants perish, farmers cannot grow crops, and water is poisoned. Besides this multiple universities and independent research institutes have concluded that metals such as zinc, gold and silver will be extremely scarce in 35 years due to the depletion of natural resources and the cradle-to-grave pathway in which these metals are treated. The United Nations carried out a research which concluded that currently less than 1% of the waste from electronics is fully recycled, which implies that electronics are handled in a cradle-to-grave manner. These metals are crucial to produce all kind of electronics on which our dependency as society is increasing. This waste is difficult and costly to recycle, so the general practice is to store it. This is an excellent opportunity to have a new resource of rare earth metals and creating a circular economy by closing the cycle. Management of e-waste is closely linked to Goal 3 (Good health and Well-being), Goal 6 (Clean water and Sanitation), Goal 11 (Sustainable Cities and Communities), Goal 12 (Responsible Consumption and Production), Goal 14 (Life Below Water), and Goal 8 (Decent Work and Economic Growth), As defined by the United Nations University (*The Global E-waste Monitor 2017*, 2017).

THE SOLUTION

The solution team CORE contrived for this problem is a very old process which is operative for billions of years, namely the process of the earth. In the core of the earth materials return into pure elements under high temperatures and pressure. This process is called elementary retraction. Since the core of the earth is problematic to reach, team core is working on recreating this in a reactor. For this technology a temperature of 1800 degrees Celsius has to be reached by an external source. In order to achieve the optimal process, the right mix of waste steams has to be made. This operation results in the same product forms as the earth: metals, obsidian and gasses. The gasses can be purified in a gas washer, obsidian is a useful stone material which is often used in the build environment and is even able to capture CO2. The metals are useful as raw materials for all kind of applications such as the production of electronics. The team is currently working on a simulation model and after the summer break starting on the proof of concept, by processing a small batch of batteries use of a conduction oven. In 2021 we are going to experiment in a plant where a simplified version of the technology is operative. The results attained from the experiments will be used to design the plant we have mind. We aim to have the first plant operative by the start of 2024. In order to reach such high temperatures, a lot of energy is required. From a sustainability point of view, team CORE aims to power the plant with electricity. For the first plant, we can make use of the existing grid of Metalot, an Industry site. Currently 80% of this electricity is still grey. However, because of the solar panels which are being built on the site and of the ongoing energy transition we expect that this electricity will become green.

Bachelor course
Project no. 121

Cleaning of polluted gasses with water from small mobile and stationary sources

C.S. Andersen and O.N. Moon

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INTRODUCTION

When cooking food, great quantities of ultrafine particles (UFP) (diameter of 0.1 µm), together with volatile organic gases (VOCs), are emitted to the surroundings. These are toxic and harmful to animals and humans in too high concentrations and has a strong odor when concentrated. High concentrated cooking fumes are found around kitchens such as cafes and restaurants where food is prepared daily.

THEORY

Most of these cooking fumes as well as the toxic particles and gasses can be removed by connecting a ”wet scrubber” between the extractor hood in the kitchen and the roof cap to clean the polluted air. This can severely lower the major odor nuisances that some neighbors might experience, as well as lower the risk of getting sick or even die from the high levels of toxic particles and gasses. Active carbon can be used to adsorb gasses from the cooking fumes, but it will be clogged and not changed before particle and gas levels are getting too high.

METHODS

A wet scrubber consist of spray nuzzles comminuting water into fine rain, that catches airborne particles removing it from the air. Below the spray nozzles, a packed bed is used to catch particles and VOCs by adsorption. The water from the spray nozzles removes the particles and VOCs and prevents the packed bed from being clogged. A liquid reservoir, also used as a grease trap, is found at the bottom of the wet scrubber, which is connected to the spray nozzles via a filter pump. A mist eliminator is placed right before the roof cap and prevents most of the water to escape the wet scrubber.

RESULTS

The measurements of the concentration of ultrafine particles in the air were taken by two P-TRAKs. However, it could not be concluded that the wet scrubber reduced the concentration of the ultrafine particles, but the VOCs were reduced by approx. 50% according to two test persons. In addition, high concentrations (500000+ particles / cm^3) of UFP were also measured when the gas stove was turned on. If the concentration is constant of 500000+ particles and you work 7 hours, $2.1 * 10^{12}$ UFP is expected to be exhaled during a workday.

CONCLUSION

Although the constructed wet scrubber didn’t necessarily reduce the concentration of UFP in the air, the VOCs were reduced to some extent. The wet scrubber can be improved by implementing a heating element so that the water does not freeze in cold temperatures, mounting the grate better so it does not risk falling into the water at the bottom of the barrel when handling the packed bed. The diameter of the roof cap should be larger in order to minimize water blowing out to the sides and, lastly, to install a small door at the base of the barrel so that the electronics are more easily accessible.

Bachelor course
Project no. 122

Phytoremediation of wastewater for agriculture

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INTRODUCTION

There is a greater burden on our freshwater resources of which 70% is used for agricultural needs, while sewage goes unrecycled. Current sewage treatment methods are inefficient when it comes to agricultural purposes. We propose the use of phytoremediation, the process of purifying water using plants which removes all chemical compounds while retaining phosphates and nitrates which are key nutrients necessary for crop growth. This promises a low-cost method of producing nutrient rich water in rural areas and places suffering from drought, while freeing up freshwater resources to satisfy humanity's needs.

PHYTOREMEDIATION PROCESS

The roots of the wetland plant, water hyacinth, can absorb contaminants and decrease the concentrations of BOD, COD and heavy metals but is unable to reduce the phosphate and nitrate levels to the standards required for human consumption, which is why phytoremediation is not widely used. However, the water produced from this process is fit for irrigationas it preserves the phosphates and nitrates while eliminating other contaminants.

PROPOSED PLANT DESIGN

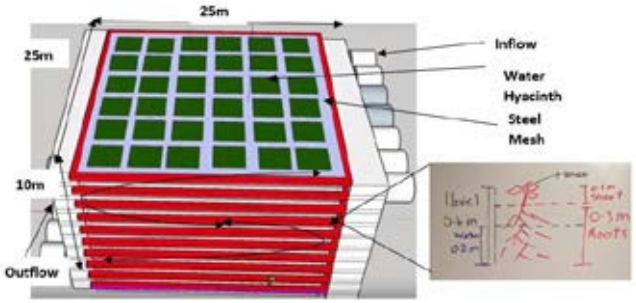

Figure 1 Preliminary plant design

Wastewater will enter from the top and will travel through the hyacinth roots on each floor. This continuous treatment process requires the water to be exposed for four days. The buildup of waste on the roots means to maintain productivity, the plant will require replacing.

FEASIBILITY AND BENEFITS

The design is built to be space efficient, utilizing minimal area compared to traditional wastewater treatment plant facilities which can span up to a hectare. This plant model is also easily scalable depending on how much waste it will be required to process. The operations for the proposed design are relatively simplistic when compared with an array of industrial processes. This allows for interested parties with lesser knowledge or experience in engineering related fields to grasp a better understanding of the process hence allowing more rural involvement in the project with regards to manpower. The results of this project are coherent with UNSDG 6 Clean Water and Sanitation.

Bachelor course
Project no. 123

MTWT – Mobile Telescopic Wind Turbine

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INTRODUCTION

When going to festivals during the summertime, we experienced that one of the biggest issues there, was the lack of electrical power to charge our phones, and stereos.

On that background we constructed the idea of a mobile wind turbine to create clean and sustainable energy anywhere. In the spring of 2018, MTWT was created. MTWT thereby became, a self-elected student project, during the thermodynamic course.

GOAL AND MARKET SEGMENT

We wish to provide electrical power generation in remote locations, where there isn't an electrical infrastructure. The goal is to create an affordable, durable and mobile source of energy. We hope to power anything, from phones when hiking the Scottish Highlands, to water pumps and lights in Africa.

The current target group is campers and festivalgoers. The reason the this, is because it is possible to test the product in some extreme situations before launching it around the world.

MTWT V. 1.0

First time around, we made a prototype to meet specifications, such as: lightweight, durable, easy to assemble and reliable power output.

Version 1.0 was a telescopic aluminium mast stabilized with an aluminium quatro-pod and a heavy earth rod. A vertical axis wind turbine, was used for the project.

Version 1.0 was submitted to be a part of the DTU/Roskilde festival collaboration, back in 2018, and every aspect of the prototype was tested. We knew after the experience at Roskilde festival that, there were a lot of improvements to be made.

MTWT V. 2.0

This semester we have continued our work, as part of the product development course at DTU. During the course we have worked on improving the product, to be lighter, smarter and easier to manage.

We researched a lot on alterative materials and constructions, in order to shave down weight and optimize strength and mobility.

We believe to have made an improved and satisfying product, for harvesting wind energy anywhere.

AROUND THE WORLD

We hope that the mobile telescopic wind turbine, may provide electric power to people in need, without the use of fossil fuels. We believe that there is demand for electrical power in in small communities, around the world, and MTWT will comply to this demand.

Bachelor course
Project no. 124

Strategy for a waste-free Folkemøde festival

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INTRODUCTION

Bornholm Regional Municipality has a vision of becoming incineration-free by 2032. It is therefore crucial to reduce and reuse all waste materials on the island. Commercial waste from events can be especially difficult to handle due to a lack of waste sorting. An example is Bornholm's annual political festival, Folkemødet, an event for which there is currently no strategy for reducing waste. To help Folkemødet towards becoming a waste-free festival and supporting the Sustainable Development Goals (SDGs), a project was undertaken in co-operation with the Secretary of Folkemødet with the aim of recommending a common strategy for waste reduction at the festival.

CURRENT SITUATION

First, the current situation and initiatives regarding waste management at the festival were mapped. It was discovered that there is scarcity of information on waste at Folkemødet, and that most waste is not recycled or reused. Through interviews it has been learnt that this absence of data has hindered student groups working with waste-reduction at Folkemødet, causing the evidence-driven relevance of their projects to be hard to validate.

Secondly, the barriers that prevent progression towards an environmental sustainable development were identified. The main stakeholders all point at the fundamental barrier being a lack of economic and human resources. A frequent renewal of the Secretariat and single-tracked focus on the economic development of the festival has contributed to a neglect of a sustainable development of the festival.

A THREE-YEAR-STRATEGY

Finally, a three-year strategy for further investigative actions and initiatives is envisioned. To aid in reducing the adverse per capita environmental impact (SDG 11.6), the strategy is build upon the waste hierarchy, which builds on SDG 12.5. The main finding was, that investigative actions should focus on data collection. New initiatives should work with:

1. Product fabrication
2. Waste generation
3. Waste collection & re-use

The proposed measures were successfully implemented at other festivals, suggesting that implementation of the strategy could reduce the amount of waste generated at Folkemødet. It will, however, demand co-operation from all stakeholders and restrictions set by the Secretary of Folkemødet.

In this project, a special focus has been put on SDG 11, 12 and 13.

Figure 1 The ISO waste hierarchy

Bachelor course
Project no. 125

Putting it all on the line: re-thinking old technologies to dry washing naturally on university campuses

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CONTEXT

The energy consumption of household appliances such as the clothes dryer places a considerable burden on the environment; dryers consume as much energy as washing machines, refrigerators, and dishwashers combined – roughly 2.5kWh per cycle – making it clear that their use needs to be reconsidered. The cost and process of drying clothes also places a significant burden on students, as drying machines are unreliable, with low levels of student customer satisfaction, and often requiring more than one drying cycle for each batch of clothing. Dryers damage the environment, are costly for customers, and are both inefficient and unnecessary. Our project proposes an alternative solution to be implemented by universities.

PROPOSED ALTERNATIVE

Many students currently use clothes horses in their rooms, but this can lead to humidity and mould and so is banned within many housing contracts. It therefore appears likely that students would use open air washing lines if facilities were provided. These facilities would consist of a cage made of wire mesh or slatted wood, and a glass roof to keep rain off while causing a greenhouse effect.

Implementation

The primary site for drying facilities would be on the roofs of accommodation buildings. This maximises the exposure of clothing to wind and sunlight, while also ensuring the facilities are only accessible to the occupants of a given accommodation block. Some accommodation buildings may already be sufficiently strong to house drying sheds; in other locations, this plan would be implemented whenever new accommodation is built. Drying facilities may also be placed in ground level sheds in green spaces near accommodation blocks, or alternatively drying racks could be provided in basements. The proposed idea involves utilizing student identification cards as a potential user-recognition system in order to keep clothing secure, and to place a time limit on the length of time for which one student can use the drying shed. Our solution can be implemented at Lancaster University and any other university as it relies solely on water evaporation as a result of the combined effect of sunlight and wind.

Bachelor course
Project no. 126

Fast evaluation of blueberries

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INTRODUCTION

Near Infrared Spectroscopy (NIRS) was investigated using a non-destructive analytical technique, aimed to construct a model for evaluation the quality of blueberries. In this study, the prediction models of sourness, density, condition of the white frost covered, brands and freshness, which were stable quality-related properties, were developed and analyzed based on Principle Component Analysis (PCA), Support Vector Machine(SVM) and Python programming based data visualization methods. After testing 119 blueberries from 5 different brands for a month, we set up and validated the models and found that the most reliable models were obtained from brands and freshness analysis using particular classification kernels. Although this project is relatively small scaled, its non-destructive method and high predictive power imply high potential in industrial applications.

MATERIAL AND METHOD

Raw Material

Using chemical and physical assessments, the data of quality-related properties of blueberries (i.e. sourness, density, brand, freshness, condition of white frost covered) were obtained.

Non-destructive analytical technique

A half DIY Near Infrared spectrometer (NIRS) were used to record the information of the blueberries instantly.

Model

The model was used to obtain the relationship between NIR spectra and the quality-related properties.

To conduct the model, the data was first visualized and analyzed using NumPy, matplotlib and scikit-learn. The spectra were assigned into several classes according to their quality related properties respectively. Then, the PCA procedure was conducted and the 2D data was imported and analyzed using SVM with different algorithm. The model was then validated and the accuracy of each model was calculated.

CONCLUSION AND POTENTIAL APPLICATIONS

The results of each model are highly diverse. Some of the model accuracy is over 70% while some of them are extremely unreliable.
Although this project is relatively small scaled, its non-destructive method and high predictive power imply high potential in industrial applications. For example:

- As a smartphone application which can predict your preference for a particular bunches of fruit in the grocery;
- As a quality indicator in food industry;

Bachelor course
Project no. 127

Mapping areas and detecting sources of pollution with collaborating robots

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DTU Electrical Engineering, Technical University of Denmark

INTRODUCTION

With the huge advancements in robot technology during the last couple of years, the use of robots in heavy industry as well as in the society is rapidly increasing. As a part of this technological development, a new need for robots and systems, which can solve more and more complex tasks, is arising. Tasks, such as search-and-rescue missions, where the objective is to quickly screen an unknown area in order to find a person/an object or to simply map a greater area. In order to complete these missions faster, a multi-agent robot system can be used, as the robots can cooperate to cover ground faster and more efficiently.

CONCEPT

The essential idea behind the project is to use a system of collaborating robots to quickly scan an area and find potential sources of pollution, when it is registered that an area has been polluted. Furthermore, the multi-agent system could be used to quickly get an overview of how much of the area has been subject to pollution - a damage assessment.

METHODS

The area, which should be mapped by the mobile robots, is visualized as a graph by the system of mobile robots. As the mobile robots screen the area, already discovered areas will be represented as vertices in the graph. The edges between the vertices thus represent connections between areas. Mapping the unknown area in such a way provides a way for the system to efficiently delegate new subareas for the robots to investigate.

The delegation of each task is issued to different robots based on the position of each robot and the position of the task source location from where new potential sub-areas may be discovered. The robot with the shortest path to the location of the task source should be delegated that task such that travel time is minimized. In order to find the shortest path from all robots to the task source, different algorithms such as Breadth First Search and Dijkstra's shortest paths algorithms are used.

PROSPECTS

The system of collaborating mobile robots developed in this project will be tested on a right-angled labyrinth, which constitutes the unknown area for this test-setup. In order to make the system applicable for a mapping of a greater area in a real world-setting, different aspects of this project would need to be changed.

For example, due to terrain constraints, drones instead of robot vehicles should be used. If so, each of the drones should be equipped with a GPS and a camera such that the system can track the positions of the drones and detect areas of pollution based upon live pictures. The shell of the project regarding the task delegation between the robots, the collection of data over the area and the modelling of the area as a graph can, however, be reused.

Bachelor course
Project no. 128

Enzymatic CO_2 utilization

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INTRODUCTION

Carbon dioxide can be exploited as a natural resource. This project presents the potential of using the enzyme formate dehydrogenase (FDH) to convert atmospheric CO_2 into valuable commodity chemicals. The project focused on information on different methods of CO_2 capture and explores uses of FDHs to utilize CO_2 in the form of formate and formic acid. The method was considered to have potential in reducing the amount of atmospheric CO_2 and producing formate in a sustainable non-petrochemical manner.

Method

We have expressed, isolated and analyzed the catalytic capabilities of carefully chosen FDH variants originally encoded in purple sulfur bacteria found on sun-exposed rocks in southern mainland China. Expression were done in *E. coli* BL21 expression strains, with subsequent purification on HisTrap FF 5 mL columns, utilizing the artificially introduced his-tag on the enzyme. Analysis was done by measuring the concentration of NADH in an enzyme solution degassed with N_2 and CO_2 over time.

Bachelor course
Project no. 129

Design for optimization of larvae production from Black Soldier Fly - *Hermitia Illucens*

E. Omraninejhad and T. Wagner

DTU Mechanical Engineering, Technical University of Denmark

INTRODUCTION

The World Health Organization expects the world population to reach 10 billion people by the end of year 2050. The expected protein demand has therefore been estimated to increase with 265 to 368 million tonnes by 2050.

This expansion of the human race will have extensive and critical global environmental impact due to the current protein production methods, where the Co2 emission is severe.

Therefore, it is inevitably to change our current farming industries and find new ways to feed the world. Scientists have pointed out the Black Soldier Fly-Larvae (BSFL) as an alternative because of its high content of protein and environmentally low impact on recourses.

Despite these positive impacts, the present farming methods demand large production facilities and high labor during manufacturing processes.

Today, the BSFL is not an economic well-balanced choice to feed the world with. The complex manufacturing processes are necessary due to the uncontrolled heat release during intake of feed, and due to the general need for caretaking during growth. Therefore, the BSFL has an extraordinarily high kilo price.

THEORY

This project is considering BSFLs as biomass and can therefore use well-known thermodynamic theories to predict the welfare of the larvaes during production. Furthermore, the facility is combined with various agricultural industries' machinery in to an innovative, automated and space saving process.

MACHINE DESIGN

The project handles the above stated challenges with a mechanical engineer aspect by upscaling the production in a combination of different existing technologies used in the traditional farming industry and re-build these facilities exclusively to fit with the Larvae in consideration.

RESULTS

The result takes the larvae production from manual manufacturing to an industrial and automated production that will decrease the production costs and thereby enable real alternatives to traditional meat production in an economic possible manner.

From UN's Sustainable Development Goals this project aims to contribute to solve both Goal 2: 'Zero Hunger' by using Goal 9: 'Thinking of innovative new ways to re-purpose old material'.

Bachelor course
Project no. 130

Sustainable facility management solutions in NIRAS I

Authors to be determined

DTU Management Engineering, DTU Mechanical Engineering
Technical University of Denmark

INTRODUCTION

This project has been part of the course “sustainability in engineering solutions” in the three weeks period in June 2019. The course includes first and foremost an introduction to environmental assessment of products and solutions in their life cycle through the use of simple tools. On this basis methods and tools are presented for the development of environmentally improved products and solutions. These methods and tools are applied in the project work. Through the course social and management aspects of sustainability will be presented.

THE PROJECT WORK

The group have been working on specific cases related to Facility Management and identified by NIRAS A/S as cases where finding the environmentally best solution is not straight forward.

This can for example concern green logistics for meetings, optimization of waste handling incl. best options for handling organic waste, optimal lighting solution for building areas, environmentally best options for menus in canteens etc..

RESULTS

The projects outcomes are: a solution developed considering the three sustainability dimensions: an environmental life check of the alternative solutions, and a plan for implementation of the solution.

Bachelor course
Project no. 131

Sustainable facility management solutions in NIRAS II

Authors to be determined

DTU Management Engineering, DTU Mechanical Engineering
Technical University of Denmark

INTRODUCTION

This project has been part of the course “sustainability in engineering solutions” in the three weeks period in June 2019. The course includes first and foremost an introduction to environmental assessment of products and solutions in their life cycle through the use of simple tools. On this basis methods and tools are presented for the development of environmentally improved products and solutions. These methods and tools are applied in the project work. Through the course social and management aspects of sustainability will be presented.

THE PROJECT WORK

The group have been working on specific cases related to Facility Management and identified by NIRAS A/S as cases where finding the environmentally best solution is not straight forward.

This can for example concern green logistics for meetings, optimization of waste handling incl. best options for handling organic waste, optimal lighting solution for building areas, environmentally best options for menus in canteens etc..

RESULTS

The projects outcomes are: a solution developed considering the three sustainability dimensions: an environmental life check of the alternative solutions, and a plan for implementation of the solution.

Bachelor course
Project no. 132

Sustainable facility management solutions in NIRAS III

Authors to be determined

DTU Management Engineering, DTU Mechanical Engineering
Technical University of Denmark

INTRODUCTION

This project has been part of the course “sustainability in engineering solutions” in the three weeks period in June 2019. The course includes first and foremost an introduction to environmental assessment of products and solutions in their life cycle through the use of simple tools. On this basis methods and tools are presented for the development of environmentally improved products and solutions. These methods and tools are applied in the project work. Through the course social and management aspects of sustainability will be presented.

THE PROJECT WORK

The group have been working on specific cases related to Facility Management and identified by NIRAS A/S as cases where finding the environmentally best solution is not straight forward.

This can for example concern green logistics for meetings, optimization of waste handling incl. best options for handling organic waste, optimal lighting solution for building areas, environmentally best options for menus in canteens etc..

RESULTS

The projects outcomes are: a solution developed considering the three sustainability dimensions: an environmental life check of the alternative solutions, and a plan for implementation of the solution.

Bachelor course
Project no. 133

Sustainable facility management solutions in NIRAS IV

Authors to be determined

DTU Management Engineering, DTU Mechanical Engineering
Technical University of Denmark

INTRODUCTION

This project has been part of the course “sustainability in engineering solutions” in the three weeks period in June 2019. The course includes first and foremost an introduction to environmental assessment of products and solutions in their life cycle through the use of simple tools. On this basis methods and tools are presented for the development of environmentally improved products and solutions. These methods and tools are applied in the project work. Through the course social and management aspects of sustainability will be presented.

THE PROJECT WORK

The group have been working on specific cases related to Facility Management and identified by NIRAS A/S as cases where finding the environmentally best solution is not straight forward.

This can for example concern green logistics for meetings, optimization of waste handling incl. best options for handling organic waste, optimal lighting solution for building areas, environmentally best options for menus in canteens etc..

RESULTS

The projects outcomes are: a solution developed considering the three sustainability dimensions: an environmental life check of the alternative solutions, and a plan for implementation of the solution.

Bachelor course
Project no. 134

Sustainable facility management solutions in NIRAS V

Authors to be determined

DTU Management Engineering, DTU Mechanical Engineering
Technical University of Denmark

INTRODUCTION

This project has been part of the course “sustainability in engineering solutions” in the three weeks period in June 2019. The course includes first and foremost an introduction to environmental assessment of products and solutions in their life cycle through the use of simple tools. On this basis methods and tools are presented for the development of environmentally improved products and solutions. These methods and tools are applied in the project work. Through the course social and management aspects of sustainability will be presented.

THE PROJECT WORK

The group have been working on specific cases related to Facility Management and identified by NIRAS A/S as cases where finding the environmentally best solution is not straight forward.

This can for example concern green logistics for meetings, optimization of waste handling incl. best options for handling organic waste, optimal lighting solution for building areas, environmentally best options for menus in canteens etc..

RESULTS

The projects outcomes are: a solution developed considering the three sustainability dimensions: an environmental life check of the alternative solutions, and a plan for implementation of the solution.

Bachelor course
Project no. 135

Sustainable facility management solutions in NIRAS VI

Authors to be determined

DTU Management Engineering, DTU Mechanical Engineering
Technical University of Denmark

INTRODUCTION

This project has been part of the course “sustainability in engineering solutions” in the three weeks period in June 2019. The course includes first and foremost an introduction to environmental assessment of products and solutions in their life cycle through the use of simple tools. On this basis methods and tools are presented for the development of environmentally improved products and solutions. These methods and tools are applied in the project work. Through the course social and management aspects of sustainability will be presented.

THE PROJECT WORK

The group have been working on specific cases related to Facility Management and identified by NIRAS A/S as cases where finding the environmentally best solution is not straight forward.

This can for example concern green logistics for meetings, optimization of waste handling incl. best options for handling organic waste, optimal lighting solution for building areas, environmentally best options for menus in canteens etc..

RESULTS

The projects outcomes are: a solution developed considering the three sustainability dimensions: an environmental life check of the alternative solutions, and a plan for implementation of the solution.

Bachelor course
Project no. 136

Sustainable facility management solutions in NIRAS VII

Authors to be determined

DTU Management Engineering, DTU Mechanical Engineering
Technical University of Denmark

INTRODUCTION

This project has been part of the course “sustainability in engineering solutions” in the three weeks period in June 2019. The course includes first and foremost an introduction to environmental assessment of products and solutions in their life cycle through the use of simple tools. On this basis methods and tools are presented for the development of environmentally improved products and solutions. These methods and tools are applied in the project work. Through the course social and management aspects of sustainability will be presented.

THE PROJECT WORK

The group have been working on specific cases related to Facility Management and identified by NIRAS A/S as cases where finding the environmentally best solution is not straight forward.

This can for example concern green logistics for meetings, optimization of waste handling incl. best options for handling organic waste, optimal lighting solution for building areas, environmentally best options for menus in canteens etc..

RESULTS

The projects outcomes are: a solution developed considering the three sustainability dimensions: an environmental life check of the alternative solutions, and a plan for implementation of the solution.

Bachelor course
Project no. 137

Sustainable facility management solutions in NIRAS VIII

Authors to be determined

DTU Management Engineering, DTU Mechanical Engineering
Technical University of Denmark

INTRODUCTION

This project has been part of the course “sustainability in engineering solutions” in the three weeks period in June 2019. The course includes first and foremost an introduction to environmental assessment of products and solutions in their life cycle through the use of simple tools. On this basis methods and tools are presented for the development of environmentally improved products and solutions. These methods and tools are applied in the project work. Through the course social and management aspects of sustainability will be presented.

THE PROJECT WORK

The group have been working on specific cases related to Facility Management and identified by NIRAS A/S as cases where finding the environmentally best solution is not straight forward.

This can for example concern green logistics for meetings, optimization of waste handling incl. best options for handling organic waste, optimal lighting solution for building areas, environmentally best options for menus in canteens etc..

RESULTS

The projects outcomes are: a solution developed considering the three sustainability dimensions: an environmental life check of the alternative solutions, and a plan for implementation of the solution.

