



**sirris** innovation  
forward



 **Winterwind**  
INTERNATIONAL WIND ENERGY CONFERENCE

An active/passive coating stack for surface icing mitigation tested under various climatic conditions

29 March 2023 – Åre - Sweden



# Active & passive coating



 COOCK Fighting Icing

 NEW SKIN

# Heatable coatings

MANY APPLICATIONS

Fillers → carbon nanotubes, ITO (Indium Tin oxide) or graphene

Company	Targeted markets
Battelle	Aviation, marine, drones
Coating Suisse	Transport, anti-ice, floor heating
nVent	Off-shore walkways
Future Carbon	General
Ice solution	Wind turbines
Signet international	Aviation
Villinger	Aviation, energy



Ref.:Coating-Suisse

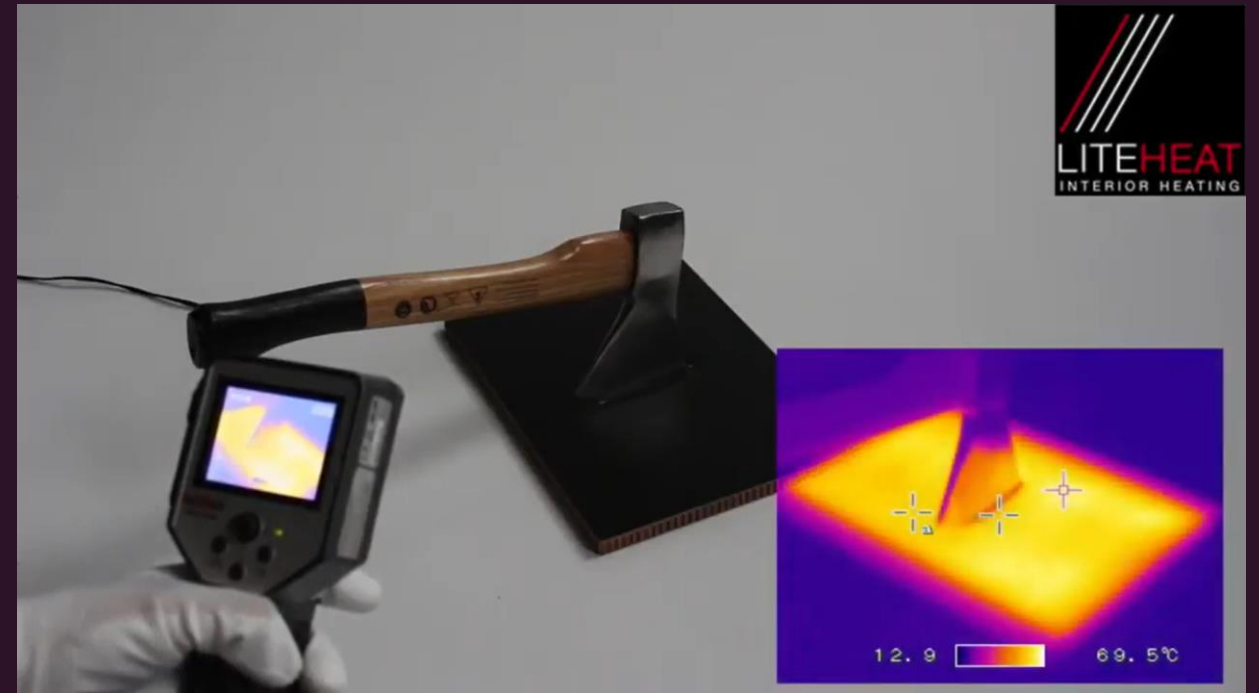


Ref.:Villinger



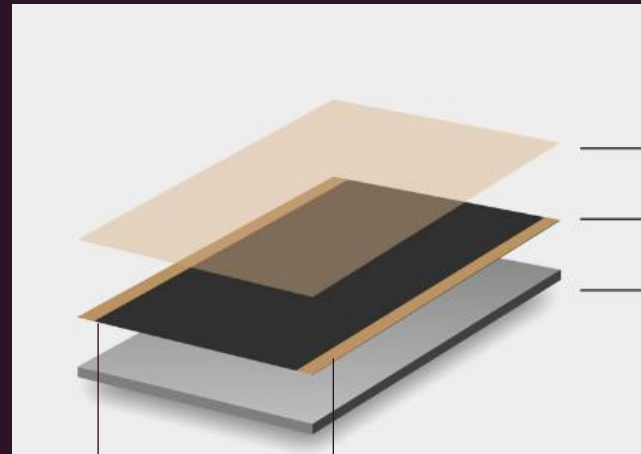
# Advantages of heatable coatings

- Easy to apply on rigid and flexible surfaces
- Heating directly where needed
- Can be overcoated
- Don't take extra space
- Still functional when damaged
- ...



