SINTEF Energi AS
SINTEF Energy Research
Address:
Postboks 4761 Sluppen
NO-7465 Trondheim
NORWAY

Telephone: +47 73597200
Telefax:+47 73593950

energy.research@sintef.no
www.sintef.no/energi
Enterprise /VAT No:
NO 939 350 675 MVA

Memo

CREATIV D 4.2.19

PERSON RESPONSIBLE / AUTHOR
Trond Andresen
Kristina N Widell
Michael Bantle

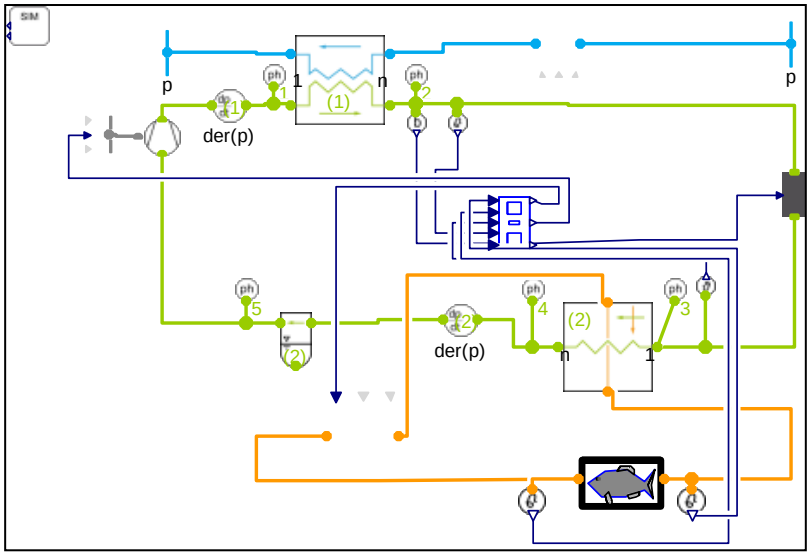
FOR YOUR ATTENTION
COMMENTS ARE INVITED
FOR YOUR INFORMATION
AS AGREED

DISTRIBUTION
Creativ consortium

PROJECT NO / FILE CODE	DATE	CLASSIFICATION
16x898	2012-11-29	Unrestricted

Deliverable 4.2.19, presentation held at consortium day, Stockholm 2012-10-22

Cases Fish Industry



Michael Bantle, NTNU

Kristina Widell and Trond Andresen,
SINTEF Energy Research

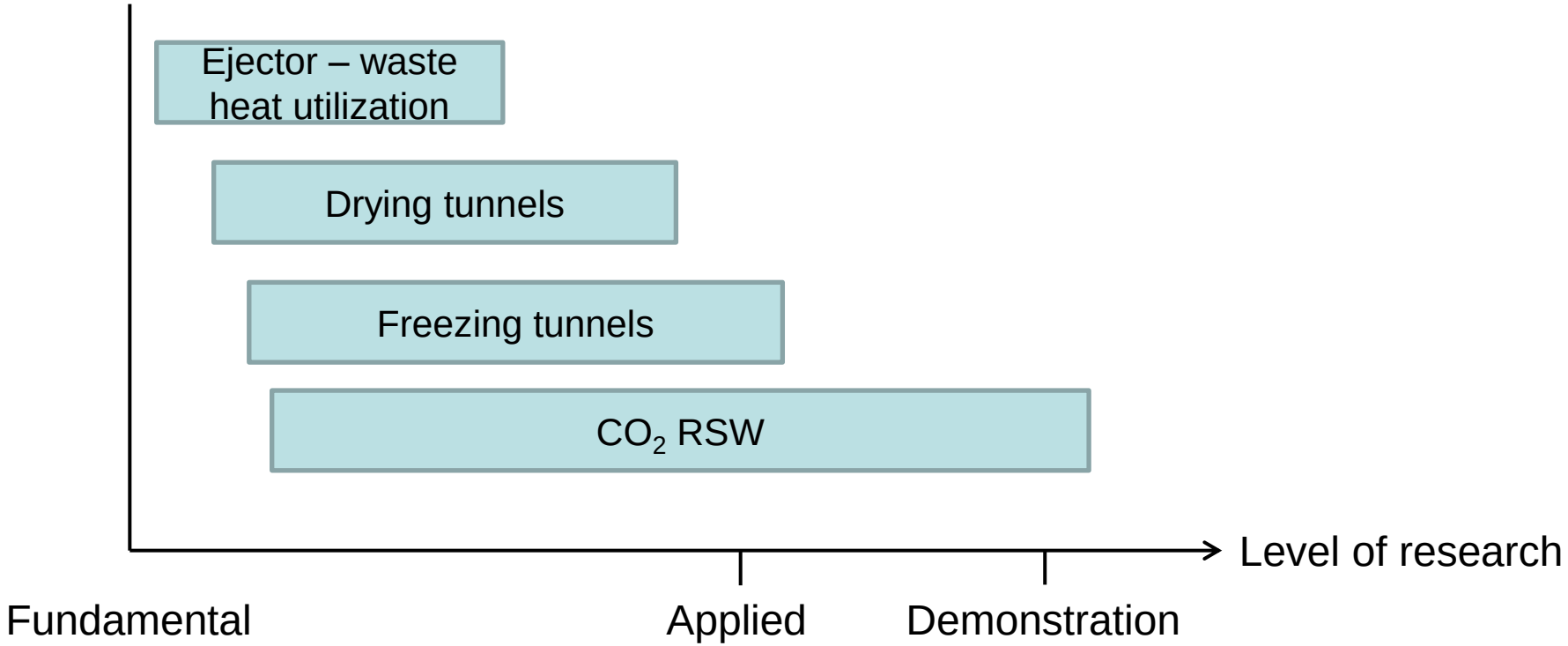
Outline

- Fish industry research topics in CREATIV
  - RSW systems
  - Freezing tunnels
  - Drying tunnels
  - Waste heat utilizaton in refrigeration
- Summary

Topics related to fish industry

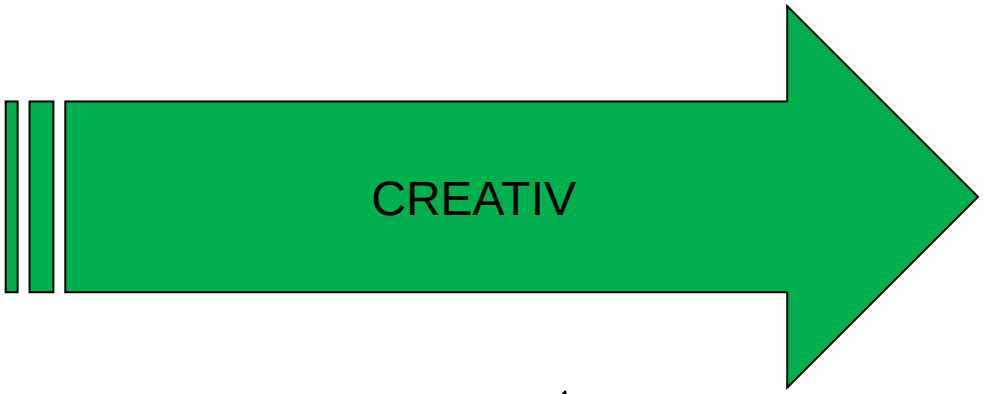
Topic	Content	Status
CO2 RSW (Co-op. applied project)	Modeling, component design and control optimization	Demonstrator on fishing vessel in operation
Freezing tunnels	Ceiling design, product and tunnel modeling, fan control strategies	Ready for demonstration
Drying tunnels (Co-op. industry project)	Product and tunnel modeling, fan control strategies	Ready for lab-scale or industrial verification
Utilizing waste heat for refrig. system improvement	Ejector implementation in refrigeration systems	Laboratory testing and conceptual studies performed

