Power production losses due to icing

their relation to
icing conditions and operation mode

Winterwind 2015 - Piteå

February 3, 2015

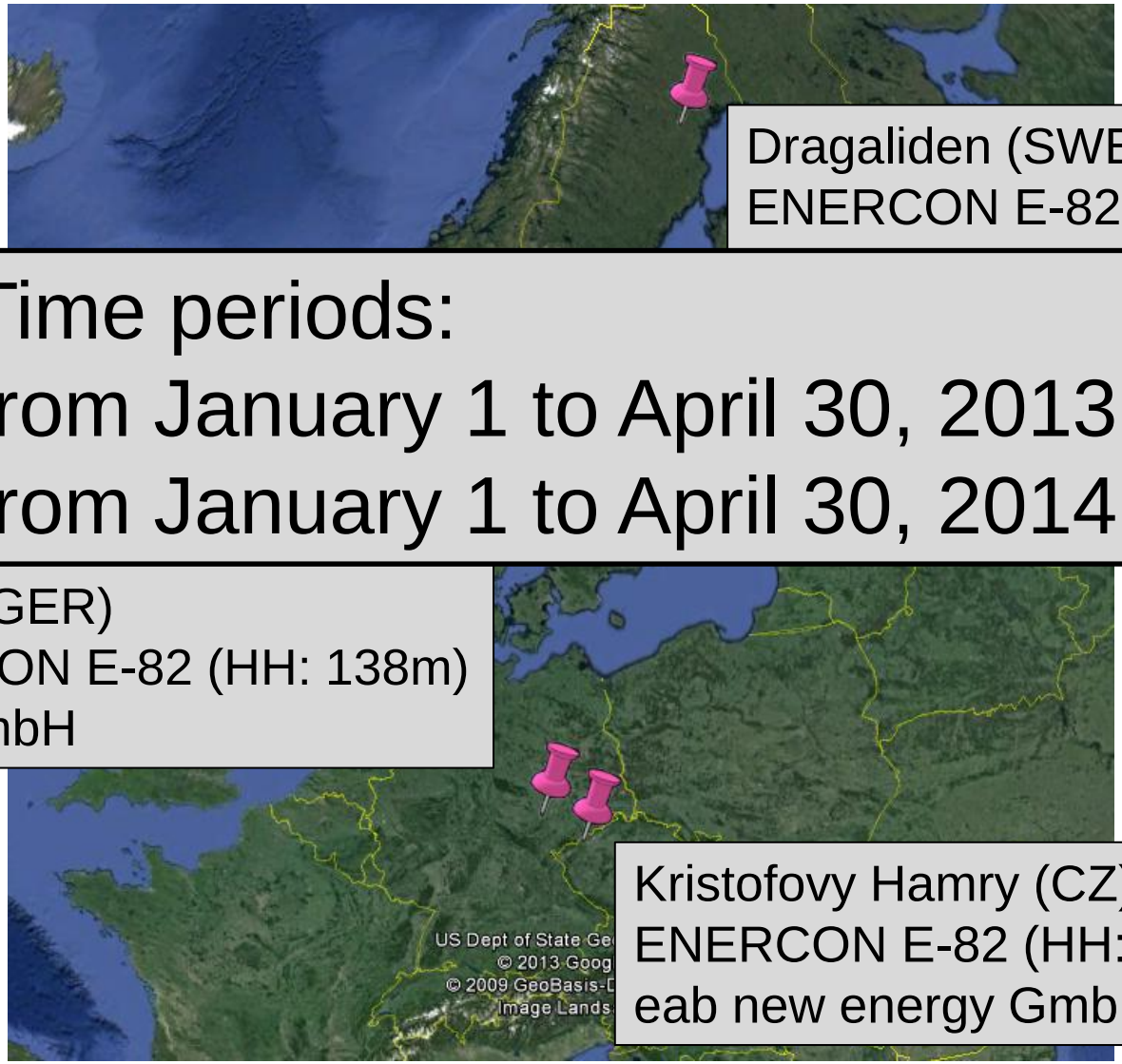
Silke Dierer, Rebecca Gugerli and René Cattin, Meteotest

