

# Performance of Enercon wind turbines under icing conditions in Europe

Winterwind 2014 - Sundsvall  
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# The roles



- Wind turbine manufacturer
- Provider of hot air blade heating



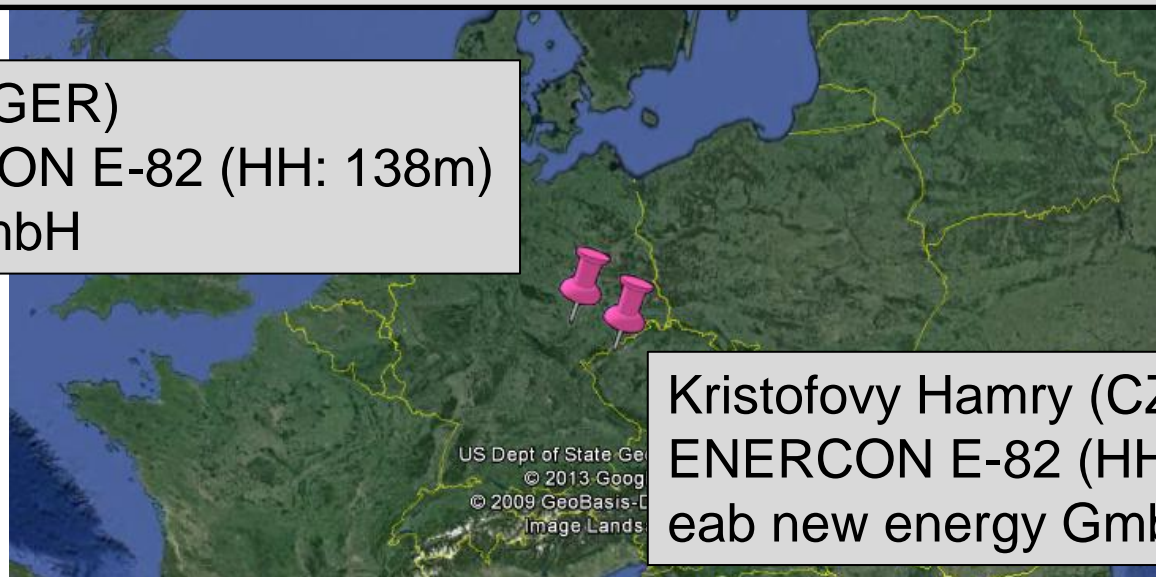
- Independant consultant
- Hired by ENERCON to assess performance of wind turbines under icing conditions

# The sites



Dragaliden (SWE)  
ENERCON E-82 (HH: 108m)  
SVEVIND AB

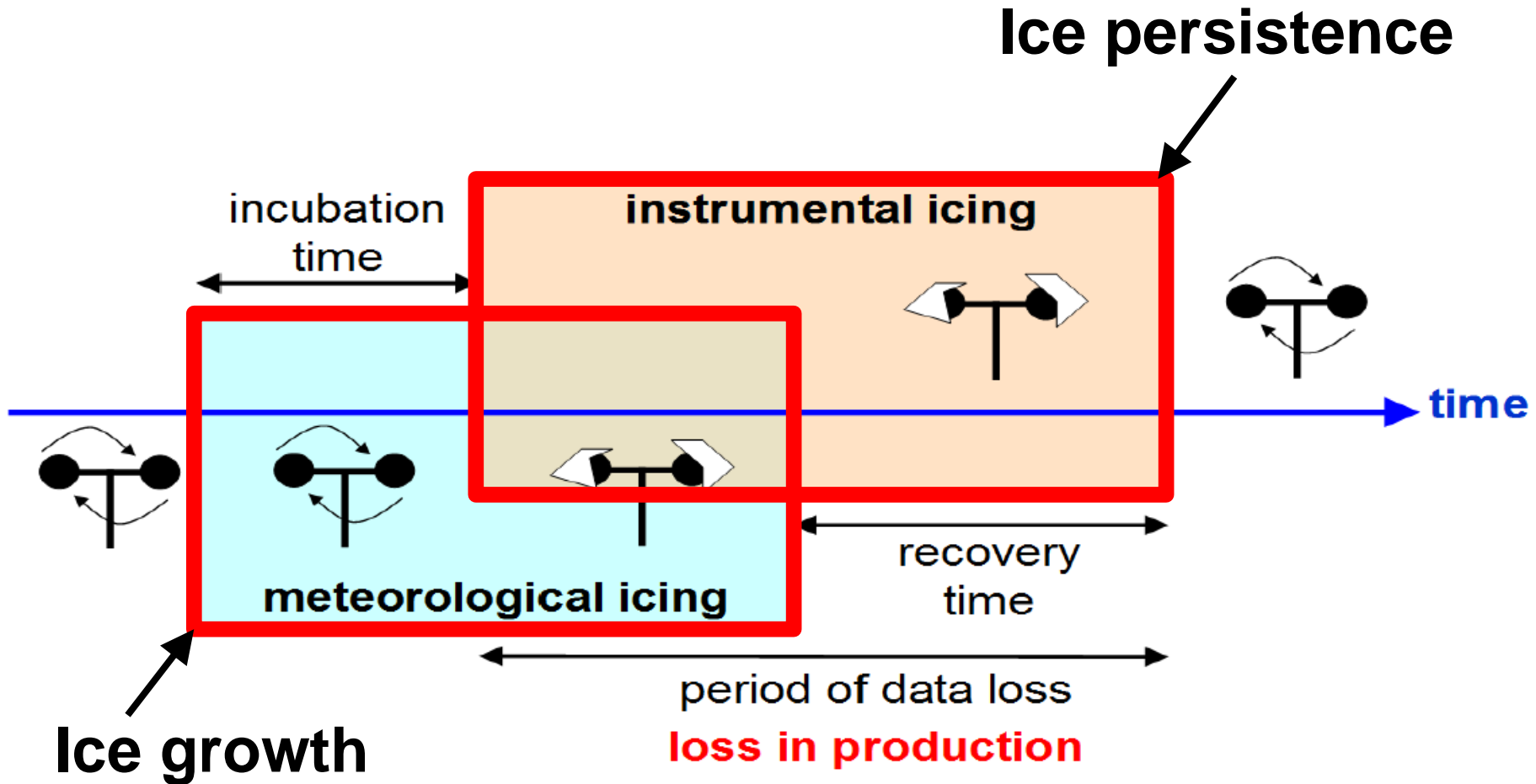
Data set from January 1 to April 30, 2013



