

**POWERED BY  
DTU STUDENTS**

## 100 DTU students engineer solutions for Roskilde Festival

Roskilde Festival is again collaborating with DTU on developing engineering solutions to the challenges involved with having over 130,000 people gathered in one place.

Once a year, Roskilde Festival becomes the fourth-largest city in Denmark with some 130,000 inhabitants. And as this city is meant to be built and taken down in a very short time, it presents a wide range of engineering challenges. For example how to ensure that the waste produced can be disposed of in the most sustainable manner, or how to reduce electricity and water consumption.

To meet the challenges, Roskilde Festival has since 2010 collaborated with DTU students on creating an even better and more sustainable festival.

So this year, about DTU 100 students will again contribute with a wide range of projects—from cooling, waste management, and acoustics, to a local smart grid which may some day make the festival independent of outside power. This means that festival-goers will meet DTU projects on the camping site, which will include tests with better signage and more efficient waste sorting.

During the festival, they will also have the chance to visit the DTU TechLab to hear students talk about their projects and, among other things, invite the audience to build their own climate-friendly refrigerator. All of these solutions are intended to further improve festival conditions and make it even greener.

"To make a city such as Roskilde Festival ever more sustainable is a continuous and huge project. Our collaboration with the DTU students helps us to locate the places where it makes most sense to make changes, and they come up with good ideas for how we can implement them," says Christina Bilde, spokesperson for Roskilde Festival.

"For example, last year's DTU project [PeeFence](#) was an excellent solution to our problem with people peeing around the fences, and we will continue this project at this year's festival. This way, the collaboration also helps young talents on the way. For example, we were very impressed with both the VOLT mobile charger and the sustainable [DropBucket refuse solution](#), which both started as DTU projects. It is another aspect of this collaboration, which we are very proud of," she says.

The collaboration between Roskilde Festival and DTU has been running since 2010, and Martin Vigild, Dean of Graduate Studies and International Affairs at DTU, who was one of the organizers of the partnership, is very pleased that DTU students as part of their education have the opportunity to use Roskilde Festival as a laboratory for their bright ideas:

"At DTU, we focus on our students being innovative and entrepreneurial. This is, after all, what they will live off when they graduate. It is an engineer's primary task to be able to create

solutions where there is a need—and doing it in close collaboration with a customer. Roskilde Festival is the perfect laboratory for our students, both because the surroundings make very high demands on their solutions, and because we over the years have had a very close dialogue with the festival, and because they actually use the students' ideas and results in their work," says Martin Vigild.

### **Meet DTU in TechLab**

**TechLab is open 4 – 8 p.m. on Wednesday and 12 noon to 8 p.m. Thursday to Saturday.**

DTU's journalists will be on site throughout the festival and can be contacted for further information about the projects:

Tore Vind Jensen, +45 3026 7710 / [tovi@adm.dtu.dk](mailto:tovi@adm.dtu.dk)

Henrik Larsen, +45 2020 9523 / [hkln@adm.dtu.dk](mailto:hkln@adm.dtu.dk)

For further information about the collaboration between Roskilde Festival and DTU, please contact one of DTU's journalists or Roskilde Festival's press service: +45 3010 8281 / [press@roskilde-festival.dk](mailto:press@roskilde-festival.dk)

### **A few facts on the Roskilde Festival-DTU collaboration:**

- In 2010, Roskilde Festival and DTU made a formal agreement to use the festival as a laboratory for innovative engineering solutions to the festival's challenges.
- Students earn five ECTS points during the project-period.
- Startup companies from DTU like VOLT, DropBucket, Kubio, and PeeFence were established after being tested at Roskilde Festival.

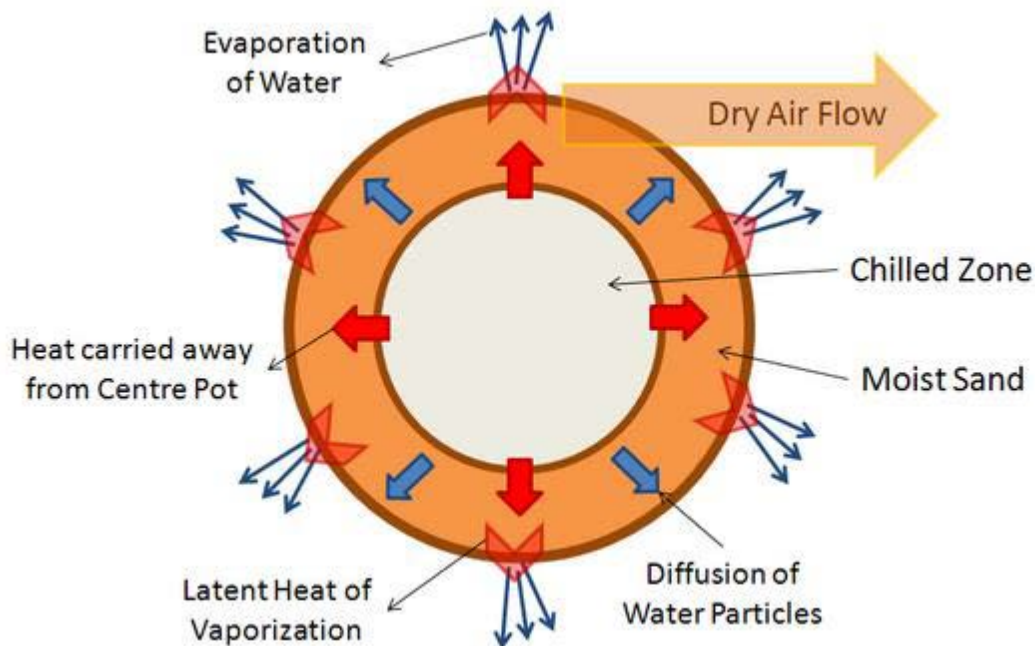
## CoolBox

We aim to develop a cheap and transportable cooling system, that doesn't require any kind of electrical supply. To do so we have to rely on alternative principles such as evaporation cooling. As inspiration source we have the zeer-pot, which is used in developing countries and areas with no power sources.