Level of research



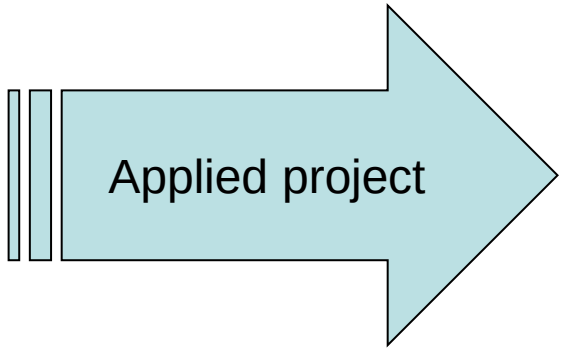
The “dream team”

Different activities and tasks but with mutually beneficial cooperation



- Provide generic knowledge methods and tools
- Educate young professionals

Provide relevant topics, operation data, practical experience



CO_2 RSW

From fundamentals to industrial prototype

Motivation

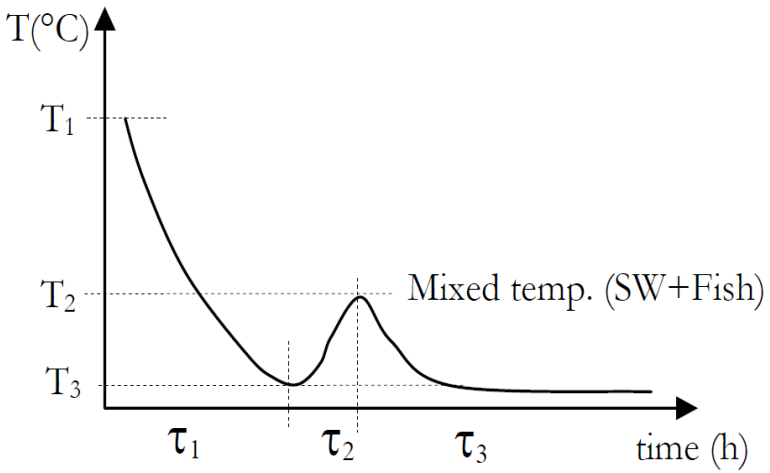
- Refrigerated Sea Water (RSW) refrigeration plants are used on fishing boats to cool and preserve the catch
- Replacement for current, environmentally hazardous fluid required
- NH3 (Ammonia) is an existing option, but has specific safety issues (toxicity) are challening for retrofit, and in smaller vessels in general
- CO2 systems have shown great performance in other applications, but require different solutions

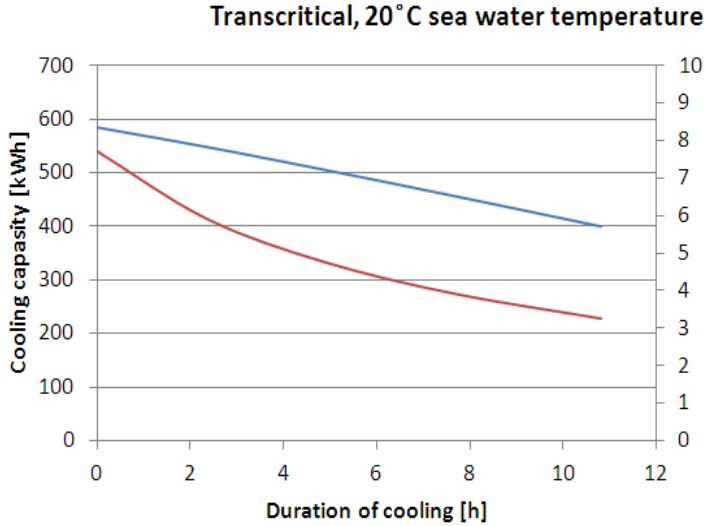
CREATIV contribution

- Project was facing a design challenge
  - Common design criteria: capacity at 0°C (RSW tank)
  - But RSW operation is dynamic
- Analyse and improve dynamic operation
  - Develop methods and tools
  - Optimize operation and component design in a transient process

=> Possibility to run high-capacity, high-COP at start up

If the system is designed for it!



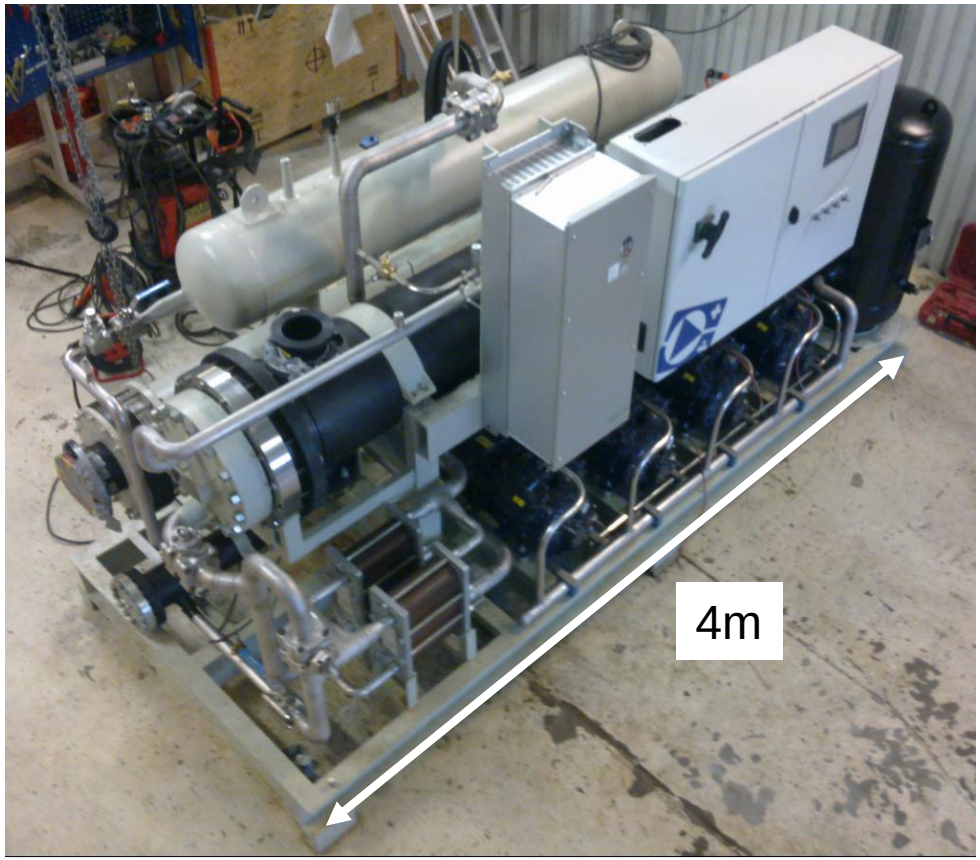


Result of collaboration

- 250kW prototype, installed on fishing vessel

Ongoing work:

- Data collection from prototype CO2 system and commercial NH3 systems during operation
- Compare CO2 and NH3 systems
- Compare operation data to simulation model
- Evaluate current control strategy – recommend improvements