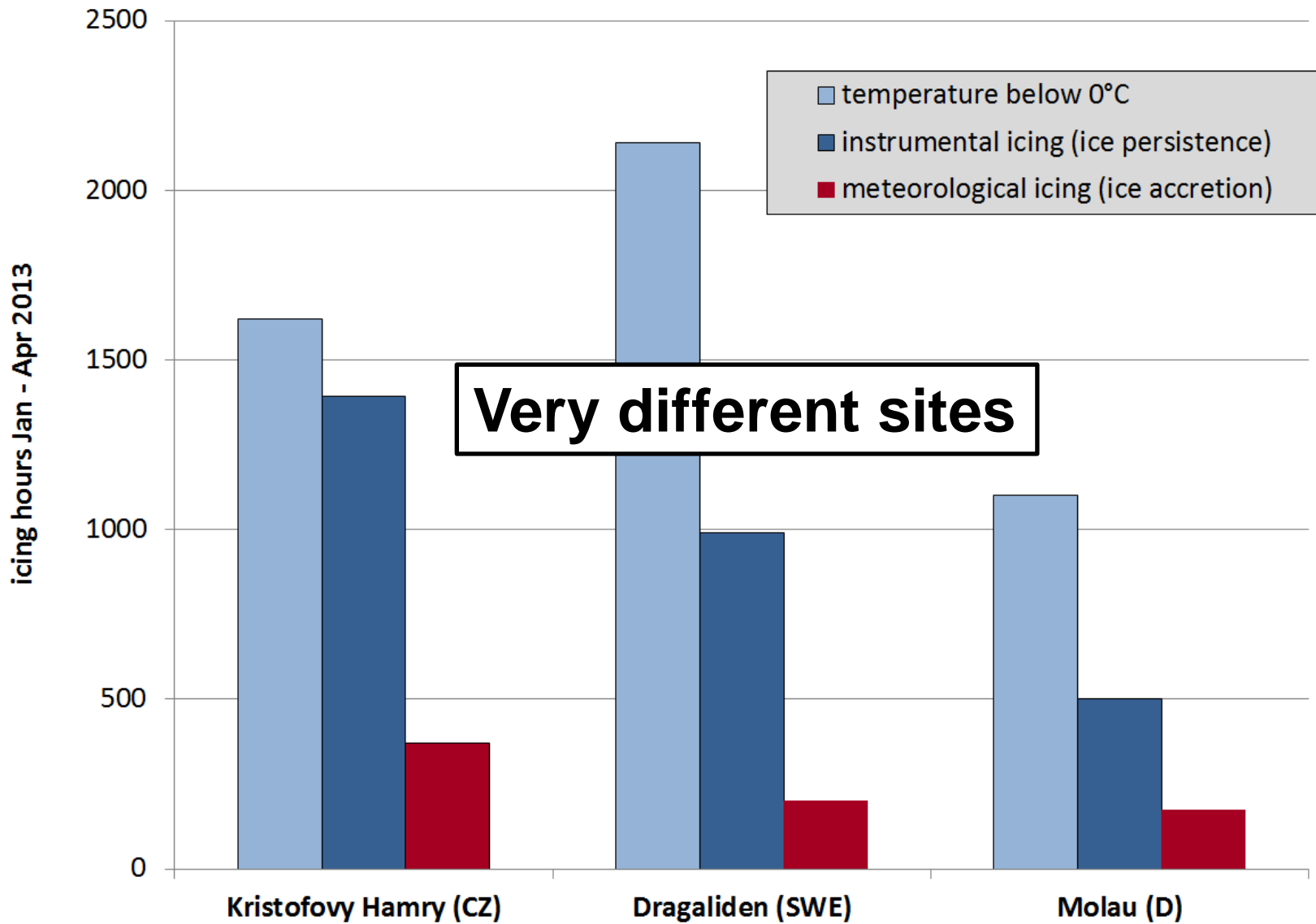
Molau (GER)  
ENERCON E-82 (HH: 138m)  
Mdp GmbH