The concept relies on evaporation cooling. A similar phenomenon occurs when we sweat, as a result of our body trying to cool us down. Our CoolBox will work in the same manner. To achieve the best results we will be testing different materials and amounts of evaporation fluids.

The performance of the CoolBox will be most effective in sunny conditions with low relative humidity. It will never be able to deliver ice-cold beers, but still much cooler beers than the air temperature.

To test our concept, we have decided to make a workshop-based presentation at Roskilde festival. The festival participants will be able to make their own CoolBox, and bring it with them to their camp. We will be assisting and guiding. We plan to bring materials enough for 15 CoolBoxes.



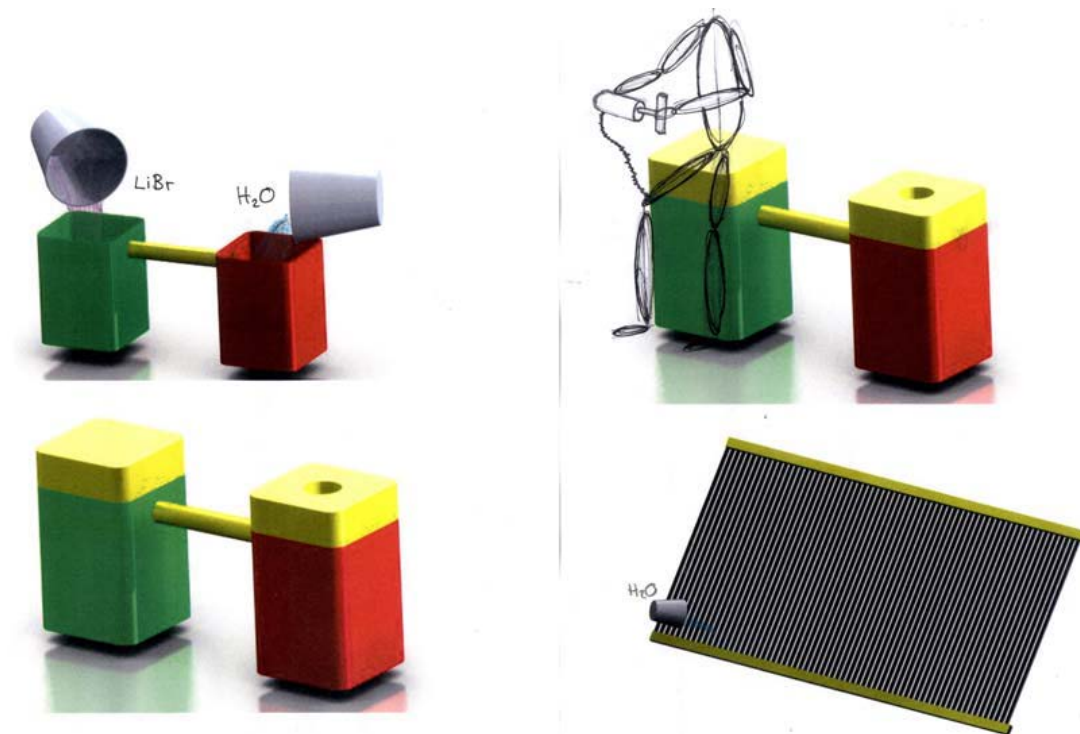
## Cool it

It is usually very hot during Roskilde Festival in July, therefore it is an observed problem that beverages often are very warm. The goal of this project is to design and manufacture an environmental solution for cooling beverages that only uses water, salt and solar energy. The method used for cooling is called absorption cooling.

The aim of this project is to cool 12 cans of beer from 20 degrees °C to 10 degrees °C in about 30 mins. The set-up is made transportable via a trolley so we can display the project in different locations at the festival, and thereby create a small event where festival guests can exchange a warm beer for a cold. During the exchange we will have the opportunity to present the project and involve them in the process.

By absorption cooling a salt solution (LiBr) is used in one container that absorbs water (H<sub>2</sub>O) in gas- phase from another container that is connected. Thereby, the pressure in the containers decreases which results in the gas expanding and the temperature falling. When the temperature falls the beverages that are connected with the water container cools down.

The evaporation temperature of the water is the minimal temperature of the beverages. The water initiates evaporation due to the heat transfer from the beverages that needs to be cooled. The salt solution will absorb the evaporated water because of chemical affinity. In order to maintain the absorption process, heat needs to be removed from the saltwater.



## The natural fridge

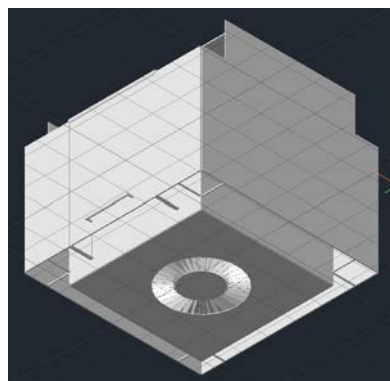
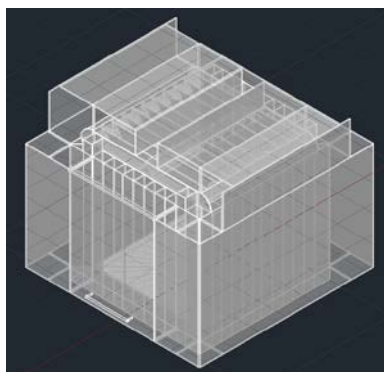
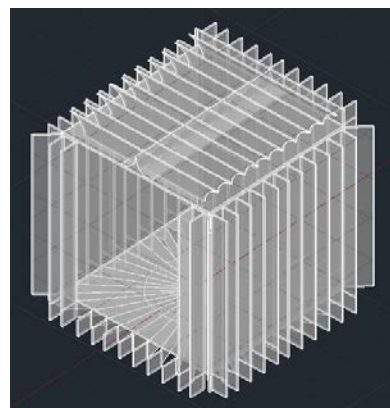
The main objective is to create a cooling concept with minimum energy consumption primarily for areas where cooling is difficult to sustainably establish energy wise.