Bachelor course
Project no. 138

Sustainable facility management solutions in NIRAS IX

Authors to be determined

DTU Management Engineering, DTU Mechanical Engineering
Technical University of Denmark

INTRODUCTION

This project has been part of the course “sustainability in engineering solutions” in the three weeks period in June 2019. The course includes first and foremost an introduction to environmental assessment of products and solutions in their life cycle through the use of simple tools. On this basis methods and tools are presented for the development of environmentally improved products and solutions. These methods and tools are applied in the project work. Through the course social and management aspects of sustainability will be presented.

THE PROJECT WORK

The group have been working on specific cases related to Facility Management and identified by NIRAS A/S as cases where finding the environmentally best solution is not straight forward.

This can for example concern green logistics for meetings, optimization of waste handling incl. best options for handling organic waste, optimal lighting solution for building areas, environmentally best options for menus in canteens etc..

RESULTS

The projects outcomes are: a solution developed considering the three sustainability dimensions: an environmental life check of the alternative solutions, and a plan for implementation of the solution.

Bachelor course
Project no. 139

Sustainable facility management solutions in NIRAS X

Authors to be determined

DTU Management Engineering, DTU Mechanical Engineering
Technical University of Denmark

INTRODUCTION

This project has been part of the course “sustainability in engineering solutions” in the three weeks period in June 2019. The course includes first and foremost an introduction to environmental assessment of products and solutions in their life cycle through the use of simple tools. On this basis methods and tools are presented for the development of environmentally improved products and solutions. These methods and tools are applied in the project work. Through the course social and management aspects of sustainability will be presented.

THE PROJECT WORK

The group have been working on specific cases related to Facility Management and identified by NIRAS A/S as cases where finding the environmentally best solution is not straight forward.

This can for example concern green logistics for meetings, optimization of waste handling incl. best options for handling organic waste, optimal lighting solution for building areas, environmentally best options for menus in canteens etc..

RESULTS

The projects outcomes are: a solution developed considering the three sustainability dimensions: an environmental life check of the alternative solutions, and a plan for implementation of the solution.

Bachelor course
Project no. 140

Sustainable facility management solutions in NIRAS XI

Authors to be determined

DTU Management Engineering, DTU Mechanical Engineering
Technical University of Denmark

INTRODUCTION

This project has been part of the course “sustainability in engineering solutions” in the three weeks period in June 2019. The course includes first and foremost an introduction to environmental assessment of products and solutions in their life cycle through the use of simple tools. On this basis methods and tools are presented for the development of environmentally improved products and solutions. These methods and tools are applied in the project work. Through the course social and management aspects of sustainability will be presented.

THE PROJECT WORK

The group have been working on specific cases related to Facility Management and identified by NIRAS A/S as cases where finding the environmentally best solution is not straight forward.

This can for example concern green logistics for meetings, optimization of waste handling incl. best options for handling organic waste, optimal lighting solution for building areas, environmentally best options for menus in canteens etc..

RESULTS

The projects outcomes are: a solution developed considering the three sustainability dimensions: an environmental life check of the alternative solutions, and a plan for implementation of the solution.

Bachelor course
Project no. 141

Sustainable facility management solutions in NIRAS XII

Authors to be determined

DTU Management Engineering, DTU Mechanical Engineering
Technical University of Denmark

INTRODUCTION

This project has been part of the course “sustainability in engineering solutions” in the three weeks period in June 2019. The course includes first and foremost an introduction to environmental assessment of products and solutions in their life cycle through the use of simple tools. On this basis methods and tools are presented for the development of environmentally improved products and solutions. These methods and tools are applied in the project work. Through the course social and management aspects of sustainability will be presented.

THE PROJECT WORK

The group have been working on specific cases related to Facility Management and identified by NIRAS A/S as cases where finding the environmentally best solution is not straight forward.

This can for example concern green logistics for meetings, optimization of waste handling incl. best options for handling organic waste, optimal lighting solution for building areas, environmentally best options for menus in canteens etc..

RESULTS

The projects outcomes are: a solution developed considering the three sustainability dimensions: an environmental life check of the alternative solutions, and a plan for implementation of the solution.

Abstracts
Bachelor final assignment

Bachelor final
Project no. 201

13 CLIMATE ACTION

Optimizing a CO2-free system for container ships

R. Engberg and J.V. Vexø

DTU Management, Technical University of Denmark

INTRODUCTION

Today, maritime transport constitutes around 90% of the overall global cargo transport, and the demand for it is still growing. Besides this, reducing CO2 emissions of maritime transport was not a specific part of the Paris agreement of 2015, where the main focus is towards CO2 emissions of air planes. Instead, the International Maritime Organization, IMO, has set the goal of keeping the CO2 emissions of global maritime transport at the current level of 2.2% of the total CO2 emissions. This share has been falling since 2007, mainly because the shipping companies have successfully managed to optimize their fuel usage, but with the demand for shipping expected to grow and the global CO2 emission expected to decrease, keeping their share at 2.2% will not necessarily be easy. The first ships fueled by liquid natural gas, LNG, has been taken into use, but while this is much better fuel if you look at CO2 emission, LNG still deduces a great deal of CO2. In this project, we have examined what it takes and how much it would cost to create a 100% CO2-free system for container ships.

SYSTEM DESIGN

To design a 100% CO2 free system for container ships we studied the different possibilities of fuel types that doesn't deduce CO2 when burned and other possibilities such as battery-driven cargo ships. We considered if it is possible for the fuel types to be produced from renewable energy sources and thereby without deducing any CO2. After deciding on ammonia as our preferred fuel type, we decided on wind energy as our preferred renewable energy source for our system. Below is a very simplified illustration of our system design:

OPTIMIZATION

With the system in place we applied it on a specific transport route to examine the costs of this 100% CO2 free system design. We calculated the different costs related to the implementation and maintenance of the new system, e.g. we considered what kind of wind turbine is more effective, on-shore or off-shore. We also considered where in the world the wind turbines preferably should be located to produce more energy. This was formulated as a mathematical problem, which was solved using integer programming with an objective to minimize costs. The results should tell us more about how economically realistic our system is right now.

Bachelor final
Project no. 202

Natto – SUPERFOOD, locally fermented legumes

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[3]The Royal Danish Academy of Fine Arts, School of Architecture

INTRODUCTION

The global growing population together with a shortage of resources and climate change needs to be immediately addressed. One of the key aspects we need to rethink is human food industry. This project aims to make a difference with the use of more efficient food sources. Production and consumption of fermented soybeans has a minimal environmental impact and a great outcome regarding nutrition and health benefits. It has been traditionally used for centuries in Japan, where it's known as *natto*. Our goal is spreading it globally.

THEORY

The fermentation of soybeans together with the bacteria Bacillus subtilis results in a probiotic superfood rich in protein, vitamins and minerals. The fermentation process reduces its anti-nutrients, increases its beneficial compounds and helps the body absorb the nutrients. Its health benefits range from stronger bones, healthier immune system, counteracts hypertension and helps clot dissolution. In Denmark, 18,9% of the population suffered hypertension in 2017. (Jensen, 2018)

	Soy	Beef
Usable protein Kgs per hectare	65,15	3,64
Used liters of water per ton	9.450	78.246

Table 1 Environmental benefits of soy compared to beef. (References 2)

METHODS

By starting a production of *natto* in Denmark, and by developing other fermented local legumes we want to contribute to reducing water usage and CO_2-emissions in food production. At the same time, we believe that the consumption of these fermented probiotic foods will have a positive impact on the health of the population.

CONCLUSIONS

We have made a home scale production in CPH and tested our *natto* on both Japanese and Scandinavian people with great response. While we do research on production we also plan to develop new tastes, products and recipes that inspire people and bring it closer to the Scandinavian kitchen. All with the same focus on health and environmental benefits.

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Bachelor final
Project no. 203

Leak detection using data-driven approaches

P. Elbek[1], J. Visbech [1], and E.D. Christensen[2]

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INTRODUCTION

Water distributions networks (WDNs) have since the Great Greeks been of considerable importance. In the modern society the demand for water is constantly at stake, and leaks do often occur, especially in developing countries. It has been estimated for some WDNs that leakages can represent up to 30% of the total amount of extracted water. Water losses in this scale can provide serious economic and ecological consequences.
Leak detection for WDNs can be performed in various ways e.g. by drones with infrared cameras or manual monitoring, but in recent years data-driven approaches are becoming more and more developed.

METHOD

By extracting data from specific sensors around the WDN, a historical dataset can be obtained. This data can be compared with data from a leakage filled network in terms of statistical measurements. The measurements are found using variations of Principal Component Analysis, and the measure of performance is evaluated in terms of a fault detection rate (FDR).
An optimal solution for sensor placements can be found using integer programming.

RESULTS

For the different variations of PCA methods, the performance on table 1 was found when applied on the Hanoi, Vietnam WDN, and an analysis of the performance of P-DPCA was made based on the size of leakage.

PCA variations	FDR [%] (μ / σ)
PCA	2.8 / 8.5
DPCA	5.8 / 15.9
P-PCA	72.8 / 31.6
P-DPCA	88.7 / 23.4

Table 1 Performance for different PCA variations

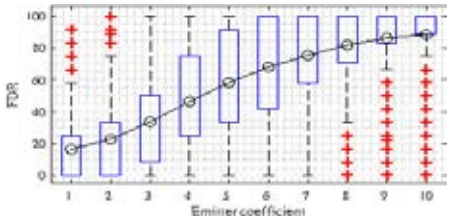

Figure 1 Performance of P-DPCA with an increase of leakage size

CONCLUSION

The best variation is P-DPCA. This performs the best at night, when the demand for water is lowest. Furthermore is it highly dependent of the size of the leakage.

Bachelor final
Project no. 204

Investigation of the catalytic oxidation of methane in the presence of SO_2

S.R. Petersen

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INTRODUCTION

The maritime shipping industry is a recognized contributor to greenhouse gas (GHG) emissions. This fact is internationally acknowledged and with regulations on the emissions, the industry is forced to take climate action by using cleaner fuels and optimizing the engine system. A new and promising technology uses liquefied natural gas (LNG) consisting mainly of methane as this fuel is much more carbon efficient than e.g. diesel or heavy fuel oil. A problem with this however, is that at low engine loadings, unburnt methane can slip out of the combustion chamber. Methane is a highly potent GHG with 21 times the effect of CO_2. Since only small amounts of methane are present in the resulting gas, the conversion has to be carried out catalytically, since the otherwise required temperatures cannot be obtained in the engine system. The aim of this project is therefore the investigate how the methane slip can be catalytically converted into less harmful CO_2.

APPROACH

This project investigates possible catalysts for the catalytic oxidation of methane in the presence of SO_2. Despite the fact that LNG contains little to no sulfur, small amounts of SO_2 can still arise from oils used for fittings, and even small amounts can be detrimental for the performance of catalysts found in literature.

The main approach of this project is therefore to find a catalyst that is resistant towards SO_2 as well as being able to convert sustainable levels of methane. The focus of the experiments has been on catalysts based on rhodium impregnated in different amounts on different types of support materials. Temperature profiling of the activity of the catalyst has been the main objective with the experiments, since finding optimum temperature for the reaction is crucial for determining the placement of the catalytic unit in the engine system.

FINDINGS

From both literature study as well as experiments it was found that rhodium based catalysts display the best performance in the catalytic oxidation of methane, when SO_2 is also present. Furthermore, it was found that catalysts with high loadings of rhodium did not perform as well as expected when taking the rhodium loading into account. The best performing catalyst was found to contain only 2 wt.% of rhodium. Temperature profiling results suggests that the unit should be placed after the supercharger.

Prospects

This result suggests a more sustainable catalyst production since less precious metal has to be used. Also, the prospects for the maritime industry to shift to cleaner fuels look clearer with possibility of a technology that is both fuel efficient as well as emission compliant.

Bachelor final
Project no. 205

A method for waste prioritization

J.H. Sund

DTU Environment, Technical University of Denmark

WHY?

The current linear approach to consumption is not infinitely applicable without resulting in the depletion of natural reserves. With the limited amount of global resources, and rise and spread of the consumer class, it has never been of greater importance to investigate potential opportunities for assisting any type of transition from the linear model, to a circular one, where waste is no longer regarded as a problem, but as a resource.

WHAT?

In transforming to a circular economy, it is unconditionally imperative that businesses investigate incorporating elements that slow, close and narrow their resource loops. Industrial symbiosis has proved to be an ideal option for businesses to achieve this more efficient use of resources. In an industrial symbiosis, the surplus resources generated by an industrial process, are neither discarded nor destroyed. Instead, they are captured and redirected for the use in other processes by one or more other companies, thus to provide a mutual benefit for all stakeholders involved, and thereby mimic a natural ecosystem. However, there is currently no methodology available to aid decision-makers in clearly assessing what resource streams and materials to prioritize in terms of recycling.

Figure 1 Infographic of the concept, "from waste to value"

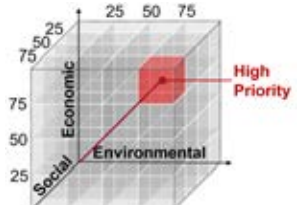

Figure 2 The 3-D RP Space, stressing the area of high priority

HOW?

This study provides a basis for a methodology, that is to aid decision-makers in evaluating nutrient flows in terms of their suitability / applicability as secondary raw materials. Thus, to contribute in making innovative collaborations and symbiotic relationships between different stakeholders more accessible. The methodology constructed in this thesis is thus a simplified version of what is to be regarded as a “Recycling Priority (RP) Methodology”. The methodology takes into consideration that sustainable solutions must not only be environmentally sustainable, but also both socially and economically. Therefore, the parameters determining the degree of RP, have been divided into three equal dimensions; Financial, Environmental and Market. The user is provided with a quantitative evaluation, where the result can be plotted in a 3-dimensional “RP Space”, as seen in Figure 2. Thus, to provide them with a concrete “score” and level of uncertainty in terms of the evaluated material’s adequacy as a new input in a given synergy.

The findings of this thesis will contribute to a larger, ongoing project titled ’Waste to Value’, conducted by COWI A/S in collaboration with Oracle Corporation.

Bachelor final
Project no. 206

Isolation of plasticizer tolerant bacteria

L.D. Gille

DTU Bioengineering, Technical University of Denmark

INTRODUCTION

Plasticizers are widely used in the plastic industry to make the product more flexible and is now found ubiquitously in the environment. Some plasticizers are toxic to humans and other forms of life. As disruptors of the endocrine system as well as their toxicity to living organisms, they are very harmful to the environment they are in. Especially in the marine environment is at great risk since it is where most effluents containing plasticizers ends up. Bioremediation by the use of bacteria have been found to be a very successful method in order to degrade these pollutants. However, only a few marine bacteria capable of biodegradation of plasticizers have been isolated.

Furthermore, enzymes from bacterial isolates have the potential to be used in the industry for various bioprocesses. One could imagine, that knowledge and availability of degradation enzymes could benefit companies economically if they are able to utilize plasticizers as an unused energy source.

APPROACH

The aim of my project is to find and isolate bacteria from the marine environment capable of degrading plasticizers, focusing on dimethyl phthalate (DMP). Starting from a marine environmental sample, several cultures of sample with and without added DMP have been cultivated to promote growth of putative bacteria. Growth experiments on selective OECD306 + DMP medium have been carried out in order to isolate putative bacteria. Pure cultures of isolates were regrown in liquid OECD306 + DMP medium to confirm degradation. Bacterial reference strains capable of biodegradation of plasticizers known from literature, were tested for their presents of known genes encoding enzymes used in the biodegradation of plasticizers. All isolates found in this study was also tested for their presents of the same genes. Selected isolates have been send for gene sequencing for identification and characterization.

RESULTS AND CONCLUSION

I found no significant difference in growth between cultures with added DMP and without, but throughout the growth experiments on the selective OECD306 + DMP plates, I found several bacteria capable of utilizing DMP as energy source, meaning that they have the potential for bioremediation of plasticizers. Some isolates have the known degradation genes encoded. Positive results have been send for gene sequencing for identification and characterization.

Bachelor final
Project no. 207

CLOSED CIRCUIT- rethinking local energy production as an urban generator

A. Schmidt

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INTRODUCTION & CASE STUDY

The electricity economy is the main contributor to air pollution emissions in Israel. In recent years, in view of the rapid population growth and the technological innovations of decentralized energy production in urban settlements, new opportunities in this field have been created. This project proposes an alternative for exploiting the byproducts of the energy production process inside cities, and channeling these products for the benefit of urban public spaces. The project examines the city of Hadera, which is located in central Israel, as a test case for cutting-edge thinking about the cyclic system of energy production on a municipal scale. This is a design project that deals with the integration of technology and up-to-date knowledge into the urban space.

THE TECHNOLOGY USED IN THE PROJECT

The proposed plan focuses on hydropyrolysis – a method based on the decomposition of organic waste by water and heat in conditions of high pressure. The heat produced in the combustion process is then used to decompose more waste. This creates a cyclic production process, although with two byproducts that need to be 'emitted' – CO_2, and residual heat, which is at a temperature insufficiently high for use in the process.

THE PROJECT

The project proposes an innovative planning design with nine small hydropyrolysis energy centers to handle all the city's organic waste, and supply ~20% of its energy demand in 2050. These energy production plants will serve as a generator to create a new municipal network of three main systems: A waste conveyance system (short distance conveyance in pipes inside the city, eliminating the need for garbage trucks); an electricity conveyance system (connection to the existing conveyance system, in low voltage and underground); and a 'green' system, focusing on planning. The green system of the city will be nourished from the byproducts of the energy production process: Since Hadera is rapidly losing its agricultural heritage due to development and construction demands, the first step would be transferring the CO_2 from the energy plants to technological agricultural projects in buildings in the city's center (an industry that is growing in recent years, and uses CO_2 to grow crops). The city will thus develop an innovative, specialized agricultural area that will mitigate the disappearance of traditional crops. Additionally, the 'residual heat' will be conveyed from the plants to municipal uses: heating public pools in winter; heating and cooling buildings up to 8 stories tall; and heating community greenhouses. Heat will be conveyed in insulated pipes over short distances. All the pipes of the new network throughout the city will be colorful and visible along the main green axis as a central component of the design language, and an integral part of the various functions along its length. To summarize, the project proposes, first and foremost, a shift in perception and renewed thinking about energy production systems in the city, which will contribute to municipal productivity and impact on the public space, on the activities taking place in the city, on culture; and educate on sustainability.

Bachelor final Project no. 209

2-photon tandem water splitting device for sustainable H2 production

F.R. Madsen and M. Voss

DTU Physics and Nanotechnology, Technical University of Denmark

INTRODUCTION

One of the biggest climate issues in modern society is the amount of fossil fuels that are being used both commercially and industrially which ultimately leads to pollution and an increased amount of CO_2 in the atmosphere. By replacing fossil fuels with renewable energy sources (such as wind, water and solar), the amount of pollution can be reduced and thereby make the world a greener place. With an increasing energy demand, the world is now more than ever in need for renewable, CO_2 neutral solutions. The challenge with renewable energy sources is, that the produced energy is only available the moment it is made. This means that any unused energy, supplied to the electrical grid, will go to waste. One way to surpass this problem is to store the energy by integrating a storage mechanism. This is not yet realized due to a lack of efficient and inexpensive storage possibilities. One possibility, with a currently growing interest, is energy stored in the form of hydrogen. This is mostly due to fuel cells being able to convert hydrogen-based fuels to electricity incredibly efficiently and with minimal emission. Another important usage for hydrogen is in ammonia and methanol production. Unfortunately, today 96% of all hydrogen is produced from fossil fuels.

OUR MISSION

Our goal is to combine solar cells with electrolysis to produce hydrogen. This is realized by combining Selenium/Silicon tandem solar cells with water splitting electrodes into a photoelectrochemical device that absorbs energy from the sun, which directly produces hydrogen. This method removes the previously mentioned problem of wasted energy, and it allows for off-grid (even off-shore) installations of solar farms where the local energy demand does not need to be accounted for. The production of hydrogen through this photoelectrochemical device is fully CO_2 neutral and is an efficient and sustainable method of hydrogen production. Furthermore, it removes an energy conversion step and therefore reduces the loss involved with the production.

Selenium solar cells for water splitting

Splitting of water to hydrogen and oxygen requires an electrical potential of at least 1.23 V. Silicon solar cells, which are currently the most affordable solar cell, cannot deliver that on their own. However, combining Selenium and Silicon solar cells in a tandem solar cell device, could provide the necessary potential. While Silicon solar cells are already developed to a point, where this is possible, Selenium solar cells are not. Selenium is a relatively cheap material with good properties for combination with silicon. This gives good opportunities for a cheap, clean and sustainable hydrogen production.

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Bachelor final
Project no. 210

New earth-abundant high band gap photo absorber

K. Børsting

DTU Physics, Technical University of Denmark

INTRODUCTION

Modern silicon solar cells are closing in on the theoretical maximum attainable efficiency (29%). This maximum arises from a trade-off in all solar cells which relates to the band gap of the specific material: A solar cell can only absorb light with energy higher than the band gap, however they can also only exploit energy equal to the band gap, meaning that any "extra" energy is simply lost. One way to work around this trade-off is to place two cells in tandem. This way one can have a high band gap photo absorber which will utilize the high energy light better but let the low-energy light pass through. A second photo absorber with lower band gap will then absorb all the low energy light and as a result, less energy is wasted.

The biggest challenge with making tandem solar cells is that it requires a photo absorber with a high band gap but most high band gap photo absorbers contain either scarce/expensive materials, such as arsenic and indium, or toxic elements such as cadmium. In this project, I have experimented with a newly discovered material called CBTS. It consists only of non-toxic, earth-abundant elements (cupper, barium, tin and sulfur) and it has a high band gap making it suitable as a top cell absorber in combination with for example silicon.

Bachelor final
Project no. 211

Recycled concrete

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INTRODUCTION

Concrete is the worlds most used building material. Every year there is produced twice as much concrete as all other building materials combined. In 2015, 8,7 million tons of concrete were produced in Denmark alone (BETON, 2017). This means that even small improvements in the concrete production can have a large impact. 60-75% of concrete consists of aggregates in the form of sand and gravel. A report from 2018 estimates, that the consumption of sand and gravel in Denmark will increase up until 2040 (NIRAS, 2018). Based on this increase, it is estimated that there isn't any sand or gravel available in the Capital region in 14 years (RÅSTOFFER, 2017), why it makes sense to find alternatives to sand and gravel.

SOLUTION

Since the largest component of concrete consists of sand and gravel, it is necessary to know the properties of these, one of the main properties for mixing concrete is the water absorption. It is therefore, also necessary to know for recycled aggregates in order to replace some of the natural sand and gravel in concrete. While there are methods to determine the water absorp-tion in large recycled concrete aggregates there are no applicable methods for fine recycled aggregates yet. This project develops and evaluates different methods for determining the water absorption in fine recycled concrete aggregates, so it can be used as a replacement to natural resources in concrete production. Results show, that it is possible to replace up to 50% of the natural sand with recycled sand. This is a big difference compared to the maximum replacement of 10% allowed in the building code today.

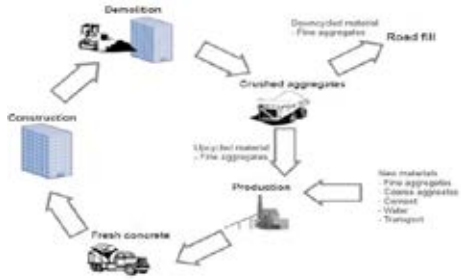

Figure 1 diagram of upcycling process.

FUTURE

With the new methods to determine the water absorption of recycled sand, we can upcycle a larger portion of old concrete in new concrete, as seen in figure 1. If this happens, the produc-tion of natural aggregates will be reduced considerably, which leads to a more sustainable future. [1]

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Bachelor final
Project no. 212

Integration of LCA in the early design process of buildings via implementation in Building Information Modelling

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INTRODUCTION

The purpose of this project was to investigate the possibility of integrating Life Cycle Assessment (LCA) in the early design process for buildings. Currently, there are no software tools for calculating the environmental impacts of buildings specifically for the early design stage. In order to achieve this purpose, a software tool in Grasshopper was developed. To decrease the burden of knowledge required by the user, a parametrical and simple approach was taken. The implementation was done by creating a database based on data from Ecoinvent via SimaPro.

The project incorporates the environmental impact from two of the five steps in LCA; production and use. The software tool is able to calculate the environmental impact from these two steps presented in 18 Midpoint impact indicators as well as 3 Endpoint impact indicators by using the ReCiPe method. The project considers predicted future energy scenarios in order to calculate the environmental impact stemming from energy consumption.

The results calculated by the software tool were validated by comparing the results of the environmental impacts from the SBI's reference house to that of LCAbyg. Results in the software tool are visualizable, both in total environmental impacts as well as in normalized values in the functional unit of impact per person per year. Furthermore, three analyses from realistic scenarios were computed to show the capabilities of the software tool.

The project has achieved the goal of being able to integrate LCA in the early design process for buildings. However, limitations and uncertainties mostly set by the shortage of information occurred throughout this project.

Bachelor final
Project no. 213

Enabling sustainable waste management through imaging and machine learning

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AUTOMATIC DATA COLLECTION FOR EASIER WASTE STREAM MANAGEMENT

The design and configuration of a solid waste management system defines its capability to reuse and reduce waste. To plan and construct better management systems, data on material type, fraction weight, and hourly flow is needed to make the most efficient system - to manage something, you must know what that something is. Today, the collection of data on solid waste at festivals is done manually. This is slow, expensive and logistically difficult. As it is not possible to probe all waste bins, the data must be heavily extrapolated. Furthermore, the format of data collection is not standardized, prohibiting festivals to share knowledge among themselves. This calls for a major upgrade!

Every year 4,5 million people attend Danish cultural events and festivals. The 130.000 guests at Roskilde Festival alone generates 2,2 million kilograms of solid waste. What if we could reuse all that material?

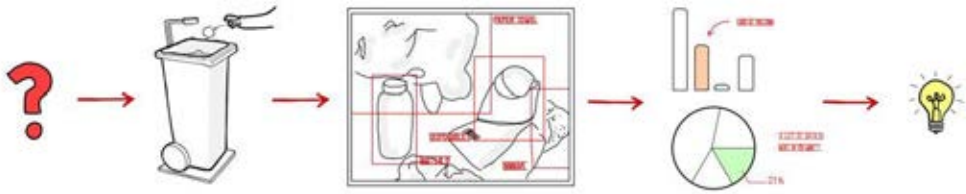

Figure 1 Process: How imaging technology applied on waste sources can generate meaningful data

WHAT IS 'WASTE'?

Through field work, conceptualization and prototyping, we have identified what data is most relevant and how to best collect it. We have constructed a proof-of-concept, that, with the addition of machine learning software, enables scientists and festival organizers to make better decisions on waste management. The concept uses imaging to identify material type, weight sensors to correlate type with weight, and timers to map the intensity of every hour on the festival.

What is 'waste'? What is it composed of? How much is there? When is it generated, and what causes people to sort the waste wrong? How can we optimize waste collection? How does external factors influence waste generation and sorting behaviors?