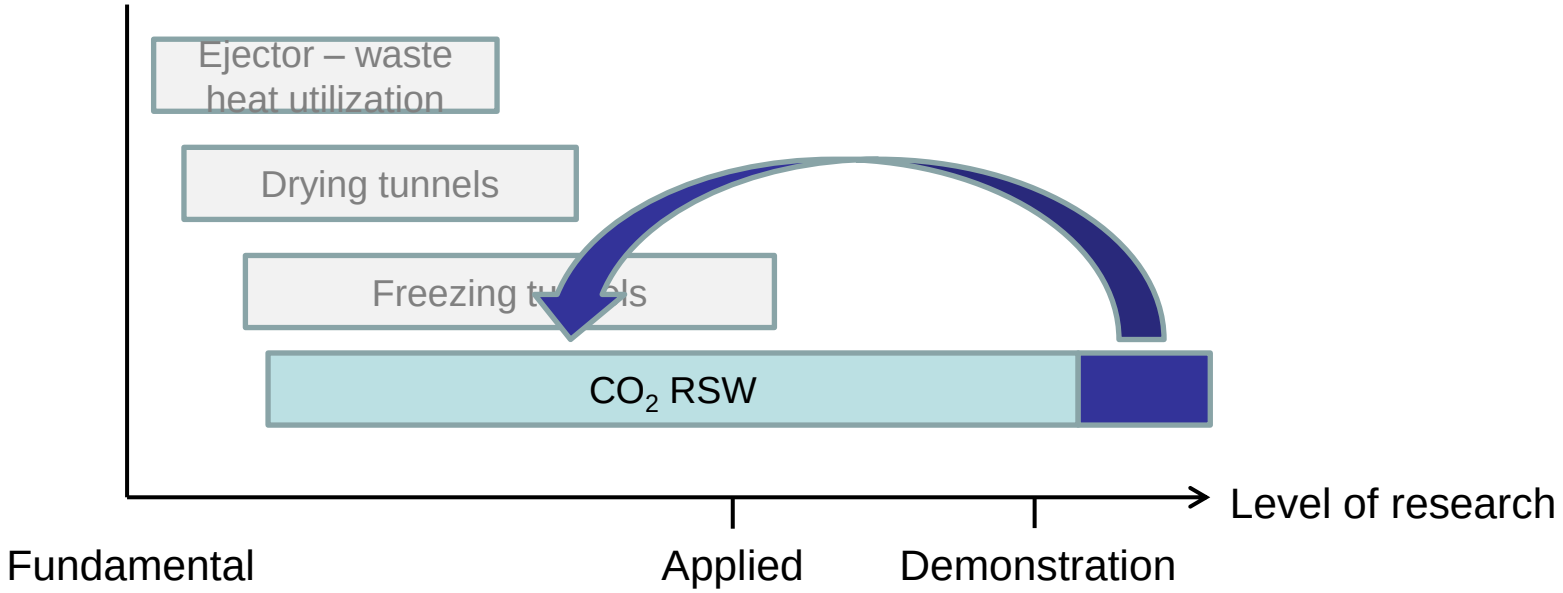
Summary

- CREATIV and applied project "*Fremtidens RSW anlegg på fiskebåt*"* with co-operation on CO_2 RSW development
- Applied project designed and installed demonstrator on fishing vessel, currently in operation
- CREATIV supported with more fundamental basis;
  - Modeling of components and dynamic model of system
  - Steady state simulations to aid in novel heat exchanger design
  - Dynamic simulation of various operation modes and conditions to determine efficient and secure control of system

* *Next-generation RSW systems on fishing vessels*

Ongoing/further work

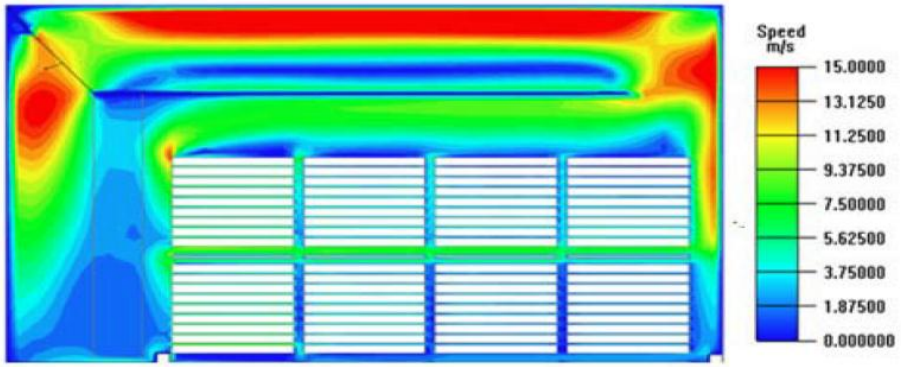
- CREATIV plans:
  - Together with industry project aquire logged data for CO2 prototype and commercial NH3 system in operation
  - Use logged operation data to verify models and suggest improvements