The basic concept originates from fundamental principles of cooling physics. The device consists of an inner compartment covered with a constantly wet material where the boundary layer is exposed to airflow thus removing the evaporated water forcing more evaporation. This extracts energy from the system, all in an insulated constellation.

When the airflow removes the microscopic evaporated boundary layer it forces the generation of a new evaporation layer and the subsequent evaporation extracts energy from the inner compartment thus generating a cooling effect.

Two other essential mechanisms are used in this concept, air pressure and capillary suction, for generating air flow and keeping the cloth material wet respectively. It means that the generation of air flow is the only energy consuming part in the concept.

Conceptually, this cooling system has potential locally and globally. Locally, it may replace temporary high-energy consuming devices such as refrigerators for festivals and camping fields. Globally, it may optimize existing cooling systems or even enable substantial cooling in areas with limited or non-existing power supply.



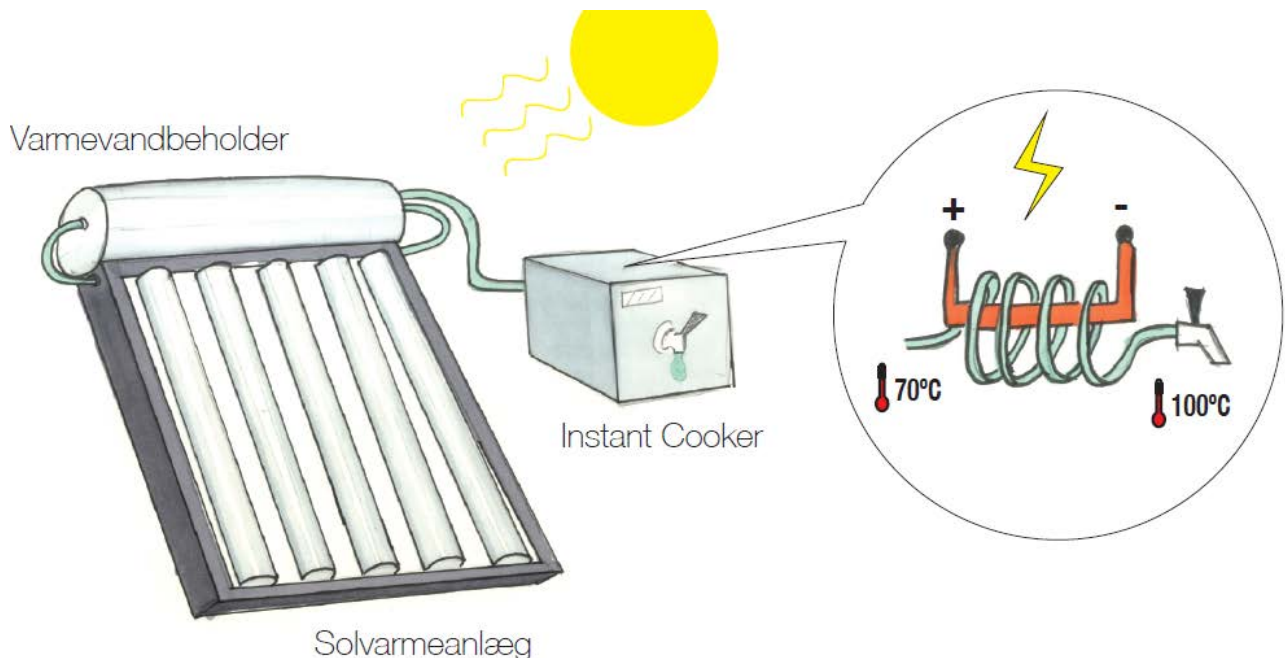
## SunCooker

SunCooker – a cooker powered by the sun - has been motivated by the idea to deliver boiling water at Roskilde Festival in a sustainable way. Boiling water consumes a lot of energy, and by letting most of that energy be delivered from the sun, it becomes more sustainable.

By using a vacuum sun panel, we are able to heat up water to about 60-70 degrees. The remaining 30 degrees is delivered by an electric heat element that are able to cook, the exact amount of water that is needed - an instant cooker. The sustainability consists of two elements; First by letting most of the energy be delivered from the sun, and second by only cooking the exact amount of water that is needed.

The vacuum sun panel heats up a tank of pure water to 60-70 degrees and keeps it warm. When activated the instant cooker boils the exact amount of water that is needed. By using an electrical heat element, the concept is independent of the sun. You are guaranteed boiling water even on a cloudy day. The design is based on existing technologies - a vacuum sun panel known from heating up eg. houses, and an instant cooker known from eg. Nespresso machines.

We think this concept can be used for supplying the camping areas with hot water for eg. Coffee and instant noodles. Also this concept can be used for shops that need small amounts of boiled water.

