# MORENPBIZ.

## More Natural Product Business by Enhanced Quality and Energy Efficiency of Drying

Interreg Pohjoinen
Euroopan aluekehitysrahasto

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# Q&A 21.4.21

## The Project Partners

**Finland**
**Centria University of Applied Sciences (Centria)**
**Oulu University of Applied Sciences (Oamk)**

**Sweden**
**Luleå University of Technology (LTU)**
**Hushållningsällskapet (HS)**

# Results summary

- mobile dryer (OUAS), adjustments and trials with the mobile dryer ongoing
- demo dryer (Piteå, Hushållningssällskapet), adjustments ongoing
- recommendations for dryer entrepreneurs
- updating Orakas dryer
- design and instructions for the construction of a modular dryer and an economic flat bed dryer
- recommendations for the drying temperatures(nettle, birch leave, rose root)
- quality characterization methods for nettle, rose root, birch leaves
- waste energy map for drying

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# MODELLING AND DESIGN OF THE DEMO DRYING UNIT

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Energy Engineering

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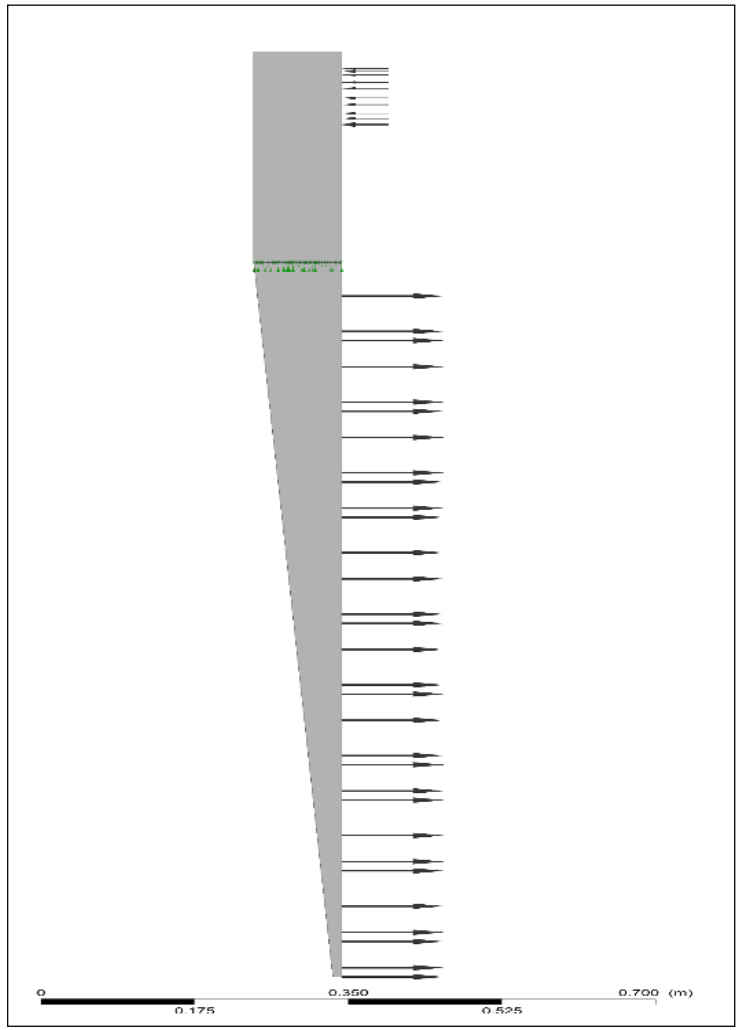
# Agenda

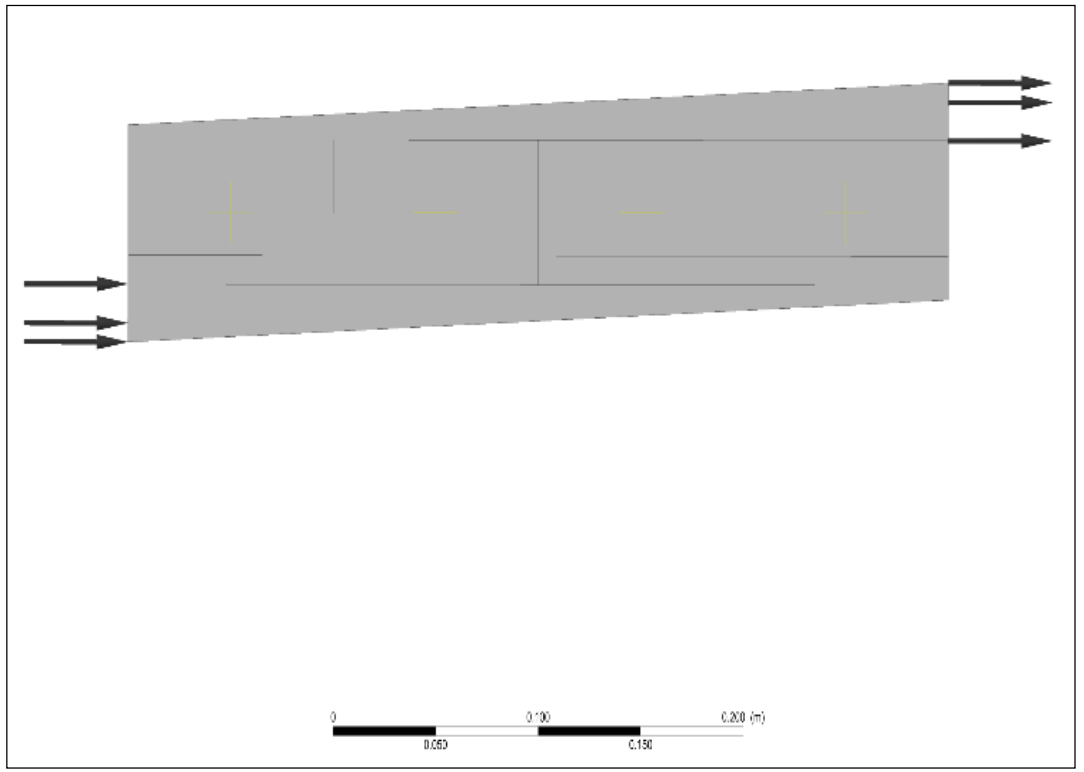
- Modelling
- Construction
- Results from first drying tests

# Modelling

- CFD (Computational fluid dynamics)
  - Solving the fluid flow and heat transfer using numerical analysis
- Why computational?
  - Experimental
  - Analytical
- Complement experimental and theoretical fluid dynamics
  - Better visualization and enhanced understanding of design
  - Testing many variations to get optimal results before physical prototyping and testing.