IMPACT

Our solution will enable scientists and festival organizers to answer these questions and more in the aim of reaching the UN's sustainable development goals 11 and 12 Acting right on the behalf of the environment is impossible without knowledge. By shining light on the hidden world of solid waste streams, our solution will help engineers, scientists and organizers make better choices.

Bachelor final
Project no. 214

Fusion energy – a clean and sustainable future

S.K. Akazawa

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ENERGY IS THE KEY

Whether it's for lighting up a city in the evenings, having the possibility of going from point A to point B or simply cooking a homemade meal, energy is necessary to function in the modern society and lead a "good life". As the quality of life increases for many developing communities around the world, the demand for energy rises with it. To meet this demand nuclear fusion could play a big part.

SAFE, SUSTAINABLE AND RELIANT - CREATING MINIATURE SUNS ON EARTH

The energy process of the sun is available to us! The fusion of light atoms, such as Deuterium, releases a great excess of energy and this is the same method that the sun uses to heat the earth's surface. As these reactant gasses are abundant on earth and accessible to all, there are minimal concerns regarding the sustainability of this energy source or potential conflicts over scarcity. It is also extremely reliable as weather conditions and the time of day have no impact on a fusion reactor's efficiency or output. Nuclear fusion doesn't result in any chemical or nuclear waste, therefore ensuring safety.

THE CHALLENGE: IT'S TECHNICAL

While there is clearly a great potential in fusion energy, there are several challenges in finding a way to maintain a steady fusion process. This is where we students can contribute. DTU recently invested in a fusion reactor called a Tokamak, currently located in building 309 at DTU Lyngby, in which its first plasma was generated in March 2019. Together with the Plasma Physics and Fusion Energy (PPFE) group at DTU, we can build our own diagnostics and perform fusion experiments without always having to submit applications to access large reactor facilities in other countries. There have already been student projects to characterize the reactor, specifically the magnetic fields in the Tokamak.

BUILDING THE FIRST DIAGNOSTICS

A large part of the fusion process is in generating and maintaining plasma within the center of the reactor chamber. The project I have been working on is building and mounting an interferometer for the Tokamak, to measure the electron density of the plasma. The interferometer measures phase shifts occurring in high frequency light that passes through the plasma and this phase shift can be used to calculate electron density. This will be the first diagnostic system on the reactor, thereby making research on the Tokamak possible. With the implementation of more diagnostic systems and continued work on the DTU Tokamak we can contribute to solving the world's energy crisis.

Bachelor final
Project no. 215

Eco-redesign of a snowboard by incorporation of recycled "ocean plastics"

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INTRODUCTION

The “trend” of snowboarding is getting bigger. It is estimated that the market will only grow in the period from 2016 to 2023. The snowboard and equipment market are expected to reach 352.01 Billion US Dollars by 2023. Annually the production of snowboards is around 1.2 million snowboards per year, with around 300.000 produced in Europe. However, what happens for the snowboards after their *End-of-Life* when their user breaks it or buys a new one. Most of the current snowboards are not recyclable. The snowboard is constructed in a *sandwich structure* consisting of several layers of different materials which all serve a specific functionality. The materials are assembled using epoxy resin making snowboards almost impossible to disassemble. Thus, valuable resources within the snowboard are lost. Furthermore, the harvesting of materials, manufacturing, and transportation has significant impacts on the energy consumption and carbon footprint. This is all contributing to significant environmental impacts on the ubiquitous climate change. This project foresees a potentiality of disrupting the current market and create a demand for more sustainable alternative. Another important notice is the projects incorporation of ocean plastics in snowboards. The project partnerships with the company **Plastix** in Lemvig who collects, cleanses, and re-granulates used fishnets, hence contributing to the ocean cleanup projects improving life below water, prolongs the lifetime of resources significantly, and finally providing for an easy and cost-friendly reusable plastic.

CONCEPT FOR IMPROVEMENT

Without even evaluating the toxicity of working with such materials as epoxy resin and fiberglass used for snowboards the majority of the environmental impacts occurs in the materials phase (81.36% at energy contribution and 72% at CO2 footprint). Estimated from a *LCC* the total contribution for one snowboard is 461 MJ and 23,3 kg CO2 eq. within all lifecycle stages.

Thus, the snowboard is redesigned from a circular perspective. The materials are replaced by sustainable alternatives such as ocean plastics and flax fibers. This reduces the energy and carbon footprint significantly. The concept also consists of an epoxy resin and new hardener which is degradable using an acidic compound. This resin has already been proven to function for another minor snowboard concept and can revolutionize the whole composite field as well. Furthermore, the concept builds upon a product/service system. The recyclability and harvesting of used materials can’t only rely on improving the snowboard, but a functional returning system. The users can hand-in their old snowboards and in return gaining a discount for a new. The snowboards are disassembled and the materials can either be downcycled or reused directly in the production of a new snowboard. This is a possibility provide a sustainable product/service solution, from manufacturers, supple chain to the final user.

Bachelor final
Project no. 216

Guide to absolute sustainable buildings through LCA

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INTRODUCTION

In this project a design guide to absolute sustainable buildings is developed. A product or a service – or in this project a building – is absolute sustainable if it does not exceed the "Share of Safe Operating Space" (SoSOS) assigned to the product or service. The SoSOS is developed through what is called the "planetary boundary" (PB), and is supposed to be shared between the natural background level and humans. The planetary boundary is a concept aiming to define environmental limits within which humanity can safely operate. There has been defined PB's for 9 different categories, such as climate change, freshwater use, ozone depletion etc. Research has shown that the environmental conditions follow a curve, which is stable at first, but when they reach the PB, they start to decrease exponentially. When the observed control variable reaches this PB it will be very difficult to make the environmental condition return to the original state.

PROBLEM

The problem is that humanity is currently exceeding the SoSOS for humanity for some of the 9 PB-categories. One of the main reasons for this, is the world's building industry. The building industry uses approximately 40 % of both the total energy consumption and total material consumption in Europe and has direct impact on all of the nine PB-categories. Furthermore, the building industry tends to be very conservative, which makes it a difficult sector to change. The building industry is not focused on and educated properly in the consequences of the current way of building and not enough about sustainable alternatives.

SOLUTION

Buildings with results from a Life Cycle Assessment (LCA) below boundaries for SoSOS, for a single-family dwelling, specified by Brejnrod et al and Bjørn and Hauschild, in all categories are considered "absolute sustainable".

In this study, a guide on how to design absolute sustainable buildings is carried out. It contains boundaries for the specific components of a building (outer walls, foundation etc.), examples on how to use it, suggestions for absolute sustainable building components, recommended LCA software, converting factors between two different methods and general knowledge on absolute sustainability regarding buildings.

COMPATIBLE SUSTAINABLE DEVELOPMENT GOALS

This solution will help reaching 5 SDG's: "9 Industry, Innovation and Infrastructure", "11 Sustainable Cities and Communities", "12 Responsible Consumption and Production", "13 Climate Action" and "15 Life on Land".

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Bachelor final
Project no. 217

Carbonate removal for EDR of mine tailings

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MINE TAILINGS

Mine tailings are a waste product of metal extraction in the mining industry. Huge amounts are produced annually and stored with the risk of polluting the ambient environment. Tailings are a slurry mixture that needs great volume for storage which is expensive.

INDUSTRY

As coal combustion is being phased out due to green initiatives the construction industry will most likely have less coal fly ash to act as substitutes in cement production (Whitley et al., 2017). Cement production is responsible for 5% of the world's total CO2 emissions. Half of EU's materials and energy and 1/3 of EU's water is consumed by the construction sector. 1/3 of all generated waste is also produced by the construction sector (Kirkelund, 2019). This project focuses on solving the earliest environmental issue in many product chains by creating a residual resource that helps substitute cement and thereby greatly decrease emissions worldwide.

ELECTRODIALYTIC REMEDIATION OF MINE TAILINGS

Electrodialytic remediation (EDR) is an electrokinetic method that carries ions through a medium by applying a static electrical field to the medium. EDR looks similar to electrolytic remediation except it utilizes a cation and an anion membrane between the compartments in the cell where the reactions and electrical field occur (Kirkelund et al., 2019). EDR has mainly been researched for remediation of contaminated soil, but also has great potential for mine tailings. Sigvardsen et al. (2017) suggests that a zero waste strategy is feasible if mine tailings can be successfully remediated. Successful remediation of mine tailings has been carried out in laboratory scale, but are currently economically infeasible when scaled up for industrial use. Mine tailings often have a high content of carbonate which creates a buffer-like effect on the electrokinetic processes. This leads to a long process time which leads to high volume demand making the process expensive. Adding too much acid to the tailings will create an excessive amount of H+ that will occupy the electric current and thereby make the process ineffective. The hypothesis of this project states that the carbonate can be removed by adding just the right amount of acid to carbonate-rich tailings, thereby greatly reducing process time for EDR.

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Bachelor final
Project no. 218

Impact of electric vehicles on distribution grids

J. Bollerslev

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INTRODUCTION

According to the Danish energy policy, Denmark has to be 100% independent of fossil fuels by 2050 [1]. This means that changes have to happen, and in October 2018 the Danish government proposed a ban of petrol and diesel vehicles by 2030, and hybrid by 2035, thus only allowing the sale of electric vehicles (EVs) from 2035 [2]. However, would the electricity grid be able to support a penetration level of 100% EVs? This project seeks to answer that question, and especially focus on the impact EVs have on the low voltage distribution grid. Even though EVs have been here for many years, it is only in the recent years they have been sold commercially as a substitute for petrol and diesel vehicles. This means that very little data regarding the consumer behaviour of EVs exist. Therefore, several assumptions would normally have to be made, when designing a model to investigate the grid impact of different EV-charging patterns on the distribution grid. Moreover, currently the charging of EVs will mostly happen during existing peak hours when people return home, plug-in their EV and start using other electronic devices, such as induction cookers, TV, etc. The French project, GridMotion has proposed a controlled charging pattern, which has been applied in field tests. Controlled charging can enable integration of more EVs because it can prevent them from charging during existing peak hours, thus preventing overloading the distribution grid. Furthermore, EVs can serve as energy storage units in the grid, which enables a transition to a 100% renewable energy-based system. This project has in collaboration with GridMotion, Danish Energy and DTU designed a model based on GridMotion's real data, to investigate the grid impact of GridMotion's controlled EV-charging compared to traditional EV-charging on the distribution grid.

METHOD

The GridMotion data has been statistically analyzed to extract information about the consumer behaviour, such as plug-in and plug-out times and consumption patterns, such as charging durations and energy demand. The extracted data allows the design of a model, which is able to assess the impact of EV-charging on any grid, while varying parameters such as the number of EVs present in the grid, charger size, etc. The impact of the common 3.3 kW chargers have been investigated, and 10 kW chargers to enable faster charging.

RESULTS

The project found that controlled charging allow integration of more EVs. However, it also shows that the distribution grid is likely to suffer from undervoltage issues. Furthermore, the statistical data extracted from the GridMotion data will allow other students or researchers to base their studies on more realistic consumer behaviour and consumption patterns.

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Bachelor final
Project no. 219

Replacing Li-ion batteries – new cathode materials for Mg-ion batteries

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SUSTAINABILITY

Batteries are omnipresent in modern society, and the demand for batteries is not stagnating. With cleaner energy in the power grid follows a need for local and mobile power usage, which is readily available through efficient batteries. Li-ion batteries are the go-to in applications ranging from electric cars to medical applications due to their unmatched power density.

The scarcity of lithium however is leading academia and the industry to other technologies, where magnesium-ion batteries are regarded as the most promising, due to its theoretically high energy density and the abundance of magnesium in the earth's crust. (Estimates range magnesium of being 1500-3000 times more abundant than lithium.)
Furthermore, magnesium battery usage doesn't lead to the formation of dendrites in the anode material, and thus might lead to improved cycling times of the battery, where lithium batteries usually drop significantly in performance after two years.

SAFETY

Many applications of batteries rely on the safety of batteries. Both in terms of toxicity, leakage, and reliable usage. In March 2007, Lenovo was forced to recall 205,000 Li-ion batteries at risk of explosion, and later in August 2007, Nokia had to recall 46 million batteries for the same reason. In 2013 Li-ion batteries was the cause of electrical failures of the Boeing 787 Dreamliner, which lead to a series of groundings, and the FAA ordered all U.S. based airlines to ground their Boeing 787's until the issue had been resolved.

The most "famous" of such failures was in September 2016 when Samsung had to recall 2.5 million Galaxy Note 7 due to a confirmed fire/overheating problem in the battery, which lead them to combust.

Some applications might not suffer from severe consequences of battery failures, but for other applications, it is the difference between life and death. This includes medical applications i.e. pacemakers.

TECHNOLOGY AND METHOD

This project investigates new potential cathode materials for Mg-ion batteries. The great advance in computer and manufacture technology, leads to much faster screening of materials through Density Functional Theorem (DFT) simulations running on DTU's super computer Niflheim.

A total of around 50 materials will be tested in terms of energy density, power density and mechanical stability. Most of this project has been dedicated to setting up a workflow that will open for easier testing of materials, reproducibility of data. Additionally, matching data structures will make machine learning methods for further advancement in screening-speed available.

As of now, around 20 materials have gone through the first screening round, where only two seem promising so far. This testing would have taken several months if not years to synthesize and test in a laboratory.

Bachelor final
Project no. 220

Green synthesis of GlcNAc conjugates

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PROBLEMS WITH TRADITIONAL METHODS IN ORGANIC CHEMISTRY

Organic chemistry traditionally requires harsh methods using problematic solvents e.g. chloroform, benzene, or dichloromethane. To produce grams of product, tons of chemicals are used, which is both burdensome for the environment and creates large quantities of chemical waste. The chemical methods are often unspecific, so the syntheses normally must be done in several steps with purification methods. This is especially true for carbohydrate chemistry.Traditional production of organic compounds is not environmentally friendly, and few compounds are feasible to make.The production of organic compounds must be made more responsible and sustainable.

GREEN CHEMISTRY USING ENZYMES

In nature organisms have found ways to do complicated chemistry in mild and aqueous conditions using enzymes. Enzymes are usually very specific and efficient making them ideal for doing chemistry that is classically unachievable.The transition to green chemistry using enzymes is actually happening.

GENETICALLY ENGINEERED GH84 ENZYME WITH A NEW FUNCTION

Enzymes from the glycoside hydrolase (GH) family 84 catalyse a post-translational modification of proteins by breaking the *O*-glycosidic bond to the sugar moiety *N*-acetyl-D-glucosamine (GlcNAc). In this project a mutation was made in a GH84 enzyme from the bacteria *Thermobaculum terrenum* yielding the enzyme *Tt*OGA D120N. This modification caused the enzyme to have a new function: *Tt*OGA D120N catalyses transglycosylation. Thus, the mutant enzyme can catalyse the synthesis of new carbohydrates.This project has investigated this function and allowed for eco-friendly syntheses of a series of glycoconjugates.

CARBOHYDRATE SYNTHESIS

*Tt*OGA D120N catalyses the linking of different nucleophilic acceptors to GlcNAc. This has been proven for attaching phosphate to GlcNAc, and in this project linking of several thiophenols and nitrogen nucleophiles to GlcNAc has been proven as well. Thus, *Tt*OGA D120N can make new *O*-, *N*-, and *S*-glycosidic bonds. Not only are these transglycosylations novel for a glycoside hydrolase, the syntheses are fast and conducted in water at neutral pH, and the enzyme itself is very stable, active and easy to make.Several compounds made are novel compounds e.g. imidazole-GlcNac. Such compounds are relevant to biological understanding and pharmaceutical development.The traditional syntheses of the GlcNAc conjugates are more complicated, meaning that using the enzyme is a green and sustainable way to produce these products.

This project has been conducted in collaboration with DTU Bioengineering.

Bachelor final
Project no. 221

7 AFFORDABLE AND CLEAN ENERGY

Efficient heating of hot water tanks

T. Gregersen and B. Waltenburg

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INTRODUCTION

Within the EU, buildings are responsible for 40% of the overall energy consumption and in Danish households 83.8% of the energy consumption is attributed to heating, with most of the heating coming from district heating.

To operate a district heating plant efficiently it is key that the supply water is cooled before it returns to the plant. For this reason, the district heating suppliers have introduced monetary incentives for the consumers to keep the return temperature low. The water is used for two purposes; heating the buildings and heating the hot utility water. In this project we have focused on how to increase efficiency in the heating of the hot utility water. In almost all cases the hot utility water is heated in a hot water tank, through a coil-based heat exchanger.The current systems that regulate the capacity of hot water tanks are very simple. In most systems the capacity is constant throughout the day, not taking peak loads or nights into account, often leading to poor efficiency.

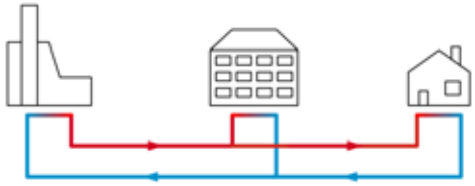

Figure 1

SOLUTION

Our solution is an IoT based control unit that can dynamically regulate the capacity of the hot water tank based on our algorithm and three additional sensors on the hot water tank.

The algorithm regulates based on forecasted consumption, dynamic capacity capability and real time trend analysis. Overall increasing efficiency and saving both consumers and suppliers money. The unit is connected to the internet and makes it possible to collect data and adjust algorithms remotely and after installation.

RESULTS AND IMPACT

We are currently testing the prototype with the purpose of validating the savings potential. This is done with our 30L prototype. We expect having results ready by the beginning of June.

We see our solution having a potentially huge impact on the way district heating will be operated in the future. With our solution it will not only be possible to lower energy consumption, it will be possible to automatically coordinate the heating of hot water tanks throughout the country, to avoid simultaneous heating and thereby decreasing peak loads. Avoiding peak loads is critical since this is the only period where the plants use fossil fuels.

Bachelor final
Project no. 222

Closing the nutrient cycle in aquaculture by microalgae as feed for copepods

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NUTRIENTS LOST IN

Too meet the needs of increasing population and consumption, the agricultural production of food is currently degrading the environment and climate. In order to counter this concerning development, sustainability in the food and feed sector is vital (Ramankutty et al., 2011). Effluents from aquaculture are often rich in organic carbon, nitrogen and phosphorous compounds, which must be treated before discharge into the environment (Bregnballe, 2015).

MICROALGAE CAPTURE NUTRIENTS

Utilization of these macronutrients by microalgae presents a way to capture in protein and lipid products for livestock and aquaculture feed(Rasouli, Valverde-Pérez, D'Este, De Francisci, & Angelidaki, 2018). However, the downstream processing steps of the microalgae (e.g., flocculation, drying, etc.) makes these production schemes unfeasible.

COPECODS AS DOWNSTREAM PURIFICATION STEP

By introduction of the copepod *Acartia tonsa* - a commonly used species in aquacultural fish feed production - the costs of processing are cut out. The copepods are easy to harvest due to their size and can be fed directly to fish larvae. Including copepods as link between algae and fish cuts out downstream processing expenses of algae feed production.The project enables recirculation of nutrients otherwise lost in the production scheme. By recycling macronutrients in the algal production, pollution footprint is minimized, closing the nutrient circle. The UN sustainability goals 11&12 describe the needs for sustainable cities and communities and responsible consumption and production("Sustainable Development Goals: Sustainable Development Knowledge Platform," n.d.). This new value chain of recycling nutrients could bring the production of aquaculture a little closer to the UN sustainability goals. This project emphasizes on the cultivation of microalgae, and optimization hereof. The aim is to cultivate the marine microalgae *Tetraselmis* sp. and *Rhodomonas salina.* Copepods will be fed in parallel with corresponding algae diet to compare the algae as feed. The nutritional value of the algae will be examined and benchmarked against existing literature. The algae will be cultivated in effluents from a 1500 ton/year production of yellowtail amberjack, *Seriola lalandi*, previously treated with a biofilter, drum filters and UV light. The algae will be cultivated in two different solid retention times to analyse nutrient removal and impact on macromolecular biomass composition. This study intends to prove the concept for a new value chain, following the model of circular bio-economy.

Keywords: Microalgae; nutrient recovery; aquaculture, food production, copepods

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Bachelor final
Project no. 223

Smart trash can

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DESIGN PURPOSE

As an industrial designer is crucial for me to work on those products that are useful to the environment, is an essential and forgotten area which is not being developed in its best disposition, intention and importance for the situation to change.

OBJECTIVE

This thesis is about the development of a trash can that is capable of select the type of residue that is going to be waste; the principal objective is to implement sensors that detect every kind of material to manage it with an autonomous product and avoid any human mistake that is not allowing to classify it.

ABOUT THE PRODUCT

Is based on a set of pallets which guides the trash to some cutting blades, which are commissioned to crush the rubbish and compact it, to improve space and facilitate their disposal treatment. It will keep four types of trash (plastic, glass, paper and organic); for this last one differs a little bit because the process to crush, it will be two blades and is going to have an accelerated decomposition liquid of the residues to become composting.

The product is intended to use in a domestic environment, which can innovate the way how disposals are treated and can delete the human dependency, to hold and recover the planet of all the contamination for poor home disposal.

METHODS AND THEORY

The investigation for developing the product head to how is managed the recycling of three different county's perspectives, sticking out their flaws, advantages and how the product could help to each scenario, and then just one of them is selected as the best case scenario to develop and study in depth to improve their recycling at home`s, is known as the first step of recycling involves how the user "uses the product" in which this case is food and to be good at recycling it in the cities, in the country's and the whole world, it must be appropriately done in home first.

Bachelor final
Project no. 224

Potential for green rainwater management in backyard environments

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INTRODUCTION

This thesis explores the potential for managing heavy rainfall following a cloudburst in three backyards of varied sizes in Copenhagen.

As a consequence of global warming, the intensity and number of cloudbursts occurring in Denmark has increased, which causes a severe challenge for the sewer system in the highly urbanised city of Copenhagen. As part of the solution, the Municipality of Copenhagen has suggested utilising the backyards. This suggestion is based on a study by Copenhagen's utility company HOFOR which shows that managing the rainwater by redesigning the roads is problematic due to lack of space. As an alternative solution, they suggest holding back the rainwater during extreme events in the backyards until capacity has been regained in the conveyance system.

THEORY

The thesis presents designs for rainwater management as well as necessary activities in the selected backyard. The amount of rainwater is based on the Three Point Approach (3PA) and is managed by stormwater control measures (SCM) in the spirit of Water Sensitive Urban Design (WSUD). For other backyard activities, a theory from "Life between Buildings" (1971) by architect Jan Gehl has been used together with various regulations. Furthermore, the thesis includes a survey which explores how the Danes view their backyards.

RESULTS

The thesis demonstrates design solutions that incorporate both daily yard functionalities and water management for the large and the medium sized backyards, while the smaller yard proved too small to fit in SCMs. It concludes that the size of the backyard area must be around 80-90% of the roof area in order to have enough space for rainwater managing alongside other yard functionalities.

Bachelor final
Project no. 225

Microbial degradation of car-tire rubber

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INTRODUCTION

Plastics are omnipresent in the environment and the handling and degradation of plastic waste is one of the current great challenges. Abrasion of car tires produces a large part of environmental microplastics and rubber, which is hard to remove from again. If society is to address the global climate crisis, the removal of plastics and rubber from the environment is key, and the use of bacteria and fungi can help in this regard, especially with micro-rubber particles. This project aims to investigate the occurrence of genes encoding for known rubber-degrading enzymes in the environment and isolate rubber-degrading bacteria with possibly new rubber-degrading activities. This project aims to isolate the bacteria, and to 16sRNA sequence the isolated strains, to identify the isolated strains on a genus level. The three proteins that are targeted are three known proteins for rubber-degradation, rox A, rox B and latex clearing protein (Lcp). If the primers for the RoxA/B or Lcp proteins hit these genes or homologues, then it would prove the existence of rubber degrading bacteria in the native Danish environment, thus enabling potential for genetic engineering with and industrial use of the microbial genes in the future.

MATERIALS AND METHODS

The environmental sampling has been done situ at locations with enrichment cultures of varying rubber exposure, followed by both genomic DNA extraction and subsequent degenerated PCR of genes encoding known rubber-degrading enzymes. The isolates will be compared with control strains for all assays, control strains which have known to have these rubber-degrading genes. The ability of bacteria to degrade rubber has been characterized in literature. In order to ensure that the strains described had the ability to degrade rubber, genes for rubber oxygenase A and B (RoxA, RoxB) and latex clearing protein (Lcp) were targeted in a PCR with specific primers as described in Broeker et al. (2008, and Jendrossek et al. (2018), [1] [2]. This was done for alll samples. Afterwards, the existence of the genes in the bacterial samples, was verified on the basis of the sizes of genes in 1% gel electrophoresis.

RESULTS

The environmental samples growth on minimal- rubber-enriched media was good, to the point where the plates were overgrowing. The PCRs have been a little difficult to optimize so far, and a gradient PCR has also been performed, without a significant yield difference in the PCR or clearer gel bands. Therefore, the PCRs for both the roxA, roxB, lcp and positive control genes have been done many times with many replicas. The samples hypothesized containing either of the rubber-degrading genes after PCR/gel electrophoresis were selected to do a PCR with 16s rRNA primers, to send to 16s rRNA sequencing. These sequences are not yet obtained, but will be analyzed with CLC Workbench / BLAST to identify the bacteria on a genus level. The potentials of utilizing these genes from bacteria from the Danish environment, would not only prove the occurrence of rubber-degradation everywhere, but also open up a lot of potential applications for these bacteria. If verified to have rubber-degrading potential, the bacteria can be applied in rubber-waste management or have the genes isolated and transformed into other organisms for large-scale enzyme production.

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Bachelor final
Project no. 226

Exploring water resources application of air-launched ground penetrating radar

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INTRODUCTION

River bathymetry, the mapping of underwater topography, is an essential part of water resource management. However, the techniques available for mapping bathymetry are few and either expensive or inefficient. Especially river bathymetry in shallow streams is expensive when performed by hand and inaccessible by boats carrying sonar equipment. Microwave remote sensing by use of ground penetrating radar (GPR) mounted on unmanned aerial vehicles (UAVs) presents a new easily scalable technique for mapping bathymetry for long stretches of shallow streams.

METHODS

The study used a Geoscanners SPG-1800 GPR unit with a center frequency of 390 MHz. The GPR unit was mounted on a small boat made entirely of plastic and transported across shallow areas of Furesø and Mølleåen in Lyngby, Denmark. Different elevation heights were tested over different water depths. The GPR data was validated by comparing to two different types of ground-truth data: in-situ measurements with a ruler and depth profiles collected simultaneously by sonar.

RESULTS

This study shows GPR can extract bathymetry at a depth of 65 cm at an elevation of 60 cm above the water surface. The GPR was shown to have an RMSE of 2.0 cm when compared to in-situ measurements. At an elevation of 25 cm the study showed the GPR to have an average RMSE of 4.5 cm with an average bias of <0.1 cm when compared to sonar profiles. The error was mostly caused by the sonar not being able to measure depths lower than 30 cm giving the GPR a clear advantage in shallow waters.

The results are encouraging and show that air launched GPR has the potential to be a very useful technique for extracting stream bathymetry especially in shallow streams.

Bachelor final
Project no. 227

Analysis of potential energy in regenerative shock absorbers abstract

L.S. Niemann

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INTRODUCTION

This project is carried out in collaboration with DTU, Vejdirektoratet and Sweco.