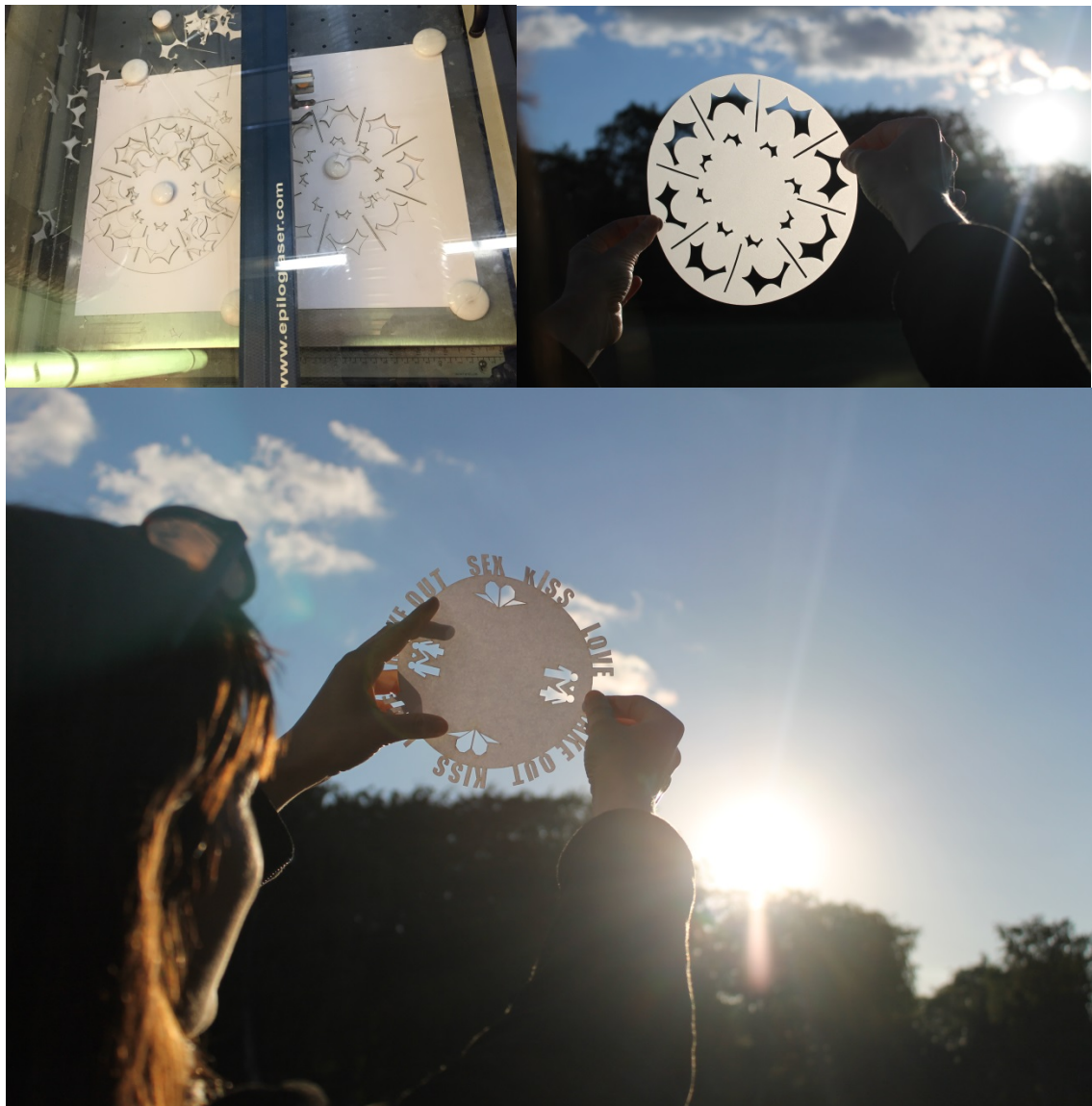


## PaprNote

PaprNote is a reinvention of the old Danish tradition of a 'gækkebrev' brought into the digital age. The story goes, that 'gækkebreve' were used between young people to send anonymous flirtatious papercuts to each other. If you got guessed, you owed the other one a chocolate egg.

With PaprNote you can send beautifully cut physical paper notes through our online platform [www.paprnote.dk](http://www.paprnote.dk) to someone you know at Roskilde Festival - could be a friend, a flirt, a colleague etc. A text message is sent, and your friend can collect the laser cut Paprnote at DTU's TechLab.

A PaprNote is anonymous and the receiver has to guess who sent it based on three clues which will be provided through our online website. If guessed, the two must meet over a beer, an ice cream or a kiss - and our mission of facilitating interaction between people is done!

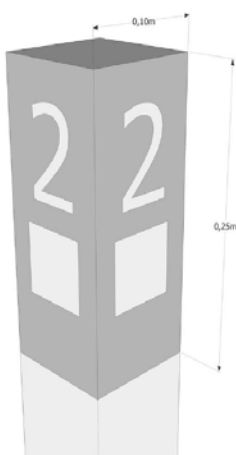
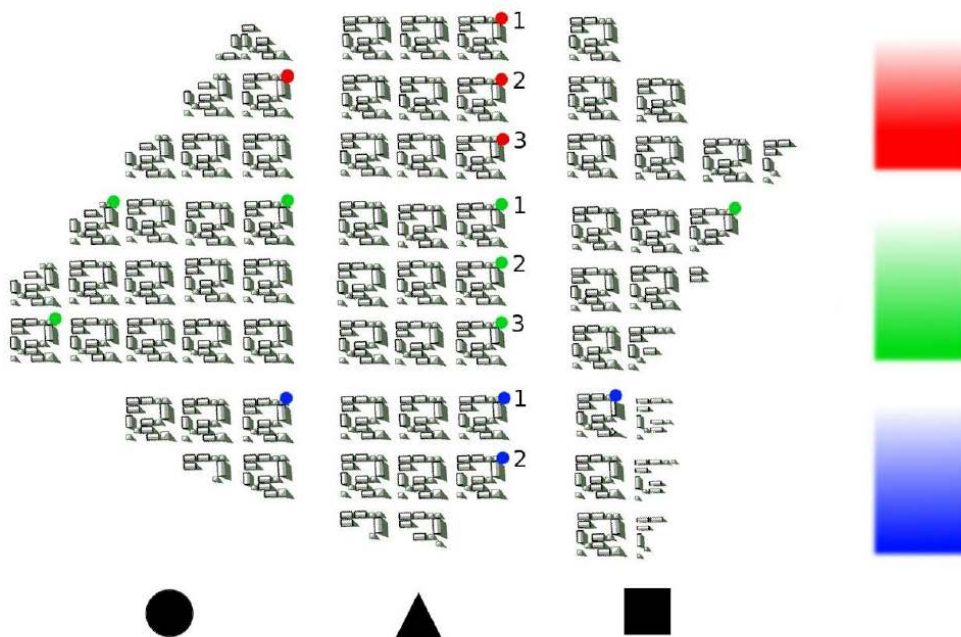