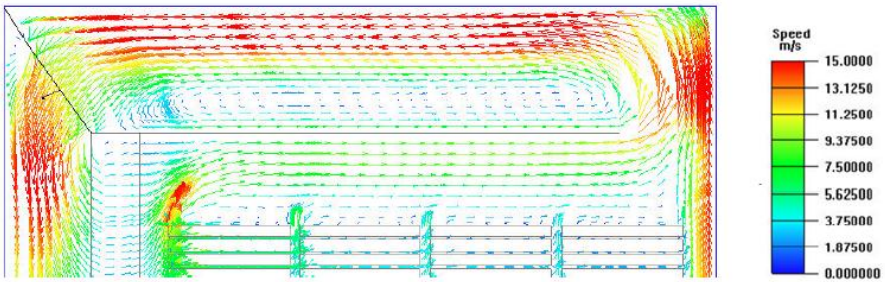
Freezing tunnels

Improving operation based on advanced simulation models

A



B

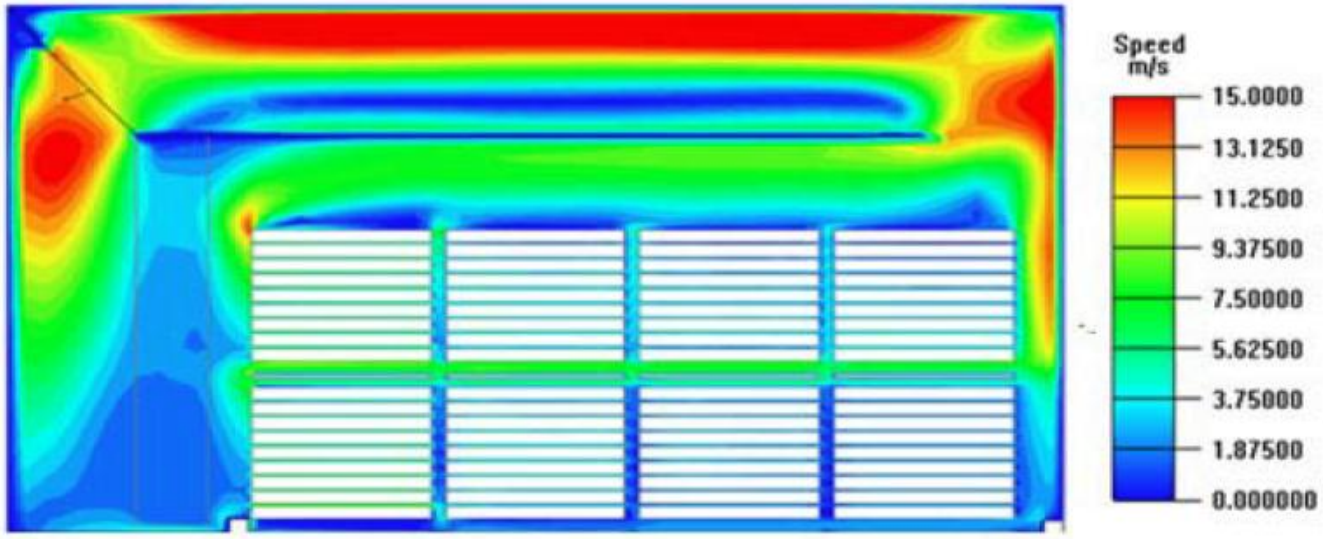


Motivation

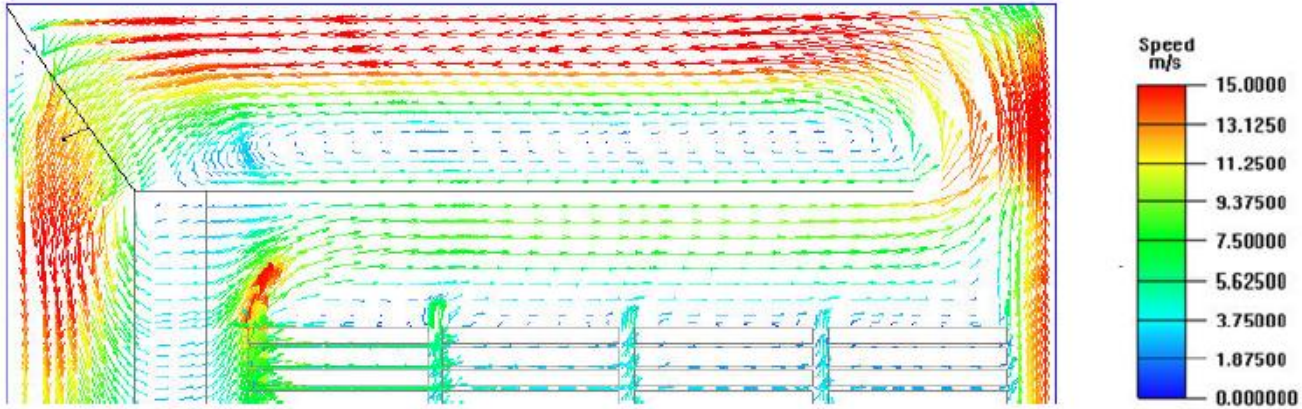
- Freezing tunnels are energy demanding industrial processes
  - Energy use may be minor part of turn-over, but significant to margins
- Studies have shown great potential for improvement to energy efficiency
- The industry is generally aware of possibilities for improvements
  - Challenging and risky to test, disturbs core processes => sticks to "normal practice"
  - Still: Different solutions for improvement have been implemented by the industry, effect is largely un-documented
- CREATIV role: Methodic approach; evaluate existing solutions and suggest improvements.
  - Focus on fan power and control: Fan power is significant, and adds heat to the freezing tunnel air. Improvements have multiple effects on system power consumption

Model Freezing tunnel

A

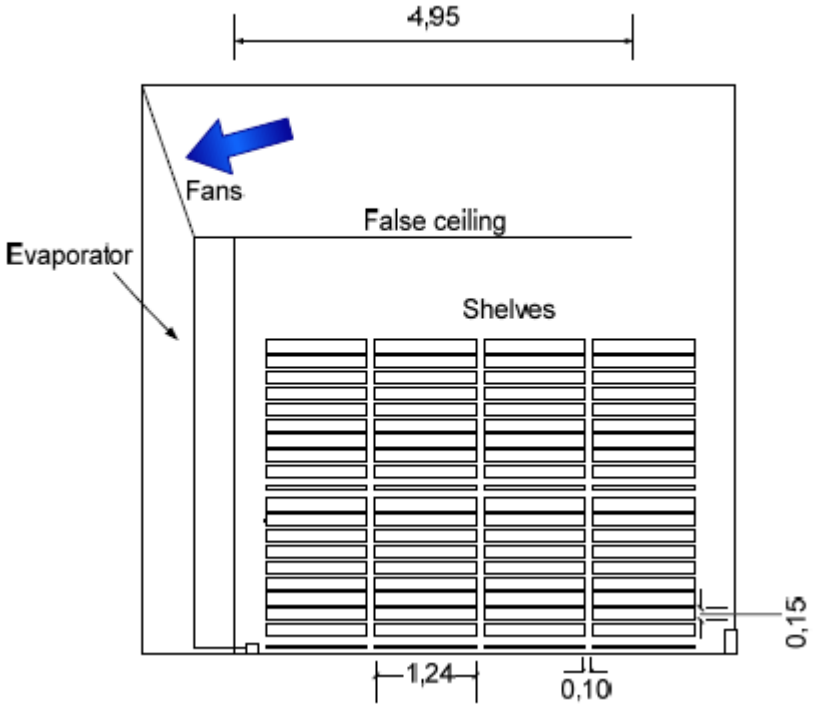


B



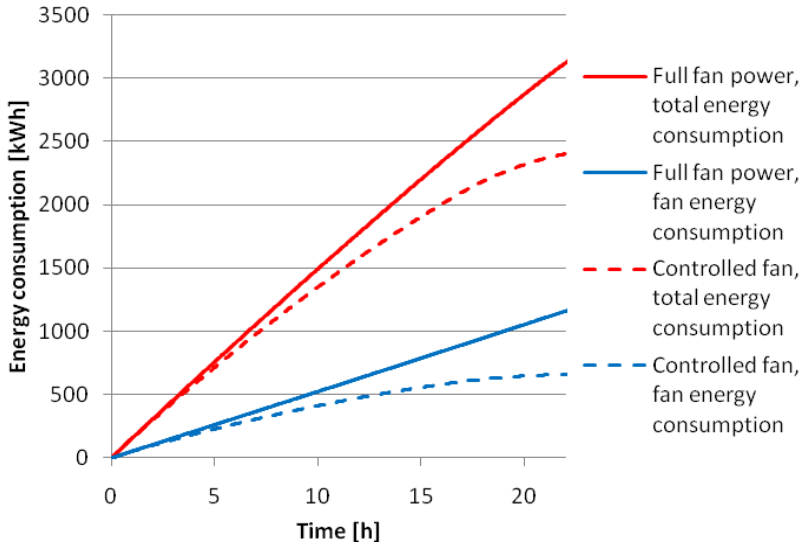
Scope

- Investigation of air flow in tunnels
- Optimization of ceiling design to improve air distribution and reduce fan work
- Investigate control strategies for fan control to reduce power consumption of fans and refrigeration system
- Industry-scale measurements and evaluation of different fan control strategies