This project investigates the possibility to utilize potential energy in regenerative shock absorbers for heavy duty vehicles, by means of road profiles for Denmark.

ABSTRACT

Knowledge about shock absorbers, road profiles, energy recovery systems, and environmental approaches were obtained.

Investigation is done through four different configurations and simulated by means of a Quarter Vehicle Model. The road excitation accumulation averages varied from 0.42 [m/km] to 1.22 [m/km].

The energy recovery abilities are found to theoretically be between 3% and 8.5%. By means of conservative design calculations, it is found to reduce costs compared to CO2 by 1700 [DKK/tonne] a year and reduce pollution done by heavy duty trucks with 49,000 tonne CO2 per year in Denmark if implemented in all danish licensed trucks.

With Road transportation being 25.4% of Denmarks climate corrected energy consumption, there is huge potential for an hydraulic regenerative shock absorber system to replace conventional shock absorbers. Research is done from basis of Denmark, but is applicable on a global scale.

Bachelor final
Project no. 228

Using IoT technology to reduce the energy consumption of heating systems with big latencies

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PROBLEM DESCRIPTION

Floor heating systems are popular in Denmark because of their contributions to a comfortable indoor climate and good health. However, many of these systems are subject to rather large temperature fluctuations which compromise their benefits. Influences such as quick weather changes and passive heating due to solar radiation through windows paired with simple control systems and the slow nature of radiant heating deteriorate indoor climate and increase energy consumption. There exist a number of smart thermostats on the market which aim to improve the efficiency of heating systems, but they address short term energy-saving measures of more agile heating systems like occupancy checks (only heat when the building is occupied) or ventilation checks (do not heat when windows are open). These measures are proven to be effective with convectional heating such as radiators, but they hardly apply to floor heating systems. Radiant heating systems simply react too slow.

DESIGN GOALS

Therefore, the goal of this project is to design a control system for radiant heating which acts predictive rather than reactive by taking into account weather forecasts and local environmental data to minimise temperature fluctuations inside the building, thus improving comfort levels and reducing energy consumption. To ensure that the net energy savings are maximised, the control system itself must have a low electricity consumption. There is no sense in saving energy used by the heating system only to waste it on a demanding control system.

SOLUTION OUTLINE

The system is laid out so that several sensor modules inside the heated space would collect data about humidity, temperature, and brightness which they send via a LoRaWAN connection to a web server. The reason why a LoRa communication is desirable is because it requires very little power and also allows the use of the system in buildings that are not connected to the internet (for example summer houses).

The server uses the OpenWeatherMap API to fetch weather forecast data and it gets a target temperature from the user through a webpage. A neural network that is trained on the specific building and weather characteristics predicts the temperatures over the prediction horizon (the next couple of hours or so) given a control signal as an input. The control signal is calculated by an evolutionary optimisation algorithm that uses the neural network's predicted temperatures as a cost function to minimise the sum of squared differences to the user set point. Once a sufficiently good control signal has been found, it is sent back to a receiving module inside the heated space that applies it to the floor heating system through a physical interface.

Bachelor final
Project no. 230

7 AFFORDABLE AND CLEAN ENERGY

Prolonging the lifetime of solid oxide fuel cells using redox reactivation

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DTU Energy, Technical University of Denmark

Introduction

With the increase of global implementation of renewable power sources the need for storage solutions which can handle said produced energy has begun and will continue to increase. Solid Oxide Cells (SOCs) are a technology which can play a large role in addressing this need, due to their high efficiency, variety of usable fuels, and wide range of potential applications. One issue plaguing SOCs is increased polarization resistance over time. The aim of this project is to investigate the effect of redox reactivation on the polarization resistance of redox-stable fuel electrodes, and to optimize the redox cycling procedure.

Method

Four different kinds of cells were created for experimentation in the scope of this project. The first cell contained the same components as previously tested cells, to confirm the experimental findings and gain insight into the changes during redox cycling. The other three cells aimed to take advantage of exsolution, a little applied method of catalysis in the field of SOCs, to optimize the reactivation during redox cycling. Electrochemical testing was then performed in both degradation and reactivation conditions to determine if the redox cycling process was effective. Lastly, the cells were imaged to investigate what physical changes had taken place during redox cycling.

Preliminary results

Initial results for reactivation through redox cycling have been promising. The tested cells clearly show regained performance after redox cycling, confirming previous behavior.

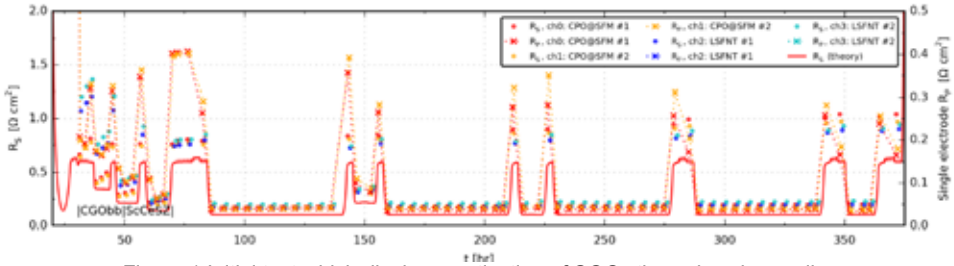

Figure 1 Initial test which display reactivation of SOCs through redox cycling

Future applications

Moving forward, the idea is to investigate this phenomenon with different kinds of cells to determine if redox reactivation is something that can be generally applied, or only in specific contexts. Long term, the objective is to create a system in which fuel cells can reactivate themselves through redox cycling, when a loss in efficiency is detected. This would increase the life time of SOCs going forward, and hence increase their economic viability.

Bachelor final
Project no. 231

Reducing CO_2 emissions of cement production with Alusilica

S. Hansen and A. Caspersen

DTU Civil Engineering, Technical University of Denmark

ALUSILICA AS A MINERAL ADMIXTURE IN CEMENT

In our bachelor thesis, we tested if Alusilica could be used as an admixture in cement. Alusilica is a waste product in the production of aluminum fluoride, a compound used in the production of aluminum. Alusilica consist of roughly 80% amorphous silica, and some aluminum, calcium and fluoride. Silica fume is already a well know admixture used in cement, which actually increases the strength of concrete. The main difference between Alusilica and silica fume is the particle geometry.

Our results showed that it was possible to replace 10% of the cement used in a mortar, without reducing the compressive strength. This is likely due to either a puzzolanic reaction between the silica and calcium hydroxide formed in cement hydration or a micro filler effect. In our project, we tested if it was possible to activate the Alusilica further by using Superplasticizer or increased curing temperature, but this did not seem to a positive impact. It is possible that the Alusilica can be activated with other methods.

CEMENT PRODUCTION EMITS MORE CO2 THAN INDIA

The global production of cement has grown very rapidly in recent years, and after fossil fuels and land-use change, it is the third-largest source of anthropogenic emissions of carbon dioxide. It is estimated that the production contributes 5-8% of the total anthropogenic CO2 emissions, and there is no sign of it slowing down in the coming years.

Since the Alusilica is already being produced as a by-product of aluminum production, it can be considered to be almost CO2 neutral to use. Today the Alusilica is either treated as waste or sold as a fluoride source. Substituting cement with Alusilica would reduce the environmental impact of cement production significantly.

In our project, we collaborated with a Swedish company that produced 135.000 tons Alusilica each year. From their production size, we estimate that roughly 6.5 mil tons is made on a global scale each year. It is estimated that cement production emits 900 kg CO2/ton cement. If all the Alusilica produced is substituted into cement, it would mean a reduction of 5.8 mil tons CO2 per year on a global scale. While this is an optimistic estimate, it illustrates the potential of Alusilica.

CHALLENGES

We concluded in our project that Alusilica likely have the potential to increase the strength of concrete, but that requires an activation of the puzzolanic properties. It would take more research to discover how this is done. More research is also required into the long-term properties such as frost resistance, chloride resistance and creep before the construction industry would use it in their products.

Bachelor final
Project no. 232

CO_2 capture by supported polymers

A.B. Jacobsen

DTU Chemistry, Technical University of Denmark

INTRODUCTION

The concentration of greenhouse gases in the atmosphere has kept increasing since the Industrial Revolution. The sources of the greenhouse gases can be traced back to among others powerplants burning fossil fuels. However, the demand of energy is not decreasing but increasing, because of growing population. CO_2 neutral energy sources have now given more focus from the politicians, but there is still many powerplants which produce CO_2. Biogas plants are among these green sources, but even though they use our leftover biomaterial to methane (CH_4) they still produce CO_2. Around 40% of CO_2 which is produced as a side product by the fermentation can't be avoided, but amount of CO_2 in the flue gas might be reduced by end-of-pipe.

METHOD

There are many promising techniques to reduce the emission of CO_2 in industrial off-gasses. The focus of this project will be on polymers of amines and ionic liquids. Amines in solution are already used in some industries to capture CO_2, but high energy costs and their corrosive nature has prompted the industry to look alternatives. Ionic liquids have shown to have same capacity as the amines. The undesired effects of the amines can somewhat be avoided by using support materials e.g. silica. The silica can be shaped into pellets with a large surface area which are filled with a polymer or an ionic liquid. The pellets are loaded into a reactor which the off-gas passes through. When CO_2 encounters the polymer or ionic liquid, a chemical reaction takes place binding the CO_2. The reactions are reversible, and the polymers and ionic liquids can be regenerated by exposing it to heat, vacuum or pressure swing. The liberated concentrated stream of CO_2 can be stored and used for other purposes like downstream conversion to fuels and other useful chemicals products.

Absorber material

There is a difference in the amino group bond strength. The primary amino group makes the stronger bond to CO_2 compared to secondary and tertiary amines. However, because of the strong bond regeneration is very energy demanding and thus costly. Therefore, secondary and tertiary amines are preferred since they are easier to regenerate.

PERSPECTIVE

In this project amino acid based ionic liquid absorber materials are selected. They exhibit high and reversible CO_2 absorption capacities and have low or no toxicity in addition to form a non-problematic end-off-lifetime waste. The CAPEX and OPEX are envisaged to be less than 50% compared to state-of-the-art technologies for Biogas Plants. This concept is now pursued for industrial implementation in collaboration project with large Nordic actor on the Biogas market.

Bachelor final
Project no. 233

Edible mushrooms cultivation in grasspulp and other sustainable substrates

O.H. Fjellander

DTU Environment, Technical University of Denmark

Introduction

Two major issues of the UNs SDGs are; optimizing the utilization of current and new resources, and minimizing the emissions of greenhouse gases per capita. In this project, four different biomasses have been investigated. By repurposing the biomass to cultivate mushrooms, they may substitute meat - thereby decreasing GHG emissions.

Theory

Cultivating edible mushrooms in a biomass demands knowledge regarding biotic and abiotic factors within the experiment. Experiments with environmental variables may suggest optimal growing conditions utilizing these new biomasses. To do a biomass repurposing for environmental reasons, a carbon footprint (CF) could be the evaluation of proper purpose using a consequential life cycle assessment (LCA) methodology.

Method

The CF will be done for five different scenarios of use for the biomasses. These include the mushroom production (scenario 1), feed for ruminants (2) and three energy alternatives (biorefinery (3), anaerobic digestion (4), combustion (5)). The CF will be structured based on a UDD (upstream, direct, downstream) approach. Scenario 1 is based on numbers found from the experimental series, regarding processing, yield, and protein amount and quality.

Results and Discussion

The results regarding one of the biomasses evaluated, alfalfa, of the experiment is shown in figure 1. Using alfalfa to cultivate edible mushrooms instead of using it for ruminants feed or energy reduces GHGs, as shown below. This project demonstrates that new resources should be incorporated in future food production.

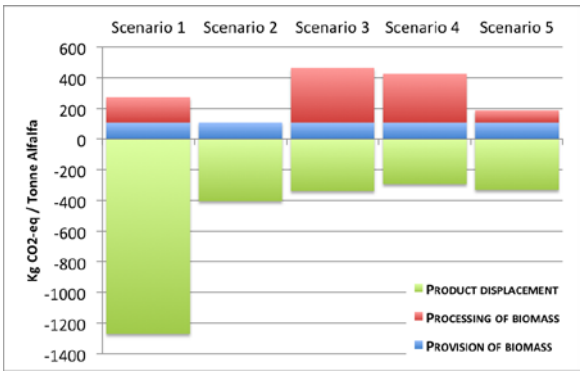

Figure 1 Carbon Footprint for the Five Scenarios


dation of plastic
TICIZERS?
compounds added to plastics to give
such as flexibility,
products
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MSc in Biotechnology

Abstracts
Master course

Master course
Project no. 301

Ecological engineering for water security in the Arctic communities: Integrating environmental and socio-economic aspects

Q.C. Monica

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INTRODUCTION

Climate change, sector development, and population growth result in rising water demand and discharge. Threats to water security are generated in Arctic regions which are often misunderstood due to the extreme climate condition and environmental challenges. Likewise, poor health status due to inadequate hygiene and sanitation systems are linked with rural Arctic residents. Water management has evolved depending heavily in mechanical constructions transforming drastically towns, however, they are not adequately designed for Arctic environments. This highlights the need to shift beyond the traditional engineered infrastructure and integrate site-specific solutions that suits the reality of island economies. Thus, ecological engineering (EE) such as restored wetlands, sewage ponds and infiltration systems may provide an innovative and cost-effective solution to wastewater treatment.

HYPOTHESIS

The study aims to assess the impacts of EE with a holistic approach, considering the environmental and socio-economic aspects addressing the following research question: *How are the biophysical and socio-economic conditions affected by EE interventions in the Arctic communities?* Based on a preliminary literature review and in relation to the research question, the following hypothesis are constructed: 1) EE delivers direct livelihood benefits through provisioning ecosystem services and savings in health care costs. Indirect savings are delivered through increased subsistence hunting and educational fulfillment due to declined illness. 2) EE increases the resilience of local communities acting as a buffer to climate change and through improved water quality.

METHODS

A case study and a mixed-method approach are suggested to be conducted. Existing data on EE interventions in towns or settlements from a specific Arctic region will be compiled from secondary sources. Quantitative and qualitative data will be collected through questionnaires and semi-structured interviews. Gaps in knowledge will be address through literature and records. In-situ measurements on water quality from households and industry discharge will include at least two settlements or towns with and without EE interventions to enable a comparative analysis. Descriptive and inferential statistics will be generated for socio-economic and environmental data. Physicochemical properties of water will be studied through a Multiparameter Analyzer (Consort C6030). Methodological limitations are expected to be alleviated through triangulation as part of the entire interdisciplinary scope.

EXPECTED RESULTS

The study expects to contribute to the bodies of knowledge by providing evidence-based results that will capture the socio-economic dimensions of EE in an Arctic community and added knowledge of the biophysical environment. Additionally, it will deliver empirical evidence on the cultural and environmental interplays which are virtually non-existent. Thus, it will support the United Nations Sustainable Development Goals relevant to water security.

Master course
Project no. 302

Development and characterization of biomass-based photocatalytic coatings

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BACKGROUND

TiO_2-based photocatalytic coatings are the state-of-the-art of self-cleaning coatings that can be used to remove pollutants in both gaseous and liquid phases, including dyes, NO_x and volatile organic compounds. However, the low quantum efficiency of TiO_2 limits its wide practical application due to electron-hole recombination. Previous work has shown that adding carbon-based materials to TiO_2-based composite has improved the photocatalytic performance. Carbon-doped or fabricated photocatalytic coatings with porous structure, stable characteristics, large electron storage capacity and higher electrical conductivity pave the way for the improvement. However, the currently used carbon source is not sustainable and therefore a biomass-based substitute is preferred in order to make a cleaner and more sustainable product.

OBJECTIVE

The aim of this project is to investigate the effect of using biomass-based carbon sources on the efficiency of TiO_2-based photocatalytic coating through comparison with pure TiO_2-based photocatalytic coating.

METHODOLOGY

Coatings containing TiO_2 as photocatalytic pigment will be fabricated where different sources of carbon will be added in order to study the effect each type has on the photocatalytic activity. The source of carbon that will be investigated is soot, which will be either obtain from flame-spray pyrolysis or from a wood stove oven obtained from the chimney or biomass char. Then each coating will be evaluated for the photocatalytic ability. By following the degradation of methylene blue under UV light with UV-vis spectroscopy, a comparison about the photocatalytic properties of different coatings can be made based on the results. Furthermore, each type coating will be characterized by Scanning electron microscope (SEM) in order to examine the surface of the coating before and after UV expositor.

EXPECTED RESULTS

It is expected that the performance of the biomass-based coating will be comparable with a traditional pure TiO_2-based photocatalytic coating and that some improvement will be observed. This project will shed light on the possibilities of developing a biomass-based TiO_2 photocatalytic coating meanwhile providing recommendations about selection of biomass-based carbon materials. The concept is believed to have potential to be applied in scale product as a facile, low energy method to degrade pollutants.
The experiments will be carried out at DTU in June 2019.

Master course
Project no. 303

Sustainable development of recyclable elastomer

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BACKGROUND

An elastomer is a polymer, which has viscous and elastic characteristics. Generally, elastomers have a low young's modulus and a high failure strain, which means the material is soft but tough. Thus, they are able to regain their original shape after applied stress. The most common elastomer is natural rubber, though elastomers can also be synthesized. Synthesized elastomers, such as ethylene propylene diene methylene rubber (EPDM) and polydimethylsiloxane (PDMS) elastomers, are widely used in daily life and in industrial applications of sealing, gaskets, soft robotics, etc. Synthesized elastomers are mostly made by a cross-linking reaction, where the polymer chains are inter-connected. A cross-linked polymer has limitations in processability, reshaping, and recycling as it does not possess a melting temperature. Thus, waste is generated as cross-linked elastomers cannot be reused and left over elastomers from the process are thrown away. Thermoplastic elastomers (TPEs) are elastomers prepared without cross-linking, which are recyclable and able to overcome the other limitations of the polymers prepared through cross-linking. PDMS is an inert and non-toxic material, which is ideal for preparing elastomers due to its mechanical characteristics. Today, PDMS-based elastomers are produced by cross-linking reaction with catalysts such as tin and platinum, which are not environmental friendly.

OBJECTIVES

The main objective of this project is to synthesize PDMS-based TPEs containing pendant 2-ureido-4[1H]-pyrimidone (UPy) units via free radical polymerization (FRP). Thereby, making a sustainable development of recyclable elastomer.

METHODOLOGY

By using 2-isocyanatoethyl methacrylate, 2-amino-4-hydroxy-6-methylpyrimidone and styrene as raw materials, PDMS-based thermoplastic elastomers are synthesized and characterized through the following steps:

1. Intermediate methacrylic-UPy is prepared by the reaction of 2-isocyanatoethyl methacrylate, 2-amino-4-hydroxy-6-methylpyrimidone.
2. AIBN is added as an initiator, and under the action of this initiator, copolymerization is initiated. methacrylic-UPy and styrene are successively polymerized and finally attached to PDMS.
3. The functional groups, their molecular weights, and the experimental conditions such as reaction time will be varied. Therefore, the effect of the changes, e.g. glass transition temperature, young's modulus, etc., on the final product will be studied.

EXPECTED RESULTS

The prepared elastomer should have good viscoelasticity and thermoplasticity. It is expected that the elastomer can be reshaped and reused multiple times without significant degradation or property changes. Thus, the new material can potentially be an excellent candidate for recyclable silicone elastomers.

Master course
Project no. 304

Roll the goal: bringing the SDGs to life

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Introduction

Children love games. Children love stories. Why not use these elements to teach them about the Sustainable Development Goals (SDGs) and motivate them to contribute to a more sustainable world?

In 2015, the United Nations introduced the 17 Sustainable Development Goals for 2030, with the aim to globally stimulate action to build a more peaceful and prospering planet. By introducing Roll the Goal, an easy-to-use tool for teachers, we want to make children more aware of and understand the meaning of the SDGs in a playful and informative way.

Challenge

The UN Sustainable Development Goals are increasingly gaining worldwide attention in the movement towards a more sustainable future. This future will be run by the children of today, and therefore it is our responsibility to make children aware of the sustainability challenges that face us all. While the SDGs have motivated many people to take action, they can be very abstract and hard to understand for children. Parents and teachers are therefore in need of easy-to-use tools to facilitate children's learning about sustainability and stimulate them to think creatively about sustainable solutions.

Solution

Roll the Goal is a simple solution that lets children connect the SDGs to the real-world context. By rolling a set of dice with different symbols, children are stimulated to create their own stories linked to the SDGs. This process is pedagogically structured through the use of a template that enables children to share and discuss their stories with peers and research real-life situations. By doing so, children gain a better understanding of what the SDGs are about and how they can act on them.

For teachers, it is a cost-efficient and easy-to-use add-on to their daily classroom activities that can be used in many different settings. Since symbols on the dice are the core of the game, it is usable for various age groups across different countries.

While Roll the Goal teaches children about all SDGs, the game itself addresses the SDG #4.7 (Education for sustainable development and global citizenship) in particular.

Results

A prototype of Roll the Goal was presented last November during the finals of the Open Innovation Call "Designing the 17 SDGs for the sustainable school of tomorrow" organized by Smart Cities Accelerator and EIT Climate-KIC in Malmö. The jury was enthusiastic about the product, emphasizing the power of storytelling for learning, the low cost, and the ease for teachers to use it. Based on the feedback we received there, and the feedback we will get during the Green Challenge, we are working on refining the prototype to make it ready to test in schools soon.

Master course
Project no. 305

Plan2Plate

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INTRODUCTION

According to the green think tank Concito, the CO2 emissions of the average Dane in relation to food is about three tonnes annually. This is more than all the energy and fuel we utilize annually or three times the amount of the emissions from flights.

SDG 12: Responsible Consumption and Production

Food consumptions account for 24% of a person's total carbon footprint which is twice as much as a car on average. These numbers call for action - it is time to challenge the current food system and SDG no. 12. Changing your car to a more sustainable model usually involves a big investment, while changing your food habits does not. However, changing habits can be difficult, even for people who are motivated to live more sustainable. Our research shows that the main barriers are lack of knowledge, lack of inspiration and the assumption that eating climate-friendly is too expensive and time-consuming.

THEORY AND METHOD

To solve challenges in big systems as the current food systems, a systematic way of thinking and manage the problem-solving processes in the context of the socio-technical system is needed. Systems engineering allows the development of optimal products, as it creates a holistic frame, where multiple stakeholders are a part of setting requirements and defining the solution.

Several methods have been used in developing this project. Frameworks from system engineering like; N-model, Demarcation model, and requirements definitions. Frameworks on sustainability such as; the SDGs and CO2 emission counting. As well as business frameworks; Strategy canvas, the four P's and canvas business model.

SOLUTION

Plan2Plate is an online solution that combines inspirational low CO2 meals with a simple and flexible planning system in order to ensure sustainable eating and the possibility to decrease shopping time and frequency. Plan2Plate tracks the progress of the user and calculates the CO2 emissions of the planned meals. Additionally, it provides tips and guides on how to make sustainable food choices. The users can create meal plans from the recipe library or upload their own favorite recipes, which will then be assessed in terms of CO2 and included in their meal plan. Either way, Plan2Plates helps users plan their sustainable food choices one plate at a time. Plan2Plate engage consumers to learn about sustainable food practices by making climate impact transparent.

The solution is initially targeting young people age 18-35 since a large part of the young generating is already interested in and invested in sustainability and are therefore more prone to change their habits.

Master course
Project no. 306

Gasification for production of ammonia from high-nitrogen biochar

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INTRODUCTION

Ammonia, as one of the highest demand chemicals in the world, is mainly synthesized through the Haber-Bosch process, where nitrogen and hydrogen are reacted on Fe-based catalysts at high temperature (400-600℃) and high pressure (150-200 bar). The process is energy demanding and typically based on fossil fuels, causing over 200 million tons of CO_2 emission on annual basis globally. To reduce the CO_2 emission, one approach is to produce NH_3 under atmospheric pressure condition using CO_2-neutral biomass as raw material. The possible source of raw materials is biochar produced from distillers dried grains with solubles (DDGS) and algae which has a high energy-density and a high nitrogen content, and presumably having a potential to produce ammonia with low carbon footprint.

OBJECTIVE

To explore the feasibility of producing NH_3 from a high-nitrogen biochar through gasification, and to determine the optimal experimental conditions for NH_3 production.

METHODOLOGY

Biochar preparation

The selected biomasses, DDGS and algae, are pyrolyzed in an oven at 600 ℃ with a N_2 flow of 2.5 NL/min for 1h. Thereby biochar samples can be obtained. The char yield can be determined from the biomass and char masses. The C, H, N and S content in the biochar will be analyzed by elemental analysis.

NH_3 production

The biochars are gasified in a laboratory scale fixed bed reactor. The gas compositions (CO, NH_3 etc.) are analyzed by Fourier Transform infrared spectroscopy (FTIR). The experiments will be carried out at varying reactor temperature (750-950℃) and different gasification agents e.g. H_2O, or CO_2 conditions. The gas flow in the reactor is fixed to 1NL/min. Based on the transient NH_3 profile in the flue gas, the conversion of the char nitrogen to NH_3 is determined. Additionally, the composition of residual ash will be analyzed through Scanning Electron Microscope and Energy Dispersive X-Ray Spectroscopy (SEM-EDX) to explore the potential of using the residue as fertilizer.

RESULTS

The experiments will be carried out at DTU in June 2019. It is expected that an effective conversion of char nitrogen to NH_3 can be achieved in the gasification process. Based on an evaluation of the experimental results, suggestions to the operating conditions in the pyrolysis and gasification processes will be outlined.

Master course
Project no. 307

Buildhub - the latest sustainable solutions

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The construction sector is among the least digitized sector and has been slow to adopt technological solutions even though the long-term benefits are significant (McKinsey, 2016). There is a huge potential in using digitalisation as a means to achieve sustainability and address the UN SDGs. Our solution allows clients to make informed decisions on technological and sustainable investments, promotes knowledge sharing, encourages adoption of latest solutions and finally allows all stakeholders to play a part in the movement towards a more sustainable construction sector through digitalisation.

Although 93% of the construction industry agree that digitalisation will affect every process, only < 6% actually make full use of digital tools (Rolandberger). There are no incentives for knowledge sharing within the industry and solutions are often internalised; thus, causing the data generated to become implicit knowledge. Typically, large building projects take 20% longer to finish and are approximately 80% over budget (McKinsey, 2016). The lack of knowledge sharing and communication between stakeholders prevents the identification of ´best practices´, the latest solutions and the biggest impact areas in a building project.

Our solution caters to the entire construction sector e.g. 1. users who are looking to share their good and sustainable practices, such as technology companies, research initiatives/projects, universities and educational institutions; 2. users looking for digital and sustainable solutions for their use, such as contractors, engineering consultants and the government; 3. building owners looking to get updated about the latest sustainable and technological solutions, as well as find the companies providing these solutions.

A digitalized platform (accessible as a website and an app), a one-stop hub for all the latest sustainable technologies and solutions and sharing of knowledge and good practice. Future projects can be optimized by using knowledge from previous projects; risks can be lowered in regard to time and costs. The solutions provided in the hub are 'ready-to-use', 'fact-based' and cater to the SDGs. It contains the following unique features: 1. Build Connect (connecting solution providers and solution seekers); 2. Progress Tracker TM (documenting the progress at the end of every phase and providing feedback) and 3. Success Stories (sharing successful implementation stories and good practices with concrete facts).