## Sustainable Signage (I)

The project is intended to improve the festival emergency crew's ability to locate a festival guest in distress within the camping area of C - along with being a help to the festival guests to navigate around the camping area.

We have made a "rough system" of the camping area by dividing it into coordinates by a color and a symbol in order to minimize the amount of colors and symbols needed to cover the area. Resulting in the system seen in the picture below:



The design of the signs are made considering the condition of the night time festival guests, who are commonly rather intoxicated, therefore the sign has been dimensioned to be difficult to remove from its designated position.

The signs themselves are wooden blocks, which is colored and marked with a symbol, defined by its coordinates in the rough system, ex. blue square, it is then given a row number depending on which row it is located.

The wooden blocks are then attached to the larger garbage canisters located in different positions in camping area C.

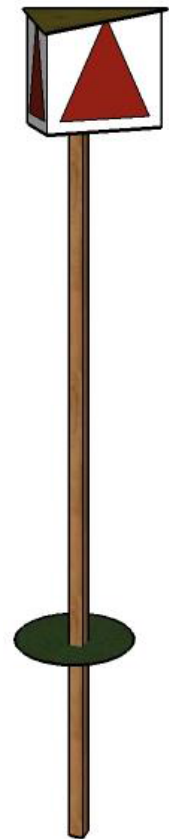
## Sustainable Signage (II)

This project is developed for the Roskilde Festival, to ease the navigation for festival participants as well as paramedics in the camping areas (C, E, G etc.). The idea is to divide the camping areas into smaller areas (micro areas). This will be done using signs that for each micro area will have its own area color code. But since there is a limit to the number of colors humans are capable of distinguishing, the micro areas will be split into even smaller areas (nano areas). These areas will then have their own area figure code (circle, triangle, square etc.).

The presented idea can be used throughout the larger camping areas, to make it easier to identify the exact position of one's location, if someone were to meet with a friend, have a public arrangement or, most important, guiding an ambulance. Now people can specify their location by, for instance, saying; "I'm at area C, green triangle", instead of directing by simply informing that they're in area C. This distribution cannot only be read from a map. Signage will be used on the main roads on the campgrounds to signal one's exact whereabouts.

The sign will consist of a triangular box, where the area codes (color and figure) will be displayed on the sides. The sign will be mounted 3.5 meters above ground, to ensure visibility, but also to keep away the equipment from festival guests. The signs will be visible during the day, but also at night due to solar cell powered LED's. The solar cell panels will be placed on top of the box, and will charge a battery during the day. A sensor will then turn on the lights as it turns dark. The lights will light up in the same color as the area color code and in the same pattern as the area figure code, and therefore be identifiable during night time.

During the trial period at this year's festival, three signs have been produced to cover a smaller area on the C-campground. The signs will be placed in the middle of the 10 meter wide roads, so there will still be plenty of rooms for vehicles and festival guests. For the test, two different figures (triangle and square) and two different colors (red and green) have been picked, for the ease of production.