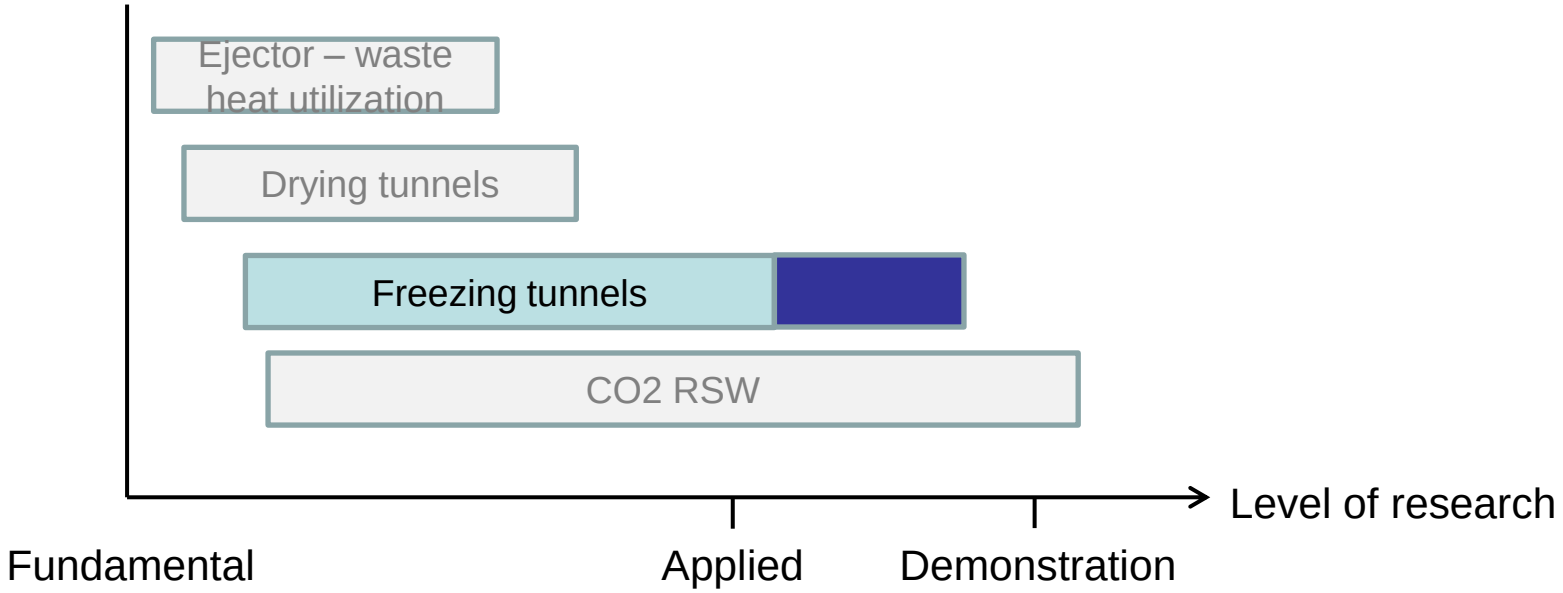
Summary

- CREATIV sub-topics
  - Optimization of ceiling design to improve air distribution and reduce pressure drop
    - Equalize freezing times for products across tunnel
    - Reduce the significant energy consumption to fans and refrig. system
  - Investigate control strategies for fan control to reduce power consumption of fans and refrigeration system
    - Shown great potential for increasing energy efficiency



Ongoing/further work

- Desirable to evaluate fan control strategies in industrial environments:
  - Challenging due to risk of disturbance on core process
  - Coupled and complex systems
  - Requires instrumentation of refrigeration system and products
  - Several sites contacted; found interest, but systems unsuitable



Drying tunnels

Methodic approach towards knowledge and system improvement

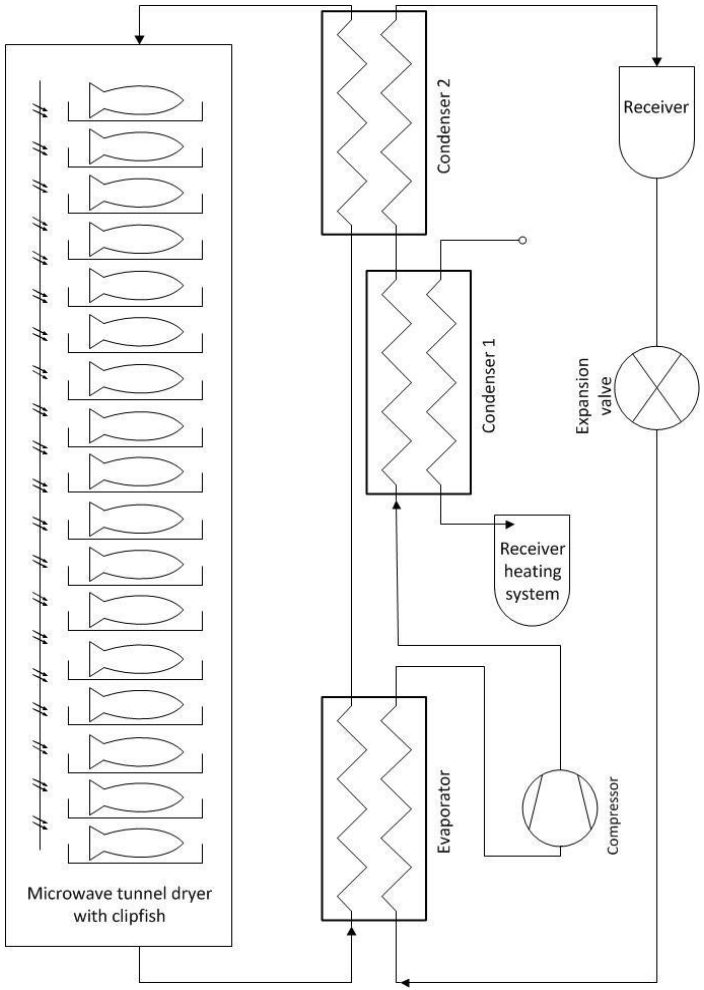
Motivation

- Drying tunnels are energy demanding industrial processes
  - Energy use may be minor part of turn-over, but significant to margins
- Studies have shown great potential for improvement to energy efficiency
- The industry is generally aware of possibilities for improvements
  - Challenging and risky to test, disturbs core processes => sticks to "normal practice"
  - Still: Different solutions for improvement have been implemented by the industry, but effect is largely un-documented
- CREATIV role: Methodic approach; evaluate existing solutions and suggest improvements.
  - Focus on fan power and control
- two approaches:
  - Improvement of existing drying technology (HPD)
  - Fundamental research on hybrid drying technology (ultrasound and microwave

Existing heat pump drying

- Determination of performance
  - Energy
  - Drying
- Develop dynamic process simulation tools
- Verification

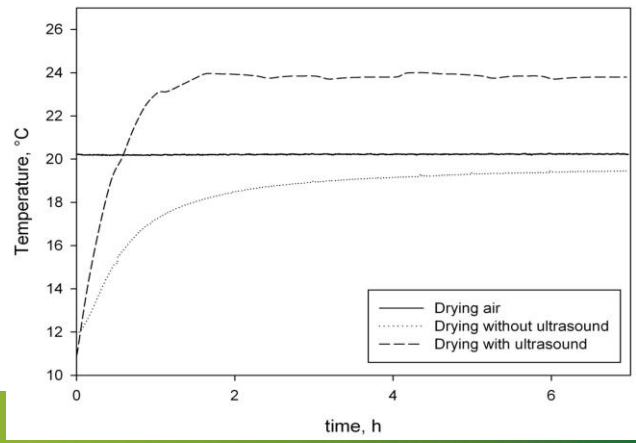
→ New drying concepts
  → Storage drying for clipfish
  → New design of tunnel
  → Controlled volume flow

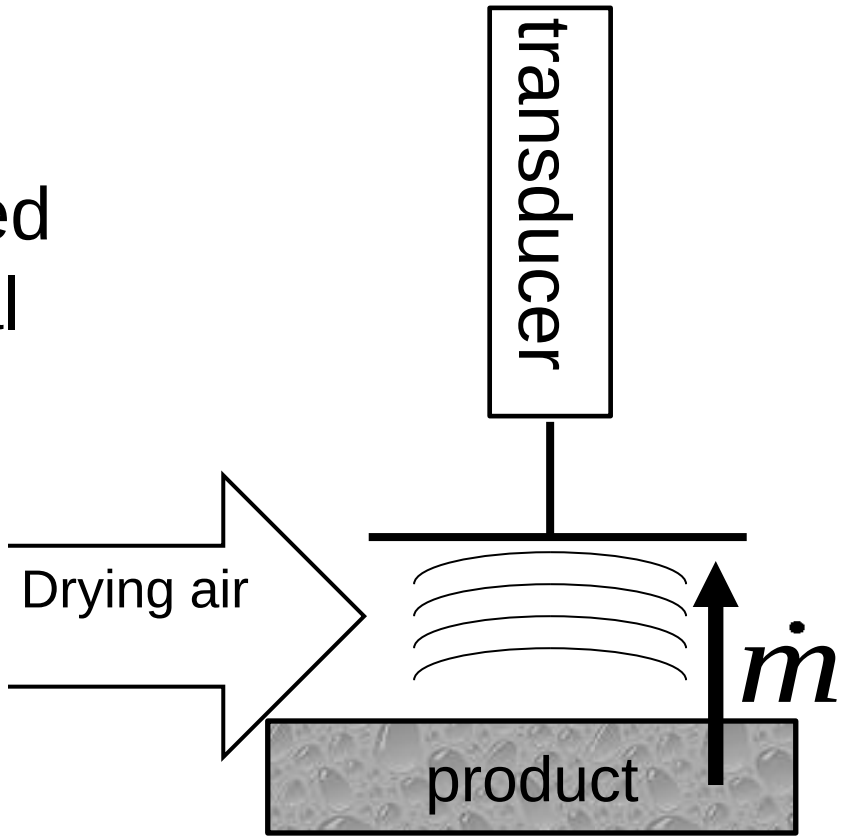


Fundamental research

- Ultrasonic drying:

→Kinetic energy used to accelerate thermal process

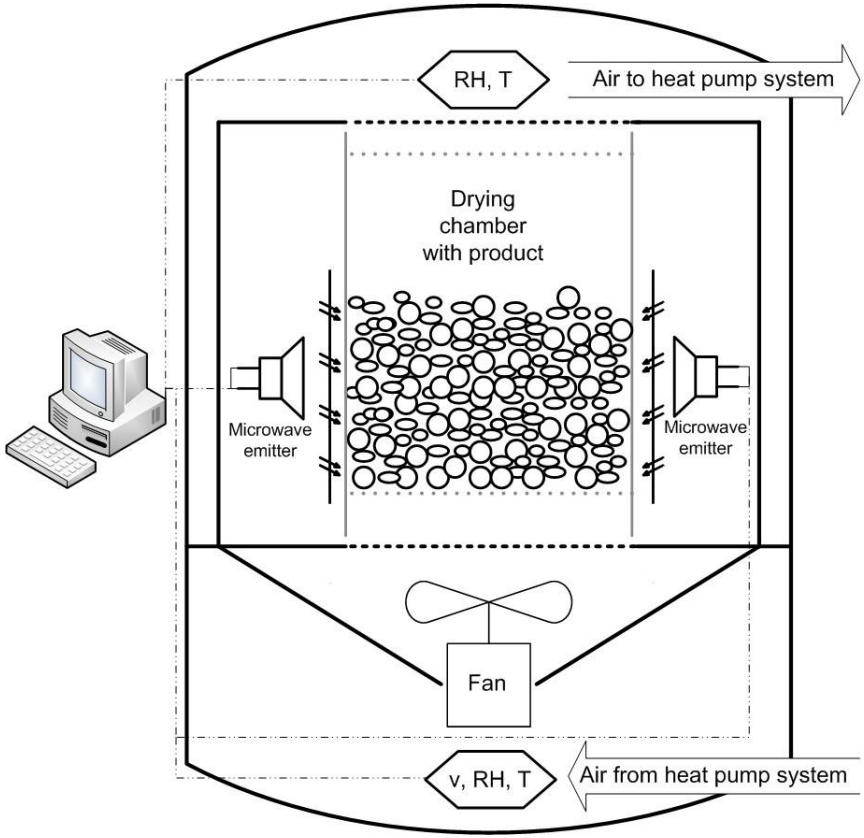




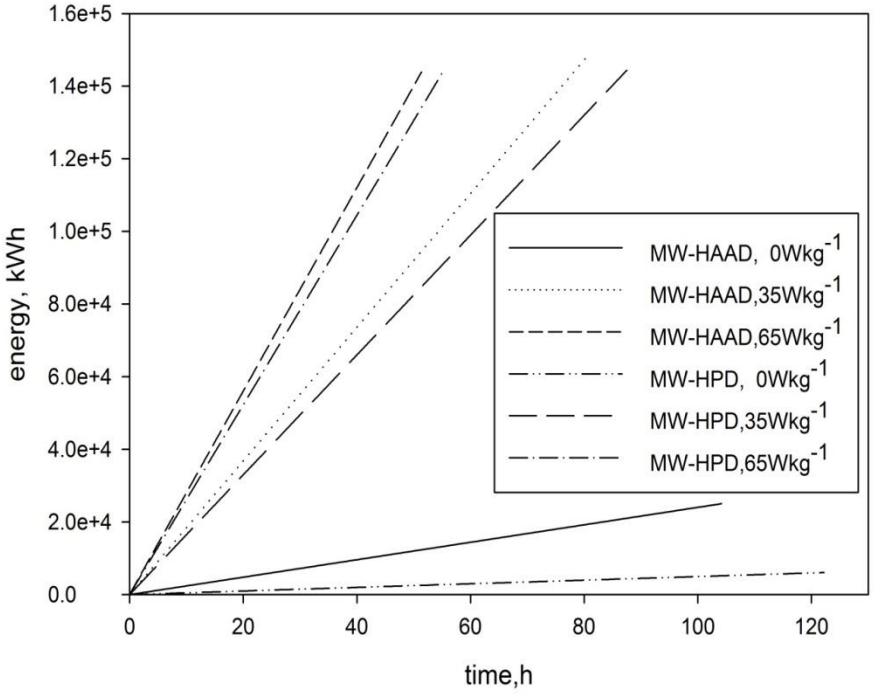
Fundamental research

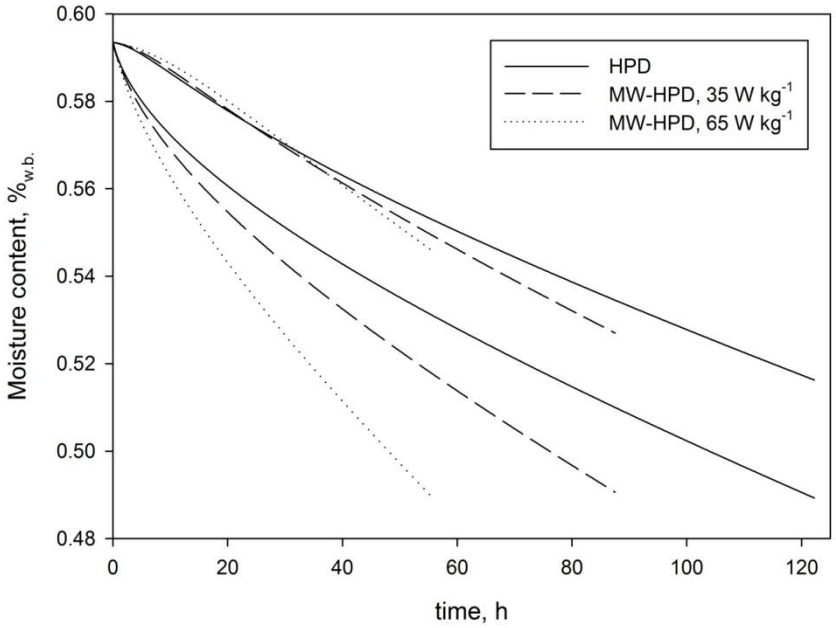
- Microwave drying

  →Drying time reductions of 90% possible



Interaction: new vs. existing technology





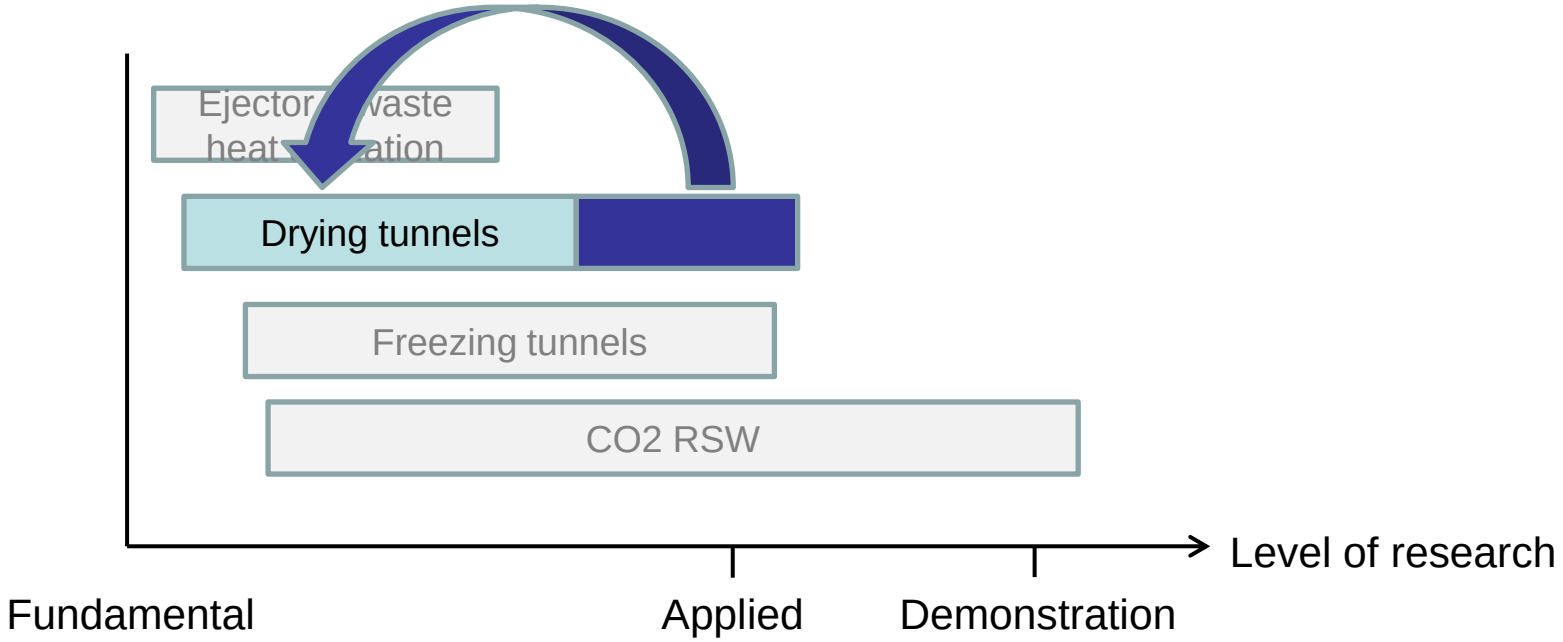
Summary

- Co-operation with industrial project "Rasjonell klippfisktørking"*
- Shares problems, solutions and methods that are analoge to freezing tunnel application
- CREATIV sub-topics
  - Dynamic modeling of the drying process
    - Product modeling; describe behaviour of product during drying (very complex)