Our solution is unique because it is:

1. Building a portfolio of cases with 'proof of positive financial impacts' for clients: *Companies can use these success stories with proof of positive financial impacts as references to build a compelling case to convince clients to support the adoption of more sustainable and digitalised solutions.*
2. Sharing of knowledge and good practice: *By sharing good practices and success stories, there is a huge potential to fill the knowledge gaps in the building industry and limit solutions from being internalised.*
3. Providing opportunities for growth, recognition and branding

Buildhub will house various sustainable solutions that cater to the SDGs addressing the problems within the construction industry. It will promote and encourage the adoption of innovative and circular thinking and practices. Therefore, Buildhub will have an indirect contribution to mainly four of the UN Sustainable Development Goals: 9 Industry, Innovation and Infrastructure, 11 Sustainable Cities and Communities, 12 Responsible Consumption and Production and 13 Climate Change.

Master course
Project no. 308

From waste to value: catalytic depolymerization of lignin to vanillin

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ABSTRACT

Lignin is the world's most abundant biopolymer composed of aromatic compounds, accounting for a share of 15-35 w% in wood and plants (Biermann, 1996). Its high abundance as well as unique chemical composition offers a huge potential towards its valorization. However, lignin still remains undervalued as it occurs mainly as waste product in pulp- and paper industries, where it is burned for energy generation. In terms of thinking of a more sustainable world, it seems important to use renewable resources in order to produce chemicals, pharmaceuticals and functional materials. Furthermore, an enhanced utilization of lignin would also include a promising chance to improve the economic viability of existing pulp- and paper mills.

The central targeted product, vanillin, finds application as flavoring agent in food industries and in the production of pharmaceuticals and cosmetics. For this purpose, catalysis plays a crucial role to help chemical processes being cleaner, faster and more energy-efficient.

Within this project, various homogeneous transition metal catalyst systems were investigated to depolymerize a technical lignin stream under mild conditions using molecular oxygen as environmentally friendly oxidant. The aim was to develop a catalyst system achieving the highest possible yield in vanillin.

The yield of vanillin showed a considerable increase from 2.7% to 4.0% (based on initial lignin) with the best performing catalyst system. However, the resulting product mixture included also high amounts of vanillic acid and acetovanillone - compounds which are of great interest too.

The catalytic conversion of lignin to vanillin shows great potential to make usage of a renewable resource, currently only being treated as waste.

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Master course
Project no. 309

Towards digital utilities enabled smart campuses

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INTRODUCTION

Abuse of utilities has been an illness for Hong Kong. Particularly, Hong Kong's extreme obsession with air conditioners costs 30% of the electricity used by the city annually, and 60% in the summer ("Hong Kong's obsession," 2016). Such constant and unrelenting abuse of ACs also caused exceptionally low indoor temperature that demands "indoor jackets". Despite such annoyance and government's appeal for higher AC temperature, there has been little success in transforming the usage mode of those utilities. One major reason is the poor set-up of AC control systems that the management companies purposely turn the AC to 20 degrees (Green Sense, 2011).

In recognition of the need to improve utilities efficiency, this project aims to develop a smart campus system that drives smart and effective management of the utility usage through the combined power of IoT devices, Big Data, and Visualization techniques.

METHODOLOGY

The proposed system serves as a data-driven system to collect, monitor, and analyze the utilities usage on the campus. Aligned to its objective, the system is represented by a four-layer architecture:

- The sense layer collects real-time data of temperature, humidity, and people distribution based on IoT devices including sensors, videos, and Wi-Fi routers
- The data layer processes the streaming data and derives information about location-specific temperature and people distribution
- The application layer applies big data analytics to derive utility usage status, identify potential zones with abuse of utilities, and help improve their usage
- The visualization layer communicates the information to the university administration and assist in their analysis

The project provides a data-driven solution for smart decision-making on utilities management. The generated data is shared with open access and beneficial to further studies on facility management, offering references for larger-scale initiatives.

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Master course
Project no. 310

Automatic single-cell biomass harvesting

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INTRODUCTION

In nature, cells are the building blocks of life and it is within these cells that biological material is produced. Through metabolic engineering, it is possible to tune these material factories into optimized production of high-valued compounds, such as phloem sap, natural rubber, and fragrances. However, an important question remains – how to extract said compounds without disrupting the cells?

In this project, a novel idea for the extraction of biomass from single cells is proposed. Taking great inspiration from the sap-harvesting insects, it was attempted to harvest biomass from single plant cells using a micrometer-scale needle. In doing so allows for harvesting without disrupting the cells, and this opens up for a potential way of obtaining a new clean energy resource (phloem sap) and other high-value compounds.

METHODS AND RESULTS

A sample of plant tissue was placed under a microscope, as seen in figure 1. The needle position was controlled by a micromanipulator. Images from the microscope were analyzed in real-time using a computer, and the tip of the needle was tracked. A machine learning algorithm calibrated the image position to the micromanipulator position. The needle was injected into manually selected target points autonomously.

CONCLUSION

The concept of autonomous injection of a micro-scale needle into manually selected single plant cells was shown in this project. Future research aims at automatic detection of the injection sites, in order to fully automate the process of extracting biomass without disrupting the cells.

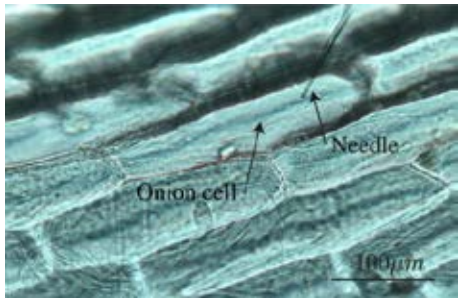

Figure 1 Microscopy image of needle injection in a single onion cell.

Master course
Project no. 311

Developing a vegan and sustainable alternative to wool

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INTRODUCTION

Wool is amazing

Wool is highly renowned for its unique material properties. Just to mention a few: it is temperature regulating, it can insulate even when wet and it is breathable – all properties which makes it highly suitable for the production of e.g. baby clothes and outdoor wear.

…but it has a price

Unfortunately, the production of wool requires a lot of energy, resources and it leads to a high production of greenhouse gases. Additionally there are ethical considerations linked to the production of wool, as cruelty towards the sheep is often involved in the process. Due to these reasons, a high percentage of the seemingly ever-increasing group of 'conscious consumers' are reluctant to use wool. Current alternatives, such as acrylics and bast fibers are no solution, as none of them match the properties of wool and many are (even more) unsustainable.

METHODS

Defining the problem and characterizing the consumer need

In order to solve the challenge, it was first of all necessary to obtain an in-depth understanding of the wool fibers, what they consist of and what gives them their attractive material properties. This was done by a thorough literature study and expert interviews. Moreover, an understanding of which of these properties are the most sought-after among consumers and why, was obtained by an online questionnaire.

Exploring solutions

The rest of the project was then continued by finding a suitable resource functioning as the basis for the new material to be developed. Based on the initial phase of the project, three main requirements were set up:

- high protein content,
- renewable/from wastestream and
- non-animal derived.

From here, the focus was on going from the basis resource to fibers.

SOLUTION AND FUTURE PROSPECTS

Based on the earlier defined requirements, a search for a suitable resource was initiated, which landed on upcycling canola cake (the leftover product from canola oil production). Canola cake has a high protein content, which can be isolated and then be transformed into fibers by wet-spinning. By modifying the wet-spinning process, the nature of the resulting material can be tweaked in order to obtain wool-like properties. In the future, experimenting with different starting materials and with the wet-spinning process, can assure the development of a novel alternative to wool that is both vegan and has an environmental impact.

Master course
Project no. 312

Empowering poor people in rural areas of developing countries through renewable energy solutions

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INTRODUCTION AND MOTIVATION

More than 1billion people in this world do not have access to electricity. Most of them are located in remote rural locations of developing countries predominantly in sub-Saharan Africa and parts of Asia. One of the reasons being, most of the time the national grid is absent or unstable at these locations which forces them to rely heavily on kerosene lamps and diesel generators to meet energy needs which are not only expensive and vulnerable to the fluctuating fuel prices but also pollutes our environment.

OBJECTIVE

Solar Seed is working to dramatically increase the numbers of electrified homes in these communities towards achieving UN SDG 7. Solar Seed was able to develop our first minimum viable product. But, more importantly, our passion for these rural communities has allowed us to produce a proof of concept prototype that meets local requirements.

METHODOLOGY

Our portable pay as you go solar system provides reliable, affordable solar energy to produce electricity. Pain relievers and gain creators involve the extension of useable working hours through artificial lighting; which allows children to study during the night without the use of kerosene lamps. Furthermore, the prototype provides a charging port for cellphones and a fan to keep mosquitos at bay. We are also planning to power agricultural pumps through solar energy to help farmers to increase their revenue and thereby leading to a better quality of life.

IMPLEMENTATION AND IMPACT

Our first customers would be the Dalit (untouchable) families in the town of Bhardaha in Nepal. We will install our system in at least 10 houses in Nepal thereby having a positive impact on the lives of 60 people during our first pilot project work. We already have established a network/close relation with the local communities in Nepal and are very much looking forward to helping us during our pilot studies.

Residual benefits are Increased economic activity and improved quality of life, improved resilience to natural disasters, and improved health of inhabitants due to reduced exposure to mosquito born illnesses. Value Proposition is reliable electricity for LED lighting, mobile phone chargers, fans, and agricultural pumps. An article was also published about our project in a famous German newspaper Süddeutsche Zeitung **(Buchwald, 2019)** and other leading newspapers in India.

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Master course
Project no. 313

Sustainable trigeneration of electricity, desalination and cooling in coastal desertic areas

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MOTIVATION

By the year 2040, the total world energy demand is expected to increase by 28% in its various forms, whereas carbon emissions must be significantly reduced to mitigate climate change. In this context, the new energy solutions must fit within the specific demands, constraints and opportunities of each geographical zone. Solar energy is an abundant resource in desertic areas such as the Persian Gulf, the Atacama Desert and the south-west US; where economic activity and rising living standards increase consumption especially in the form of electricity, cooling and freshwater.

Nowadays, water is supplied either by scarce freshwater sources, leading to ecosystem damage and aquifers depletion; or by conventional seawater desalination, which is expensive and requires extensive chemical pretreatment and electricity usage. Cooling is also produced from electricity, which is mainly supplied from fossil-based grids. On the other hand, electricity could be produced by photovoltaic power plants; however, its intermittent nature and the lack of cost-effective electricity storage involve the availability of fossil backups or extensive grid infrastructure.

AN ALTERNATIVE SOLUTION

This project consists of the technical and economic assessment of a trigeneration system, able to meet the aforementioned demands from storable solar energy while minimizing the need for electricity from fossil sources. It exploits the synergies from technologies individually available on the market allowing for increased energy efficiency, reduced operating cost and higher flexibility.

Electricity is produced by a solar concentrating power plant, where solar irradiance is stored in molten salts to run a low-temperature Organic Rankine Cycle which is able to operate whether during day or night The waste heat from the power plant is used to run both an Absorption Refrigeration System to produce cooling and a Multi-Effect Desalination System to produce freshwater. In this manner, electricity consumption for cooling and desalination is reduced by approximately 90% and 55%, respectively, compared to conventional systems.

EXPECTED RESULTS

The context of this analysis takes place in the Chilean city of Antofagasta, located in the Atacama Desert, in which the solar irradiance is highest in the world. The system is modelled and further optimized to find the lowest cost of production, which is compared to the substitute options of producing electricity from photovoltaic plants or of buying electricity from the grid. Moreover, the cost trade-offs between each commodity are evaluated to further optimize the system depending on the commodity which is prioritized during the design phase.

Master course
Project no. 314

Smart parking

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INTRODUCTION

Parking occupancy detection is on of the promising topics in the future smart cities, which working for sustainable cities and communities. In this project, a smart parking for object detection and recognition capabilities are desired to implement the solution for Smart Parking Campus. Make a safe, resilient and sustainable campus.

CONCEPT

The project is about designing a Smart Parking solution for DTU campus, which aims to solve the employees and students' pain of finding a parking space vacancy in Campus, and hence to optimise parking stalls allocation as well as traffic guidance and management in the Campus. Meanwhile reducing the driver consumes considerable time and decreasing it contributes to polluting the environment with vehicle emission.

Solution

The solution will exploits cutting edge technologies such as IoT, Edge Computing and Deep Learning. Deploying a module for parking occupancy detection and traffic flow management which can count how many cars are parking in the parking lot and how many vacancies for parking. Meanwhile, providing the traffic guidance for drivers and pedestrians in this safe and smart campus.

Master course
Project no. 315

Nordic eco-conscious travel

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INTRODUCTION

We are Nordic Eco-conscious Travel Team. Our mission is to help corporations to achieve green target by provide sustainable travel solutions in the Nordic region. After the deal of Paris Agreement, environment problem arise from different organizations, i.e., many organizations (companies, universities, municipality) fail to reach their sustainability goals. One key reason is the substantial GHG emission caused by business travels (Stubbs & Cocklin, 2008; Kahn & Morris, 2009). They are aware of the problem yet still rather to choose less sustainable travel tools due to several (such as time) constraints. As a result, some brands lose value from fail to achieve green image. Therefore, we hope to help organizations to reach ambitious sustainable goals through travel eco-friendly.

THEORY

Root Cause Analysis (RCA) is adopted in identify identifying the root causes of faults and problems for this challenge. Rooney and Heuvel (2004) suggests 4 steps to implement this problem-solving technique, i.e., (1) identify and describe clearly the problem, (2) establish a timeline from normal situation until the problem, (3) distinguish between the root cause and causal factors, (4) draw a causal graph between the root cause and the problem. We do not plan to propose solutions for the moment. We focus on digging the root causes instead. The beauty of RCA is to understand the initial cause in order to differentiate us from others by providing a solid foundation for the business model. Therefore, we position our targets are those organization who fail to achieve environmental goals.

METHODS

We are building a solution on top of the root causes. We have been creating an online eco-conscious user platform that promotes eco-conscious travel. In general, the performs main two mechanisms, i.e., (1) identify causality problems using RCA and (2) address the problems with possibly solutions. It offers the options for eco-friendly transportation across the region, knowledge platform on your carbon footprint. Our solution will also provide tree planting projects to offset business travel emissions so as to safeguarding the bio-diversity. Webpage prototype: www.nordicecoconscioustravel.com. The prize money for the Green Challenge will be contributed in building more capacity and data to make it accessible for the public to use. The goal is to make sustainable Nordic travel solution possible!

RESULTS

Our business model helps the organizations to achieve their ambitious sustainability targets via different channels. Firstly, the platform helps organizations to understand their business travel patterns by knowing how much carbon emission caused by different travelling methods. Secondly, to create alliances with tree planting and forestry departments to regenerate the eco-system and enhance biodiversity by offsetting business travel emissions. Thirdly, to facilitate the connections between transportation companies and organizations to coach firms on the impact of carbon emissions to create eco-conscious mindset in the long-run. It's the project goal to collaborate more with Nordic Innovation and Nor-Shipping on green mobility in the Nordic region from our niche market

CONCLUSION

To sum up the abstract, sustainability means people and planet first by meeting the needs of present generation without compromising the future generations to meet their own needs. Our platform is not only bounded by addressing problem and providing solutions for our potential customers. We hope the ultimate target is to change the organization's business travel behaviour. This account for individual's preference to choose type of transport and other more effective offsetting options and reducing needs of business travels and replaced by other means such as virtual rather than physical conferences. We only live one Earth. It is our duty to ensure our generation is safeguarded. Change of behaviour and mindset takes the least resources to achieve sustainability goals. Therefore, we desire to provide solutions with unique initiatives to make a difference in the long-run.

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Master course
Project no. 316

9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

Palm oil conversion to biodiesel in an innovative process with CaO solid catalyst from biowaste

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INTRODUCTION

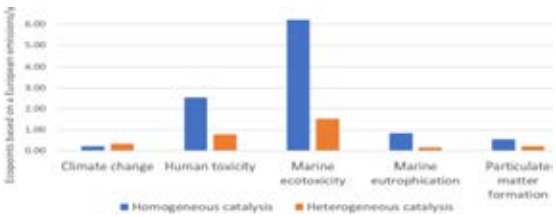
This project is an investigation on the process design for the transesterification of palm oil with methanol for biodiesel production using an innovative catalyst in order to reduce the complexity of the process and the energy use. The process has been designed to convert 5 tons/hr of palm oil into 4.6 tons/hr of biodiesel at EU standards along with 0.5 tons/hr glycerol with a purity of almost 100%.

CATALYST AND PROCESS

The chosen catalyst is calcium oxide retrieved from bio-waste (like eggshells) through a calcination process [1]; this solid catalyst is easy to recycle, can be re-used more than 13 times, does not require complex neutralization passages and does not need the harsh conditions required by conventional systems such as the homogeneous alkali-catalysed and the supercritical processes [2], leading to a much simpler design and less waste. The process simulation was performed on PRO/II software with a CSTR reactor with a retention time of 1 hour, a conversion rate of 93% and a methanol: oil molar ratio of 18:1, with 83% of methanol recycled after the reactor.

ECONOMIC EVALUATION AND SUSTAINABILITY ASSESSMENT

An economic evaluation was performed as well as a Monte Carlo uncertainty analysis. The uncertainty analysis indicates that the probability to have a return on investment lower than 0 is about 10% and the chance to have a payback period higher than plant life (15 years) is 15%. Despite these risks, the profitability metrics show a return on investment of 46.9 %/year, a net return 5.21M$ and a payback period of 1.6 years. The process was then optimised through heat integration, reactor price and retention time optimisation.
A Life Cycle Assessment was carried out to compare this innovative process to the alkali-catalysed conventional design [2]; the homogeneous catalysed solution displays a heavier sustainability impact than the new process.



Graph 1 Sustainability impact in Ecopoints; confront of homogeneous and heterogeneous processes

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Master course
Project no. 317

Conversion of CO_2 to sustainable compounds

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INTRODUCTION

One of the biggest global challenges today is the emission of CO_2. For the last couple of months we have been working with this problem in the master course HardTech Entrepreneurship. In the course we have been given a technology that allows for a more efficient conversion of CO_2 to different hydrocarbons than current state-of-the-art methods. For this piece of technology we have developed a business plan that will aid companies in reducing their CO_2 emissions, whilst providing the world market with more sustainable fuels.

PROBLEM

In 2017 the total amount of CO_2 emissions in the EU was 4,4 Billion tons. The largest emissions are created by electricity and heat production, agriculture and industries using fossil fuels. Legislations and laws are forcing industries to reduce their emissions. In 2005 the EU emissions trading system was initiated to fight the greenhouse gas emissions. The cap for emissions is reduced every year, thereby reducing the total emissions. A 24% decrease in available quotas is expected from 2019-2023 and a 12% decrease in the following years affecting the quota price. From April 2017 until April 2019 the quota price grew from 37 DKK/ton to 204 DKK/ton. Companies have to rethink their emission patterns or they are facing increasing fines.

Another approach to the climate challenge is the SDGs. In 2015 the UN developed 17 goals essential for sustainable development. Focusing on CO_2 emissions, the goals 9,11 12 and 13 are promoting the needs for better solutions. Each of these goals translates to concrete targets and indicators. Target 9.4 presents the need for the adoption of clean and environmentally sound technologies for the industry. Here the success is measured by the value added pr. amount of CO_2 emitted, underlining the need for solutions to tackle the continuous emissions.

SOLUTION

Using a new and more efficient method for converting CO_2 to different hydrocarbons we avoid emissions by substitute the currently used chemicals produced from fossil fuels with our green chemicals. As well as capturing the current emissions hereby creating a second life cycle for the CO_2

Our business model revolves around companies, which pay CO_2-quotas due to their emissions. We will take the CO_2 emissions and convert it into carbon-based compounds, such as methane, methanol, ethylene and more. In this way the companies save money on quotas and we make money on selling compounds to the world markets. One example of a market that we could enter is the methanol market. This market is worth more than 200 billion DKK and is expected to increase by 100 % in 2023.

Master course
Project no. 318

A forum for action: hybrid peer-to-peer sharing of renewable energy as a local incentive to sustainable development

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AIM

A Virtual platform for p2p energy sharing and circulation based on a hybrid p2p technology and the Ethereum smart-contract ecosystem. To facilitate growth of sustainable Renewable capacity additions to meet the goals of the Paris agreement by 2030. We do this through increasing the value-generating potential of preinstalled residential PV Solar systems by offering users a platform that serves both to share any surplus of renewable energy to entities in the community, albeit residents, businesses and institutions.

CHALLENGE

Last year, energy-related CO2 emissions rose by 1.7% to a historic high of 33 Gigatonnes. Renewable capacity additions need to grow by over 300 GW on average each year between 2018 and 2030 to reach the goals of the Paris Agreement, according to the IEA's Sustainable Development Scenario (SDS). Around 60% of the net additions of renewables are needed each year to meet long-term climate goals. Currently, Residential PV solar systems are an expensive investment with an unfavorable ROI of any generated energy surplus sold back to the grid due to high transmission costs. Renewables are further not utilised during periods of oversupply in the grid, and wasted as a consequence. An opportunity to build a forum for action and to explore bottom-up incentivised measures to meet our common challenge and a shared future.

METHOD

Employing a Virtual platform for p2p energy sharing and circulation based on a hybrid p2p technology and the Ethereum smart-contract ecosystem modified to allow the sharing of renewable energy surplus and tokenized value within the social-network. The platform is accessible from a smartphone application. The application is connected to the smart-meter of the residential PV-system and reports energy consumption and generation. E-tokens are generated through the act of sharing each Wh of surplus produced with the social Network and the energy "cloud". The cloud can power EV charging towers, public edifices, public spaces, infrastructure services, local businesses and farms. The virtual platform further creates a transparent and a disintermediated space for real activities, participation and co-creation to emerge through common social interactions, value transactions and exchanges mediated by e-tokens.

FUTURE

A social networking platform that can transform locally self-produced renewable energy into a complementary energy and economic resource for the community. and one of the main tools towards sustainable development and CO2 abatement. Relating the intention behind Top-down policy directives to a local community level, using tokenized energy as a reward for Sustainable Development oriented actions and related activities. We aim to help build a more resilient, healthy and wealthy society.

Master course
Project no. 319

Angsa - countering the trashed parcs with Computer Vision, AI and Robotics

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PROBLEM

Global pollution of the environment is a huge problem in the 21st century. From all the trash particles, the most harmful and difficult to remove are the small trash pieces like cigarette buds, small plastic particles and beer caps. Especially public parcs and animals in the parcs like ducks or fishes suffer from the pollution. Also, on beaches at the seaside, the problem of small trash was observed, which is carried into the water by the wind. The difficulty about removing small trash, that it is difficult to detect by a human eye having the offset to the ground of 1.5 meters. Moreover, there are no auxiliary means so far to pick it up which are better than the own hand and fingers. There are not enough resources from public and private institutions to keep parcs clean from micro trash, because it is a completely manual and time-consuming process.

SOLUTION

Angsa develops a smart trash picking robot, which is able to detect small trash particles and suck them in completely autonomously. It can be deployed at a certain spot in the parc and given an area, in which it can move. It is operated with the help of a smartphone interface and has an operating time of three hours. After battery goes down, it returns to its charging stations where the collected trash can be deposited. Thus, Angsa minimizes the cleaning hours invested by the parc officials for micro trash to 10%, helping to clean parcs and other public areas.

TECHNOLOGY STATUS

Ansa currently works with Computer Vision, AI and Robotics. The trash particles are recognized using a neural network which is currently focused on detecting cigarette buds. It will be extended to other trash particles such as beer caps and small plastic pieces until august 2019. The trash particles are targeted using a robot arm with four degrees of freedom including an ultrasonic sensor to detect offset from the ground. The vehicle drives autonomously with the fusion of diverse sensors including GPS, accelerometer and ultrasonic. Depending on the feedback from the pilot project in July 2019, the use of stereo cameras for detection of obstacles is discussed.

Master course
Project no. 320

7 AFFORDABLE AND CLEAN ENERGY

Autonomous sailboat

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Introduction

The main function of the sailboat is to navigate itself automatically based on the control system. We aim to design a control system of the sailboat, for the prototype. When given a coordinate of a destination, the boat will be able to adjust the angle of the sail and rudder to get there along with an optimal route with the highest efficiency of wind energy. Because the boat's power is from wind energy, this is a good reason for Green Challenge.

Furthermore, we also want to design many extension modules for the boat to achieve different goals. Like, collect environment information by using pollution evaluate sensors, or collect rubbish of water surface by a mechanic basket to make the earth much greener.

Mechanical design

For the prototype, we plan to just buy a small remote control sailboat model, which is used for model sailboat competition. And we need to do some modification on the boat. The first step is getting rid of the remote control system. Then we put our automatic control system on it. But we would still try to build extend module like trash collect basket through 3d printing.

Hardware solution

Here is the structure of our Hardware part, we select these based on our previous experience, which means we have the confidence to use it. And compared with other components in the market, the hardware above is more stable or have higher accuracy or have faster sample speed.

Control algorithm

Basically, the elementary concept of the control system is a closed loop system. The input is self-location, self-direction, destination location, wind angle, wind speed, and boat speed, the output is the angle of Rudder, the angle between sail and boat. So the input of the first control loop are wind angle and speed, and the output is the sail angle. For the second loop, the inputs are the route, boat-direction, and wind direction, the output is the rudder angle. The third loop's inputs are boat self-location and destination-location, and the output is the route. And an external loop is for the boat speed, aiming to approach the highest efficiency point.

By building the mathmatistic model of the ship, we can get the state space of the boat. According to the state space, we use Matlab to analyse dynamic performance. And the next step is to design the control system and use Simulink to make the preliminary test of the algorithm. Finally, we adopt the algorithm on the hardware and fine-tune the control system.
In conclusion, this project is eco-friendly with big development prospects and market value.

Master course
Project no. 321

NO_x reduction by reburning of waste plastics

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Introduction

The emission of nitrogen oxides (NO_x), primarily consisting of nitric oxide (NO) and nitrogen dioxide (NO_2), causes environmental and health issues, such as acid rain, photochemical smog, greenhouse effect, and health deterioration. Globally, 84% of the NO_x is emitted from combustion and other industrial high temperature processes. To meet the increasingly strict emission regulations, a number of technologies have been explored and practiced. Among the different technologies, reburning is an in-furnace technology for reducing NO_x in large-scale combustion facilities. The frequently used reburning fuels are natural gas, coal and biomass. A proper candidate for the reburning fuel is waste plastic, Due to its high volatile content and favorable heating value. Furthermore, it is available in large quantity and a relatively cheap cost. To explore the feasibility of using waste plastics to reduce NO_x in the reburning process, experimental studies simulating industrial reburning processes are needed.