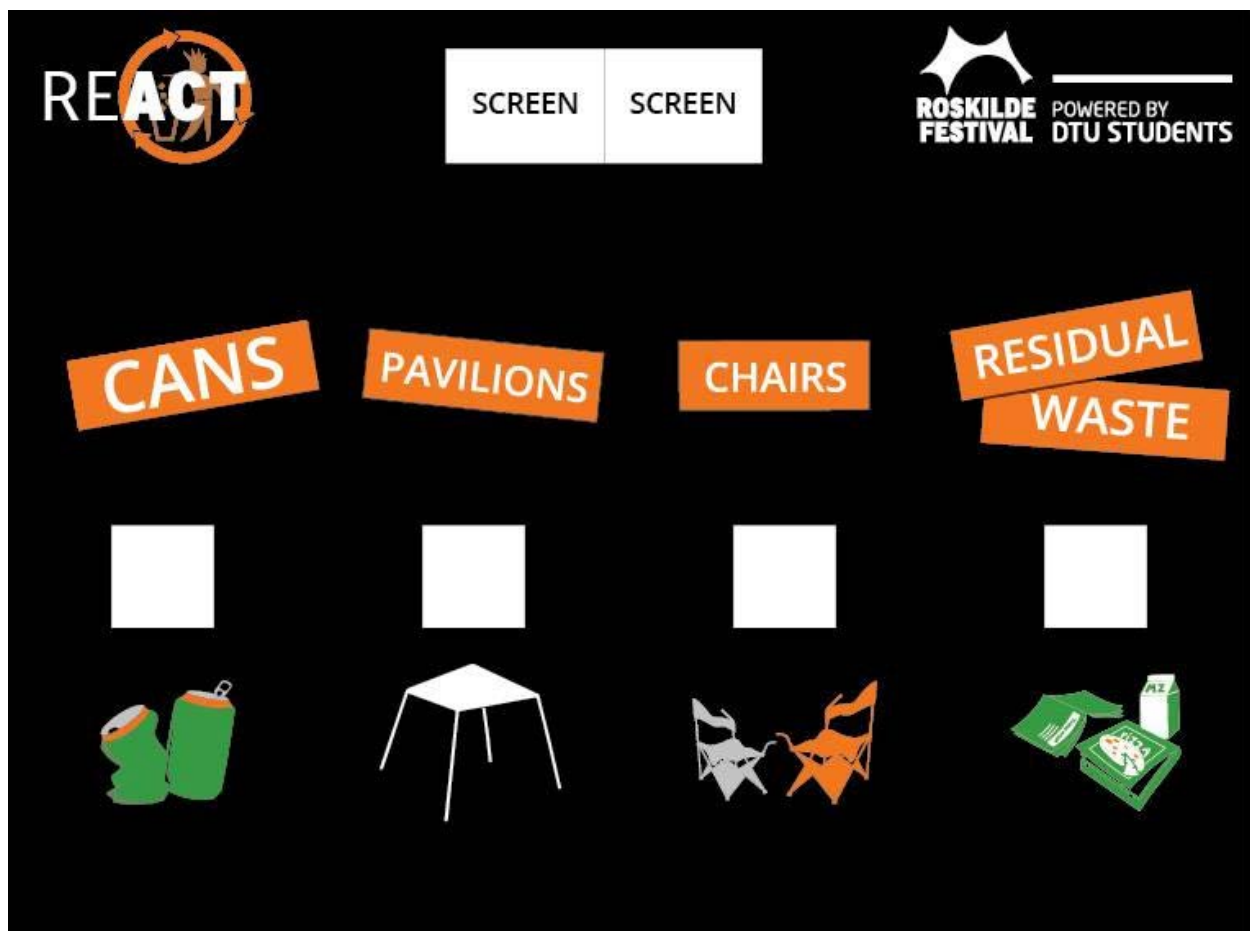


## ReAct barometer

This project seeks to gather information about the waste produced at Roskilde Festival 2015. Furthermore it seeks to engage the festival visitors to collect and sort their trash, through the establishment of a sorting wall with a nudging element: A live barometer that shows the amount of collected and sorted trash.

The project consists of a sorting wall with four sorting options: General waste, cans, broken pavilions, broken chairs. The sorting wall will be approximately 18 m<sup>2</sup> and will be covered by a printed tarpaulin that displays the sorting options. In the wall, four sorting holes will be placed, so that the festival visitors can throw trash through the wall. On the back of the wall, four 660-liter containers will be placed to contain the trash. The wall will be placed at the existing sorting stations called the ReAct-stations in camping West (E) and East (L).

On the top of the sorting wall a live barometer will be placed. The barometer shows the total amount of trash collected at the ReAct-station and at the sorting wall. The barometer consists of two screens displaying the amount of trash in tonnes. The function of the ReAct-barometer is to establish a nudging effect for the festival visitors to see the progress of trash collected during the festival. To establish a contest element, the ReAct-barometers at the two sorting walls, will show the two total amounts to compare the areas.



## Portable speaker

A wireless speaker system is developed to present the other projects to an audience. The speaker system incorporates a commercially available wireless microphone system and a custom-made enclosure designed to best reproduce speech.

The wireless microphone system consists of a small portable transmitter and a stationary receiver. A head set is mounted on the transmitter, so that the person who presents a project has both hands free during the presentation.

For the project, we have chosen to use four 6.5 "Visaton BG 17 full-range drivers. These have limited frequency response for both high and low frequencies, but seems to be well suited for the speaker system due to their frequency response in the midrange area that is most important for the reproduction of speech.

The box in which the system is implemented comes in two parts, the first of which is for all the electronics. The second part of the speaker cabinet is designed specifically for the four full-range drivers, and to reproduce speech.

In addition to being designed so as to reproduce speech, there will be straps mounted on the box so it can be worn as a backpack. The box will be relatively light weight, so you can carry it for a few hours at a time.

## Smart Grid

A lot of energy is used during Roskilde Festival, especially in some hours of the day. Roskilde festival has rented large generators which will produce the amount of energy exceeding the local grid capacity. They cost about 2 million. kr. in rental costs, and the festival would like to be able to do without them, if possible.

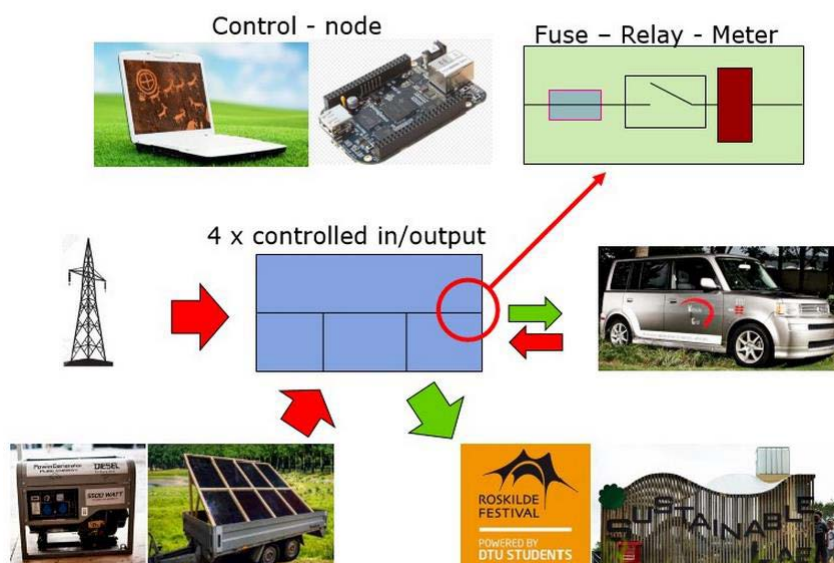
The Smart grid project aims to identify and optimize electricity consumption in DTU's TechLab, but may involve stalls and the entire festival through analysis and visualizations. We will try to show that with proper management of consumption and small flexible energy producers, it is possible to keep the power consumption evenly throughout the day in TechLab. The goal is to show that the connection to the power grid can be cut and the system can operate independently in "island operation".