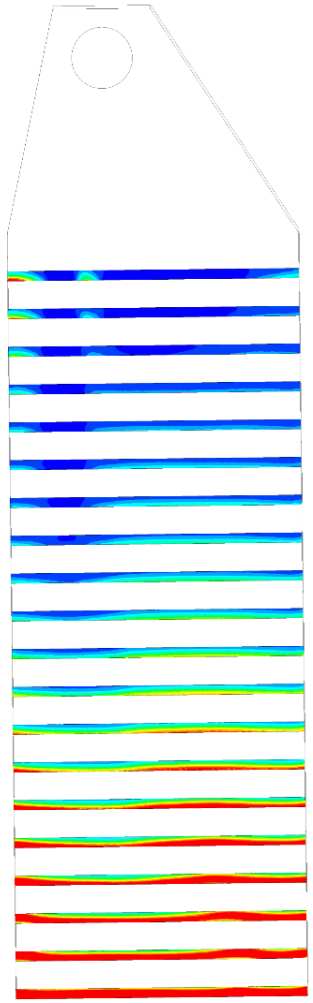
# Modeling of demo dryer

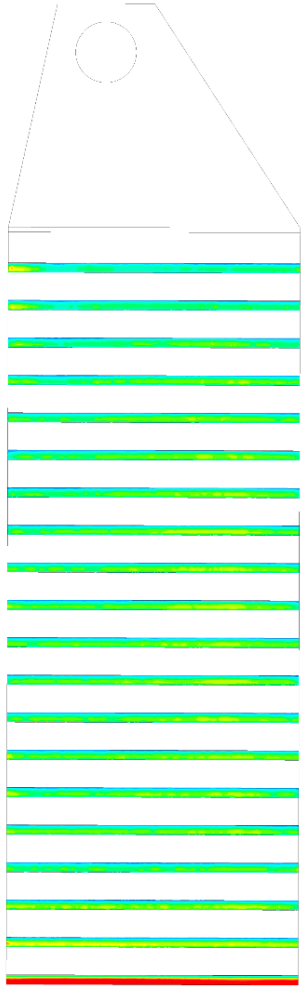


# Modelling results

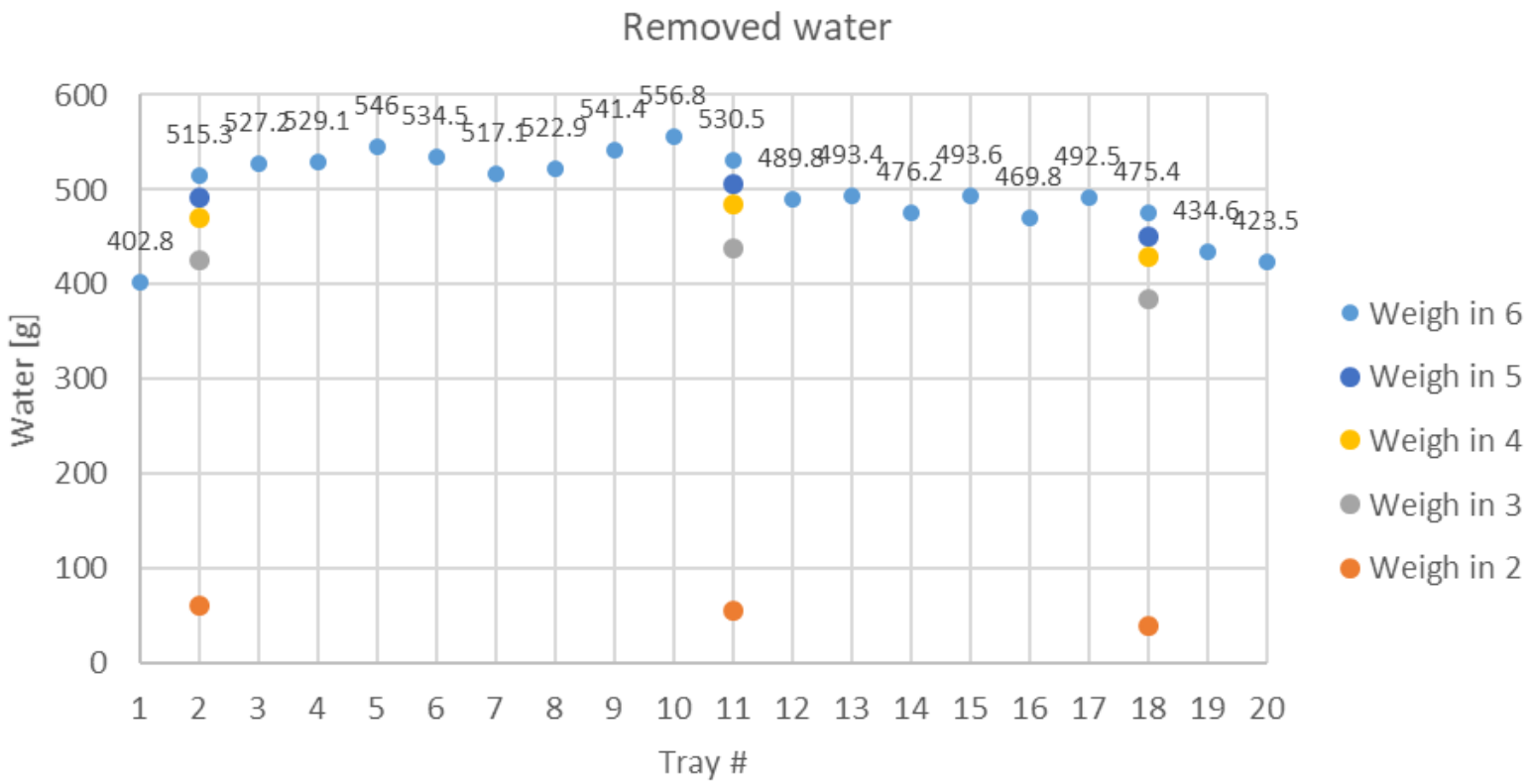
- Before optimization (left)
- After optimization (right)



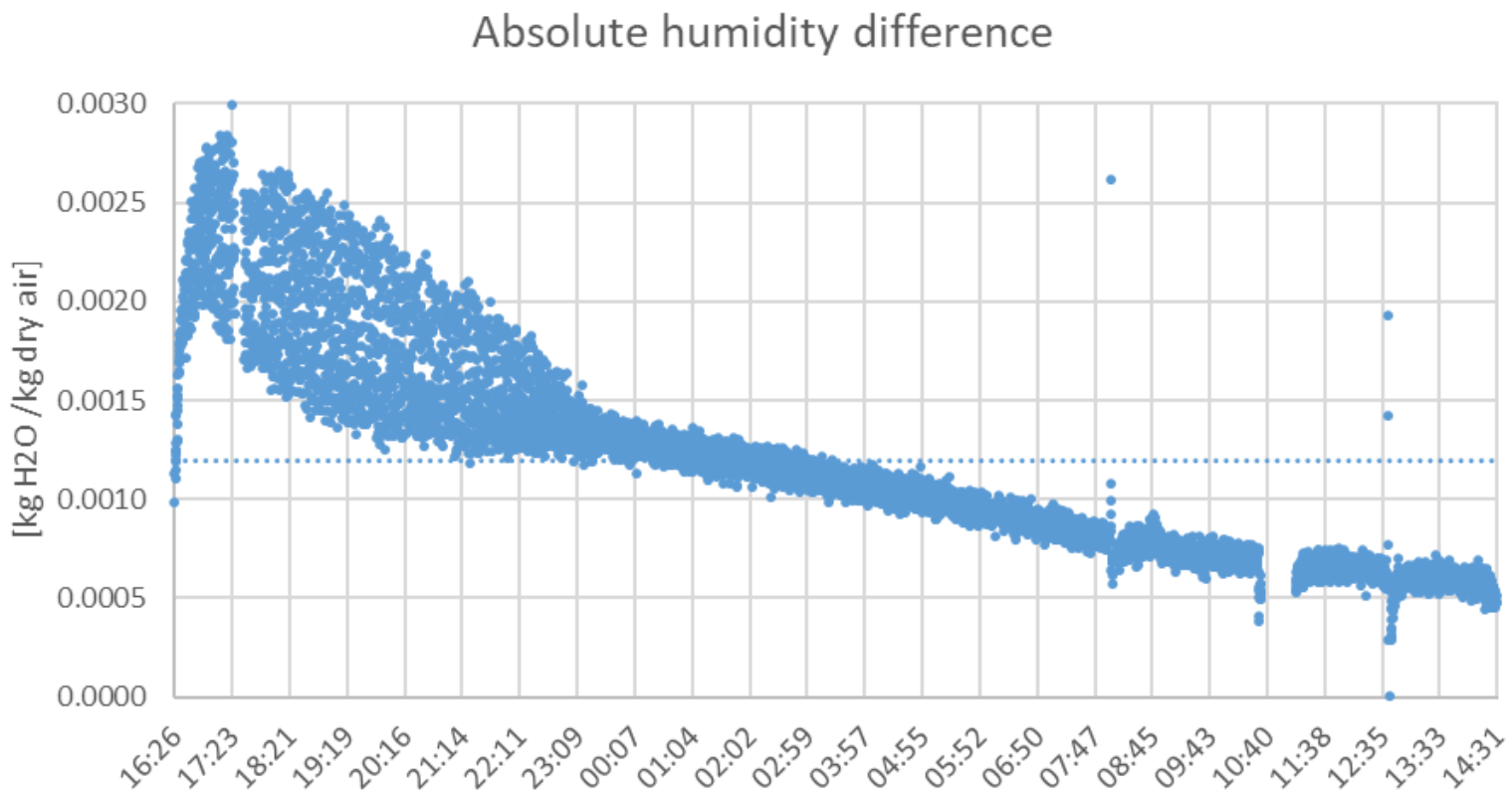


# Dryer

# Results from first drying test



# Results from first drying test

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# Demo dryer Öjebyn Agropark


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# The organization model:

Three potential cluster identified; Jokkmokk, Tornedalen and Öjebyn

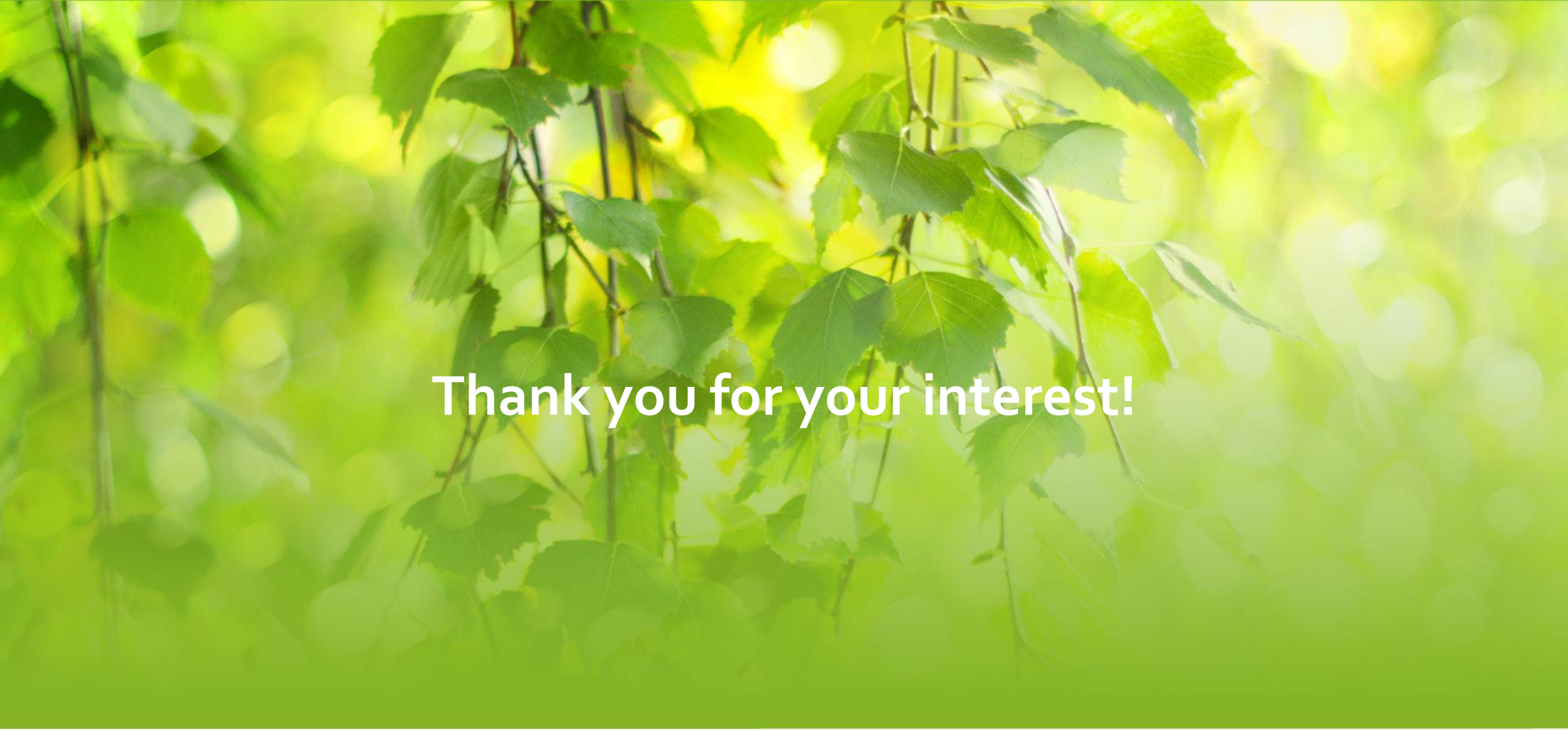
**Jokkmokk** - small scales entrepreneurs using herbs and plant as an essential part of their production, on-going cooperation between the entrepreneurs, willingness to grow and a supportive business advisory service.

**Tornedalen-** small scale business concentration within food, and interested in developing new products. A newly developed Berry center, with a potential to grow also into wild herbs and Berries.

**Öjebyn –** Öjebyn Agropark is a center for innovation and testbeds for the green sector. The stationary dryer will be based here. Test fields for plants and greens. Demonstrations and Disseminations.

# What we have in mind

- The assessment made during the project period is that a drying association or a drying collective should be established, consisting of companies that are engaged in picking and drying
- The association will initiate competence development and course activities linked to drying and picking as well as provide a bookable concept for the dryer in Agropark Öjebyn
- By establishing an association, a clearer platform is also created for an increased exchange of skills between companies and pickers in Sweden and Finland. Special initiatives will be launched for new companies to emerge and for jobs to be created in picking and drying.

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# Possibilities to use waste energy in drying application

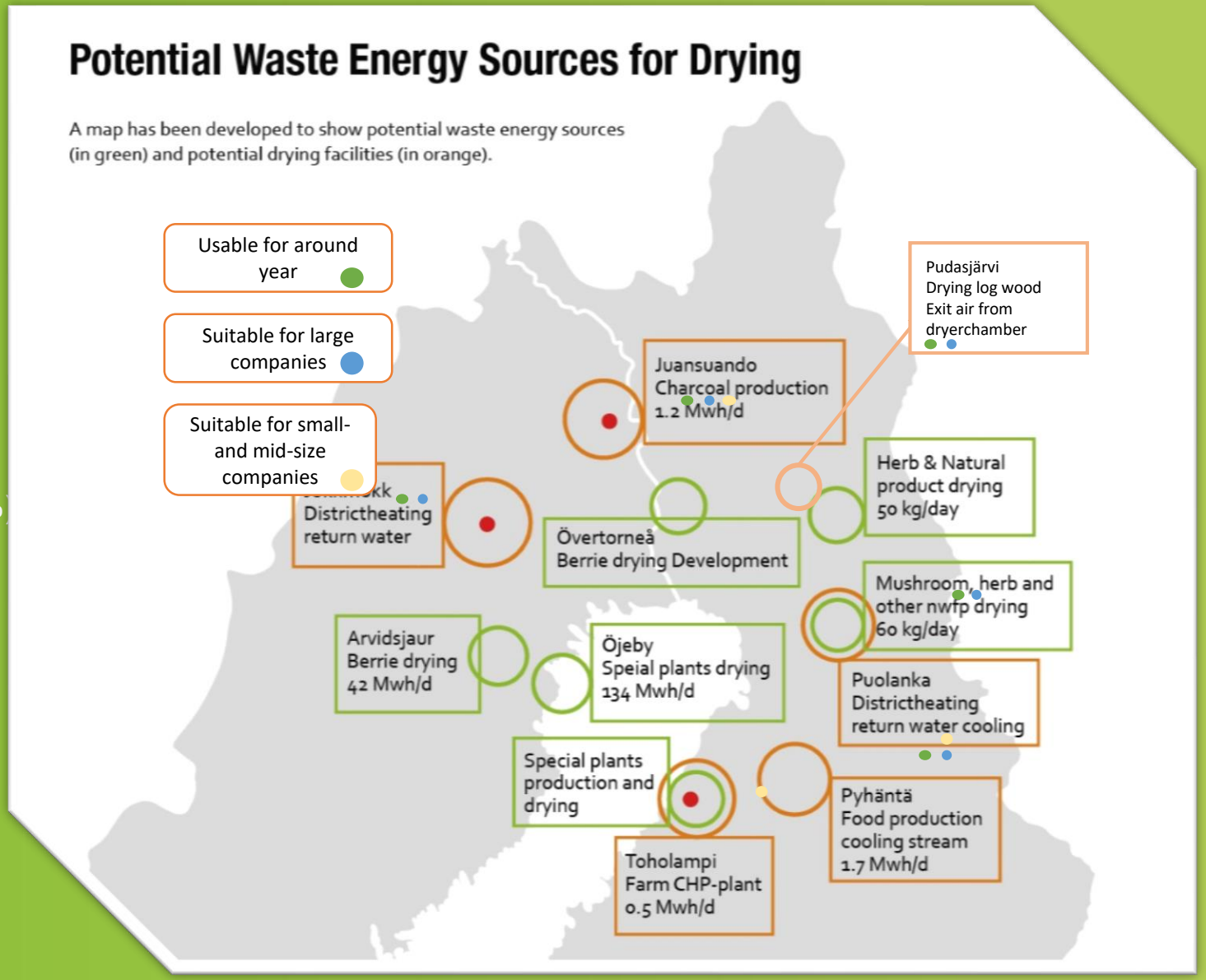
Possible waste energy sources

- District heating plants
- CHP-plant excess heat for part of year
- Food treatment facilities for excess energy

Overall excess heat can be found from places that are not using heat generated by heating or cooling process.