Ref.:Villinger

# Preparation of test sample



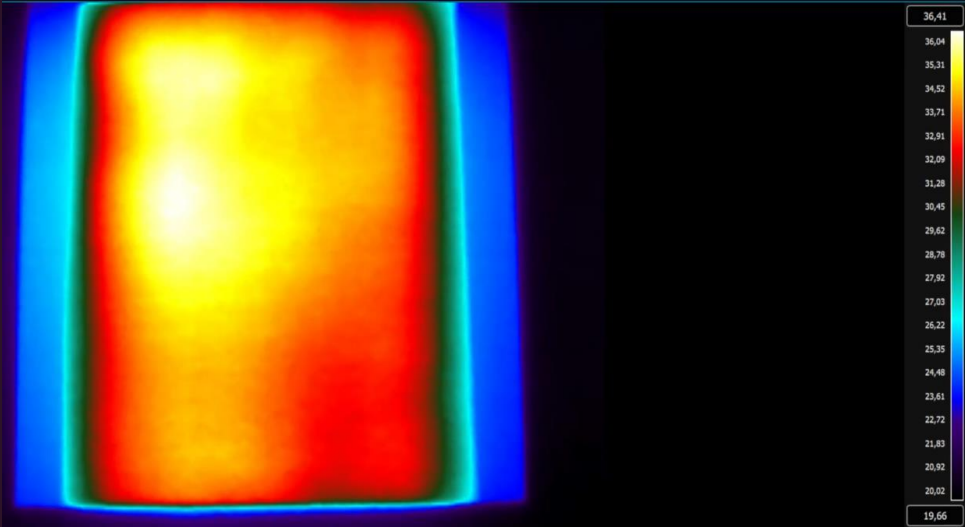
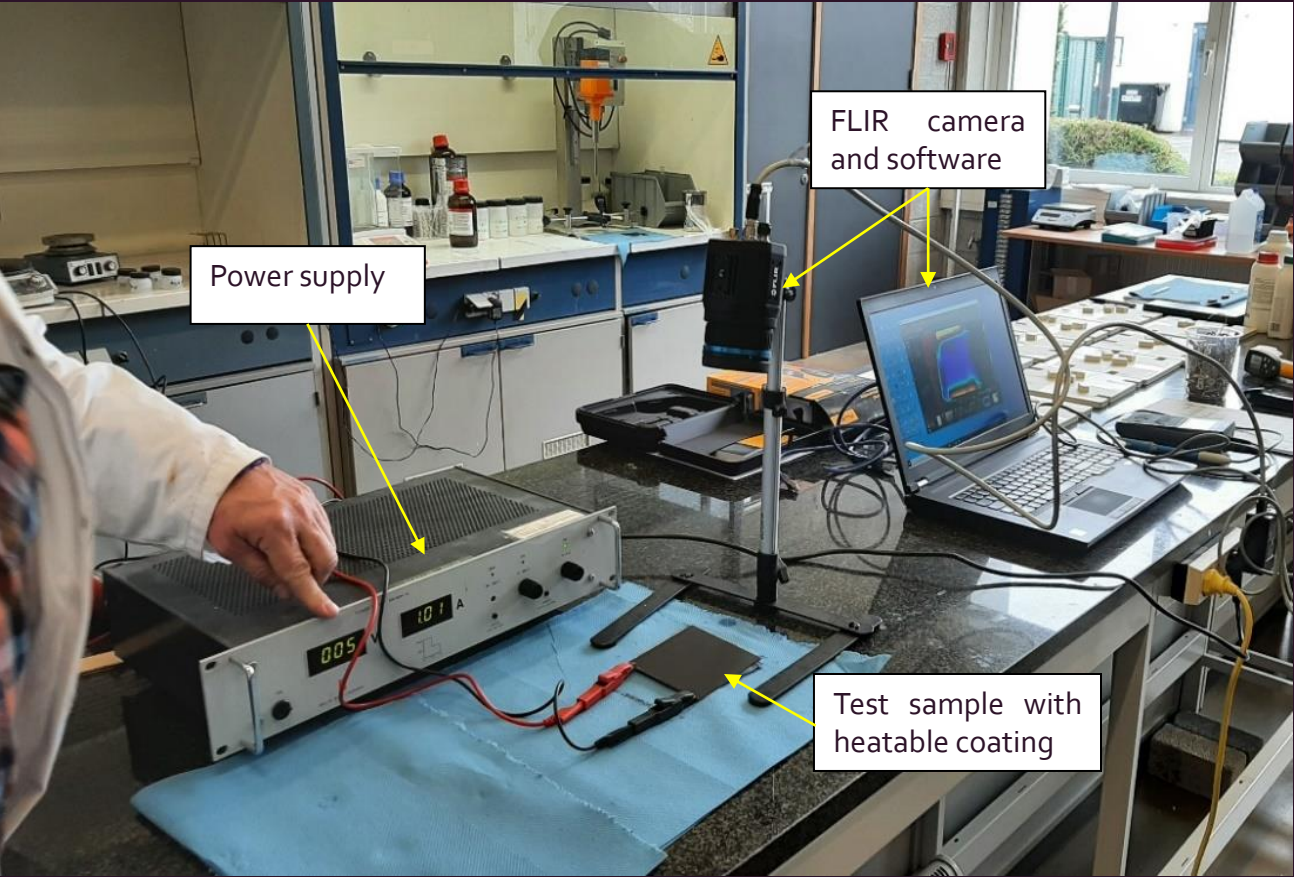
Hydrophobic topcoat (NANOMYTE SuperAi)