During the week we will do measurements of average consumption in order to calculate the extent to which we can supply power to the stalls and the festival as a whole. The hope is that the festival will run only on green energy in the future and be independent of the Danish electricity grid.

The Smart Grid project is carried out in three sub-projects:

- Mobile smart grid - a mobile SYSLAB where everything can be controlled, as in the future smart grid. A solar trailer represents solar and wind energy, including the challenges that varying production provides. A modified electric car that can both receive and give power will act as a large battery.
- Interactive installation where four string lights will show the current flow in the cables, and where the public can help to control it.
- Analysis: What does it take for DTU's camp to be self-sufficient? Measurements + visualizations.

## SYSLAB in a box



## Life Cycle Analysis

The project examines the environmental aspects of abandoned tents at Roskilde Festival. Every year guests bring 50,000 tents to the festival. When the festival ends, many of those are left in the camping area. Clean-up work takes several months and removes about 1,500 tonnes of waste.

Why do many guests leave their tents behind? What could motivate them to donate them or bring them home? Could the abandoned tents be handled in a different and more sustainable way? Is it worth it?

We study three scenarios where the tent problem is addressed in alternative ways. Scenario 1: All tents given to charity. Scenario 2: All tents are produced and purchased through the festival (guests purchase tents online). Scenario 3: Everything is the same as today, but guests must disassemble the tents and sort the waste.

The study will use life cycle analysis to quantify the proposed solutions in terms of environmental and economic factors. A questionnaire will reveal the festival goers attitudes to the different scenarios - and their knowledge of the current situation.

Finally, the scenarios will be evaluated for their feasibility from an environmental and economic perspective.



## Energy consumption at the food stalls

Every year, the Roskilde Foundation has to rent electric generators to provide the whole festival with electricity. Their full capacity is only approached punctually during the festival; the rest of the time, smaller generators would be sufficient. Moreover, the stall owners pay a fixed amount for unlimited access to electricity during the whole festival: since the price is not dependent on the consumption, they are not encouraged to save energy. Roskilde Festival would like to switch to a consumption-based tariff, in order to give incentive to some energy savings.

This project investigates the possibility of reducing the festival's peak power consumption in order to decrease the size of the generators. This year a preliminary study of the possible electrical energy savings that would be achieved by controlling the operation of the fridges at the festival's stalls will be carried out.

An intelligent control of the fridge can be set up by defining an acceptable temperature range inside: below a certain threshold temperature level, the fridge can be switched off. It is actually how a fridge regulates its temperature in normal operation: by changing the temperature range and adapting the cooling power to the predicted use of the device, one can increase the time periods during which the fridge is off. If all the fridges at the festival are equipped with an intelligent switch device, the energy saved could become significant.

Moreover, if the daily electrical load pattern of the whole festival is known, the consumption peaks can be localized and the cooling consumption better distributed outside the peak moments. This would allow Roskilde Festival to lower the capacity of the electrical generators they rent, and therefore to save money.

As an example, if the power consumption of the festival is the highest during the evening, when the stages host the main artists, drinks can be cooled down in advance during the day and some fridges can be switched off in the evening. It can also be a good idea to increase the cooling power of the fridges in the morning after the concerts end, when the festival energy demand is low, so that the cooling demand can be decreased during lunch time.

If a consumption-based tariff for electricity is set, the unit price could also differ according to the time of the day. Indeed, in order to encourage stand owners to distribute their consumption outside of peak hours, the festival could sell electricity at a higher price in hours of high demand.

## Analysis of water use in food stalls

Currently the festival does not get any specific data for water use of the individual food stalls. This does not give the volunteers in the food stall any incitement to use less water. This project will analyse the water use in two selected food stalls.

The project consists of three elements:

**Measuring water use:** By using a flowmeter the water use of two food stalls will be measured. We will collect data for both the water use throughout the entire festival as well as water use for specific time intervals. We will compare the water use to sales figures for the stall, to see if there is any correlation.

**Nudging of users using water saving tips:** During the project we will develop an info sheet that gives the volunteers specific tips to use less water. This sheet will be hung in strategically smart positions in the stall, e.g. above the sink.

**Nudging of users using specific data of recent water use:** The second part of influencing the users consists of info boards, informing the volunteers of the water use used within the last couple of hours.

There will also be measurements taken on the first and the last day in order to decide the overall water use of the two food stalls. The results will be presented in a report of data and analysis, as well as a report of recommendation for Roskilde Festival.