Kristofovy Hamry (CZ)  
ENERCON E-82 (HH: 78m)  
eab new energy GmbH

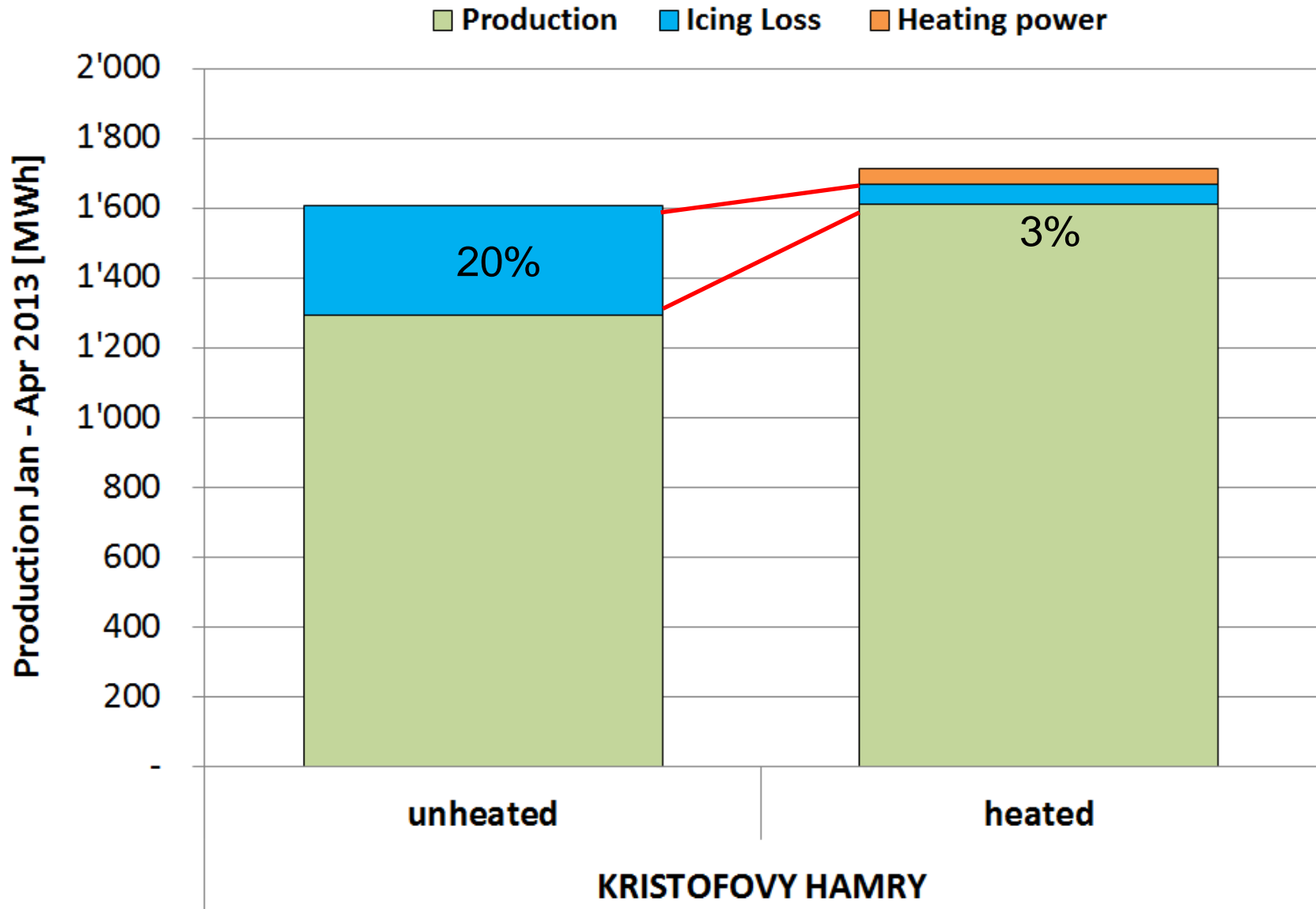