Theory

In the reburning process, a high-volatile fuel is injected downstream of the main combustion zone, creating a fuel-rich zone where NO_x is converted mainly to HCN, and then HCN further reduces NO. Reburning typically occurs in a temperature range of 900-1500 K, with a NO_x reduction efficiency of 50-75%. The global chemical reactions of reburning is as follows: $CH_i + NO \rightarrow HCN + \ldots$, $HCN + O_2 \rightarrow NO + \ldots$, $HCN + NO \rightarrow N_2 + \ldots$
Plastics undergo thermal decomposition in O_2-deficient atmosphere, generating primarily is a mixture of hydrocarbons of low molecular weight (CH_4, C_2H_6, C_2H_4, C_3, C_4). At high temperatures, the intermedia of hydrocarbons, CH_i radicals, are needed for the reburning reactions. The yield of gaseous and the fraction of each component change with the pyrolysis temperature and residence time.

Method

NO_x reduction by reburning of waste plastics will be studied experimentally in a high temperature entrained flow reactor (EFR). Different plastic powders and simulated gases mixture containing N_2, O_2 and NO are mixed in the EFR. Then the volatiles released from plastics react with NO_x in the EFR. By changing the EFR temperature, the raw materials, the O_2 concentration and λ, an optimal condition for each plastic type in the reburning process can be obtained.

Expected result

The experiments will be performed in June 2019. Based on theory and existing work on reburning and plastics decomposition, we expect plastics will be an effective reburning fuel and can achieve a high NO reduction efficiency. The outcome of this project will shed light on the feasibility of using waste plastics as a reburning fuel in industrial processes to achieve both NO_x reduction and treatment of waste plastics.

Master course
Project no. 322

Recycling of outdated wind turbine blades

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INTRODUCTION

Old blades from wind turbines have a high potential to be resized or recycled caused by the properties of the glass fibre reinforced polymers (GFRP) which accounts most of the material. GFRP has both tensile and compressive strength and is lighter than steel and concrete. The current landfill at end of life (EoL), is therefore not an optimal solution. The missing large-scale recycling opportunity for the blades is the main issue of the wind power industry regarding sustainability, therefore a sustainable large-scale solution incorporating stakeholders across the industry is desired.

THEORY AND METHOD

The principles form Circular Economy (CE) and a modified butterfly model has been the main starting point for developing and rating of different solutions. Issues and bottlenecks have been identified through interviews with researchers and experts at DTU Risø, Ørsted and a company utilising the old blades for noise barriers. The problem has been addressed from the owner (Ørsted) to the future stakeholders/entrepreneurs from a perspective of keeping the material value at the highest level through several cascades.

RESULTS

A decision chart and a stakeholder map have been developed for Ørsted, leading to the most promising solutions identified. The stakeholder map includes guidelines for implementing contact to possible stakeholders.

The environmental advantage of the solutions depends on the substituting material and the amount of energy and type of additional materials needed.

The most promising solutions are:

- Drains and rain resilience designs in larger cities.
- Facade elements and sun screening – Lendager Group is interested in using this solution for a large office construction in Århus.
- Urban architecture (resized/cut into roof for bus shelters, benches, bike racks)
- Load carrying elements in constructions (resized/cut into columns/beams)
- Insulation (granulate)

At final EoL a solvent solution reclaiming the glass fibres and dissolving the resin are developed by Technological Institute.

CONCLUSION

There is a great potential to save both resources of value and GHG-emissions if resizing the outdated wind turbine blades and substituting construction materials and elements for urban architecture.

Master course
Project no. 323

Incept sustainability

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INTRODUCTION

22% of all Danish companies have integrated the SDG's into their strategy. Despite this, surveys shows that less than 1% of all people know what the SDGs are. People with crucial decision making power in companies do not seem to include sustainability in everyday decision making - resulting in many improvement opportunities missed. However, 78% of all employees want to help their company become more sustainable. This is why we have developed Incept Sustainability, an online e-learning and management system for businesses that want to ensure everyone in their team has the skills and tools to work towards or build the sustainability strategy of their company. The system consist of flexible e-learning to reach every employee while collecting quantifiable data to measure and build progress around sustainability. **Visit:** www.Inceptsustainability.com.

THEORY

Learning can increase skills and enhance employees engagement and have therefore become a business-critical priority. Furthermore, the corporate learning market has undergone a digital transformation as this learning experience can reach every employee. By cultivation and teaching sustainability among employees, companies can save resources, energy and money as well as increase their eco-friendly reputation.

METHODS

Currently, the SDG framework, LCA and several frameworks on sustainable business plans have been used in order to develop the interactive learning material.

SOLUTION

Our e-learning and management system is built on two main pillars; Interactive learning guides and a management system. The learning guides are short, interactive and flexible, with the goal of ensuring that any employee understands and have the tools to make sustainable decisions. The management system enables companies to track learning progress, gather data on the sustainability progress and help optimize efficient reporting. The first guide package "Implementing sustainability in your business plan" are currently being used by 70-100 in the Startup University World Cup online program by Venture Cup. Furthermore, testing with DFDS and Sofakompagniet have been arranged when the next guide package "Sustainability Awareness" has been developed.

CONCLUSION

By introducing a learning and management system for companies it is possible to enhance decision makers to base decisions on sustainable principles as the SDG framework.

Master course
Project no. 324

Utilization of side streams from green biorefining in ethanol production

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INTRODUCTION

In Denmark alone 21-26 million tons of green biomass is produced every year and is thereby the second most widespread crop grown in Denmark covering approximately 23% of the land used for agricultural purposes. Green biomass has a favorable nutritional distribution which could help solving the increasing demand for animal feed and human food. Further it is considered a great substitute for both cereal and soy owing to a high protein content and a significantly small environmental footprint. Thus, many studies have examined and developed methods to extract the proteins from grass a.k.a. *green biorefining*.

Nevertheless, the process of green biorefining leads to some side streams: Grass pulp which is the solid fiber fraction after juicing the grass and the brown juice which is the residue liquid fraction of the grass after coagulation and separation of the proteins. This brown juice consists of noticeable amounts of soluble sugars, minerals and organic acids. Currently this residue juice is being used as a fertilizer, but according to Danish legislation such products can only be used for fertilizing purposes four months per year. Thus, it would be interesting to investigate other uses for this brown juice which could make it a higher value product.

Brown juice as fermentation medium in ethanol production

As stated in the introduction noticeable amounts of soluble sugars are present in the brown juice along with minerals such as zinc which might constitute a great environment for yeast to ferment the soluble sugars which is found to be mainly glucose and fructose.

In this project brown juice from the grass-like crop alfalfa (Lucerne) has been investigated as a fermentation medium for vodka yeast (*Saccharomyces cerevisiae*) and a process has been designed to prepare the fermentation to distillation to produce an alcoholic liquid suitable for human consumption which reminiscent of vodka or schnapps.

PROCESS AND FINDINGS

The up concentration of the brown juice should be done by freeze drying and afterwards rehydrated to the wanted concentration. To obtain the highest ethanol yield in the fermentation the addition of yeast nutrition is necessary to create the optimal environment for the yeast. The highest ethanol content obtain yet is 0.8% (v/v). Several apparent aromas where observed after fermentation thereof, sensory analysis was performed to review if people liked/disliked the aromas compared to e.g. malt extract fermentation. This analysis did not show any clear differences in the likeability between these two products.

PERSPECTIVES

Distillation of the fermented product still needs to be performed thus; it would be relevant to investigate if formed aroma-compound will be transferred to the distillate. GMO bacteria could be used to facilitate the fermentation which might increase the ethanol yield if anti-fungi compounds are found to be an obstacle.

Master course
Project no. 325

AgriWater: The future of fresh water

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WATER SHORTAGE IN AGRICULTURE

Considering how much water we have on Earth – 72 % of the planet to be precise – it's curious how many cities and countries are in serious droughts and water shortages. This is due to the fact that most of the water is salt water, unfit for drinking. At the same time we preach that everyone should conserve their personal water use – but only 10 % of the fresh water used is the everyday use. Taking shorter showers is not going to solve the global water crisis. Astonishing 70 % of all fresh water use, however, is used by the agricultural industry. The same industry, that requires intense cleaning of e.g. waste water, only to immediately "contaminate" the water with fertilizer salts.

The solution is to make use of the vast amount of salt water to drive an osmosis balance in order to create a "fertilizer concentrate" from the saltwater on one side of the membrane to the fertilizer salts on the other side. The saltwater will flow continuously on the left side in order to create a steady flow of fertilizer concentrate on the right side, which is the AgriWater – water that already contains fertilizer and doesn't need to be cleaned 100 % to drinking water quality, but is ready to be watered onto the fields.

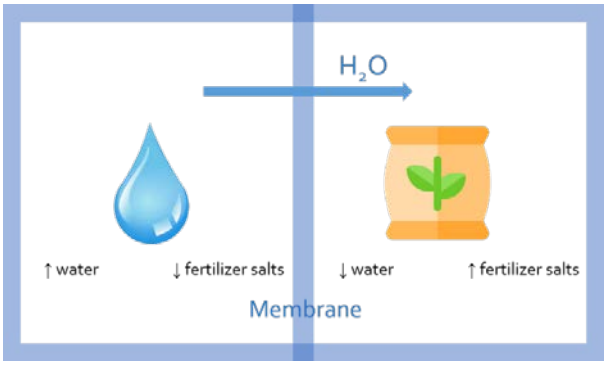

Figure 1 Overview of how the osmosis works.

SUSTAINABILITY

AgriWater ensures a more efficient way of allocating water resources and thus contributes to SDG number 6 for Clean Water & Sanitation, and more specifically the two targets 6.3 for improving water quality, wastewater treatment and safe reuse as well as 6.4 for increasing water use efficiency and ensuring freshwater supplies.

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Master course
Project no. 326

DeTectUs: rapid detection of adalimumab in blood plasma for arthritis treatment

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Rheumatoid arthritis treatment

About 1 % of the entire global population will get rheumatoid arthritis in their lifetime.

The standard treatment is given to each patient based on the type of arthritis as well as severity at the point of treatment. There is no personalization of the medication currently, and no formal tests are conducted after the first diagnosis of arthritis. This can result in side-effects from too much drug as well as issues with too little drug for the specific patient.

The goal of our biosensor is to measure the exact level of the drug adalimumab (anti-TNF-α monoclonal antibody) in the blood plasma of the patient within 7 minutes; fast, precisely and accurately. Secondary to this comes the importance of the biosensor being easy to use in a doctor's consultancy setting.

By using state-of-the-art surface detection technology, we enable doctors to measure the exact level of adalimumab in the blood of the patients at any given time, further enabling them to tailor the treatment of arthritis to each patient individually.

Along with the development of the biosensor, we are looking into possibilities for potential market release and commercialization.

Sustainability

By customizing the treatment given to each patient, we reduce their dose-related side effects both from too much and too little medicine, as well as reduce the amount of medicine wasted. This way, we contribute directly to solving the Sustainable Development Goal (SDG) 3, specifically target 3 B as seen on Figure 2 – and secondarily to solving the SDG 12, target 12.4. The latter is in focus as we try to incorporate the full life cycle of all sub-components in our planning of the sensor, and thus taking *responsible management of chemicals and waste* into account in both the production phase as well as in use and later disposal.

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Master course
Project no. 327

Solar powered IoT

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INTRODUCTION

Internet of Things (IoT) devices and applications are expanding rapidly. It is predicted that up to 64 Billion IoT devices will be active by 2025 (Petrov 2019). The devices are here to stay as they among other applications enable cost savings and energy efficiency, within cities, communities and households. Most of the companies using IoT devices are certain that these device help generate revenue. Around a fourth of all devices are expected to be used within smart cities and communities. A challenge, however, lies in the power supply of these devices. Some are stable and connected to the power grid (e.g. a smart fridge), whereas others rely on battery power. As batteries has a finite amount of power within them, devices run out of power, thus not delivering the functionality it was designed to do. To prevent this, batteries need to be changed or be sufficiently large, such that they last the entire lifetime of the device. Changing batteries is not desirable as it is costly, and the work might lead to more emissions (e.g. a person drives around to change the batteries). Larger batteries are not to be desired either, as they take up space and sparse resources, as well as production emissions.

SOLUTION

The solution developed is a “plug’n play” power supply. It relies on outdoor use, as it is based on using a solar panel, to charge a battery. This enables devices to transmit more data without draining the battery too fast, as the sun will recharge the battery. The product relies on a few cheap components, with good energy conversion.

RESULTS

From the tests of the product it was evident that with good conditions, one could charge an 18650 Lithium battery (4000mAh) within a few days. By averaging over the number of sunny hours in Denmark, this corresponds to around 30 full charges a year. Thus, would the power source be able to support even quite power-hungry application, without any maintenance, thus reducing resources, time and emissions spend on changing batteries. This also minimizes the use of rather rare metals such as Lithium, as less are used to power the application, compared to a larger battery package.

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Master course
Project no. 328

3 GOOD HEALTH AND WELL-BEING

Machine learning accelerates antibiotic discovery

A.M. Nielsen and M.B. Bendtsen

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GOOD HEALTH AND WELL-BEING AT RISK

Antibiotic resistance is ranked as one of the ten greatest threats to global health by the World Health Organization, WHO. Deaths caused by microbial infections, such as by MRSA, are expected to exceed deaths caused by cancer in 2050. Today over 700.000 deaths are drug-resistance associated. Reports from WHO show, that the clinical development pipeline of new antibiotic agents for mitigating the rise in resistance worldwide is lacking far behind. It is crucial that novel antibiotics are discovered and brought to the clinic.

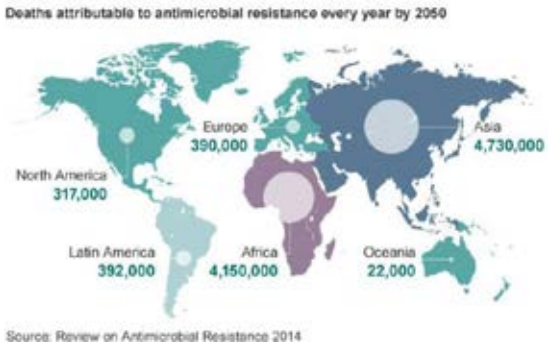

Figure 1 Predicted deaths cased by antimicrobial resistance in 2050. Adapted from BBC.com.

THE CAUSE IS THE SOLUTION

While microbes such as pathogenic bacteria are the cause of disease, these microbes are also the solution. Bacteria produce molecular artillery against one another, and these molecules are antibiotics. Terpenes are a class of secondary metabolites produced by bacteria that are of great interest due to their potential antimicrobial activities against pathogens like MRSA. The production of terpenes and other potential antibiotics are the workings of consecutive enzymatic reactions catalyzed by enzymes encoded in the genome of the microbes. However, finding these enzymes and their genes is a tedious and difficult processs that remains a bottleneck for scientists.

MACHINE LEARNING AUTOMATES GENOME MINING

Exploiting the abundant genome sequence data available for bacteria and mining these genomes for genes encoding interesting enzymes, has potential to greatly speed up the process of discovery of antibiotic biosynthesis enzymes. antiSMASH is a genome mining and biosynthetic gene cluster prediction tool with over 500 thousand jobs run to date. In this project we automated the terpene synthase classification in antiSMASH by applying machine learning on biological sequence data. Our strategy was to build Hidden Markov Models that can mine bacterial genomes for terpene biosynthesis genes, thereby accelerating the discovery of terpenes with antibiotic potential.

Master course
Project no. 329

The role of the engineer in circular buildings of the future

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The interest in the concept of circular economy (CE) is growing and industries seem to understand the necessity of implementing it. The building industry has a great environmental impact since it accounts for up to 40 % of the global CO_2 emissions and consumes 40 % of our resources worldwide. In Denmark, the construction industry accounts for 40% of material- and energy consumption, 33% of water consumption and it is often seen that 10% extra material is ordered to the construction site to avoid shortage. The need to change the traditional ways of constructing buildings into innovative and sustainable designs are very high thus it is found necessary to implement circular methods to retain the value of the materials and components while keeping them in the value chain. The dominant conservative mindset in the construction industry must be challenged by creative and rethinking engineers, architects and other important stakeholders who are responsible for making a circular transition possible in the future. To make this reality a common understanding of how to get there must be clarified across professions in the building industry.

The study investigates the potentials and barriers that exist within the Danish construction industry in terms of transitioning to circular economy. Furthermore, the purpose of the study is to differentiate between the stakeholders who are more interested in implementing circular tools and the ones who are less likely to do it as well as the cooperativeness between the stakeholders. Finally, the focus of the study is to identify where, how and with what tools the civil engineers of the construction industry as well as the next generation of civil engineers, will become more important in the transition to circular economy and thereby more sustainable buildings. The Sustainable Development Goals that can be applied to the study is 9 and 12, where targets 9.4 and 9.5 and 12.2-12.8 are relevant, since the study aims at clarifying how to make the construction industry more resource efficient.

A motivation factor for the conductors of the study, who are three Architectural engineering students, is to clarify what they can except as engineers and with what mindset they should work in to push the boundaries. Therefore, the study aims at creating awareness by reaching out to the stakeholders of the Danish construction industry by interviewing 3 engineers, 2 contractors, 2 architects and 1 client advisor to understand the current impression and interpretation of what sustainable buildings and CE are. Based on the conducted interview, the following main issues will be assessed in the study:

- The Impression and interpretation of sustainability
- Impression and interpretation of circular economy
- Communication between stakeholders
- Experience in participation in the early design phase
- The approach towards a sustainable conversion in the building industry
- Legislation of sustainability in the building industry

The study will be completed by writing a report where the full procedure of the study including theory, illustration as well as interpretation of results and a discussion will be included. With the intention to create further awareness in the construction industry, the core of the study is used to conduct a scientific article.

Master course
Project no. 330

Co-ordinated voltage control of hybrid power plants with communication robustness

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ABSTRACT

Hybrid Power Plants (HPP) comprise of a combination of solar, wind and energy storage (typically battery) and are good solution to ensure usage of different Renewable Energy Sources (RES) optimally and secure a larger than 50\% integration into the power grid. With an increase in distributed renewable energy sources, the power system is relatively more prone to voltage stability issues. Solving these problems will help integrate more RESs into the grid without causing voltage stability problems. The power system has stability problems with regards to voltage, frequency and rotor-angle which are typically handled using counter-measures (usually primary / local control) that are meant for Conventional Power Plants (CPP) with Synchronous generators where input source can be controlled. Providing such counter-measures from RESs for voltage stability is still a topic of research and yet to be realized at a large scale. The aim of the project is to develop and study a Co-ordinated voltage controller that manages the voltage of the whole plant at the substation level and allows certain failure modes to occur and still tried to maintain an acceptable level of voltage thus respecting the Danish Grid Code. The proposed type of control ensures that RES based HPPs can work independently without external grid support during faults, both internal and external.

For Distributed Energy Resources (DER), communication is important. Voltage (and fault ride through) support in HPPs have to be delivered with respect to a single reference point i.e. Point-of-Common-Coupling (PCC) i.e. the point where HPP connects to the rest of the grid. In contrast to other studies, this project analyses together, the sensitivity to grid and communication faults, and proposes fault tolerant control strategies. The study of the proposed control strategy will check if it improves the chances of an HPP performing better in terms of keeping itself stable in cases of faults and also provide reactive power support to the grid, if needed.

Master course
Project no. 331

Lignin-based second-generation biofuel from wheat straw agricultural waste

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Ecooil comprises of five DTU engineers who have produced a cleantech solution for solving crop waste burning problem in India, Punjab with 2nd generation biofuel production from waste during the HardTech Entrepreneurship Course.

PROBLEM

The Indian capital New Delhi is one of the most polluted cities in the world with 2.5 million people dying from air pollution in 2017. The burning of agricultural waste and its effect on the air quality is particularly severe in Punjab, a state in northern India, where 19-20 million tons of both paddy and wheat straw is generated annually. 90% of this waste is burnt on the fields, which is an ancient practice done by the locals to nourish the soil. There has been no proper disposal, monetary value or consumption value for the crop residues, hence burning is still the easiest option even though farmers risk potential fines for burning crops.

SOLUTION AND BUSINESS MODEL

Our solution towards the responsible utilization of waste crops is to use our novel solvolysis process, where we add ethanol to the waste paddy straws and heat it at high temperatures and pressure to produce lignin-based 2nd generation biofuel. Ecooil's business model is B2B, where we build, own and operate (BOO) a 2nd generation bio-plant facility. Biochar is sold through our supplier Farm2Energy and eventually, sold to farmers to nourish farms as a substitute to fertilizers. OMC's are our potential buyers of oil with the current market value of 700$/ton, which we can be linked to though Farm2Energy. Our customers are Oil Marketing Companies (OMCs) and local agricultural sector of India.

PRODUCT AND VALUE PROPOSITION

Product Specifications:	**Value proposition:**
• Biofuel 1-year shelf-life stability • Zero sulphur content & non-corrosive to engines • Equivalent energy density to diesel making it blend easily with current fossil fuel technology	• Monetary value for waste - farmers profit 3000$ annually by selling waste and avoiding fines • OMCs save 20,000$ with a better-quality diesel blend and nourish a cleaner environment

Table 1 Overview of product specifications and value proposition in the business proposal

Master course
Project no. 332

CE.BOT: handling oil spills in ports

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ABSTRACT

In a world of increasing pollution of the sea and ports in particular, this project provides a possible solution for the reduction of harmful long chain n-alkanes and polycyclic aromatic hydrocarbons (PAHs) in the sea surface microlayer (SML). In order to do so, the concept of a floating device (called 'CE.BOT') was developed. The 'CE.BOT' is able to specifically separate oils (n-alkanes and PAHs) out of the SML with a super-oleophilic, polytetrafluoroethylene (PTFE) - coated mesh membrane. Once separated, the oils are degraded to H_2O, CO_2 and fatty acids by a series of immobilized enzymes. Those enzymes are immobilized inside modified calcium-alginate beads, which are oleophilic and therefore absorbing the hydrocarbons. After the degradation has taken place, the harmless products can be released to the sea and the atmosphere, respectively.

The project is the product of an intensive research of the real needs of experts and possible customers such as authorities, environmental agencies, boat owners and companies working in ports.

Master course
Project no. 333

SocketHacker

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Introduction

SocketHacker is a project, oriented towards sustainable future of transportation and electrical energy. We aim to help the planet using modern approaches and technology and work towards the sustainability development goals and, since we are implementing it in Sweden, also Swedish fossil-fuel free transportation goal of 2050.

Problem

We see a huge increase in electric vehicles, their amount has already doubled since 2016 and in march of 2019, for the first time there was more electrical than traditional vehicles sold in Sweden and Norway. While this has a lot of potential for greener transportation future, it is already causing the issues in the power grid by increasing the load and contributing to the so-called peak load problem.

The grid and different energy sources

The electric grid works on the premise that supply must meet demand at all times. If they fall too out of balance at any point, they cause problems in the infrastructure, with possible outages and breakouts. With the old power sources. keeping up with the demand was easy by increasing the energy generation due to high dispatchability of the power plants, which in turn produce a lot of Co2 emissions. However, as they started to replace them with renewable energy sources to reduce them, the problem became that we have no influence over the amount of wind or sun, so supply is no longer unlimited. Therefore, we need a solution for a balanced grid

Solution

A really innovative approach to the aforementioned issues is balancing from the demand side instead, which requires widely spread power storage and smart meter technology and both can be found in the EV charging stations. Furthermore, that way we can use electric vehicles as a solution instead of letting them contribute to the problem.

How our technology works

We devised a system with a network of EV charging stations to use them for balancing the grid. Using real-time data and predictions about the electricity demand and charging station occupancy, we remotely regulate the power flow towards the stations to influence the grid load. With a large amount of charging stations in the network, it's possible to only affect the experience of end users very little and since balancing actors are entitled to special pricing for electricity, we can compensate them by lowering their costs.

Conclusion

Our team consists of three incredibly motivated international students with complementary skills and interests, all passionate about making a change in the world. SocketHacker is a way of "hacking" the grid to make the transportation greener, electricity cheaper and the grid healthier.

Master course
Project no. 334

Vertical moss blinder

J. Ko and C. Kim

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PROJECT DESCRIPTION

Introduction theory/method

Micro-dust becomes more and more serious in Korea over time. We thoguht that we need 'Urban Greening' in order to purify atmosphere. However, in the already developed large cities, It is difficult to secure a space for greening. Therefore, we will focus on 'Building Greening' which is doing greening using building structure such as rooftop and wall. By the way, building greening using trees is costly to maintain and manage and It is difficult to create an environment for trees to live well.

Theory/method

Moss can solve the above problems of trees by numerous advantages that can replace trees. The moss only takes 1% of the area and requires only 5% maintenance cost compared to trees. Therefore, the moss can replace 275 trees by occupying only 3.3m^2. The moss grows in a variety of environments compared to other plants. Moss has an advantage of growing without soil which means it has a light weight. Also it is easy to maintain and manage because of slow growth rate. Since the moss is not difficult to grow, we will use IoT to control the temperature and humidity rather than man-managed.

Product

We named out product ‘Vertical Moss Blinder’. It consists of blind-like moss panels attached to the walls of the building. The sensors measure the temperature and humidity of the moss and send data to the controller. The controller determines watering and fertilizing based on the temperature and humidity climate data. The solenoid valve receives the electric signal from the controller and adjusts the irrigation valve. Based on the results of the survey, we decided to use ‘Rhacomitrium Canescens’ among many moss species. We will grow the moss on the nonwoven fabric layer. This moss is strong against dry, heat, cold and can grow without soil. When the moss is grown on nonwoven fabric layer, the fabric layer is entangled with the moss to fix moss well. The nonwoven fabric has the advantage that it can watering and draining itself.

Expectations/result and conclusion

By utilizing ‘Vertical Moss Blinder’, we expect to save on heating and cooling costs. In fact, building greening can save about 20% of the cooling energy in summer and 16.6% in winter. The biggest superiority is that it can remove micro dust which induces air pollution. Also, the moss blinder can be a new trend to design beautiful urban environments. Nowadays, many buildings are designed environmentally friendly which means out product is at the center of the fashion.

Master course
Project no. 335

Strategic technology plan of a novel fast charging station

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ABSTRACT

A concept has developed for a novel way of structuring and incorporating a FCS into the distribution grid. The concept designed is scalable, flexible and has a high technological readiness level. The enhanced ability to support the grid is ensured by installing PMUs at the radial which gives accurate real-time data on power flows and this data is key to enabling the system to provide support and allowing better control for the DSO. The unit allows for the system to connect multiple DC buses with batteries. Thus, the power flow of the system can be tailored to the demand. The shared energy storage of the FCS allows the system to support any specific type of charger that is in use with battery power and can be used to decrease import and internal load and peak shave.