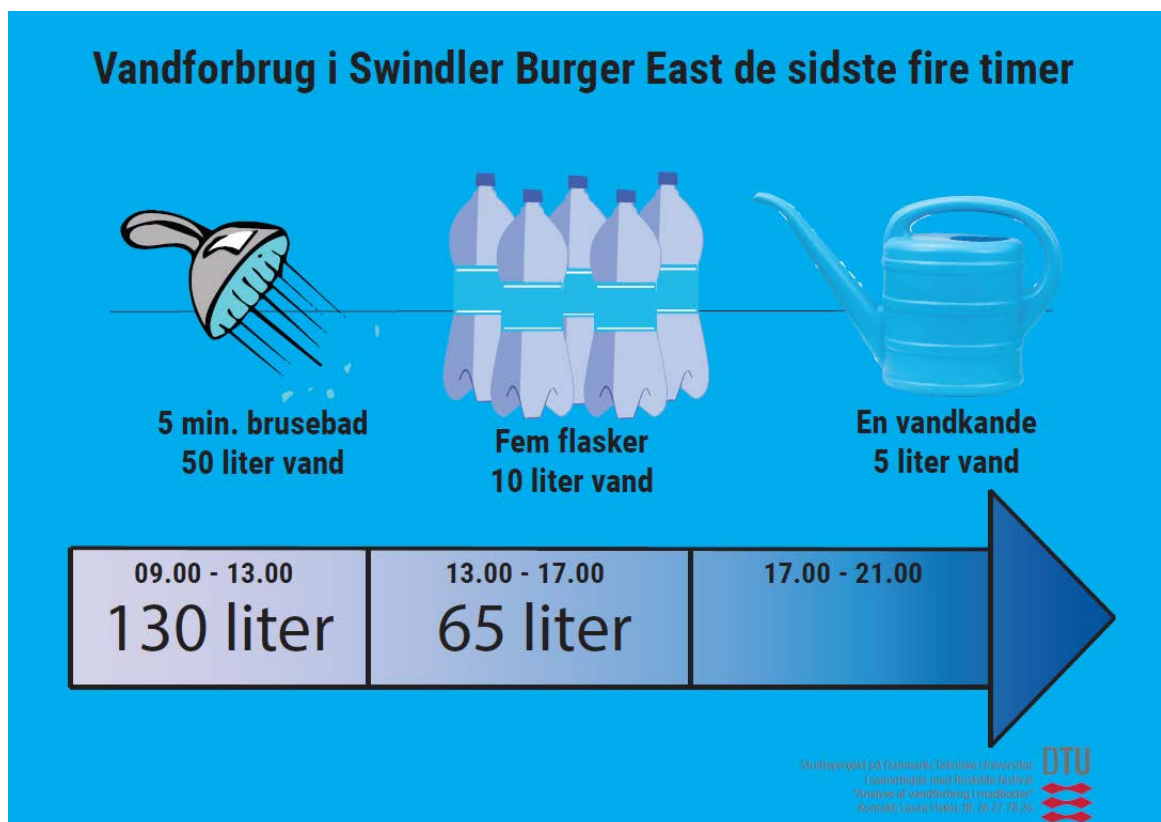


Illustration shows the water consumption in litres – and compares the result to a five minute shower (50 litres), five 2 litre bottles (10 litres) and a five litre watering can.



## Waste projects

One of the most significant environmental impacts from Roskilde Festival is undoubtedly the waste that is produced. Three projects examine festival goers' behavior and try to understand what it would take for them to be better at sorting their waste, and use the bins and recycling stations that the festival provides.

1. 50% of the tents at the festival are purchased for the purpose of the festival, and 35-45% of the tents will be left at the camping grounds. The project will examine why so many tents are left behind and the festival goers' attitude to new initiatives concerning, for example, collection or rental of tents.
2. Starting in 2015 Roskilde Festival provides bins at each of the parcels that the camping areas are divided into. This project investigates how a gamified solution could encourage people to increase the use of bins in the camping area. A poster with the faces two artist will be posted above the bins - one bin for each artist. During the festival the amount of trash the artists' have "received" will be shown.
3. A third group examines whether the festival guests change their behavior after being informed about the possibilities to recycle their waste and use bins in the camping areas. Garbage bags will be collected from four plots in camping East (L and N). In two of the areas students will explore the festival visitors' knowledge and inform them about the festival's new initiative of providing more bins. Later a follow-up study will show if awareness of the possibilities are improved and the composition of waste has changed.



## Planning shifts

Roskilde Festival is highly dependent on voluntary engagement. Each year, more than 30.000 people do volunteer work before, after, and during the festival. A voluntary worker is part of a team doing a specific job. The work is divided into shifts, and each volunteer must have shifts corresponding to at least 32 hours of work. No shift should be over- nor understaffed.

Additionally, volunteers can request to be put on shifts with their friends. This should be fulfilled whenever possible. Currently, the manpower schedules are constructed manually. As the number of volunteers increases, and more requirements are added, it quickly becomes a tedious and errorprone task.

In this project, we consider the problem of constructing manpower schedules, assigning volunteers to shifts. We only consider the subset of jobs concerned with transportation. Roughly 100 people are to be divided on 60 shifts.

We develop a software application for automatizing the constructing of manpower schedules. The application uses Operations Research techniques for optimizing the schedules with respect to the requirements.

Using the application in future years' planning should ease the task of constructing manpower schedules, as well as increase their quality. Highquality schedules are desirable because they utilize the volunteers in the best way possible, while pleasing them by putting them on shifts with their friends.

## KOSMOS – Transport analysis

The festival organizers are interested in mapping their internal driving for the duration of the event. It is desired to develop a system that continuously clarifies the environmental impact of each drive, as well as a way to optimize the driving. The solution is the development of a dual function program.

The program's first function is to map internal driving. This is done through the installation of GPS trackers into festival vehicles. Data is collected on vehicle location, which maps distance covered and creates a graphical overview. It is then possible to determine the environmental impact of each route over a given time frame.

The program's second function is to reduce the festival's overall driving time and vehicle use by optimising trips. This is done through increased communication between members. A web page is created for members to post whether they have extra space or are requiring a vehicle and can be seen by all. Users input information on the space available or required and have the option of uploading a picture for transparency. It is then possible for the user to accept or decline a request when the description matches the user's needs. The program works in the same way for those seeking out an offer.

A single vehicle has been chosen to pilot the project. Future plans include the development of a mobile application that replaces the necessity of a GPS tracker and simplifies data retrieval.