# Icing Conditions



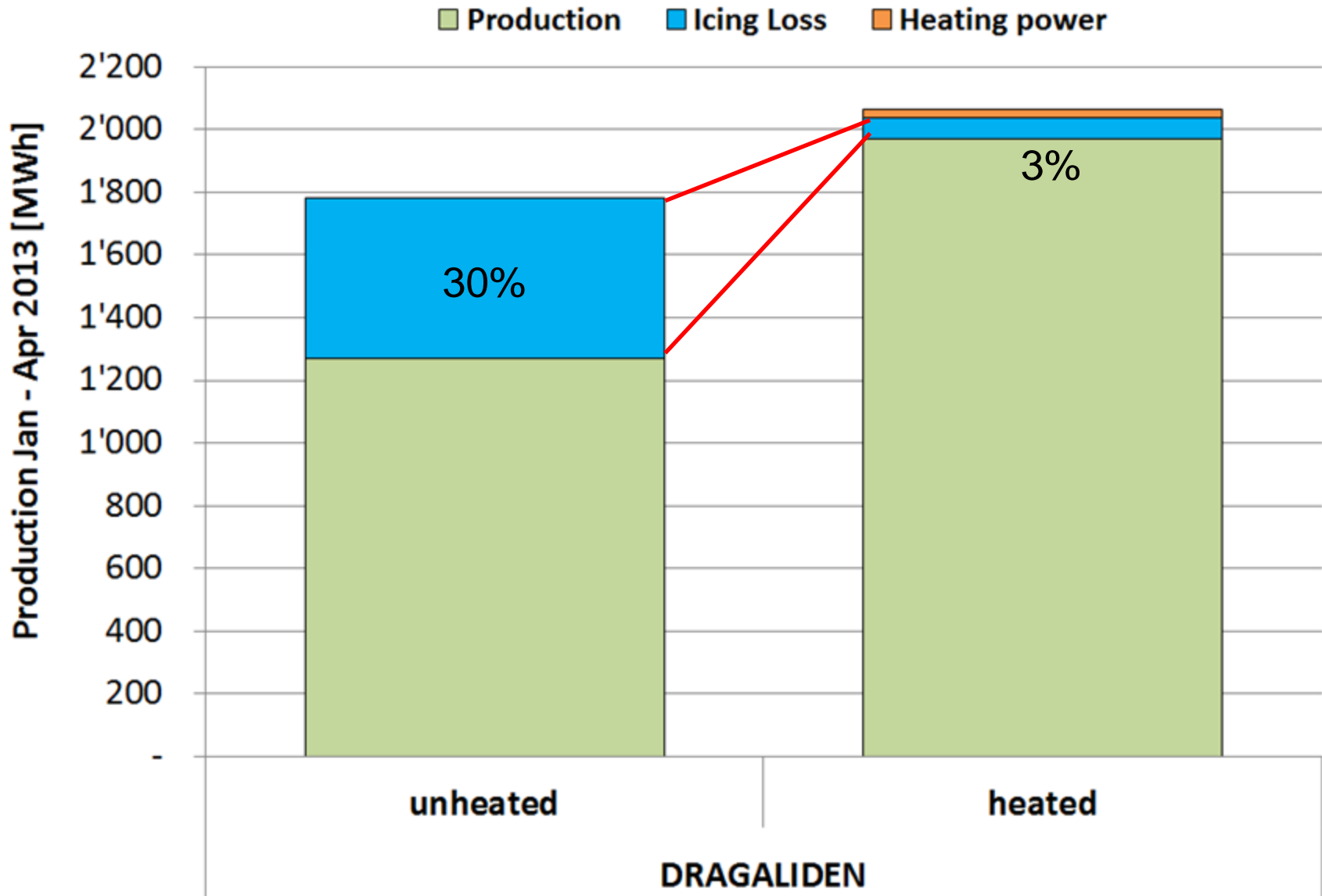
# Icing Conditions (camera)