Heatable coating 75 $\mu$ m CSG-IRE-550-5

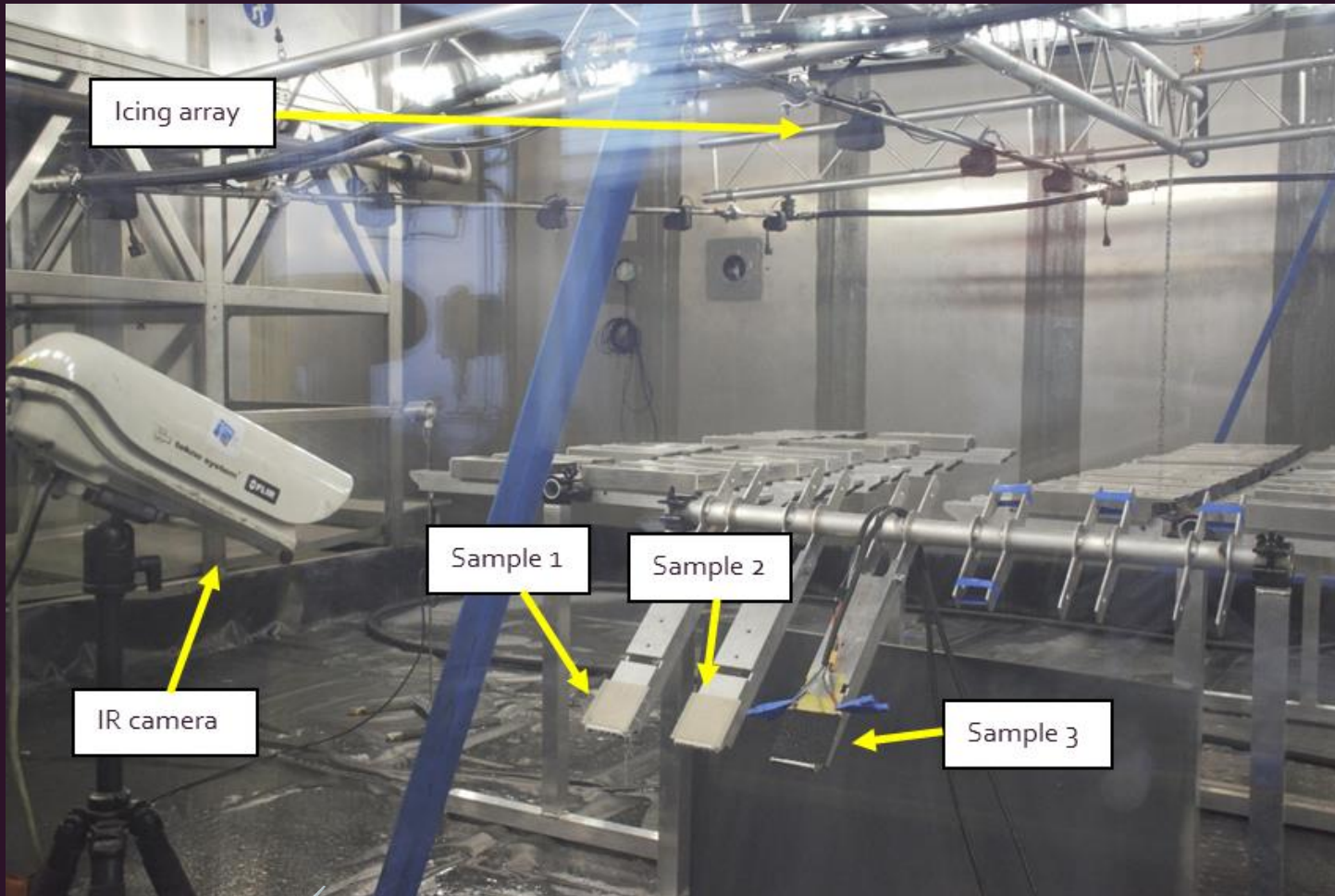
Glass-fiber reinforced composite

Copper foil connectors

# Functionality test set-up lab scale



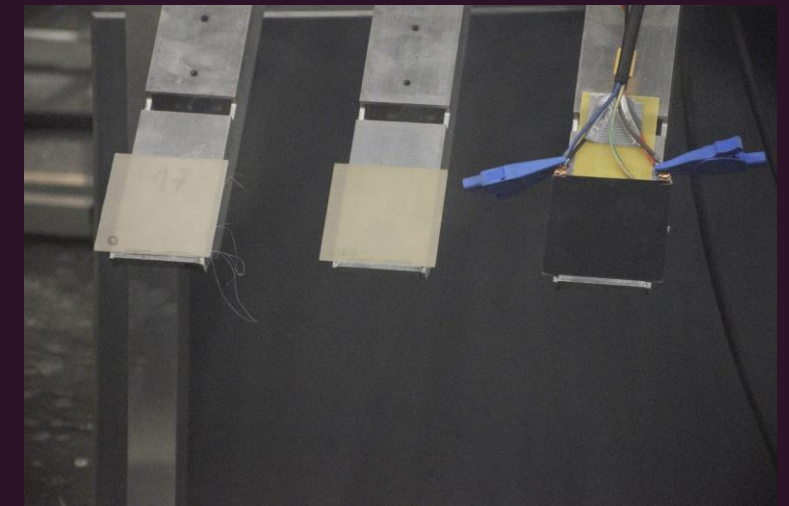
# Functionality test icing conditions: test set-up