    - System modeling; describe behaviour of refrigeration system and air circulation
  - Investigate control strategies for fan control to reduce power consumption of fans and refrigeration system

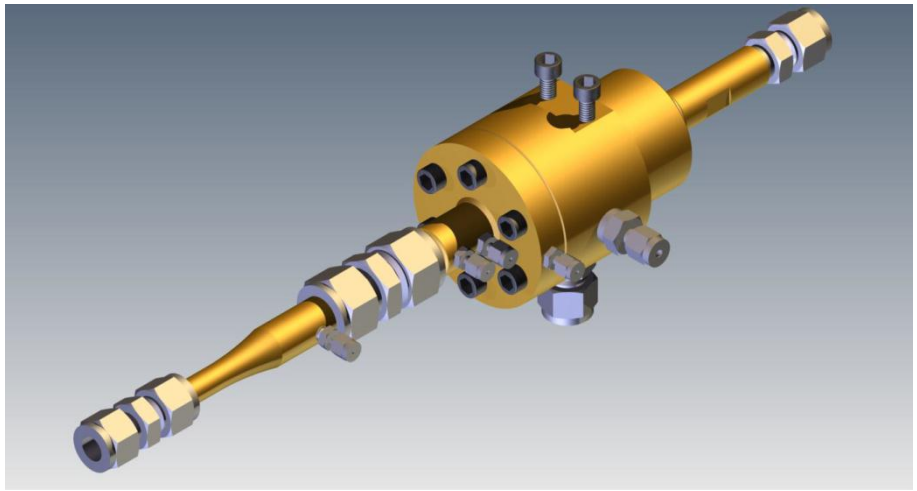
* *Rational clip-fish drying*

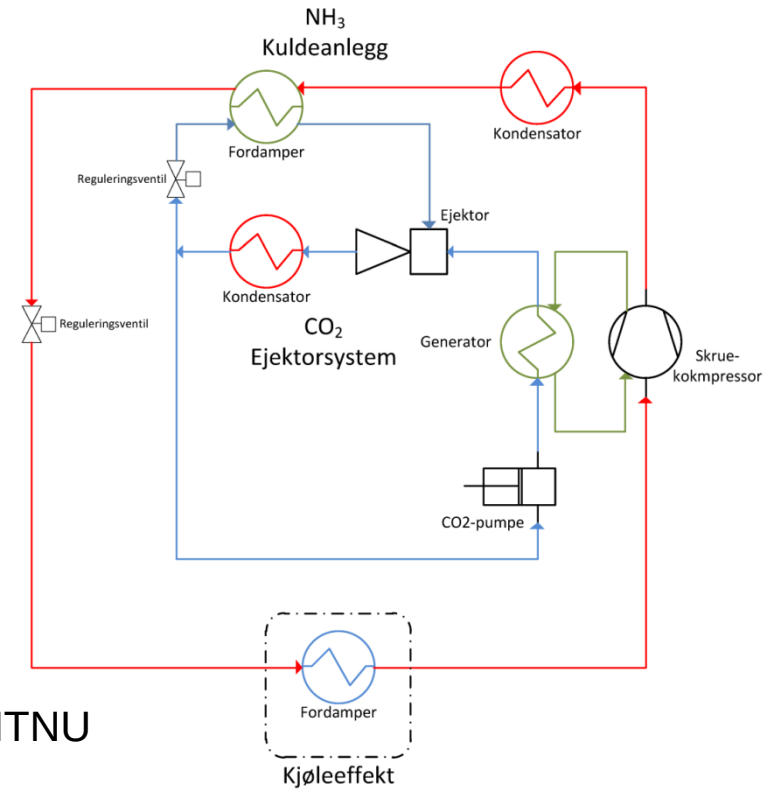
Ongoing/further work

- Verification of models through lab/industry-scale measurements and evaluation of different fan control strategies
- CREATIV models and methods planned used in industry project tasks – natural platform for bringing the results out to the industry