Price vise using waste heat is smart:

- districtheating returnheat for 100Kw connection at Toholampi is 37€/Mwh (vat.0%) + fees 2500€/year (vat.0%) but connecting fees are slightly higher 15000€ (vat.0%)
- Costs are approximately half of comparing to straight district heating



# Connections and costs of taking waste energy in use

District heating return water costs vary much due the level and quantity of usage

- in good cases reduction in energy price can be half

Almost every other method of using waste heat is varying how user wants to setup systems but basic setup would need:

- heat exchanger for 5kW-50kW: 100€ - 400€
- pump units for closed system 50€ - 300€
- tubings depending of length 3€/m
- heater unit for 5kW – 50kW 300€ - 600€

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# Possibilities to use waste energy in drying application

## Hygienic factors in using waste heat

- If using air supplied waste heat it rarely fits straight for purpose
  - Normally good filtering or total separation of air streams is needed.
- Water circulated systems are easier to harness in use
  - Easier to find radiator element to fit dryer heating purpose
- Environmental factor also need to be looked at
  - Does environment cause contamination
  - Does no fit the purpose

Imago

## Price factor in using waste energy

- For getting good quality the relation between profit and costs need to be in line
  - Using waste energy can cost a lot at first but its normal in starting an investment.
  - Is it water circulated or air circulated system
    - Water circulated system is easier to do and less expensive in many cases
    - In air circulated systems energy needs to be first converted in water circulated system so it can be controlled in process

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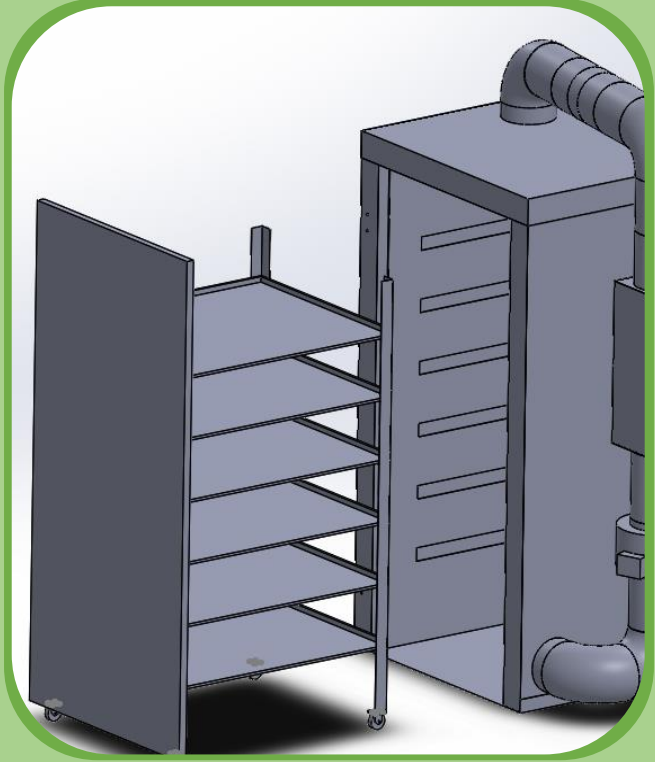
# Development of a modular dryer

This dryer is designed to be chained so that producer can have three step drying

1. Pre drying free water. Free water is evaporated in last chamber with partially moist air and bit lower temperature.

2. Partially bound water is evaporated in mid chamber so air is still relatively dry an warm.

3. bound water is evaporated in first chamber with highest temperature and driest air.



## Area and capacity for drying

If a dryer is used as a single unit it can be loaded full 3 cm thick layers depending of material.

When chained more units the thickness of layer should be less so it wont restrict too much airflow.

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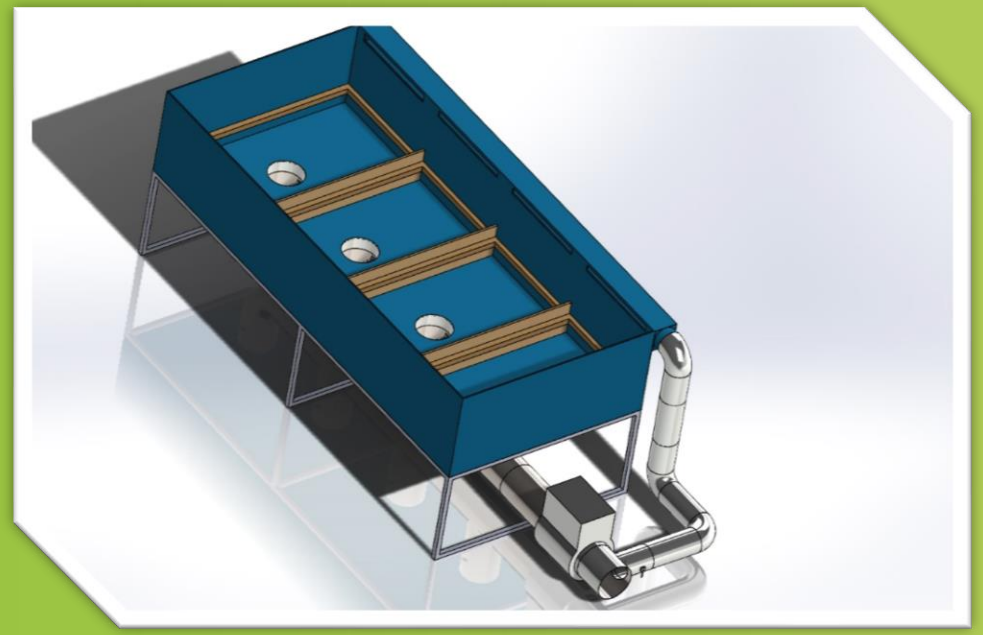
# Updating the design of a flatbed dryer

Starting point is an old farm flatbed dryer

- originally suited for grain
- no temperature control or airflow control
- no cover -> efficiency poor

Basic modifications designed only using basic components

- controllable airflow and heating unit
- air recirculation and soft cover for better efficiency



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# Importance of  airflow direction in dryer

Costs over quality in drying equipment is hard to determine but in aims to get even drying results -- more designing is needed for basic products

General configuration in almost all commercially available dyers

- heater fan unit at the bottom
- shelves holding products are horizontal and normally from 3 to 6 shelves
- airflow in dryer is vertical
- trough blowing hot air only one sycle

This configuration causes typical problems of household dryer

- uneven drying, fast drying at bottom and slow drying at the top
- possible temperature differences inside dryer
- hefty electricity consumption

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# Normal household dryer updated economically as an example (convection dryer)

## Starting phase

- Temperature control
  - Inaccurate temperature controller causes waving in temperatures ±10C°
  - In products that need accurate temperature in drying some valuable content might be lost
- Airflow
  - In many cases airflow is vertical from down to up
  - Large temperature differences

Drying birch leaf with Orakas dryer after updated thermostat

Accuracy gained ± 5 C°

By turning dryer on its side airflow is made horizontal and better. More simultaneous drying for products.

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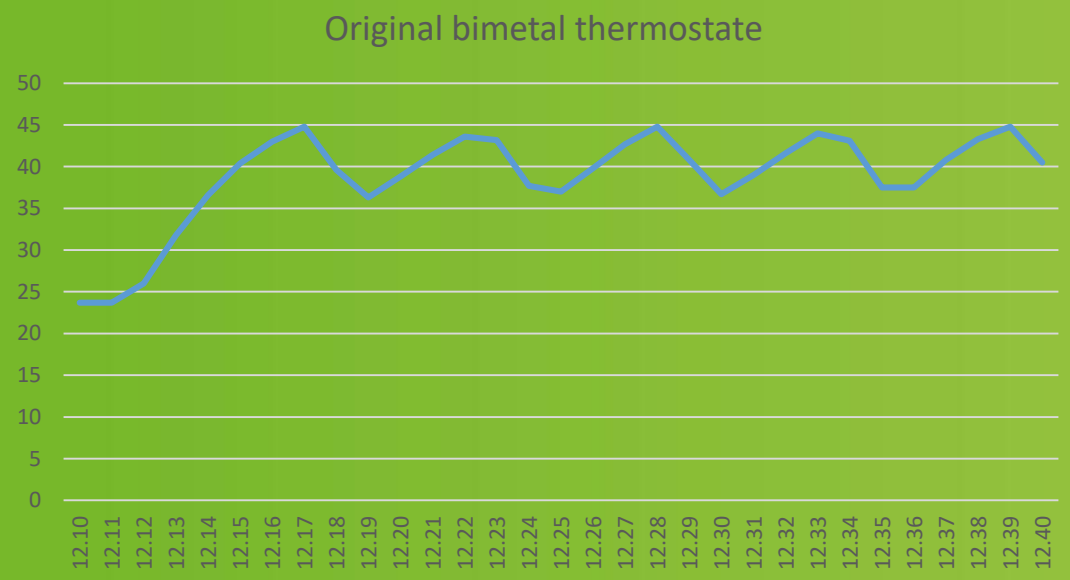
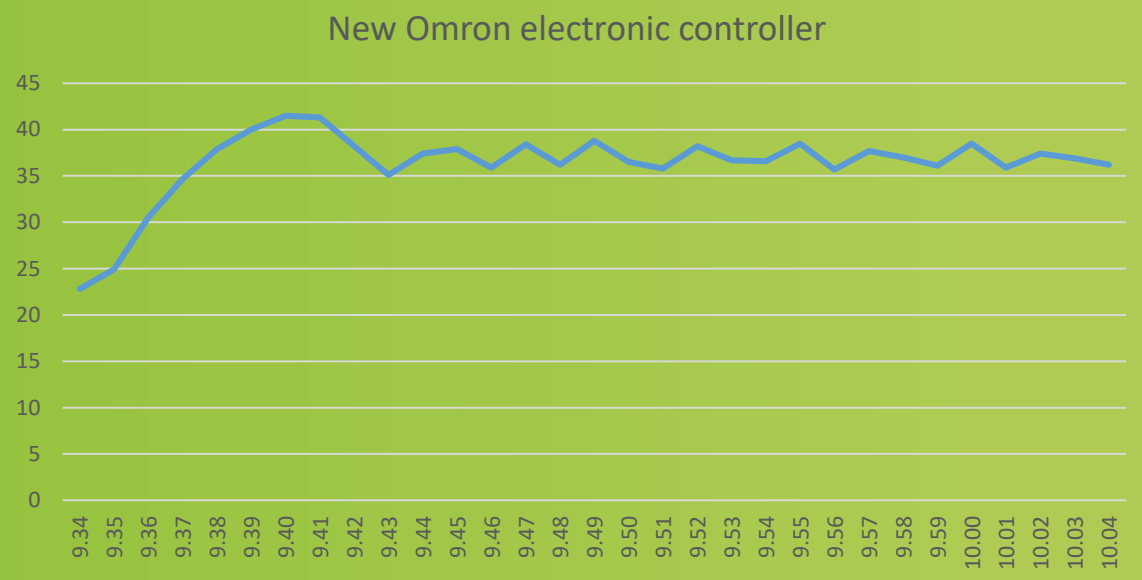
# Updating dryer thermostat to new Omron PID controller