Master course
Project no. 336

Storage of excess wind energy and utilization of flue gas CO_2 through sustainable methanol production

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As a larger production of wind energy and other types of renewable energies are predicted in the future, utilizing the excess energy from these sustainable energy sources can increase the energy efficiency of the wind farm by making good use of all the electricity produced. Moreover, CO2 emissions from industry, that contribute to climate change, are also an increasing problem that requires a solution. In this study, we present a novel concept, which aims at solving these two problems by integrating excess energy from wind farms and CO2 from flue gas into an innovative production process using methanol as an energy storage/carrier. The excess wind energy is used to produce hydrogen through water electrolysis and CO2 is captured from flue gas, e.g. from the cement industry. Compared with the traditional methanol production which heavily relies on natural gas as its source of hydrogen, carbon, and energy, this process has a smaller environmental footprint. The novelty of our concept relies on shifting the focus from operating a methanol production plant towards valorizing the excess renewable energy, which is wasted otherwise and considering methanol as a value-added product (as opposed to Szima & Cormos, 2018). Therefore, the plant capacity of 30 000 metric tons per year is scaled based on the quantity of the excess wind energy of the largest wind farm in Denmark. This capacity is significantly lower than those of traditional methanol production plants, which range up to 1.9 million metric tons per year (Ferrostaal, 2015). This adds a constraint to improve the process integration efficiency of the proposed concept. Hence, a techno-economic analysis is performed to investigate the overall feasibility of the proposed concept by identifying key design decisions and essential cost drivers. As results obtained show high sensitivity to both electricity and methanol prices, an uncertainty analysis was conducted in order to determine their effects on the profitability metrics of the proposed novel process. A sustainability analysis is complementarily carried out to emphasize the added environmental benefits of the proposed concept in comparison to the traditional methanol production process.

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Master course
Project no. 337

WECU – keep the world green

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Introduction

Illegal logging is the number one cause of deforestation worldwide, resulting in a loss of approximately 76,000 km2 of forest every year. Reducing this number is one of the most important steps in mitigating global climate change, as forests are the only effective solution to sequestering CO2 we currently have. Much of this deforestation takes place in developing tropical countries where weak institutions are unable to enforce regulations, as the affected areas are often very large and very isolated. Furthermore, the affected areas are often old-growth rainforest, which is habitat to an enormous number of species. Once the old-growth is cleared it is not regenerating for a very long time, making the loss of biodiversity even greater. Illegally sourced lumber accounts for 5-10% of all traded lumber, the profits from which are sometimes used to fund various paramilitary groups only furthering the instability of the affected areas.

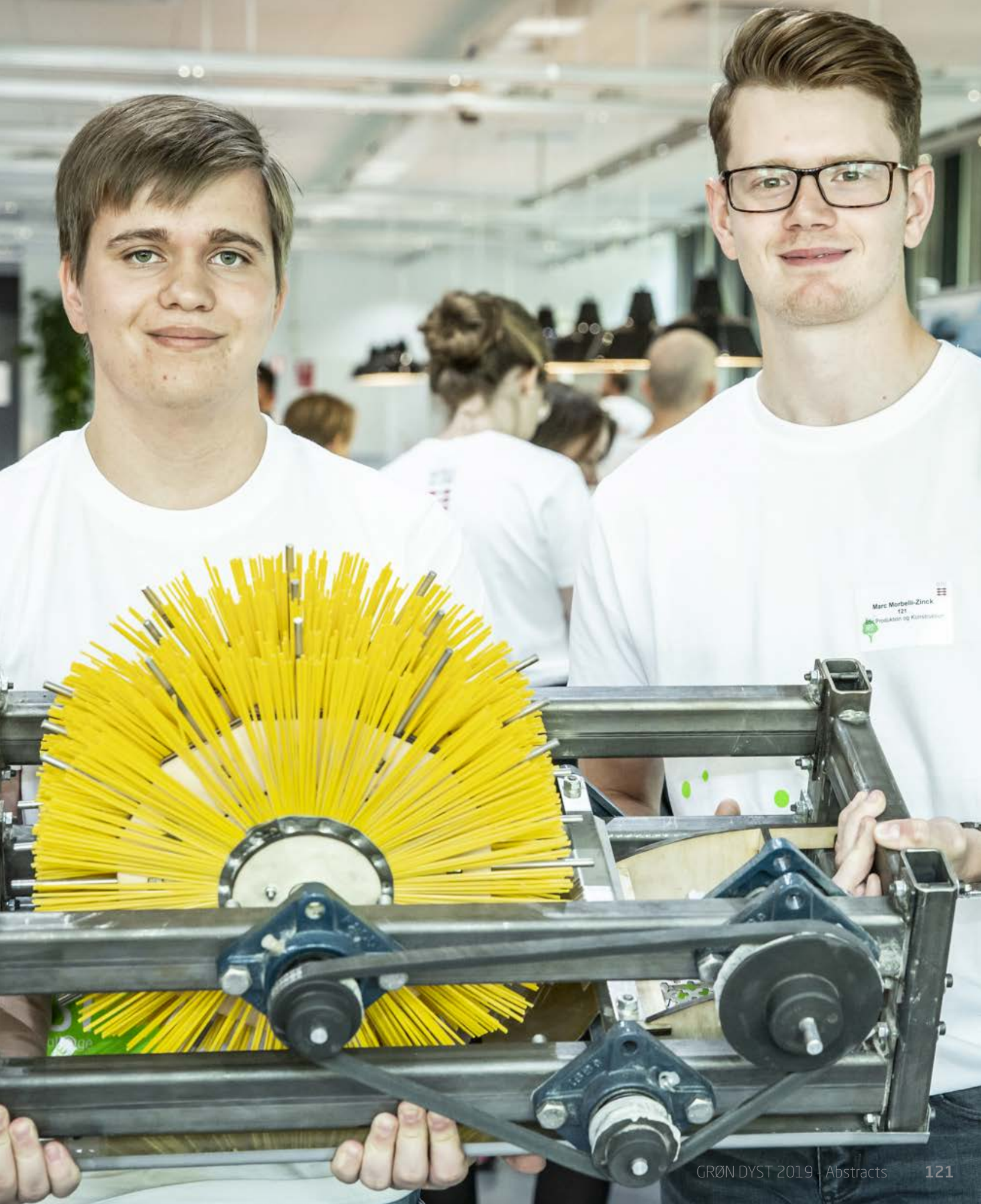
Methods and theory

One of the major challenges in combating this problem is detecting the geographical location of the illegal logging. Currently, Mount Kenya Trust has four ranger teams who patrol approximately 1420 square kilometers of nearly untraversable rainforest. Where there are no roads they patrol on foot or horseback which practically makes effective law enforcement impossible. The patrol routes are planned based on word-of-mouth intel or more or less random chance, and a result of this is often a very late discovery of sites of illegal logging. Furthermore, the most advanced technology used is handheld GPS-devices for recording the location of discovered sites of illegal logging.

This is where WECU comes in. WECU provides a service that allows intelligent monitoring of large areas of land and quantification of changes in biomass. The service consists of a website where customers can log in and access data about the forest they are managing. They will be able to see data about areas that have lost biomass, indicating that trees have been removed, and statistics about the quantity that has been lost. This allows our customers to more effectively patrol their forest and in doing so, it will help preserve the forest. The data is obtained using Sentinel 2 and radar satellite images from the Copernicus project, which is free of charge and freely available to the public. WECU then adds value to this free data by combining it with change detection and other algorithms, creating a color-coded map that indicates for the customer where to pay attention. Thus the website will be very user-friendly and does not require prior knowledge of satellite data to use. WECU also has many plans for the future development of their technology, such as using Very-High Resolution satellite imagery, detection of positive developments in biomass, and the possibility of making a pattern recognition system via a neural network.

Conclusion

The WECU project described above is focused on a greener and more just future for everybody, and what makes it special is that it utilizes satellite data to highly increase the effectivity of law enforcement in illegal logging and deforestation, thus helping protect and preserve our trees, and as such, our planet.


Marc Morbelli-Zinck
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Abstracts
Master thesis

Master thesis
Project no. 401

3D printing mushroom-based composite materials

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INTRODUCTION

The 12th Sustainable Development Goal aims to ensure sustainable consumption and production patterns facing down the challenge of decoupling economic growth from resource use. Additive manufacturing (AM) technologies offer promising new opportunities to reimagine the current production paradigms for sustainability by offering ways of using less material throughout the production process and production "on demand" rather than "for demand". However, outside of PLA-based filament extrusion not many AM technologies have successfully incorporated bio-based materials, and still utilize fossil-based polymers. I aim to show, that combining the processing advantages of AM technologies with the inherent characteristics of mycelium-based composite materials is a powerful coupling and can be a way to reduce harmful waste and decouple the manufacturing of products and parts from fossil-based sources.

PROBLEM

Bio-based composites made from fungal mycelium and cellulosic substrates have proven to be a sustainable material owing to three main qualities; being bio-based, biodegradable and exhibiting mechanical properties akin to other natural materials (wood) or polymer foams, which makes it suitable for many types of products. These materials and products are made by taking advantage of the abilities of saprophytic mushroom species to interlock substrate material within a network of filaments called "hyphae". The desired product is made by filling a mould with inoculated substrate material to yield a desired shape akin to a casting or embossing process. This means, that fungal composite materials are currently defined by the limitations of the current manufacturing methods i.e. types of substrate and choice of geometry.

SOLUTION

By using additive manufacturing technologies like LOM (Layered Object Manufacturing) and powder solidification methods to selectively deposit inoculated substrate material I aim to offer an alternative to the current way of producing fungal composites through casting or pressing. This will allow for a free choice of shape incorporating hollow geometry, voids and overhangs, further enhancing the mechanical properties with a tailored structure in addition to reducing the amount of wasted material in the production process. 3D printed mycelium-based composites can prove to be a vital part of reaching the 12th Sustainable Development Goal by offering bio-based and biodegradable parts and products for future sustainable and circular economy systems.

Master thesis
Project no. 402

Design and analysis of hybrid renewable microgrid system for the UN humanitarian aid

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INTRODUCTION AND MOTIVATION

World Food Programme (WFP) is one of the world's largest United Nations humanitarian aid organization fighting hunger worldwide. Most of the WFP humanitarian facilities are located in remote locations of developing countries where the national grid is absent or unstable. Currently, more than 300 WFP office locations are completely off-grid and are running on diesel generators only, which results in burning more than 6.1 million liters of generator fuel to power WFP offices worldwide. This is an expensive and environmentally unsustainable way of producing power, causing harm to the environment, increasing the cost of humanitarian operations, and reducing WFP's net effectiveness in supporting beneficiaries.

OBJECTIVE

For Long-term reliable and clean energy supply, WFP seeks to identify sustainable alternatives and to accelerate the design and development of renewable energy solutions for use in remote WFP locations with unstable/unreliable/no grid and continue efforts by the UN in reducing fossil fuel energy consumption and environmental impact to achieve UN SDG 7.

METHODOLOGY

My master thesis aimed at developing a concept design and analysis of hybrid renewable systems including battery storage to meet the energy demand at WFP humanitarian office locations in energy efficient, environmentally friendly way and thereby achieving a reduction in operating cost by reducing dependency on diesel fuel. In the final stage, a business case was developed to analyze the cost savings, payback period and reduction in CO_2 emissions. The thesis was carried out in close cooperation with the experts from the UN WFP.

IMPLEMENTATION AND IMPACT

My thesis results have shown that by implementing the hybrid renewable solution in the UN off-grid locations, it was possible to achieve upto 40% reduction in operating cost and upto 85% reduction in CO_2 emission/ fuel consumption. My results are currently being implemented by the UN in more than 300 locations worldwide with a potential of CO_2 emission reduction of 16000 tons/year. With the cost savings achieved WFP can help feed additional 4,20,000 children every year. An article was published recently about my master thesis in Technical University Munich newsletter **(Technical University of Munich Newsletter, 2019)** and German newspaper Süddeutsche Zeitung **(Buchwald, 2019)**.

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Master thesis
Project no. 403

Congestion management solutions for renewable energy integration: Israel as a case study

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ABSTRACT

The share of power generation from renewable energy sources (RES) must significantly increase if the world is to address climate change and reduce greenhouse gas emissions in the energy sector. However, the integration of distributed RES changes the power flow in the electrical system. As a result, power congestion appears in lines that weren't planned for distributed generation. One possible solution for this challenge is adding transmission capacity or backup and storage facilities, but these are costly solutions that take a long time to implement. This study explored additional options for managing the transmission network to enable a significant penetration of RES into the grid. We have generated simulations of the transmission grid for various RES and conventional scenarios. The primary focus of these simulations was the transmission lines overloading in the southern part of the county, where the major potential for large and medium solar systems exists. The study shows significant changes to the behavior patterns of the transmission network when RES are introduced. The study results show that the share of renewable energy generation in the Israeli fuel mix can grow significantly by reducing conventional power generation in the southern district during RES peak production hours. It is also shown that the distribution of the RES (location and size) has a dramatic effect on the grid's congestion. Optimally distributing these sources may allow deferral of infrastructure and additional integration of RES. Lastly, we show that the current transmission planning security criteria should be changed due to the new power flow regime introduced by RES.

Master thesis
Project no. 404

Enterprise estates for affordable housing delivery in Nigeria

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INTRODUCTION

Housing is defined as the process of providing safe, comfortable, attractive, functional affordable and identifiable shelter in a proper setting within a neighborhood, supported by continuous maintenance of the built environment for the daily living activities of individuals/families within the community while reflecting their socio-economic, cultural aspirations and preferences. In addition, housing includes the sustainability attributes of energy efficiency and resource conservation for improved quality of life, (Nigerian National Housing Policy, 2012).

PROBLEM STATEMENT

According to the Managing Director of Federal Mortgage Bank of Nigeria (FMBN), the housing deficit is estimated at 17 million units (and counting), and a conservative benchmark cost for a house at (say) $15,625 per unit, the Government would require a whopping $265.6 billion to provide for this housing shortfall. This calls for collaboration between the public and the private sector.

OBJECTIVES OF PROJECT

The objectives of this project is to:

1. significantly improve the well-being of the poor, the needy, and a critical mass of the citizens who fall into this group;
2. provide a sustainable way of reducing the housing deficit in the country, estimated at about 16-17 million units nationwide, as at 2011;
3. provide a window of opportunity for governments at all levels to demonstrate their commitment to the provision of social housing as a social responsibility to the citizenry, thereby institutionalizing an efficient, responsive and sustainable mechanism for housing delivery.

PROPOSED SOLUTION

The Enterprise Housing Estates Scheme is a novel housing initiative specially adapted to holistically address the housing and other socio-economic challenges particularly amongst the Low/No-income earning groups. The scheme involves estates that are designed to serves as cottage industry sites equipped with an Enterprise Centre (EC) where processing of the products of the cottage enterprises are undertaken. It utilizes the concept of Cottage industry clusters, to create sustainable training estates targeting the poor segment of the population, that is willing to work. Providing secured and sustainable income for the beneficiaries, from which they can conveniently pay rents/mortgage for occupying the estates in a manner that is sustainable.

Master thesis
Project no. 405

Decoupling of affluence and environmental impact

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INTRODUCTION

Global warming and climate change are some of the greatest global catastrophic risks of our time. The latest IPCC special report conclude that we should limit global warming to 1.5 °C above the pre-industrial level to mitigate the impact on the ecosphere. This study illustrates how the climate targets can be met in Denmark while still maintaining a high living standard.

THEORY AND METHOD

The carrying capacity of 1.5 °C has been used to determine the absolute sustainable level of CO_2–eq/person.year. The "safe space" 0.46-1.7 ton CO_2-eq/person.year. Several scenarios have been created to reduce the current impact of 13.9 CO_2-eq/person.year in Denmark (excluding international transport) and 18.7 ton CO_2-eq/person.year (including international transport), while keeping the living standard (indicated by HDI).

The scenarios for Denmark have been divided into: 1) General scenarios, 2) Circular economy (CE) scenarios, illustrating how much implementation of CE can reduce the CO_2-emissions, 3) A back-casting scenario taking starting point in Maslow's pyramid of needs. Furthermore, scenarios for improving the living standard in Kenya, while keeping the emissions at a minimum have been examined.

LCA has been used to calculate the savings from each scenario, and an input-output model has been used to calculate the total national CO_2–emissions and relate the savings from each scenario to the national impact.

RESULTS

The basic needs of food, clothes and residence can be fulfilled with an impact of 472 kg CO_2-eq/person.year with the current technology level; however, demanding large consumer changes. Combining change in consumption patterns and eco-efficient technology results in the largest CO_2 savings.

The largest savings occur when the electricity and heat mix are improved with more renewable sources, the transport sector is electrified with the future electricity mix and people use public transport instead of cars, the demand for new textiles are reduced markedly, meat and dairy are substituted from the diet and replaced by beans and grains, food waste is reduced, the living area per person is reduced, and the construction materials are reused. 33% of the Danish impact is caused by import; therefore, Denmark is depended on other countries to improve their eco-efficiency as well.

CONCLUSION

The eco-efficiency needed in Denmark is around a factor 10-40, this factor can be reached in some sectors e.g. the transport sector; however, many industries cannot reach such a great improvement. Therefore, development and implementation of carbon capture and storage (CCS) is needed within the shortest timeframe to reach an absolute sustainable level of Green House Gas (GHG) emissions. All sectors and consumers must act towards choosing the right technologies, improving the eco-efficiency and changing consumption patterns to limit the need for CCS, since the timeframe is very uncertain.

Master thesis
Project no. 406

Web tool for quantitative sustainability assessment of hygro-thermally optimized insulation systems

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INTRODUCTION

The potential consequences of climate change and the concomitant rise in global mean temperature has received global attention and priority. As the existing building stock accounts for 40 % of the energy use and 36 % of the greenhouse gas (GHG) emissions in Europe (Vilches, Garcia-Martinez & Sanchez-Montañes, 2017), energy retrofits for improvement of the energy efficiency of existing buildings offer a great potential for reducing the European GHG emission levels. This project creates a web tool for supporting decisions of the most appropriate insulation system for energy retrofits of historic buildings. The web tool provides a quantitative sustainability evaluation of hygro-thermally optimized insulation solutions through a GHG emissions indicator.

METHOD

Through the user interface of the web tool, the user is required to define the building for renovation through five input parameters concerning location, the existing wall, and the heating system of the existing building. Based on these choices, the user is presented with the GHG emissions indicator for the insulation systems. The LCA of the insulation systems consists of the following life cycle stages: The production and assembly stage, the operational energy use stage, and the end-of-life stage. The impacts from production, assembly and end-of-life are considered induced impacts, whereas from operational energy use the impacts are considered avoided impacts via saved energy consumption for space heating.

RESULTS

The web tool produces 210,180 different impact profiles for the insulation systems. The sustainability performance of the insulation systems changes between countries of installation and considered life cycle stages. In most application scenarios, the avoided impacts from saved energy consumption exceed the induced impacts. In 2 % of the scenarios however, the induced impacts exceed the avoided impacts which means that insulation retrofits in these scenarios are not environmentally justified. Across all analyses, the mineral wool insulation system is the least GHG intensive solution.

CONCLUSION

The impact profiles generated through the web tool illuminates that the environmental justification of insulation of historic buildings depends on the geographical location of installation and the installed heating system in the retrofitted building. To further improve the sustainability performance of the energy retrofits in historic buildings, the implementation of insulation recycling solutions and measures for reducing production impacts of insulation systems are needed.

Vilches, A., Garcia-Martinez, A., & Sanchez-Montañes, B. (2017). Life cycle assessment (LCA) of building refurbishment: A literature review. *Energy and Buildings*, *135*, 286–301.

Master thesis
Project no. 407

Utilized blue light therapy to raise common health

A.E. Nielsen and E. Stepukonis

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INTRODUCTION

Lifestyle diseases are a growing problem in the modern world. Obesity, heart disease, cancer, mental illness, diabetes and of course general fatigue and stress is a direct cause of a corrupted circadian rhythm. Even though everyone knows the importance of good sleep and regular routines, people do the exact opposite in the rush of busy and highly variating life schedules and bad circadian rhythms are therefore becoming daily more normalized.

Our vision is to help the user to get total dominance of the circadian rhythm, and the possibility to optimize the peak of performance and in that way raise the common well-being.

This is not the first solution that addresses this problem. But the existing solutions are based on symptomatic treatment, not on the cause like our solution. That is the case with meditation apps/programs, refreshing lamps or pharmaceutical products.

We have investigated the effect of calorie and step counters, that shows good results repeatedly - regarding weight loss. That is living proof of that with information and comparison with the ideal use, it is possible to correct yourself better than if you just tell the user repeatedly how they should do.

SOLUTION

The circadian rhythm is controlled by light intake, activity, and meals. Meals and activity are possible to do all day long, but it can be difficult to get the right amount of light.

Our solution is a combination of a smart light source and personal guidance. The light source can be controlled both manually and automatic as a part of the personalized guidance. The light source optimized, to give the user the components of the sunlight that controls the circadian rhythm.

The guidance will be given through an application that gathers the usage of the lamp automatically. The application compares the usage with personal information and daily routines to calculate the small changes the user needs to take control of their own circadian rhythm.

NEXT STEP

To make sure that our product isn't just another (health) gadget, we have focused on making everything as usable as possible. Our next steps are therefore different kinds of usability testing of both the light source and the application.

Master thesis
Project no. 408

13 CLIMATE ACTION

Biocovers to mitigate landfill methane

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INTRODUCTION/PROBLEM

Disposal of municipal solid waste (MSW) to landfills results in generation of landfill gas (LFG) consisting of 50-60% methane (CH_4). CH_4 is a potent greenhouse gas (GHG) and thus contributes positively to the overall radiative forcing - causing global warming. Worldwide 70% of the MSW generated is disposed to landfills and this make up 1-5% of the total anthropogenic GHG emissions. To reach the Paris Agreement and the Sustainable Development Goal 13: Climate Action, reduction of GHG emissions is necessary. Different options for reducing CH_4 emissions from landfills exist including gas utilization, flaring, and biocovers. The option with focus on here is biocovers, where biological processes oxidized CH_4 to CO_2 thus reducing the radioactive forcing.

SOLUTION

A biocover consists of a gas distribution layer and above this a layer of bioactive material. An optimal material for the bioactive material is compost, where methanotrophic bacteria utilize CH_4 as a carbon and energy source. A gas collection system consisting of pipes are also often installed in the landfill to direct the LFG to the gas distribution layer. Figure 1 shows the principal of a biocover.

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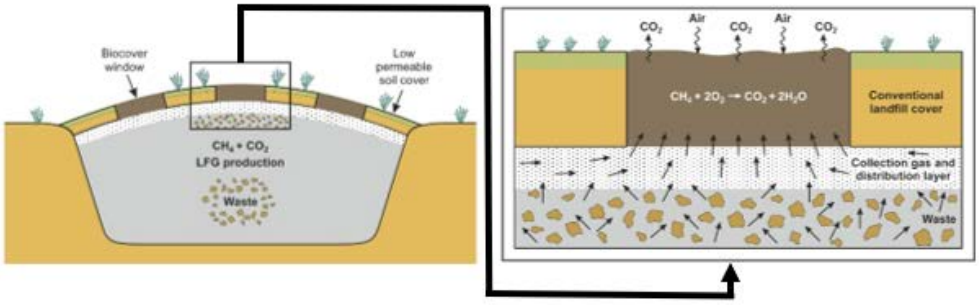

Figure 1 Biocover which facilitate biological CH_4 oxidation and reduce GHG emissions from a landfill. Adapted from Kjeldsen, P., & Scheutz, C. (2019). Landfill Gas Management by Methane Oxidation. In R. Cossu & R. Stegmann (Eds.), Solid Waste Landfilling - Concepts, Processes, Technology (1st ed.). Candice Janco.

Efficiencies up to 97% reduction of CH_4 for biocovers, with compost, have been reported. And a full-scale biocover in Denmark at Klintholm landfill has reduced CH_4 emissions by 83%.

Master thesis
Project no. 409

Hydraulic impact on fish migration in Sariakandhi fish pass of Bangladesh

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ABSTRACT

The importance of open water fish in our socio-economic regime has recently drawn the attention of the policy makers of the country. FCD/FCDI projects mainly serve the agricultural interests, but it interfere fish migration. This inevitably affects the open water fisheries sector as migratory routes. Nursing grounds of many species of fish are hampered and disturbed for these projects also. In order to permit fish migration in rivers, it is necessary to maintain conditions that help migrants reach their spawning grounds. To overcome obstacles, such as hydraulic structures, placed in the path of migrating fish, structures must be designed to assist the fish to pass them. The periodic and directed travel of fish mainly for feeding, breeding and over coming adverse climatic conditions is called migration. Fish passes are constructed to allow normal breeding migration and to ensure natural route of fish movement.

The concept of a fish passes is relatively new in Bangladesh. At present, two Fish passes and two fish friendly structures are constructed. These are Fish Pass in Jamuna to Bangali River at Sariakandi in Bogra, fish Pass in Kawadighi Haor of Monu river in Moulovibazar, fish friendly structure in Lohajong river of Tangail and fish friendly structure at Morichardanra in Chapainawabganj. Fish fry, spawning and hatchling movement from Jamuna to Bangali River was the main objective of Sariakandi Fish Pass Project. The Fish Pass Project of Sariakandi is necessary for the development of the dominant fishes like catfish and small fishes. The structures will also aid in efficient development of the carp fishes. Spawning migration, mainly in carp fish, in the study area was found to begin at the 2nd week of May and continue up to the 3rd week of July. Catfish migrations began at the last week of March and continue up to the 2nd week of June.

Fish fry and hatching movement from Jamuna to Bangali river was the main objective of Sariakandi fish pass project. The study also found that there were seven major category migratory species in the project area and the fish pass is contributing positively for growth of fishery resources in then study area. During the monsoon carp fish is the dominating migratory species. Carpfish migrates in a higher velocity, whereas, catfish migrates in a lower velocity. Some problems were found in the operation and management of fish pass

Key word: FCD/FCDI projects, Nursing grounds, Hydraulic structures, Natural route, Dominant Fishes, Peak migration.

Master thesis
Project no. 410

Application of swarm UAVs to environmental modelling and area mapping

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The impact robots have had on environmental modelling, for use in sustainability research and obtaining data from inhospitable environments cannot be understated. Devastating cold, heat, radiation and terrain are all barriers to receiving information. This project involves applying the continuously advancing research in UAV and swarm robotics to gather information on these environments.

Unmanned Arial Vehicles (UAVs) have shown to be useful for completing complex tasks such as area mapping, target searching and acquisition. However, a current issue with UAVs is the rarity of a long flight time with a payload. One potential solution to this issue is to use multiple agents in parallel, communicating with each other and a ground station. This requires the control of a multi-agent system (MAS) of UAVs, to allow the agents to work together to accomplish common objectives.

The capabilities of swarm systems are beginning to be recognized in agricultural fields, with applications such as spreading seeds and pesticides. These Mobile Agricultural Robot Swarms (MARS) are relatively small robots that can cover a large area in short span of time. This was shown to be highly beneficial for the sustainability of agricultural processes (Blender et al., 2016). Current research also suggests implementing swarms of UAVs for pollution monitoring surrounding large industrial sites (Alvear et al., 2015).

This project suggests using both MEMs environmental sensors and RGB cameras as a payload that can capture information such as relative pressure, humidity and temperature. Using low energy communication systems such as Bluetooth, the system will be able to transfer information across the swarm back to the ground station. This can allow the system to not only build a map of the field of interest (e.g. temperature), but also locate maxima and minima of the field.

To achieve this, this project proposes implementing Simultaneous Localization and Mapping (SLAM) and navigation algorithms to allow UAVs to navigate an unknown environment while avoiding obstacles. The implementation of an autonomous UAV provides capabilities in climbing the gradient of a field of interest (e.g. temp, radiation, algal bloom) to reach the peaks and hotspots of the environment. The ramifications of obtaining access to environments in such detail are huge, ranging from characterising the environment of nuclear plants to allow for safe and cost-effective decommissioning, to mapping the spread of algae in oceans.