Sample 1: no coating

Sample 2: Hydrophobic coating

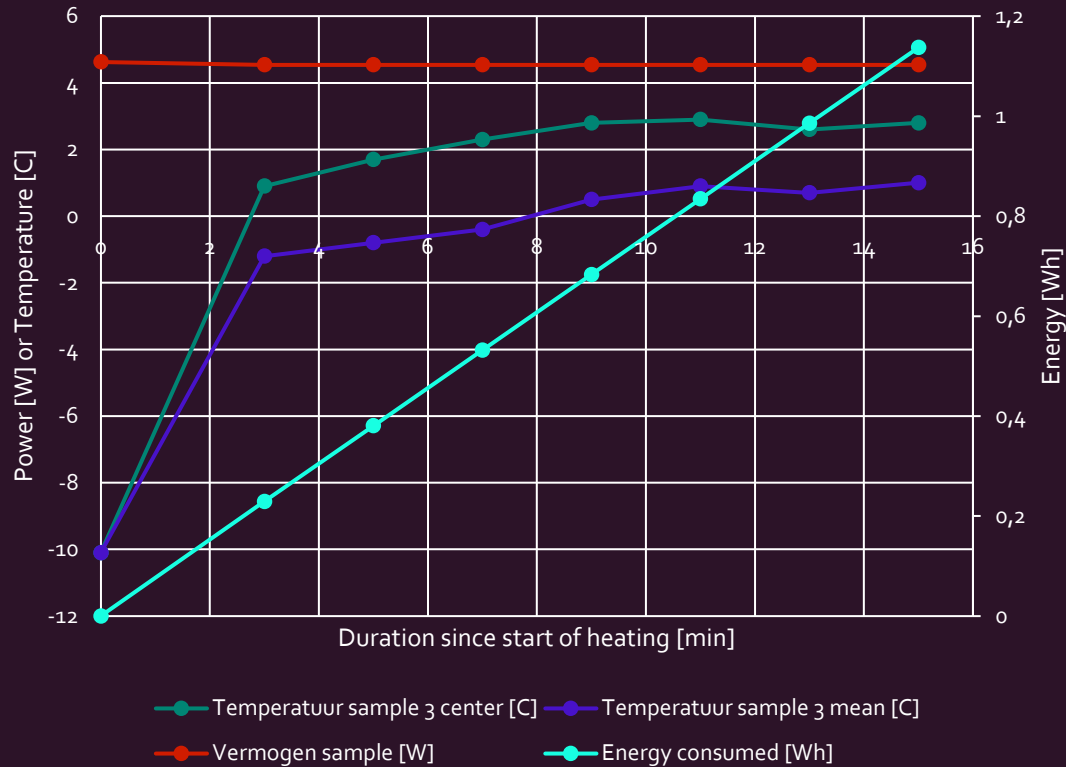
Sample 3: heatable/hydrophobic coating



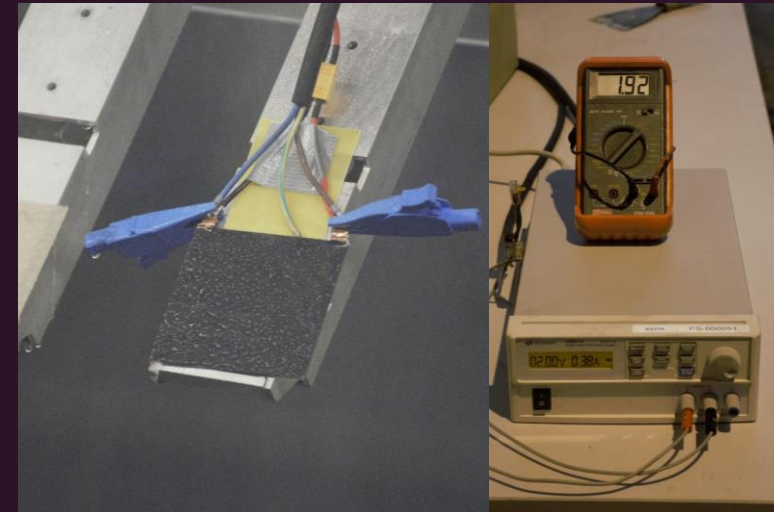


# Functionality test icing conditions: calibration

POWER FOR CONSTANT TEMPERATURE

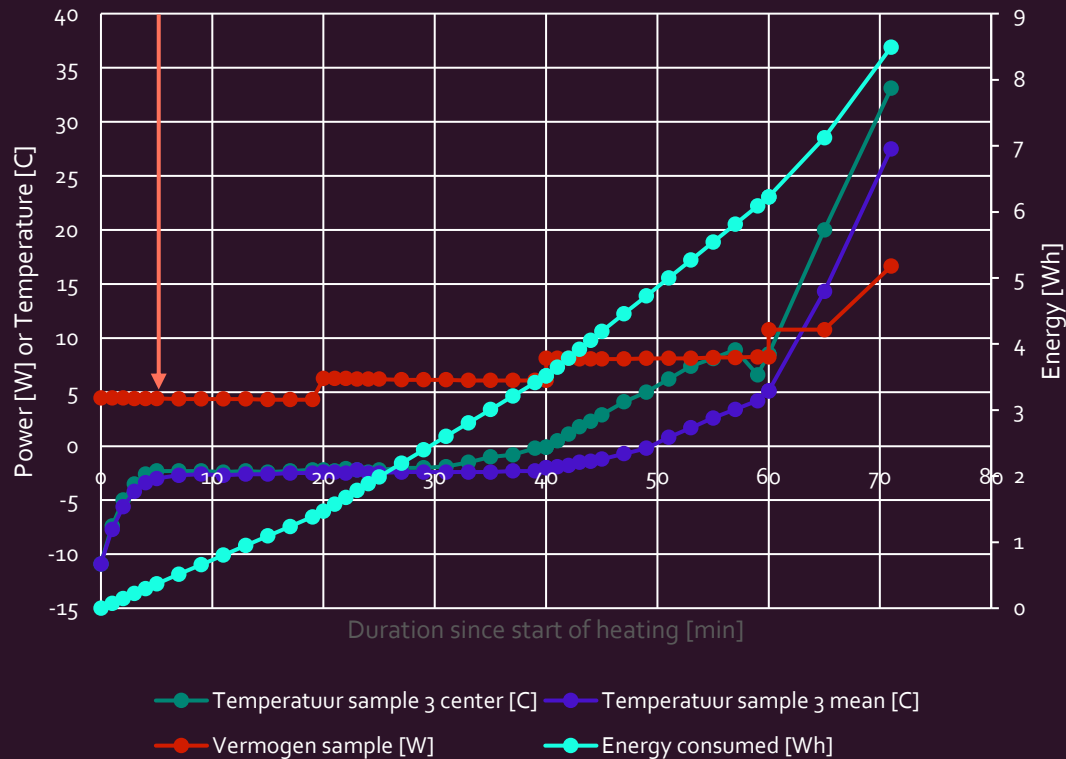


- Power: 4,5W
- Sample surface temp: +1C
- Ambient temperature: -10C

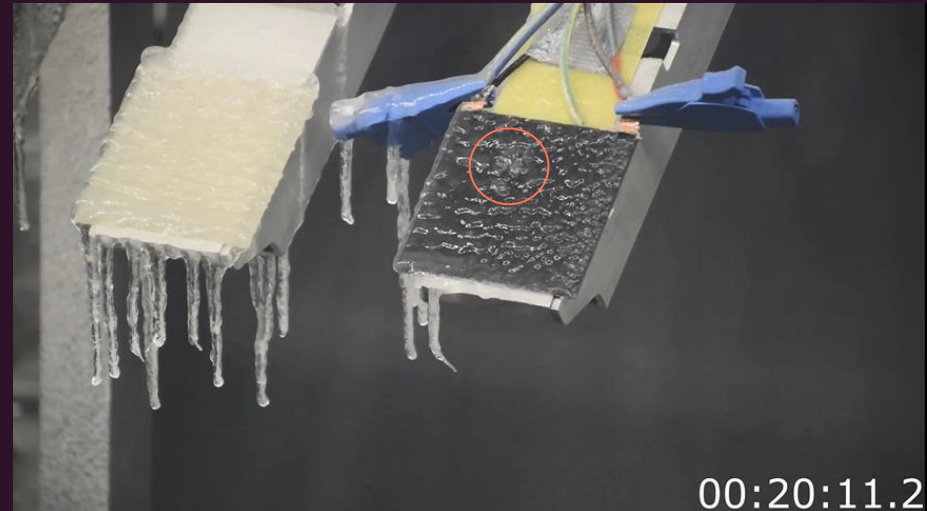


# Functionality test icing conditions: de-icing

ICE MELTING MODE