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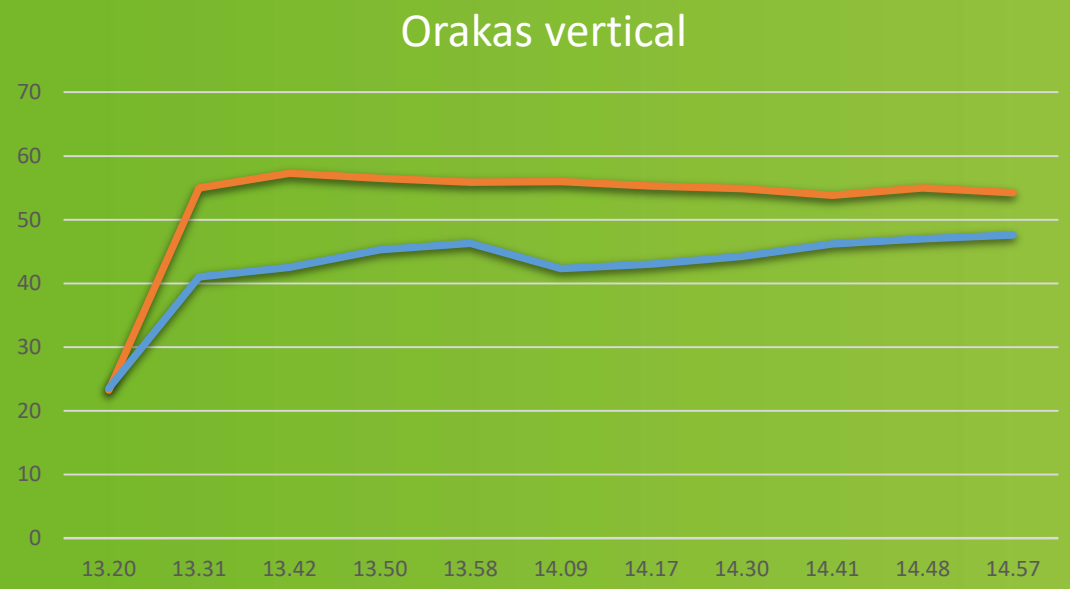
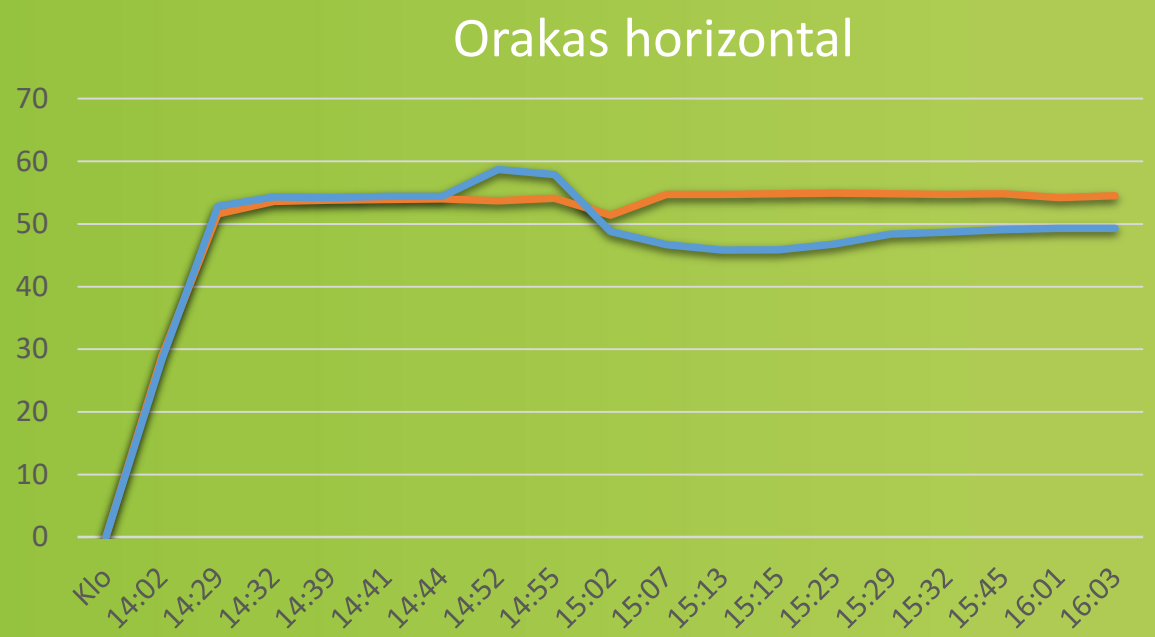
# Advantage in leveling temperature differences by horizontal airflow




Exit end

Heater end

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# Normal household dryer update economically (convection dryer)

Adding air recycling channel

- Gains energy efficiency
- Costs per gained advantage is low (5-10€)
- Dryer is heating faster at starting point
- In some cases works as an extra insulation

In original design heated air is blown only once trough dried batch

Air is recycled again in the lower part of dryer via simple veneer channel and mixing naturally with fresh air at lower part of dryer.

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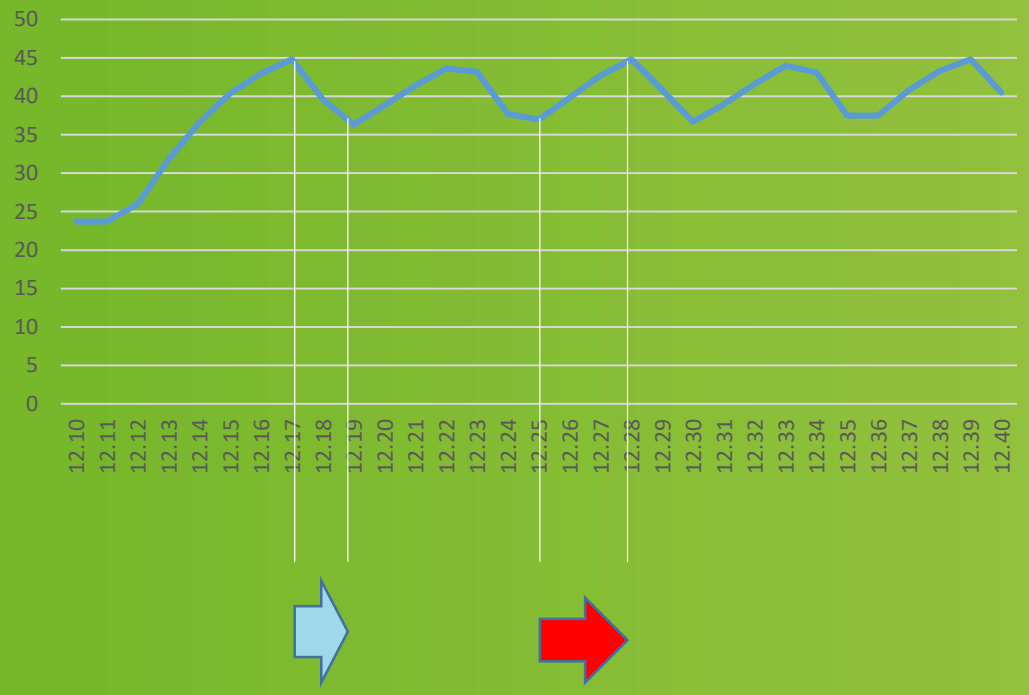
# Normal household dryer update economically (convection dryer)

Orakas dryer without air recycle channel




Dryer cooling faster than heating

Orakas dryer with air recycle cannel


Dryer heating faster than cooling

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# Introduction to quality

- Plants contain many compounds that affect
  - Healthiness
  - Color, taste, scent
- Chemical composition in plants varies depending on species, growing conditions, geographical location and growth stage.
- However, the chemical composition of the end products also varies depending on the type of harvesting and processing (freezing, chopping, milling, drying).
- Competition in price is extremely hard, but a quality product can stand out in the market.