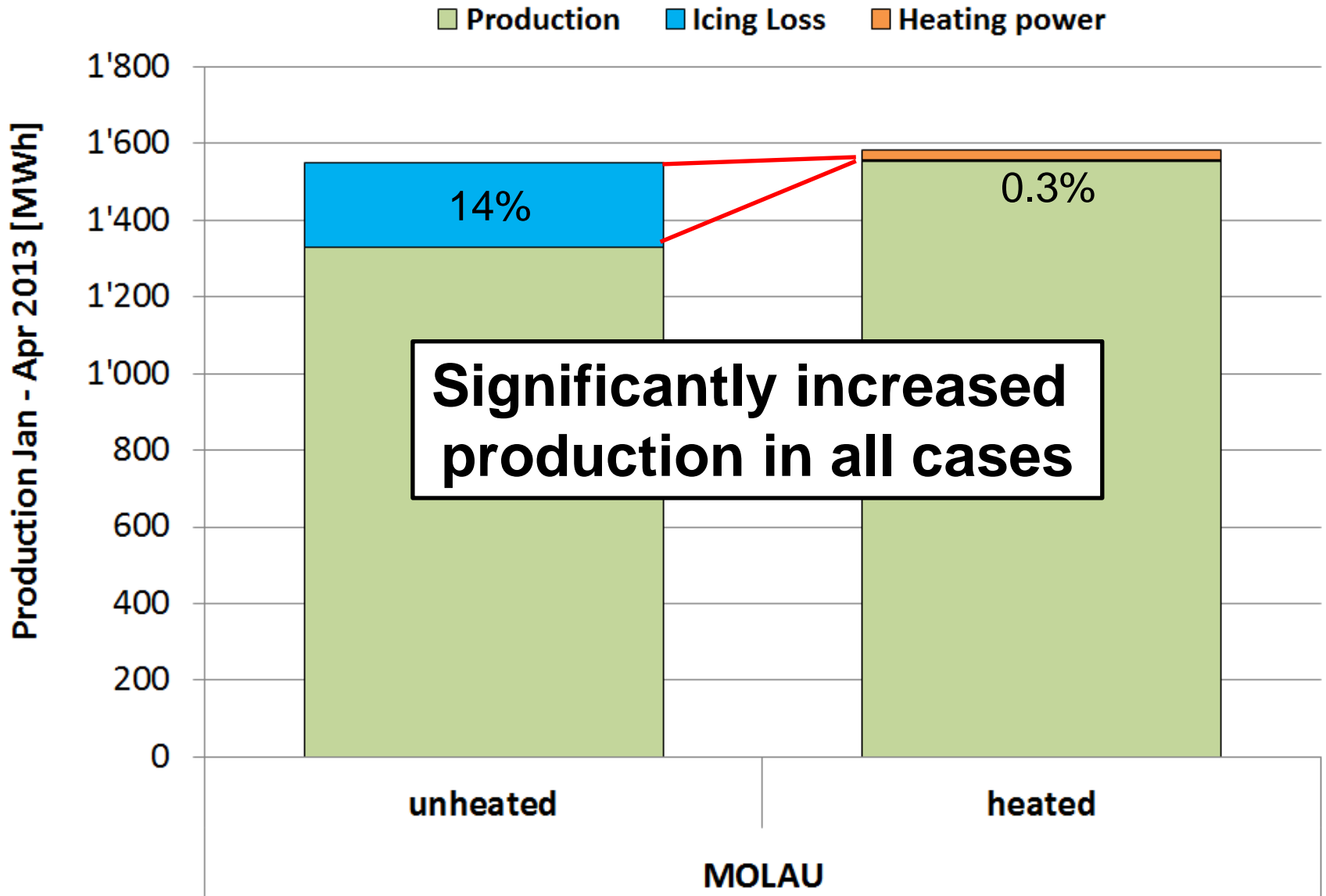
# Heated versus unheated WEC



# Heated versus unheated WEC



# Heated versus unheated WEC





# Performance versus ice loads

## 5 ice load classes

light

light to moderate

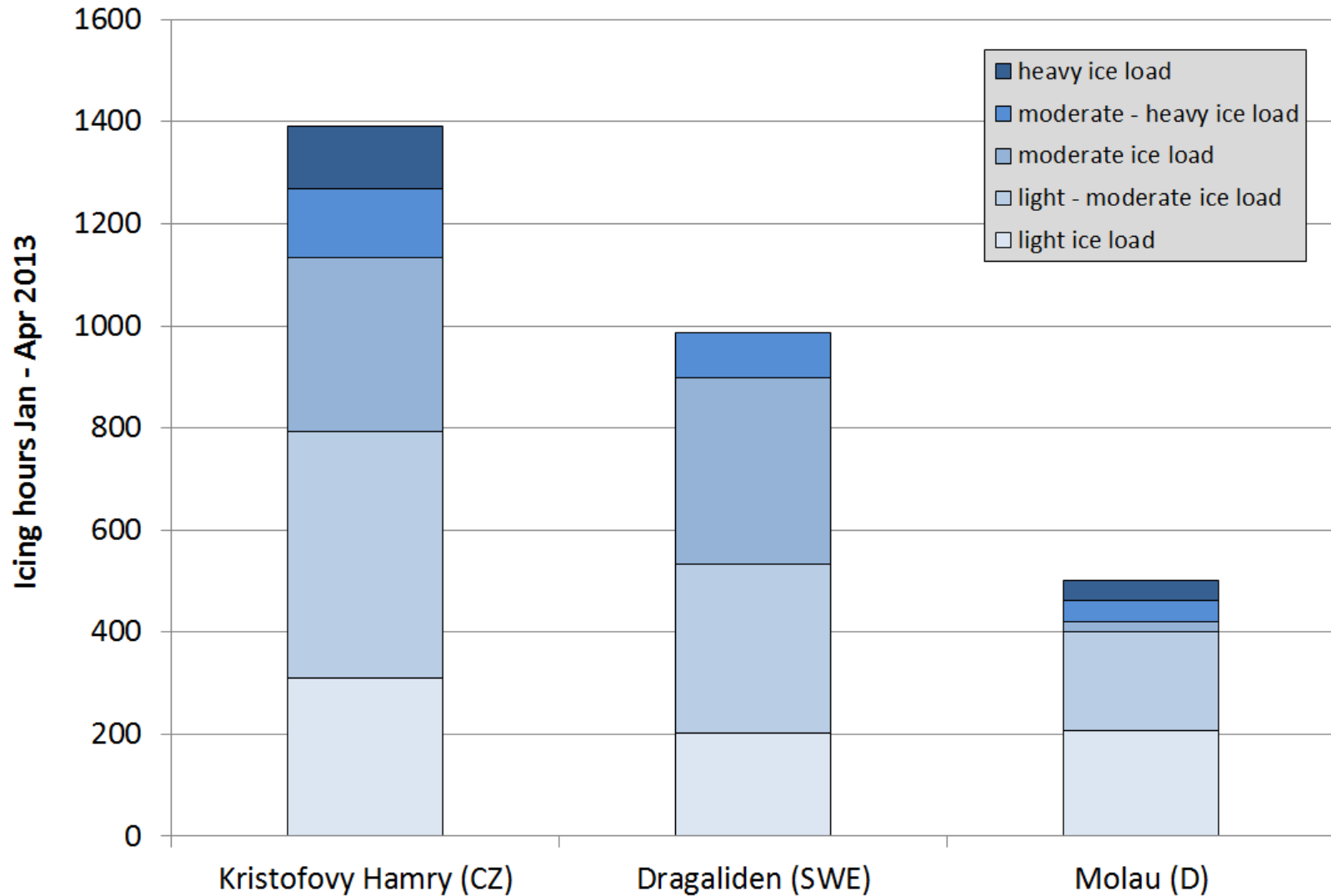
moderate

moderate to heavy

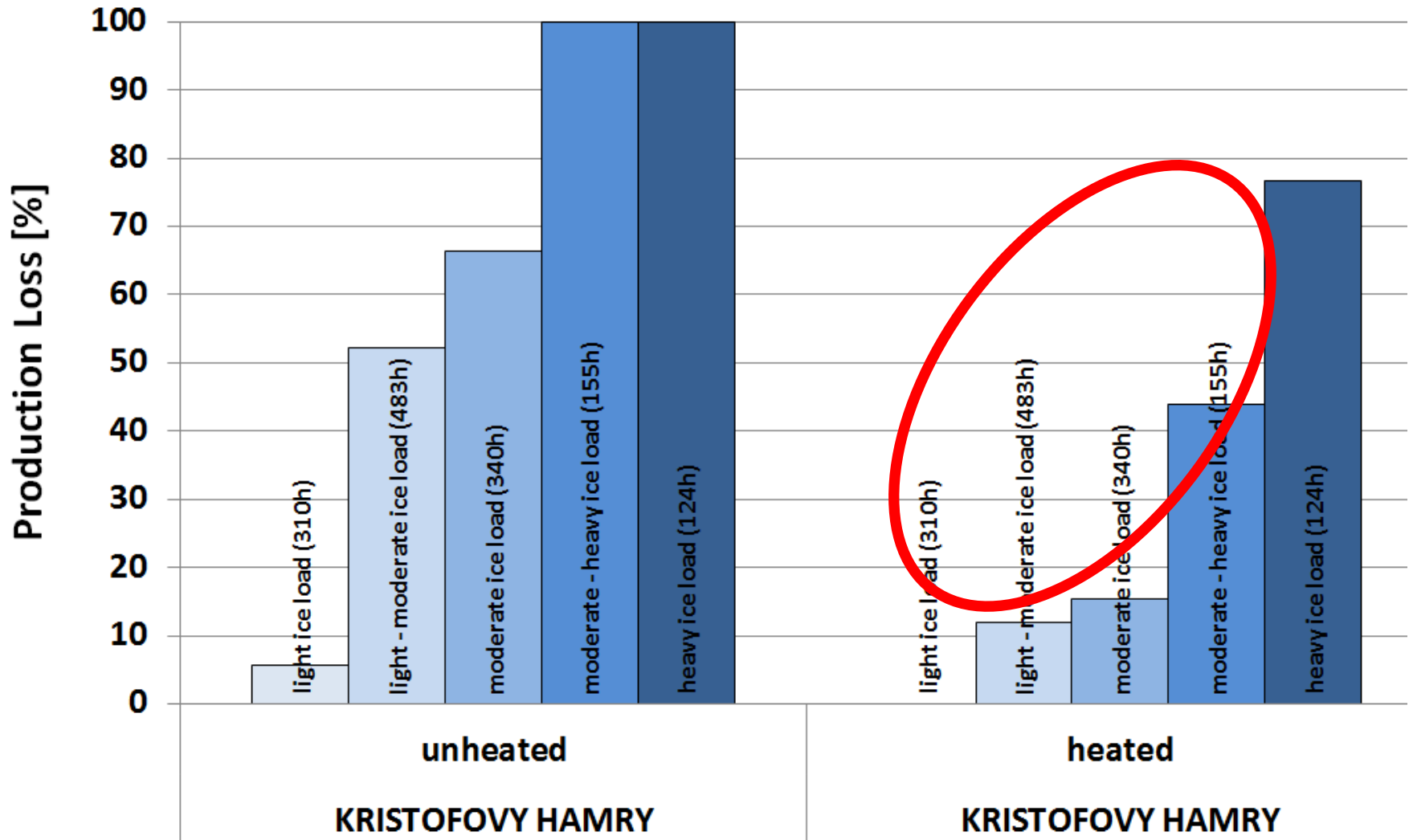
heavy



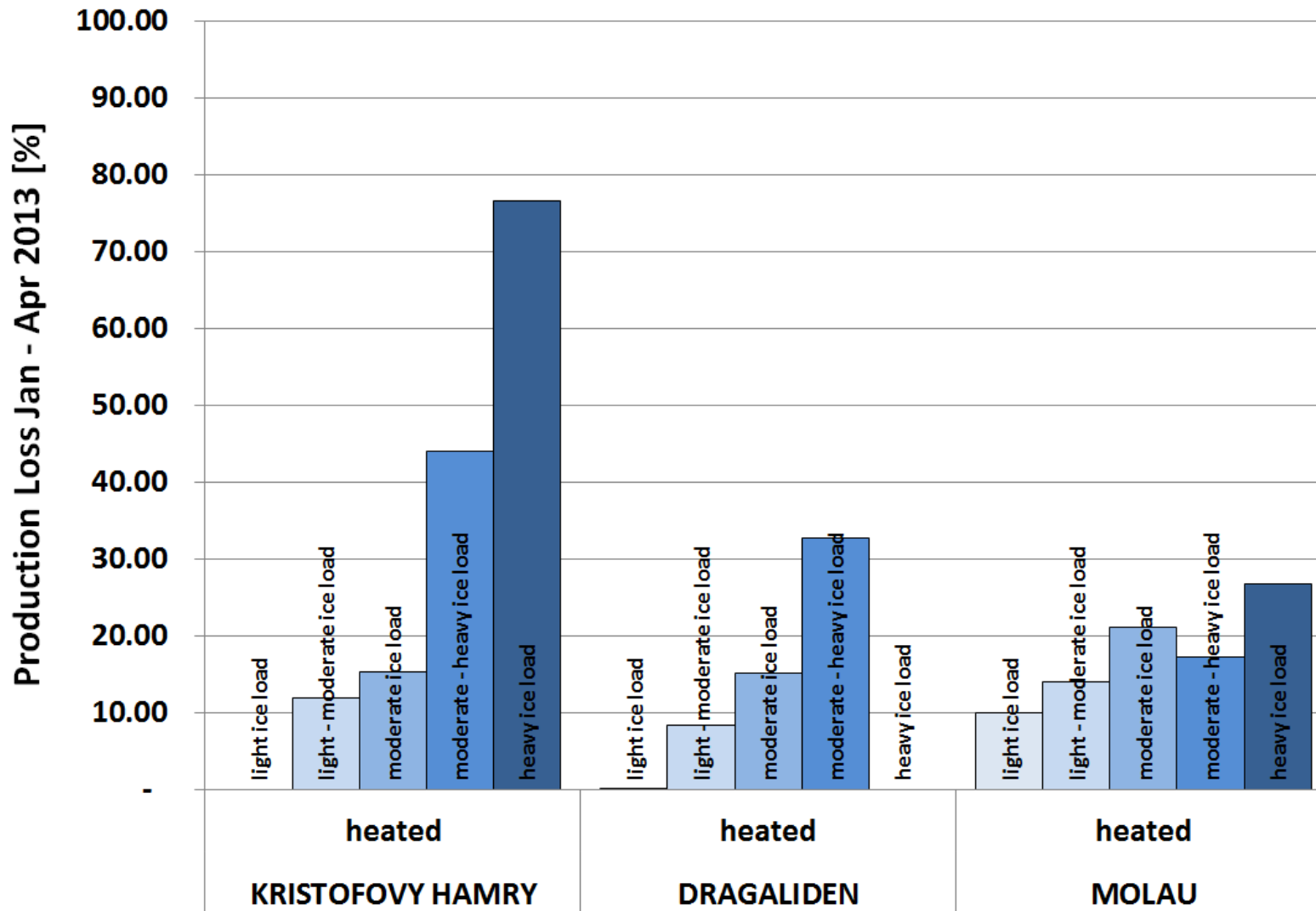