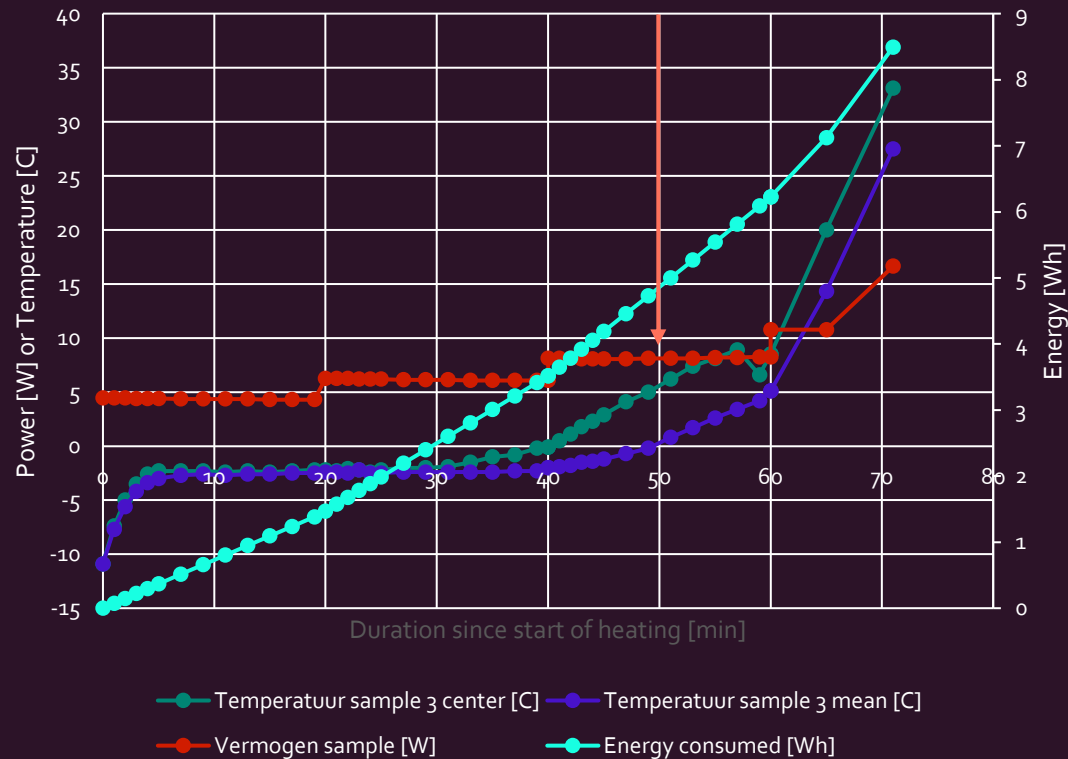


- Layer of ice 0,5-1,0cm
- Ambient temperature: -10C
- Increasing power: 4,4W -> 16,5W
- First signs of melting after 6 min (small bubble under ice)

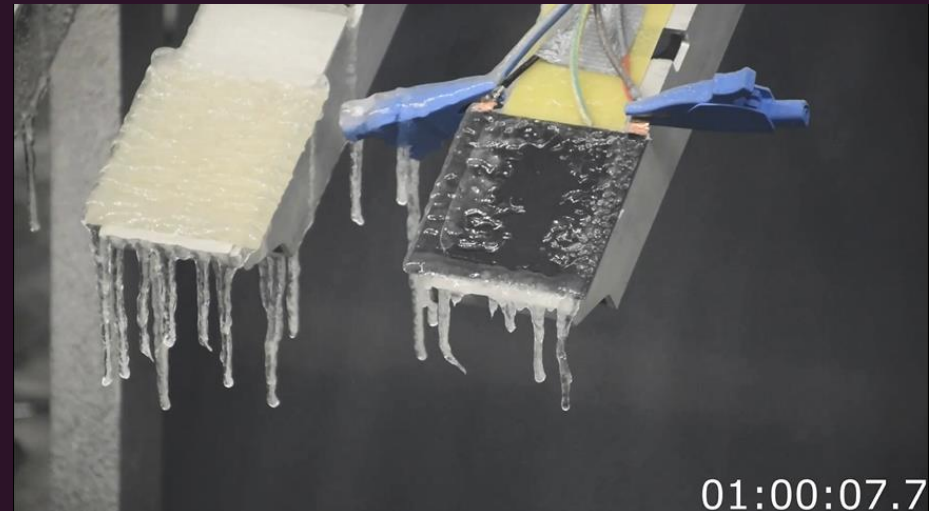


# Functionality test icing conditions: de-icing

ICE MELTING MODE



- Layer of ice 0,5-1,0cm
- Ambient temperature: -10C
- Increasing power: 4,4W -> 16,5W
- First ice free areas after 50 minutes