Utilizing refrigeration waste heat with ejector





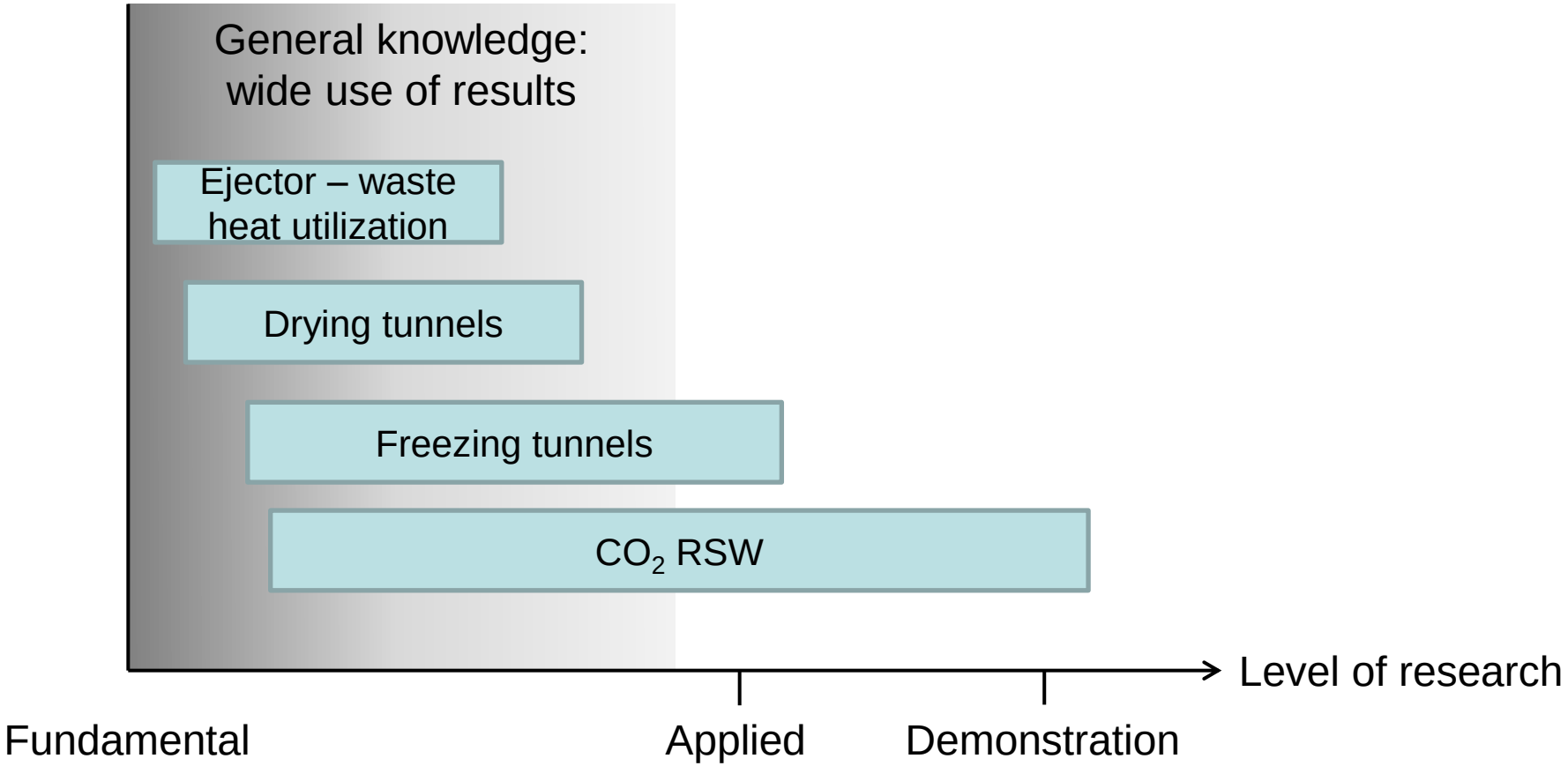
Source: Øystein Hundseth, MSc Thesis, NTNU

Motivation and summary

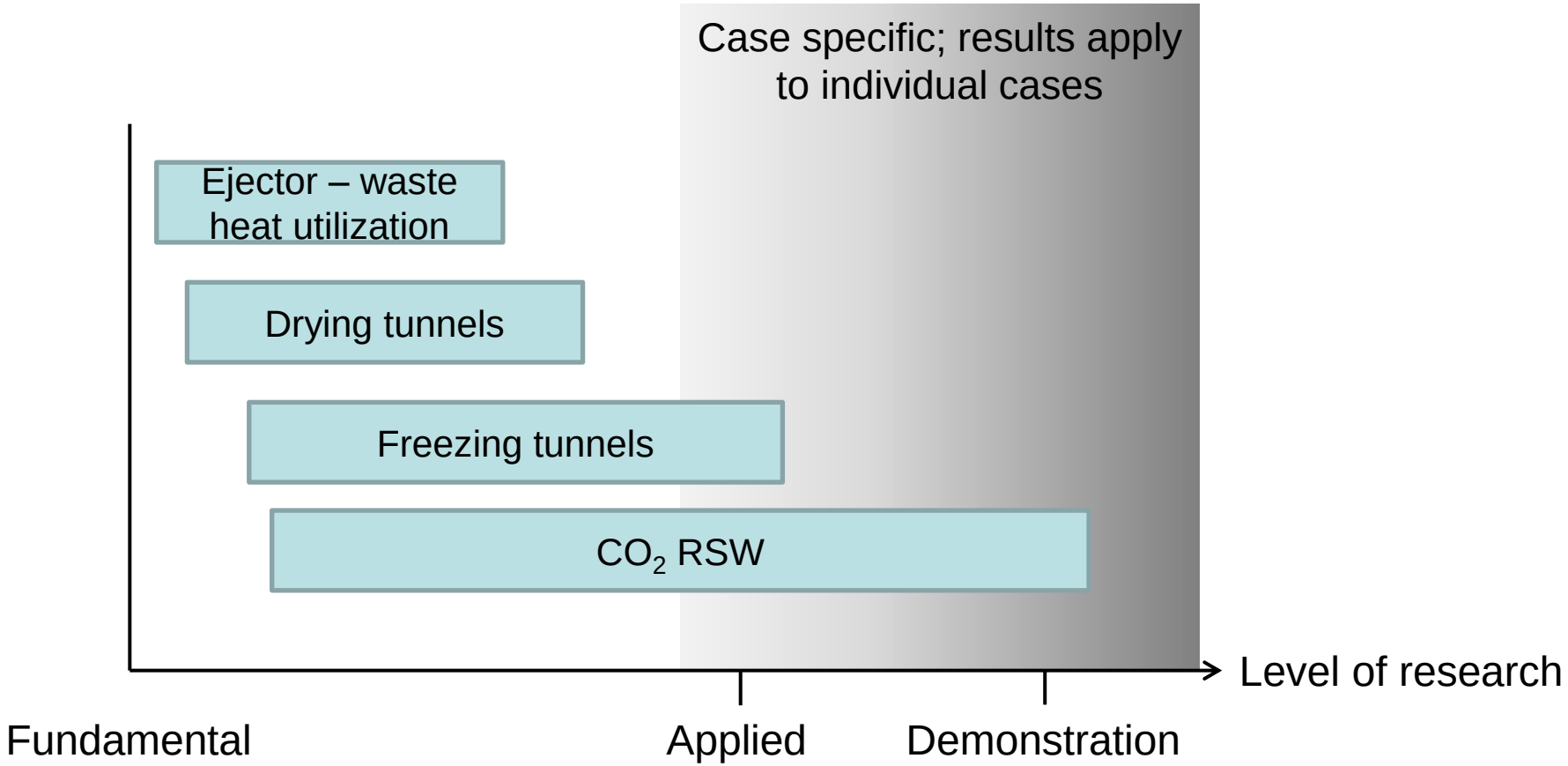
- There are significant unused wast heat from refrigeration systems
- This energy can be used to improve system efficiency or converted to cooling using ejector cycles.

- MSc Student Øystein Hunseth investigated opportunities through conceptual studies and laboratory experiments
- Heat source: Screw compressor oil cooling (60-90°C)
- Gains in efficiency was found with current setup, no further activity

Level of research - Summary



Level of research - Summary



Summary and conclusions

- Topics with industry project co-operation experiences significant synergy
- Significant progress on important topics
- Work spans from near-fundamental level to demonstration and prototypes
- Some challenges to demonstrate concepts in industrial environments

Thank you for your attention!