# Ice loads



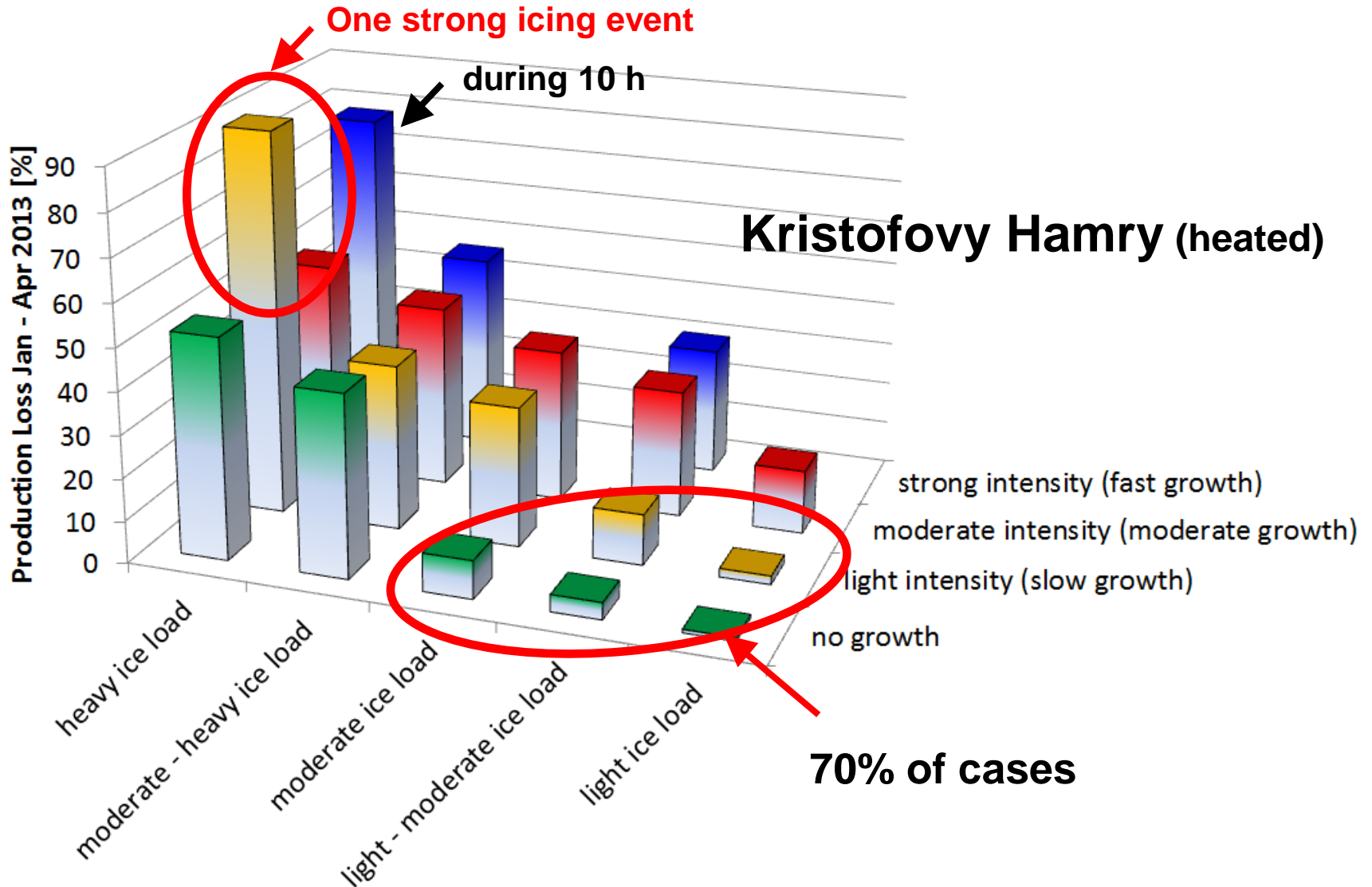
# Performance footprint I



# Performance footprint II



# Performance footprint III



# Wrap up



- The blade heating significantly **increases the production** in all cases
- Performance strongly dependant **on site conditions** (ice load/intensity)
- **Limits:** Less good performance during:
  - icing events with **high ice loads**
  - icing events with **high icing intensity** (ice growth)
- These situations are not very frequent
- **Blade heating control** during strong icing events can be optimized
- **Icing conditions** need to be known in detail (ice load/intensity)
- It is a **case study** with 4 months of data! → study will continue

# Input to panel discussion

- More **field data of real wind turbines** is required to generate a ***performance footprint*** of a specific wind turbine type under icing conditions
  - **Homework for manufacturers** (operators)
- Much more detailed **site-specific icing information** required to be able to receive a ***performance guarantee*** for a de-icing system
  - **Homework for project developers**

# Thank you for your attention!



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