# Functionality test icing conditions: de-icing

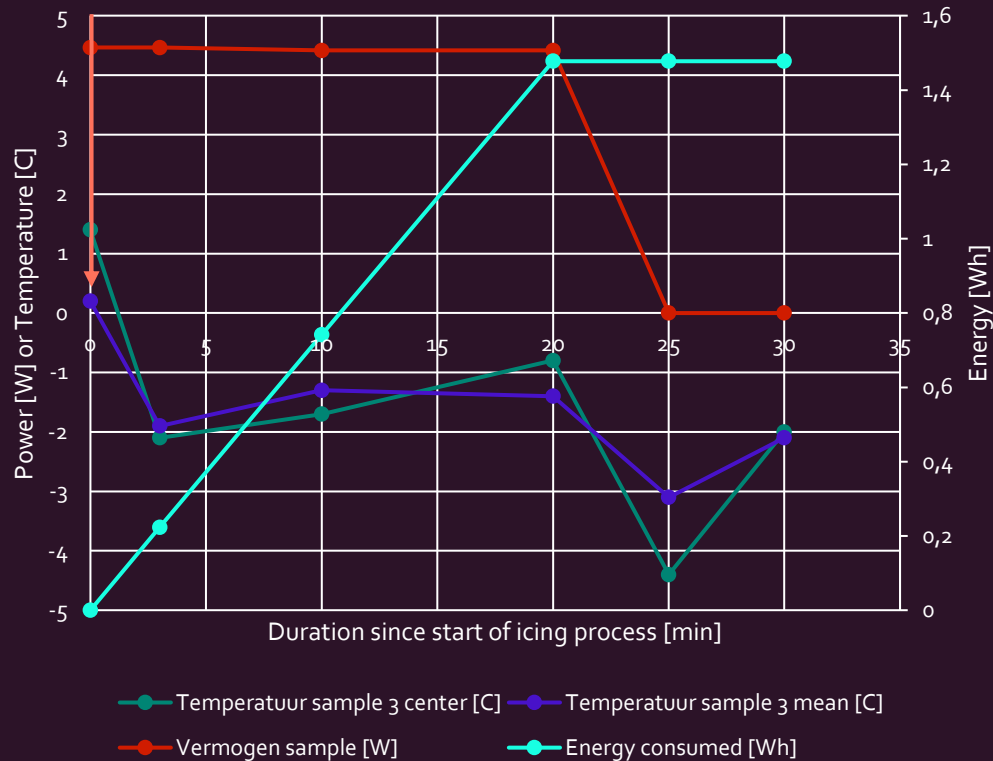
ICE MELTING MODE



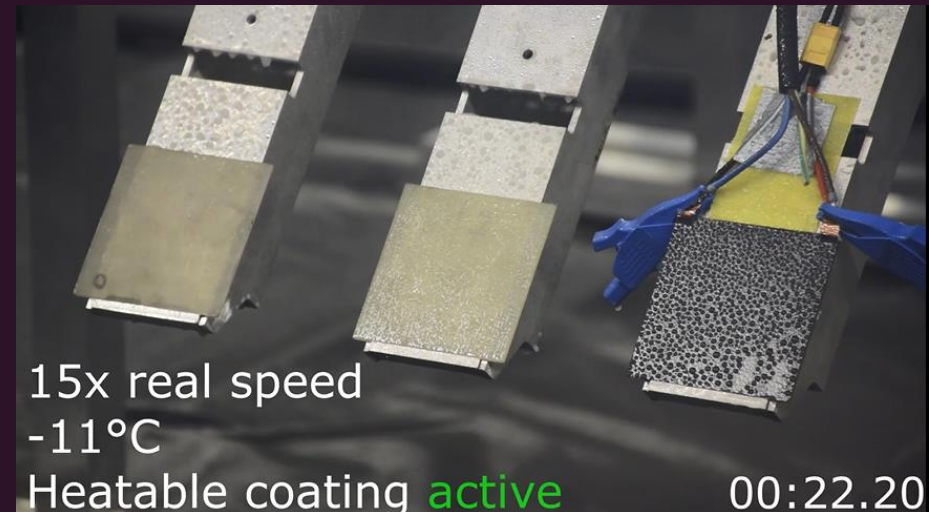
- Stopped after 70 minutes (too high surface temperature)
- Edges remained frozen
- Only droplets
- Larger area's & dynamic environment
  - Risk of ice throw