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# Introduction to quality

- If you want to improve the quality of your product, a few things should be considered in advance:
    - When the material is harvested?
    - How is the material processed, can it be processed fresh?
    - If the material is dried, what drying method or dryer is used?
    - What is the optimum drying temperature and the end point of drying?
- In MoreNPBiz –project, we studied the effect of dryers and drying temperatures on polyphenol content and antioxidant capacity.

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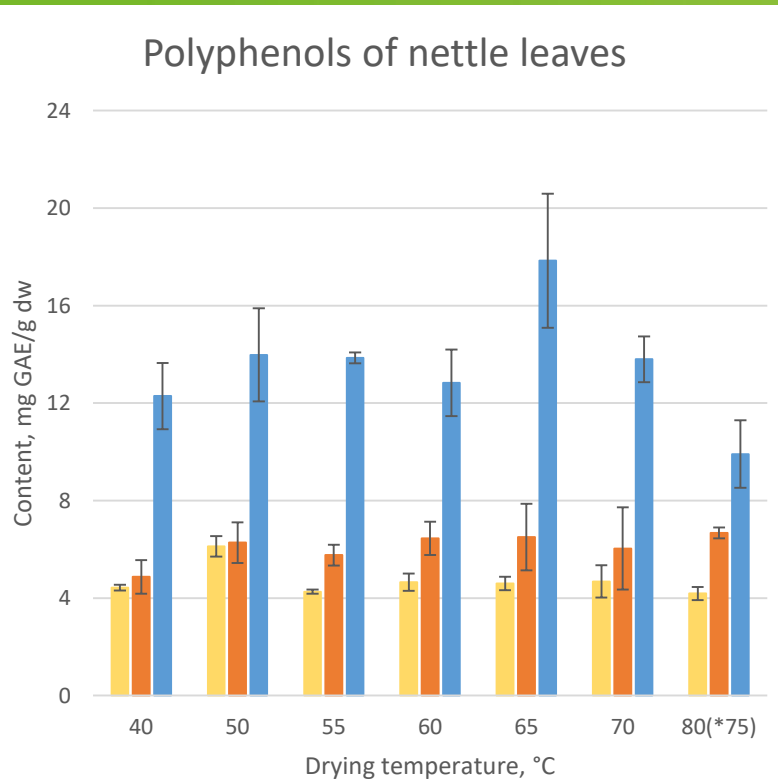
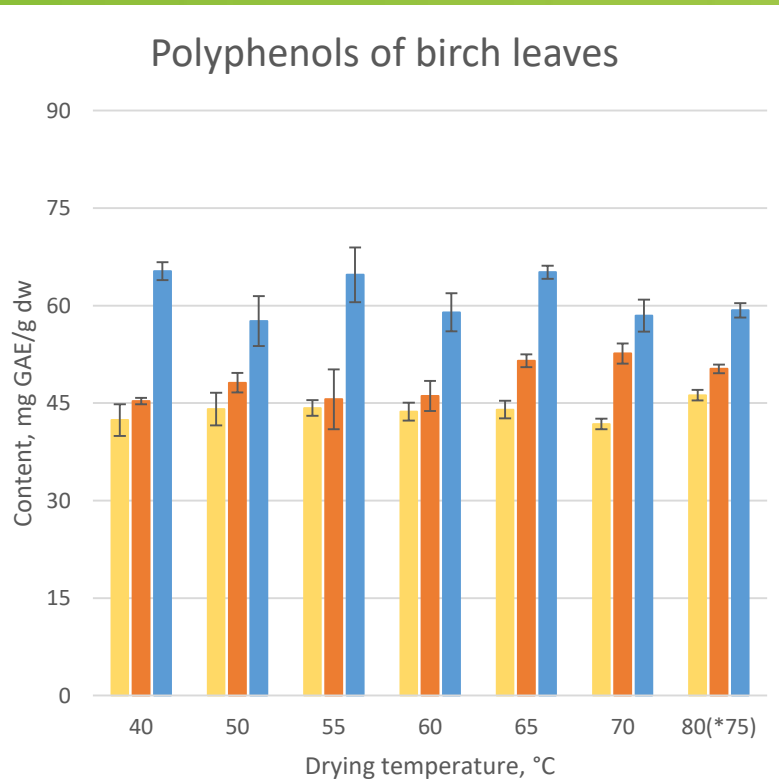
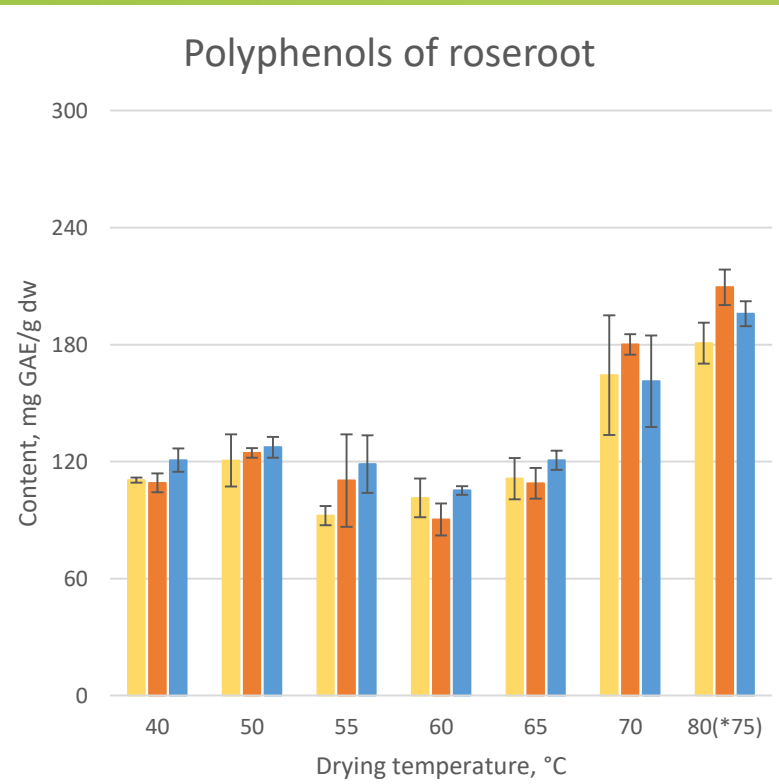
# Quality results – Polyphenol content

- The highest polyphenol contents were achieved with vacuum dryer
  → material is less in contact with oxygen
- Difference between heat oven and Orakas is small, but slightly higher contents are obtained with Orakas.



# Quality results - Effect of dryer and drying temperature

- Dryer had a greater effect on polyphenol content and antioxidant capacity than the drying temperature.
  → The selection of the dryer is important.

- Drying temperature from 40 to 80 °C did not have significant effect on polyphenol content or antioxidant capacity. In many cases, higher drying temperature gave better results.
  → Higher drying temperatures (over 60 °C) could be used, which would save energy and time and improve microbiological quality.

- Drying temperature should be optimized for each material/product separately
  - E.g. if the product is used as an aromatic scent, different compounds than polyphenols and antioxidants are wanted to preserve. What is the optimum drying temperature then?

- Color, taste and scent can be observed by human senses and laboratory analyses may not be necessary to verify quality. However, the content of active compounds should be verified with analyses.