Additional benefits of swarm robotics for the purpose of data acquisition include building a more comprehensive dataset across a large area, minimised human risk and the flexibility to work with a multitude of environments and sensors. This project's proposed solution has the potential to greatly improve the efficiency and reliability in the field of environmental monitoring and modelling.

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Master thesis
Project no. 411

Using the planetary boundaries framework for evaluating transport and energy sector exceedance from the safe operating space in LCA contexts

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INTRODUCTION

There is a growing concern in the society, and it would benefit with an increased focus to improve the relevance of the environmental footprints in sustainability assessment frameworks. The sustained effort of human consumption and activities, driven by human population growth is pushing the limits of the Earth's biosphere. The increasing environmental pressures on the planet have led the discussion to define the biophysical limits and revisiting these limits have gained momentum over the past decade.

THEORY AND METHODS

The recent attempts at defining and formulating absolute boundaries or limits for the different environmental pressures have led to the concept of planetary boundaries (PBs). The PBs framework proposes absolute biophysical limits and define a safe operating space (SOS) within which humanity needs to limit its environmental pressures. Applying the framework can emphasize the relevance of environmental footprints in testing outcomes of policies in the long term. The concept of PBs using the Planetary Boundaries-based Life Cycle Impact Assessment methodology (PB LCIA) is applied on a case study from UNEP-DTU assessing the "Development of a Tonga Energy Efficiency Master Plan (TEEMP)". The functional unit here would be providing electricity and meeting the transport mobility needs for a given year. Four scenarios; Baseline 2018, Business as usual 2030, TEEMP 2030 and Transformational Change 2030, are modelled to find out the desired level of transformation needed to be adhered when framing policy targets.

RESULTS

The characterized results are used as a reference to estimate the exceedance in the planetary boundaries, which are allocated based on the different sharing principles. The ratio of exceedance from the SOS based on the different sharing principles for the scenarios are presented. The influence of the different life cycle stages in the system are presented to understand the main contributions segments toward each of the PB impact categories.

CONCLUSION

The approach to establish LCA principles to evaluate policy changes is presented and the PBs have been downscaled to a country level to have meaningful and relevant absolute environmental assessment of the transport and energy sectors in Tonga. Concluding remarks are supported with quantitative assessment to enforce using the PBs framework to evaluate transport, energy and other sector's exceedance from the SOS using LCA principles and modeling.

Master thesis
Project no. 412

Bacillus as microbial solution: protection of mushroom production against pathogen attacks

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INTRODUCTION

Mushroom is one of the main agricultural product in Europe. However, it's production is constantly threatened by pathogen attacks, such as Trichoderma aggressivum. Bacillus species, on the other hand, is an interesting candidate for biocontrol application. It has biofilm forming capacity and produces secondary metabolites which inhibit fungal growth. Both properties has been suggested to influence biocontrol potency.

Our project aim to investigate the efficacy of selected Bacillus strain in protecting mushroom production against Trichoderma attack.

METHODS

We divided the experiments into three:

1. Agar assay – screening of B. subtilis strain with strong anti Trichoderma properties as well as investigating which secondary metabolite plays prominent role in inhibiting Trichoderma using simple agar co-cultivation technique.
2. Attachment assay – growing A. bisporus and B. subtilis together in liquid media and subsequently visualize them under laser scanning confocal microscope to observe B. subtilis attachment on A. bisporus.
3. Mushroom kit test – artificial inoculation of mushroom growing kit with Trichoderma and Bacillus (under controlled experiment) to observe biocontrol potency of Bacillus.

RESULTS

Below are the summaries of the experiment results:

1. Agar assay: six tested B. subtilis strain display comparable inhibition to T. Aggressivum, plipastatin mutant of the B. subtilis strain display noticably reduced inhibition – this suggests that plipastatin is important for fungal nhibition.
2. Attachment assay: B. Subtilis attach to the hyphae of A. Bisporus, moreover the biofilm negative mutant is displaying severely reduced attachment capacity.
3. Mushroom kit test: the result remain inconclusive. This is currently in development.

Master thesis
Project no. 413

Reuse of bricks as a building material

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INTRODUCTION

The thesis is about the reuse of bricks as a building material, with focus on the Norwegian market because the author is from, and future workplace is in, Norway. Findings can still be used elsewhere. The background for this topic came out of six interviews held with people from the industry in Norway, January 2019. The six people came from a producer, a contractor, people from relevant organizations and others with relevant experience or influence. The outcome from the interviews was a broad agreement around the importance on circular economy, and that bricks could contribute as a reusable construction product more than before. Therefore, the focus became about this topic.

MAIN PART

To plan for reuse and not build something twice is something of the most sustainable we can do and could be a contribution to a world which are overproducing. Why recover new clay, when existing bricks can be used again. A masonry building built before 1960, can easily be torn down and the bricks can be reused. The reason for 1960 is that cement mortar was broadly used after this, and the cement in the mortar makes it harder to separate mortar from the brick. Lime mortar used prior to this point are much easier to separate from the brick and the brick could easily be reused. A single brick does not contribute much, but 2000 reused bricks can together save 1 ton CO_2. One square meter of masonry wall are approximately 65 bricks, and by every 30 m^2 wall with reused bricks, 1 ton of CO_2 can be saved. There are rules for certifications on reused building materials, and certification is difficult for materials without a harmonizing standard. A material without a harmonizing standard can be certified through an EAD (European Assessment Document), that forms the basis for an ETA (European Technical Assessment). This is made for used bricks in Denmark, and the ETA is a European document, and can be applied in Norway as well. The thesis contains of several tests done on bricks, determining densities, water absorptions, frost resistance and a new non-destructive test that tries to determine salt content in bricks. The bricks are five different batches, two picked from an old building down town Copenhagen, two batches from the company selling used bricks and one batch of new bricks, so a comparison could be made.

CONCLUSION

The results tell that the color difference on the bricks have a huge impact, and it tells if the bricks are brunt at a high or low temperature. A brick burnt at a higher temperature have coarser pores and lower porosity, which makes it more resistant to frost, and the frost resistance is often a decisive requirement. The used bricks are more expensive, because it demands a machine or manpower to clean them and stack them on pallets. The price should on the other hand not have an impact when the environmentally aspect are better. The bricks should be handled as they were handled when they were built with the first time, with lime mortar. The lime mortar is more flexible, and a mortar with cement makes the wall stiffer. Regardless the quality, used bricks can be nearly always be used in inside walls that aren't load bearing, and every brick contributes with saving the environment by lowering the CO_2 emission. Reduced CO_2 emission by reusing bricks, makes this sustainable.

Master thesis
Project no. 414

3 GOOD HEALTH AND WELL-BEING

Early detection, progression and staging of cancer and tumors in the human brain and liver using ^{13}C detector coil arrays

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INTRODUCTION

Dissolution Dynamic Nuclear Polarization (dDNP) has proven to be a powerful technique for the study of metabolism with 13C-enriched bioprobes in cancer and heart disease. One potential new application that has attracted much attention lately is the early detection, progression and staging of brain and liver tumors, However, due to the low permeability of the blood brain barrier, the amount of the injected compound that actually enters the brains is inherently low, which imposes a big challenge for the receiving hardware. On the other side, the size of the human liver is relatively large, and together with its position in the human body, it becomes challenging to examine it using the existing technologies.[1]

METHODS AND THEORY

An array design of 2x14 detector channels is to be used for a human head. The detector coils are surface coils with diameter of 80 mm.The performance of each single element of the array will be evaluated, with special attention to its noise level, and MRI safety. Furthermore, a comparison of surface coil vs. volume coil (low impedance vs. high impedance) will be made for the human head. This part is to be implemented in an 8-channel array, and the purpose is to improve MRI image quality and patient comfort.

Figure 1 From the left, 8-channel coil array detector, process of scanning using MRI with the implemented arrays, and a 3D image of the liver being scanned.

For the liver, a two-channel receive coil is implemented. Each of the channels consists of a volume coil having a diameter of 120 mm. The design contains matching networks for the frequency of interest, as well as carefully designed trap circuits which will make sure that there are no interferences while doing the imaging. Both channels are to be positioned in such a way that they follow the body shape, and which is more important, that they can scan the liver from two sides, rather than one side,as used in the commercial technologies.The prototype of the liver coils has already proved to be more efficient than the commercial product, and now the final product is sought after. The final design of the coils for the human liver is to be used by the National Danish Institute for Magnetic Resonance and Hvidovre Hospital, and coils for the human brain are to be used at Aarhus University Hospital.

CONCLUSION

The project described above is focused on a healthy life for all, and what makes it special is that it both concentrates on body organs where tumors are found more frequently, and it also takes into consideration the system level, as well as the component level design, through which it surpasses the performance of the existing technology in the market.

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Master thesis
Project no. 415

Effect of land use on the water and CO_2 exchanges between the land and atmosphere

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INTRODUCTION, OBJECTIVE AND MOTIVATION

Since the industrial revolution, natural lands have been transformed in a rate far greater than ever before in history. One of the primary motivations of these land use changes are to provide agricultural fields, in order to secure food for the ever rising population. However, the agricultural sector comprises a large environmental footprint that have effects for the Earths atmosphere and climate, and its population. It is important to optimize agricultural water usage and the crop yield in order to strive for many of the established sustainable development goals such as zero hunger, life on land, clean water and sanitation, climate action etc. Remote sensing from Unmanned Aerial Vehicles (UAS) proves to be an important tool for management when trying to increase the amount of carbon assimilated by crops per unit of water. By using multispectral (6 bands) and thermal cameras, it is possible to create images of carbon assimilation, water usage efficiency and various vegetation indices that depicts the crop yield, which again is in direct contact with water and CO2 levels in the atmosphere. Compared to satellites, UAVs have very high spatial resolution, low costs, and flexible operation times. The high spatial resolution makes it possible to validate models that generate results such as the vegetation's gross primary production (GPP) with high correlation to in-situ data. The object of this project is to validate the Priestley_Taylor Jet Propulsion Laboratory ET model by correlating the remote sensing results with in-situ measurments obtained by eddy-covariance towers in a sugar cane field in El Viejo, Costa Rica. In addition, the potential of various vegetation indices obtained by the remote sensing data are explored to assess crop yield in a test-field.

METHODS

Multispectral and thermal images are obtained by drone flights over the sugar cane field in El Viejo, Costa Rica. The images are corrected in order to obtain the actual reflectance of the various spectral bands. The images are stitched together to create an orthomosaic map that convers the whole field. The spectral bands are exported to be used in the model and the results are thereby correlated with in-situ data.

RESULTS

Various vegetation indices, GPP and evapotranspiration are obtained through the Priestley_Taylor Jet Propulsion Laboratory ET model and correlated with in-situ data. The model can thereby be up scaled to include satellite data which provides the opportunity of interpreting the temporal change in water and CO2 in the atmosphere and how the concentrations are affected by land cover changes and use. Also, vegetation indices obtained from pictures taken over a test-field are interpreted to see the vegetation yield and stresses as a response to various agricultural techniques.

Master thesis
Project no. 416

Potentials for using ambient air as heat source for large-scale heat pumps

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INTRODUCTION

According to the International Energy Agency IEA[1] is heat the largest energy end-use, where approximately 50% of the total energy consumption in the world goes to heat energy production. This is heat which is mainly provided for space heating and industrial processes. In 2017 was only 10% of this heat energy produced from renewables, with the majority being bioenergy.

According to the environmental goals of Denmark are the 400+ existing district heating companies expected to supply CO2 neutral heating by 2035 [2].

An affordable sustainable solution with high availability is therefore required to be found.

THE SOLUTION

Ambient air is everywhere and this is a heat source. We might believe that 25°C is warm, and -2°C are cold, though with heat pump technology this can be brought up to 70°C of district heating water. The implementation of large scaled air sourced heat pumps (LSASHP) on MW scale is a novel solution introduced over the past 2-3 years, and this is a technology which has gained momentum with the phase-out of the PSO-tariff in Denmark, enabling a Power-to-X culture, or P2H for heating. The LSASHP is modular, using already proven commercial technology from the refrigeration industry. It requires little area, about 102m^2/MW, no large construction work is required and has a simple regulatory process, in comparison to e.g. groundwater. It is therefore easy to implement, with low initial costs. Though this is an area of little research, and challenges exist with operating in the cold humid weather with risk of frosting, where energy then is required to defrost.

This project is a master thesis which investigates the potentials for using outdoor ambient air as the heat source for large scale heat pumps, applicable for district heating. –Facing the challenges of cold humid weather conditions.

The product

A model has been developed to simulate the heat pump operation through dynamic weather conditions. This can be integrated into the operation for estimation of frost growth during cold periods, and predict the performance degradation, together with when to most cost-efficiently defrost. A second model is created for estimation of defrost time, and energy loss. Thirdly a CFD simulation has been made for estimation of most efficient orientation in relation to wind.

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Master thesis
Project no. 417

Assessment of freshwater ecosystems using remote sensing from unmanned aerial vehicles

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INTRODUCTION

The world's surface water bodies are vital parts of the natural ecosystem because they sustain life, contribute to the biochemical cycle and provide ecosystem services for human beings. However human activities such as climate change, land use and land cover change combined with urbanization have resulted in organic and inorganic pollution as well as invasion of species and reduction of natural habitat in many freshwater ecosystems. This has resulted in eutrophication, harmful algal blooms, loss of water clarity and loss of benthic organisms. Assessing surface water quality consists of monitoring biological and chemical properties of the water body. Traditionally, in situ water samples are manually captured and then analyzed on site and in lab for water quality indicators such as Chlorophyll-A, Colored Dissolved Organic Matter (CDOM), Secchi depth, temperature and Total Suspended Solids (TSS). Although in situ measurements are highly accurate they are point-based and therefore do not provide spatial or temporal variability. Furthermore, the manual labor is expensive and time consuming. These limitations could be aided by combining hyper spectral remote sensing with in situ methods. Drone UAVs can be easily employed and do not depend on cloud cover as satellite remote sensing does. Hyperspectral data has high spectral accuracy and can therefore capture spectral 'fingerprints' of individual substances. Captured images therefore contain detailed spectral information, that, when correlated with in situ water samples can potentially uncover the concentration of water constituents.

AIM AND METHODS

The aim of this project is to develop a statistical model which explains the relationship between concentrations of water constituent parameters Chlorophyll a, CDOM and TSS and their respective hyperspectral reflectance spectra. It is done in the Danish stream Usserød stream in Nivå. Hyperspectral images are taken with a 138 spectral band CUBERT camera employed on drone UAV. Also, data from a spectroradiometer is taken to aid model development. Data from hyperspectral images and the spectroradiometer are statistically correlated with water samples using Partial Least Squares Regression (PLSR). Orthomosaic maps are created in the program Agisoft, to hopefully be able to map the water quality.

RESULTS

The results of this project will expectantly be a model that can be utilized to aid water quality determination of streams for Chlorophyll a, CDOM and TSS. Also, with maps of water constituent concentrations the water quality can be mapped and therefore spatial knowledge can potentially uncover unexpected pollutions or algal blooms. The developed method of using PLSR could potentially also be used to uncover other water constituents or pollutants.

Master thesis
Project no. 418

Climate change effects on copper phytotoxicity of *salix viminalis*

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ABSTRACT

The ecotoxicity of copper and its omnipresence in the environment creates the foundation for the high environmental risk ranking it is associated with. The environmental pollution by copper compromises the ability of the environment to foster life and renewal of its intrinsic values. The presence of this naturally occurring substance in all environmental compartments is substantially increased as a result of anthropogenic activities, inflicting threat to both human and plant health. Thus, remediation of copper requires special attention in the protection of soil quality and water quality. The main objective of the project is to research the toxic effects of copper on plants under changing climatic conditions. Copper is an essential heavy metal for enzyme processes and chlorophyll production at low concentrations and is therefore beneficial and even required for plant growth, while excessive levels in the soil and water matrix may impose detrimental and toxic effects on plants, resulting in inhibited growth and productivity. Thus, copper pollution in the environment poses an increasing threat to both plants, humans and ecosystems as a whole, as metals reach the food chain through plant uptake. Furthermore, projected change in future climatic conditions may affect the plant toxicity and uptake of heavy metals.

Experiments of phytotoxicity is conducted on willow tree cuttings where the toxicity is measured by the inhibition of transpiration. The experiments are performed in 4 climate chambers where the willow trees are exposed to different copper concentrations of 0.2, 0.5, 1, 2, and 5 mg Cu/L, to assess the effect the climate conditions temperature and CO2, have on copper toxicity to willow trees. Each climate chamber contains a treatment of which the willow trees are exposed to, where the first chamber has ambient conditions, the second has elevated temperature, the third has elevated CO2 and the fourth has both elevated temperature and CO2 conditions.

In the ambient chamber, the willow trees transpiration decreases with increased concentrations of copper, and for the willow trees exposed to 5 mg Cu/L, necrosis is observed. In the chamber with elevated temperature, the transpiration decreases over time for both exposed and unexposed trees. The chamber with elevated CO2 shows similar results as the ambient chamber, as the transpiration is more inhibited with increased concentrations of copper. The transpiration of willow trees in the chamber with both elevated temperature and CO2, shows similar results as in the chamber with elevated temperature, with decreasing transpiration for both unexposed and exposed willow trees.

The climate conditions influence the copper toxicity on willow trees which is an important parameter to account for in future pollution policy making to ensure healthy ecosystems and human populations.

Figure 1 Willow trees exposed to 5 mg Cu/L at ambient climate conditions

Master thesis
Project no. 419

Shared living for a minimal impact

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INTRODUCTION

Material consumption is one of the biggest polluters. A regular Danish family emits 5 tons of CO_2 only due to their material consumption (CONCITO, 2017). Many of the belongings are used rarely, simply take up valuable storage space or end up as waste disposal before their potential end life.

Access over ownership

Convenience is one of the main drivers for material ownership. As more items become available on the market at lower prices, it becomes increasingly difficult not to be tempted. However, a movement is starting to prioritize access to services, goods and tools. This can save money, storage space and the environment.

METHOD

A scenario is imagined, where 5 households live in a partly shared economy (car, kitchen, tools, etc.). It is compared to a reference model of 5 regular Danish household live individually. In both scenarios, the buildings will be nearly zero-energy buildings that fulfill the 2020 building regulations. The energy consumption as well as carbon emissions is analyzed for both scenarios.

VISION

The hope is to demonstrate a potential living situation that is both convenient, cost-effective and environmentally friendly.

Master thesis
Project no. 420

LUC experiments to investigate transport of tracers and pesticides in fractured clayey till

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INTRODUCTION

The extensive use of pesticides and an increasing frequency of extreme rain events are important factors contributing to pesticide contamination of groundwater. Clayey-till deposits can be highly hydraulically conductive due to fractures and macropores that act as preferential flow paths, which can facilitate leaching of dissolved contaminants to the groundwater below. Strong rainfall events can furthermore lead to non-equilibrium sorption of pesticides, in which case the risk of pesticides leaching to groundwater would be underestimated when equilibrium sorption coefficients are used. This factor needs to be investigated with respect to the transport behavior of pesticides with different chemical properties in soil types above groundwater aquifers. Flow-through experiments using the large undisturbed column (LUC) method by Jørgensen et al. (2019) allow investigations of solute transport in a large soil sample (0.5 x 0.5 m). Solute transport can otherwise be difficult to measure in field experiments lacking control of boundary conditions and in small-scale idealized laboratory experiments where the representation of soil heterogeneities is often limited.

METHODS

Flow-through experiments, imitating an extreme rain event (80 mm/d) followed by normal flow (10 mm/d) were performed using a LUC from a clayey-till site in Holbæk, Denmark. In-situ pressure and temperature conditions were reproduced by installing the LUC in a permeameter. Hydraulic tests were performed, and the saturated hydraulic conductivity of the column determined. A conservative tracer (bromide) and a pesticide mixture were injected to obtain breakthrough curves (BTCs) at the LUC outlet. A dye tracer was then injected, allowing the visual inspection of the main flow paths when the LUC was opened and dissected. The flow and transport experiments were evaluated using numerical model simulations in COMSOL Multiphysics.

RESULTS

Measured BTCs showed different patterns due to the distinct properties and interactions of the injected solutes during their transport within the complex, fractured medium. The BTC for bromide reflected the behavior of a conservative solute which does not undergo sorption or degradation. The BTC for tebuconazole was retarded by sorption and/or diffusion mechanisms, reflected in a slower increase in outlet concentrations during high flow compared to bromide, and a more pronounced decrease simultaneously with the reduction of the flow rate. There was a strong contrast in hydraulic conductivities of fractures and matrix. Flow paths were dominated by gray fractures and biopores (iron-reduced) while no dye tracer was observed in red fractures (iron-oxide stained) or in the matrix.

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Master thesis
Project no. 421

Design of compact, private and sustainable space with recycled and upcycled materials

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INTRODUCTION

Today we see increasing trend of environmental awareness in companies and in individuals. We all want, somehow, to contribute to reduction of environmental impact caused by our activity on Earth. Our mission is to popularize zero waste philosophy and paradigm of circular economy by creating spaces for everyday use with upcycled and recycled materials. We want to prove, that from user experience perspective there is no difference between spaces made out of new, or reused materials, and hence, to impact current resource management practice. With our designs we want to help our customers who want to demonstrate interest in sustainability by reusing waste materials and manifesting environmental concerns. The three main problems around compact private space that we are tackling are: high cost and resource demand, current image of recycled and upcycled products and lack of user experience focus.

METHOD

We have tested our idea by building a prototype of our first product. We called it Mellow Pod. Currently we are conducting indoor climate tests at DTU as a part of Master Thesis project, iterating and adapting the project to indoor use. We are testing indoor parameters such as temperature, humidity, noise and CO_2 level and overall user comfort.

As for the outdoor use, we have a collaboration with food truck company – Adri Eats. Adri Eats rents out our modified Mellow Pod and uses it as a food stall during street food events. We successfully delivered Mellow Pod during two events: Aalborg University Gala Party and Street Food Festival København, which took place in Hans Tavsens Park.

IMPACT

With our design and product we are trying to address the SDG 12 (responsible consumption and production) in construction industry. We would like to utilize this project commercial and environmental success as a reference case study, or as a proof of concept, and basing on it start a new trend in architecture. This trend would involve implementation of recycled and upcycled materials on a design stage of construction project, and potentially could significantly impact resource management and environmental impact of construction industry.

Master thesis
Project no. 422

Online forecasting of ammonium loads and concentration at the inlet of Damhusåen WWTP

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ABSTRACT

The recent years' increasing focus on quality of natural water environments generates a need for improvement of effluent quality from waste water treatment plants (WWTP). Ammonium (NH_4^+) toxicity poses a risk to quality of natural water environments and NH_4^+ peaks in recipients are primarily the result of effluent from WWTPs. The present study assesses the performance of an online forecast model. Near-future forecasts of NH_4^+ concentrations can give early warnings which can lead to preventive measures being taking. In case of extreme events, the water is bypassed to receiving waters past the secondary treatment. If timing of dilution can be accurately forecasted, bypass can be activated according to predicted dilution time and consequently reduce the discharge of untreated waste water and thus, improve effluent quality. With the purpose of obtaining a comprehensive time series of ammonium concentration measurements, the Water Smart Cities project (WSC) launched in 2017 a monitoring program at Damhusåen WWTP in Copenhagen. An online NH_4^+ ion-selective-electrode (ISE) sensor was installed at the WWTP and provides real-time NH_4^+ measurements of the influent waste water. Thus a long continuous time series of NH_4^+ are available as an outcome of the WSC monitoring campaign. However, inspection of campaign measurements, showed significant deviations from statutory daily composite samples, which lead to the assumption that the absolute values of the online sensor measurements are inaccurate. Nonetheless, it is believed that valuable information on NH_4^+ patterns can be acquired from the online sensor data. This study proposes an approach for online data correction of NH_4^+ time series using statutory daily composite samples. The correction of time series changes the absolute values of the NH_4^+ concentration, but keeps the overall daily patterns which are important for forecasting purposes. The corrected measurements were used as input to the online forecast model. It is expected that this correction results in better performance of model. This study addresses different challenges with ISE-sensor data for forecast purposes and assesses possible ways to use the data, despite the quality of ISE-sensor data. The results emphasizes the importance of well performed and well documented calibration of ISE-sensor.

Master thesis
Project no. 423

Bio-based carbon fibres: Investigation of the carbonization step of lignin-cellulose based precursors

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INTRODUCTION

Light-weight materials, like carbon-fibre-reinforced-plastic (CFRP), are essential in order to reduce CO_2 emissions of vehicles. However, carbon fibres (CF), today to 90% fossil based, are not yet sustainable. Currently bio-based CF are intensively studied. The challenge is to achieve properties required for use in the automotive industry, 1.72 GPa in tensile strength (TS), 172 GPa modulus (TM). Blending lignin with cellulose, the second and first most abundant bio-polymers, was found to enable precursor fibre (PF) preparation by dry-jet wet spinning. Optimisation of processing and stabilising the PF and converting to CF resulted in properties of 1070 MPa (TS) and 76 GPa (TM) (Bengtsson,2019). However, the final step of CF manufacturing, the carbonisation step, was not yet optimised.
The purpose of this project was to examine stabilised lignin-cellulose PF fibres in the final carbonisation step for further improvement of the properties towards the set targets.

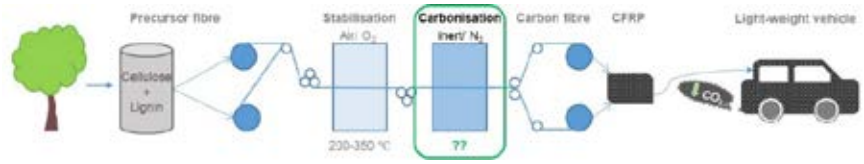

Figure 1 Sketch of the process for lignin-cellulose carbon fibre application

THEORY

Studies on fossil-based CF experienced enormous property improvements after adjustment in carbonisation parameters (heating rate, final temperature and tension). The investigation of different carbonisation treatments is based on those findings.

METHODS

The impact of carbonisation heating rate, temperature and tension on lignin-cellulose based CF was examined for tensile properties, yield (TGA), chemical- (EDXA), as well as macro- (SEM) and micro-structural (WAXS) behaviour.

RESULT & CONCLUSION

The contributed work shows that lignin-cellulose PF can be produced more sustainably with lower energy consumption. It further more contributes with a further understanding of the lignin-cellulose PF behaviour during carbonisation to possible future property optimisations.

REFERENCES

Bengtsson, A., Bengtsson, J., Seddin, M., & Sjöholm, E. (2019, April 10). Carbon Fibers from Lignin-Cellulose Precursors: Effect of stabilization condition. Retrieved May 20, 2019, from https://pubsdc7.acs.org/doi/pdf/10.1021/acssuschemeng.9b00108

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Sustainability and climate change are high on the global agenda. Engineers play a central part in a sustainable development of society. Engineers from DTU can and must continue to contribute to the development of technological solutions that respond to the global challenges. Therefore DTU has initiated

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