# Functionality test icing conditions: anti-icing

ICE PREVENTION MODE

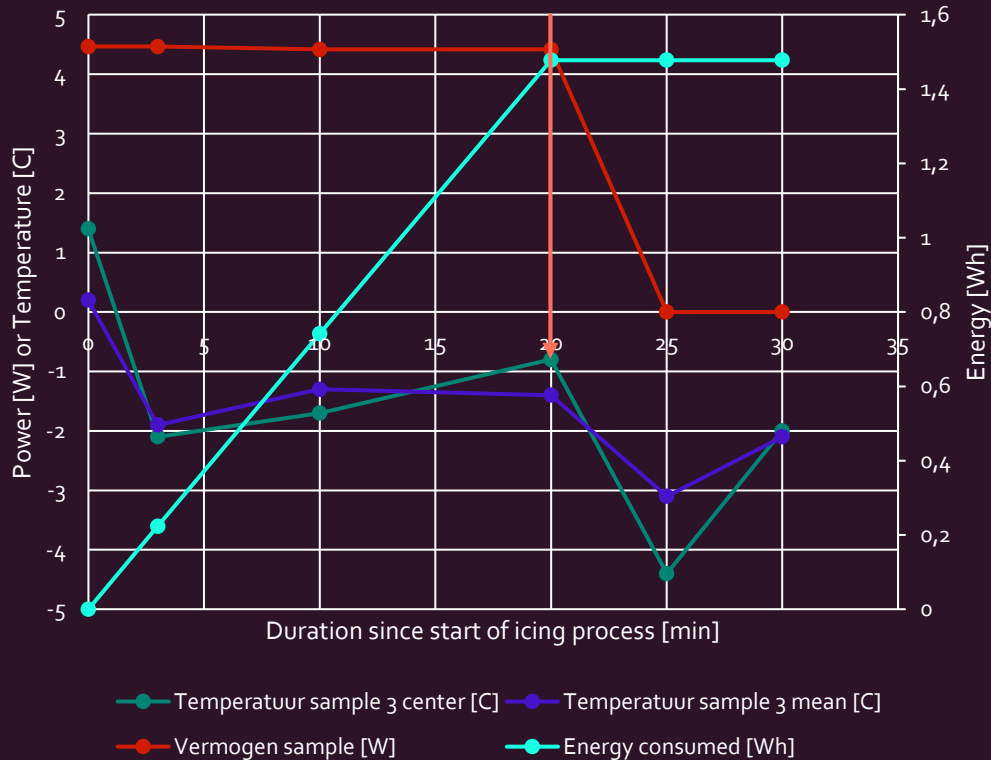


- Power: 4,5W
- Sample surface temp: +0,2C
- Ambient temperature: -11C

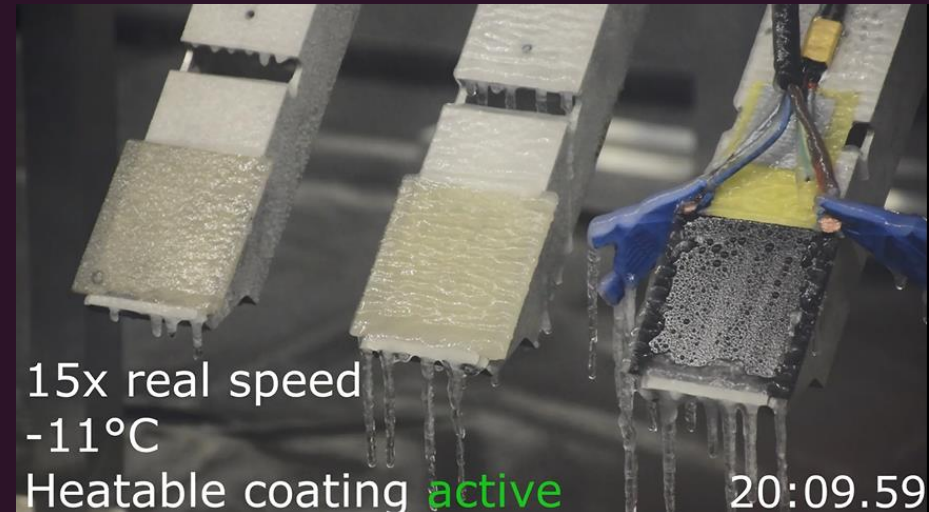


# Functionality test icing conditions: anti-icing

ICE PREVENTION MODE

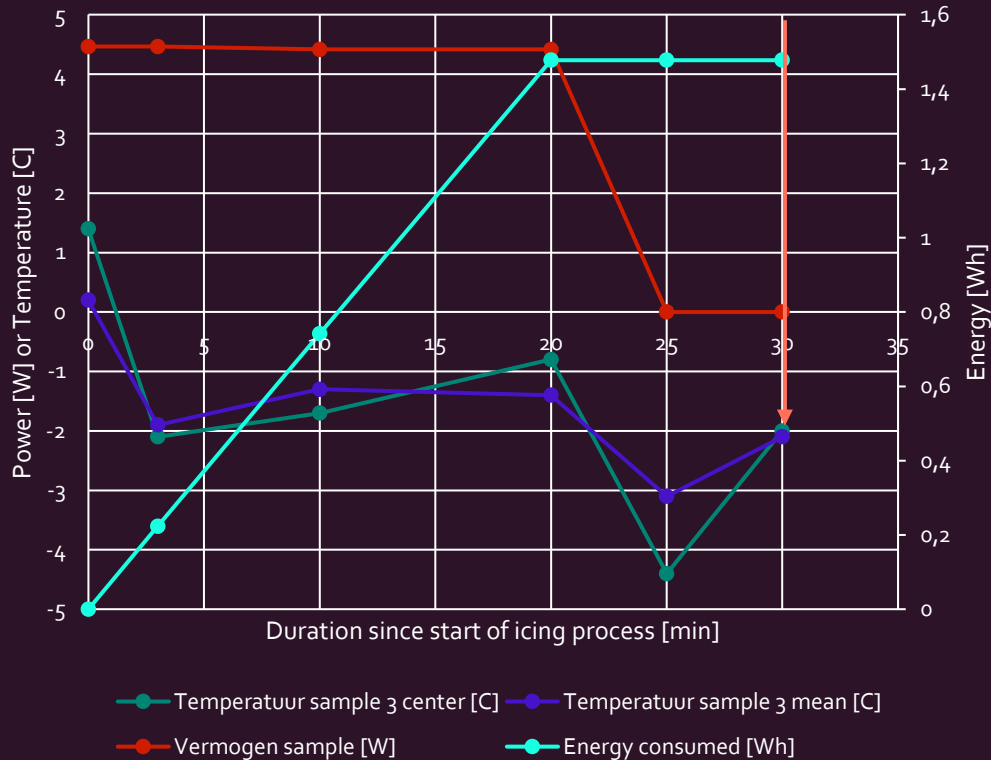


- No ice formation
- Power supply switched off

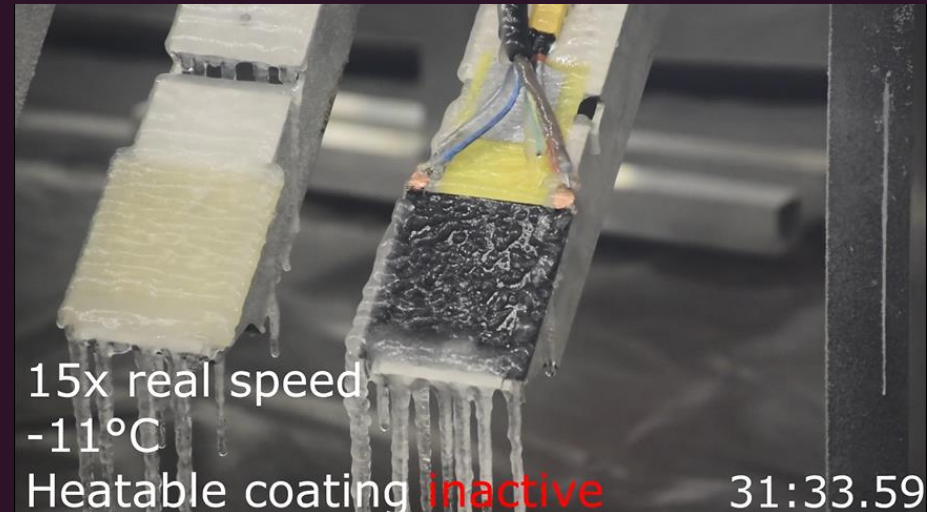


# Functionality test icing conditions: anti-icing

ICE PREVENTION MODE



- Sample covered in ice in 10 minutes
- Prevention consumes less power
- No risk of ice throw in dynamic environment