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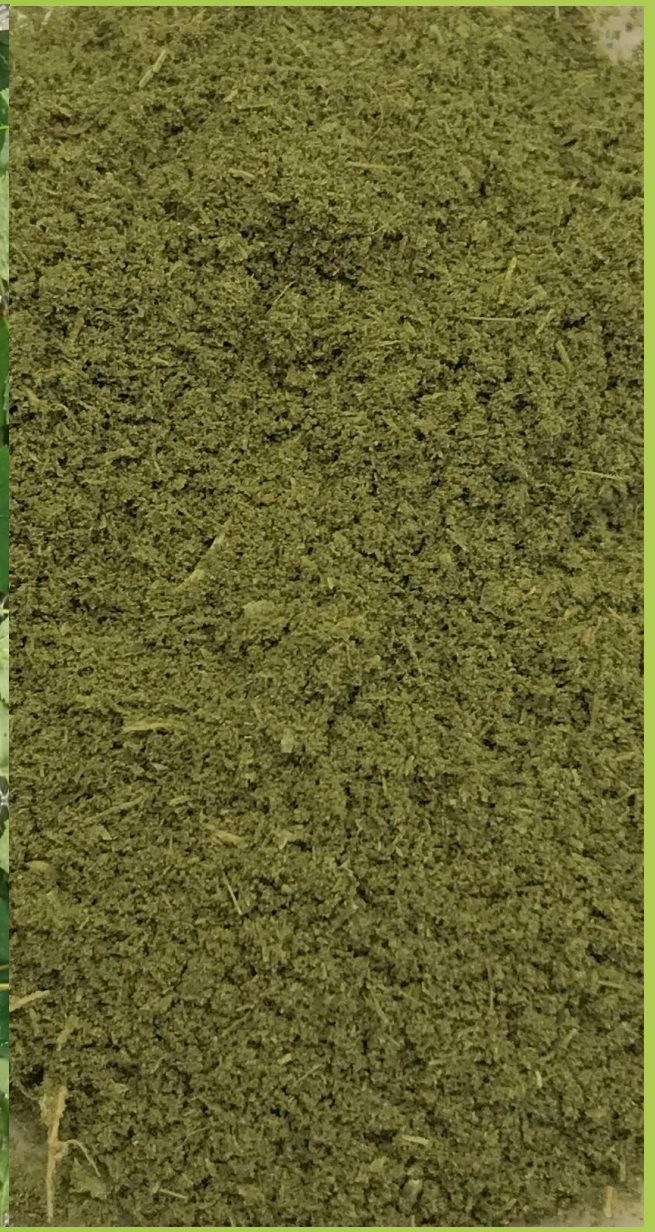
# Moisture content

- Often, the end moisture content of 10 wt-% is suitable for many products.
- Drying much under 10 wt-% leads to unnecessary energy consumption. It can cause changes in structure, color, taste and odor of the material or cause heat sensitive compounds to degrade or evaporate.
- Drying much above 10 wt-% will shorten the shelf life of the product and cause early microbe growth and mould.



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MoreNPBiz tasks of OUAS (Oamk)

- **Evaluation of the functionality of plant dryers in the companies. Proposals for improving their energy efficiency and performance.** *Luonnontuoteyrittäjien kuivureiden toimivuuden arviointi ja energia-tehokkaiden parannusehdotusten tuottaminen.*
- **Improving product quality by speeding up the start of drying process. A mobile dryer prototype was developed for this purpose.** *Liikuteltavan kuivuriprototyypin rakentaminen. Tavoitteena on luoda tekniikkaa, jolla kuivausprosessi saadaan aloitettua nopeasti keruun/korjuun jälkeen laatuvirheiden välttämiseksi.*
- **Studying business opportunities in plant drying and preparation.** *Kuivaamiseen ja kauppakunnostukseen liittyvien liiketoimintamahdollisuuksien kartoittaminen*


- The typical failure in the flat bed dryer is the uneven air flow on the grate. To balance air flow rates, one has to build more ”labyrinth” to the air channel.

- Mostly the fans used in flat be dryers were too effective. A variable speed drive is a necessary tool to decrease air velocities and excess energy consumption.

- Report of our study in Finnish and Swedish available on the website https://tki.centria.fi/hanke/morenpbiz/1936

- Improving existing cabinet dryers requires services of a professional electrician to make the modifications to the wiring system.
- At least old thermostats should be replaced by more precise devices.
- One model of modernisation of the old cabinet dryer in on the way in collaboration with Ampplance Oy. This model will be published on the MoreNPBiz website.

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**Mobile dryer** consists of a frame and an easily movable drying box with a perforated steel grate.

The centrifugal fan is controlled with a tyristor. The 12 kW heater sounds big, but as it should be able to heat incoming air from 10 - 15 °C to 40-50 °C , effective thermal input is needed.

*Several errors were made during the design work.*

*In the beginning we wanted to design a two-layered mobile dryer, and an effective fan was purchased.*

*As the construction work proceeded to practical solutions, we noticed that the 2-layer model will be too heavy for the trailer. As a result we have a dryer with a too big fan and an appropriate heater.*

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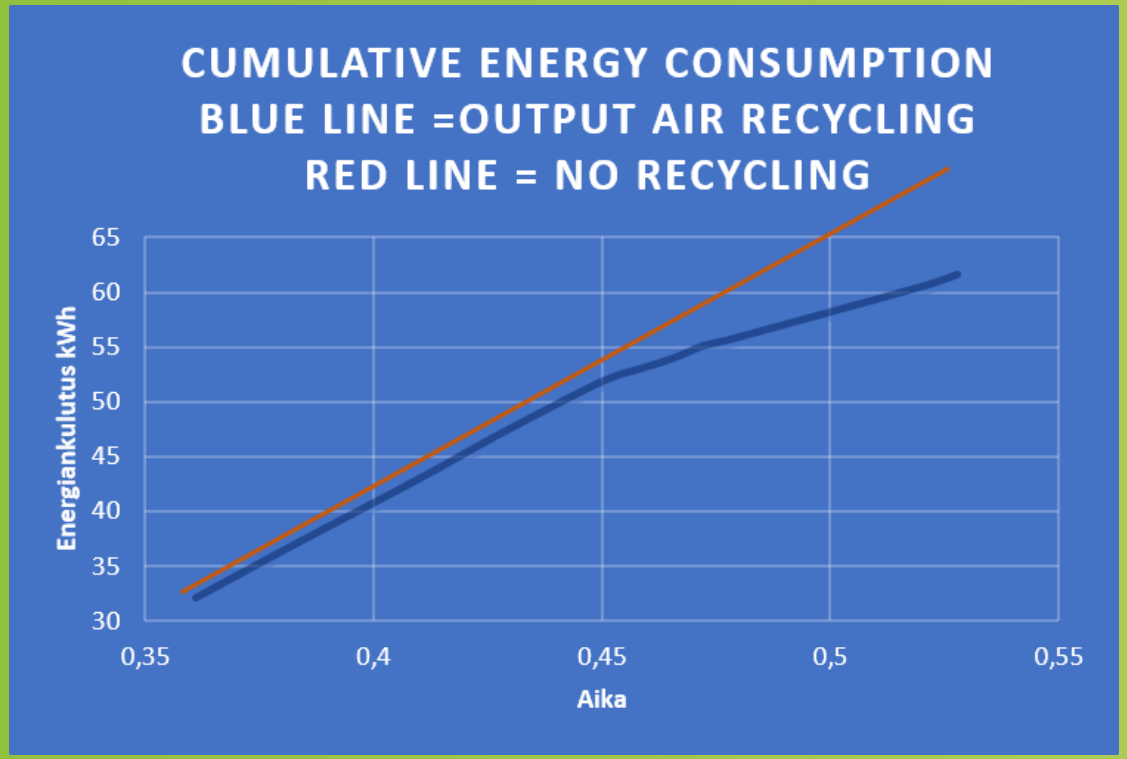
Recycling output air in the later half ot the drying process decreases electricity consumption approx. 20 – 30%. We used a simple dust hose as a recycling hose.

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**An economic calculation of a drying and preparation unit was made.**

The unit works 6 months and dries and prepares annually around 10 tons of fresh herbs, mushrooms, vegetables and berries. The unit employs one part time (2/3) worker.

The cost of drying and preparation of herbs was calculated to be approx. 2,00 €/kg fresh material in order to keep the business viable. This cost if calculated as €/kg dry product, would be around 12 - 14 €.

Besides drying and preparation, other services had to be included to make the business profitable (washing, extraction...)

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NP companies usually purchase dry herbs from their subcontractors, and the price can vary between 20 – 30 €/kg.

This means that after the drying costs the subcontractor will earn from picking and collecting natural herbs around 8 – 16 €/dry kg or 1,5 – 3 €/fresh kg.

**This kind of unit could suit to a half-time entrepreneur**

**Still futher development of the branch needed to make drying business profitable and fair.**

**To save working hours:**

- **Automatisation of the drying processes**
- **Bigger batches to be dried**
- **Cultivation of herbs and special crops instead of extensive collecting**

# Questions

- Pakurin kuivauksesta/drying of chaga:
  - kuivaus 10-14 kosteus%:iin?
  - Drying to 10-14% moisture?
  - Mitä aiheutuu liiallisesta kuivauksesta?
  - What happens if chaga is dried too much?
  - Miten voi luotettavastii mitata pakurin kosteuden?
  - How can moisture of chaga be measured reliably?
  - Kuinka paljon kosteus vaihtelee pinnan ja sisäosien välillä?
  - How much is moisture varying between surface and inside chaga?
- Pakastekuivaus/freeze drying
  - Mitä kuivattu, analyysituloksia/miten ominaisuudet säilyvät
  - Which materials have been dried/analysis results?/properties after drying?
  - Missä tehdään analyysejä?/ are there any laboratories?
  - Onko kasveissa ihmisen hyvinvointia auttavia  yhdisteitä? Are there any ingredients for wellbeing?
    - Cosmetics, health food?

- What is the best way to dry herbs, fruit, meat and sausages in large volumes?