# Comparison with other solutions

- Electrical resistance embedded in the resin
  - 435 W/m<sup>2</sup> to 650 W/m<sup>2</sup>

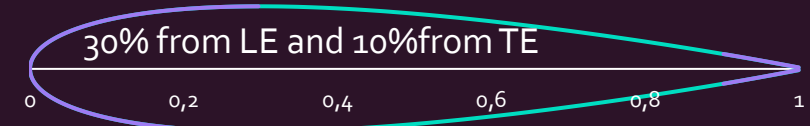
- Heatable coating demo Sirris
  - 450 W/m<sup>2</sup>



Source: EO CYCLE

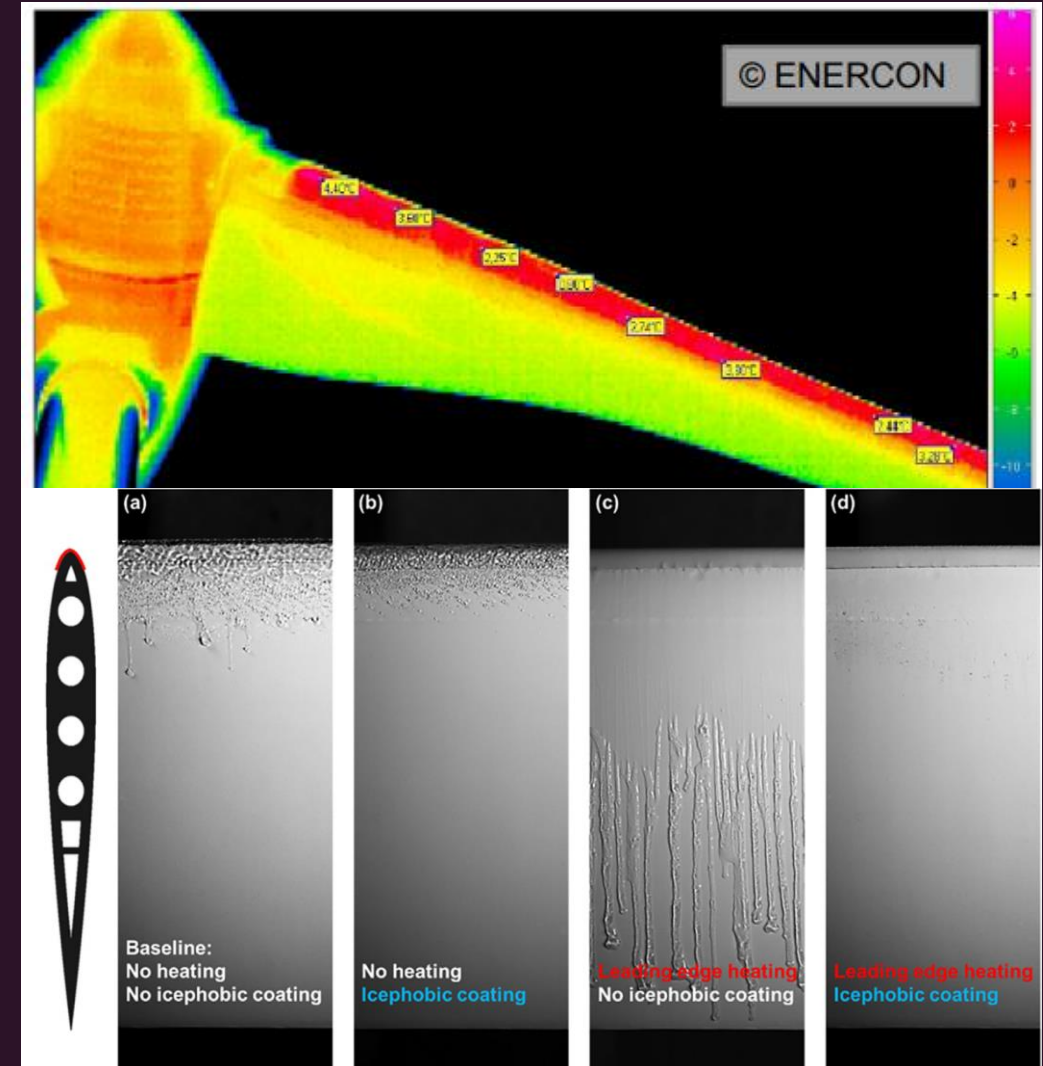


# Comparison with other solutions



- Hot air inside the blade E141 EP4
  - Power: 225kW, 75kW per blade
  - Hot air: heating full mass - > slow

Blade surface with heatable coating	Estimated surface [m2]	Power per coated blade [kW]
100%	436	196
50% LE	230	104
30% LE – 10% TE	191	76
30% LE	141	63
Optimal surface: Even less?		



# Conclusions & Future work

- Feasibility of heatable coatings with hydrophobic topcoat
- Anti-icing was successful at a low energy consumption
  - Temperature just above 0°C.
  - Droplets roll off the hydrophobic substrate
- De-icing takes more time and energy but could be faster in dynamic environments
  
- Future work includes
  - Larger surfaces
  - Dynamic tests
  - Calculation of energy/power consumption for large real-life applications
    - Taking different conditions into account
    - What surfaces to heat?

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