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# Drying fruits and berries

- (Heat pump assisted) drying on drawers /*kondenssikuivaus hyllyillä*
- **Preventing browning before drying** /*ruskettumisen esto ennen kuivausta :*
  - Dipping fruit slices to hot water (potato, carrots, NOT onions)
  - *Kalttaus kuumassa vedessä (peruna, porkkana, EI sipuli)*
  - Soaking in a dilute sulfite solution or ascorbic acid/citric acid solution
  - *Liottaminen sulfiittiliuoksessa tai askorbiinihappo/sitruunahappoliuoksessa*
- **Osmotic dehydration/*osmoosikuivaus***
  - Fruits – Dipping slices/pieces in hot water (?)/ *Palojen/viipaleiden kalttaus*
    - Soaking fruits in a strong sugar solution 1-2 days/ *Liotus vahvassa sokeriliuoksessa*
    - Rinsing → Final drying / *Huuhtelu → Loppukuivaus uunissa*
  - Berries – Dipping berries in hot oil (80 °C) for 10 min / *Kalttaus 80 –asteisessa öljyssä*
    - Soaking berries in a strong sugar solution 2-3 days /*Liotus vahvassa sokeriliuoksessa 2-3 pv*
    - Final drying / *Loppukuivaus*
- **Drying as purée /*Kuivaus soseena***

# Drying herbs in the best way in large amounts
# *Yrttien kuivaus isossa mittakaavassa*

Drying all year around or seasonal? */Onko tuotanto ympärivuotista vai kausittaista?*

Probable turnover of the dried products? / Todennäköinen kuivattujen tuotteiden liikevaihto?

**Belt dryer** - expensive - large production unit– over 10-15 ha of herbs/ *Hihnakuivuri-kallis – yli 10 – 15 ha yrttejä*

**Flat bed dryer** – cheap -– small or large production. If large, usually several dryers / *Lavakuivuri – halpa – iso tai pieni tuotanto. Jos iso, yleensä useita lavakuivureita rinnakkain.*

**Heat pump assisted cabinet dryer** - preferably for large production units as the price of the device is relatively high. / *Kondenssikuivuri – mieluummin isolle tuotannolle, koska laitteisto suhteellisen kallis. 2-3x lavakuivurin hinta?*

**Vacuum dryer** – very expensive – for valuable products or large production

**Freeze dryer** – very expensive – for valuable products or large production.

# Drying chaga /Pakurin kuivaus

**Assessing the end moisture content:**

- Take few samples and measure their D.M. content by drying them in the oven at 105 $^{o}$C for 24 h
- → estimates of the average moisture content
- Weigh the material to be dried, and start drying
- Calculate how much water should be evaporated until the material reaches 10 % moisture content
- By weighing the dried material you find out whether enough water has evaporated , continue drying if needed
- Ensure the result by crushing the material it a bit

**Drying roots and tubers**

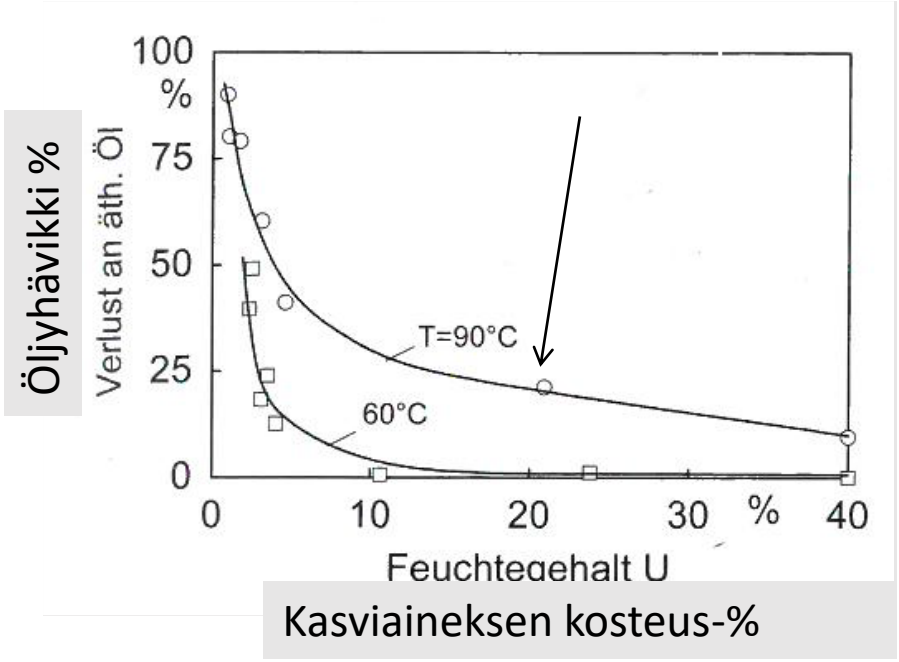
- Pausing the heat for 1-2-3 hours in the middle of drying improves the inner and outer quality → Moisture from the inner tissues has time to diffundate towards the surface during the break

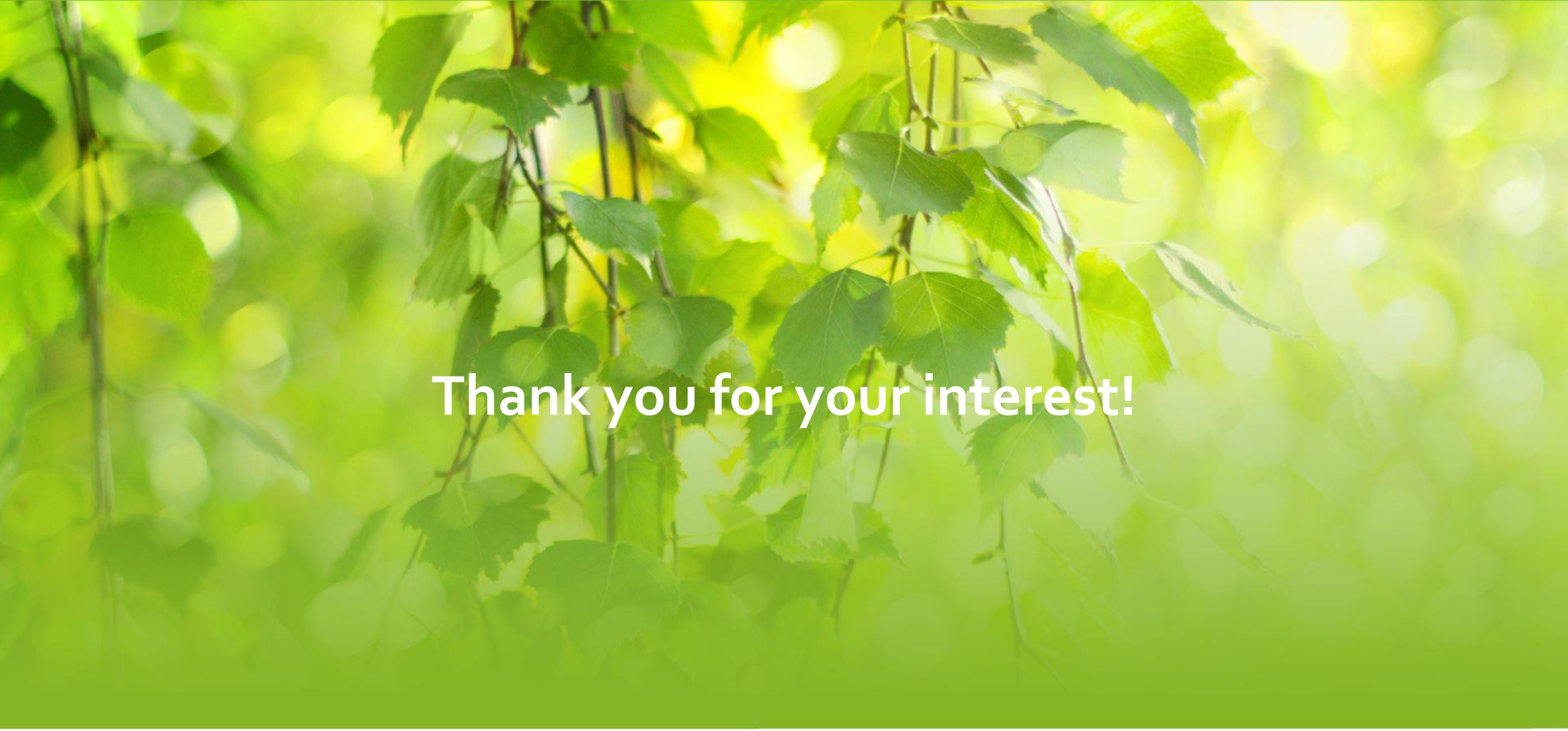
- For carrot slices the pause should be held when there is still 30-40% moisture in the root

**Too much drying**

- Quite little research available on this topic

- Essential oils seem to evaporate if material is dried too dry



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