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)

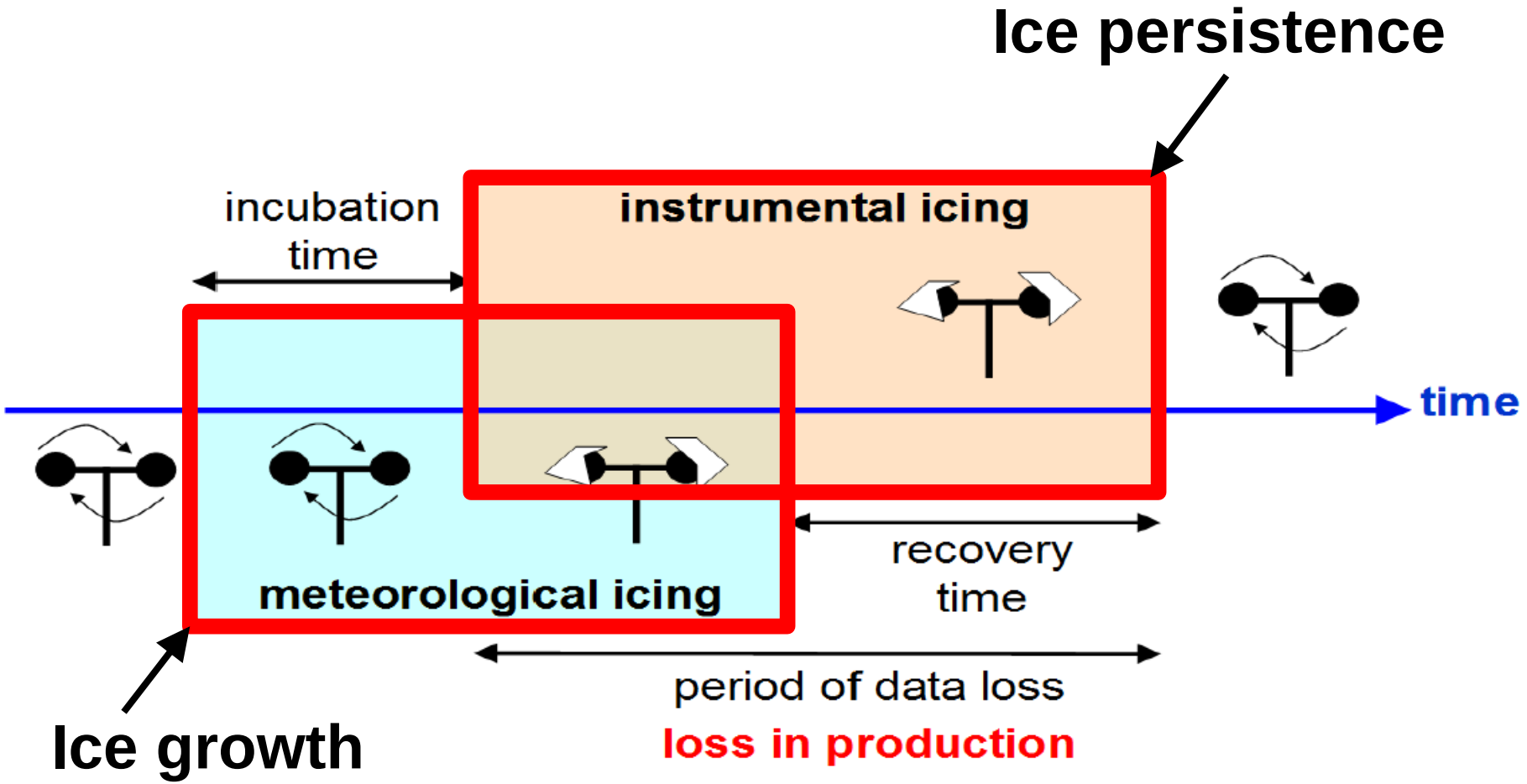
Data s , 2014

Time periods:
from January 1 to April 30, 2013
from January 1 to April 30, 2014

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

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

Icing conditions



Ice load classification

5 ice load classes

light

light to moderate

moderate

moderate to heavy

heavy

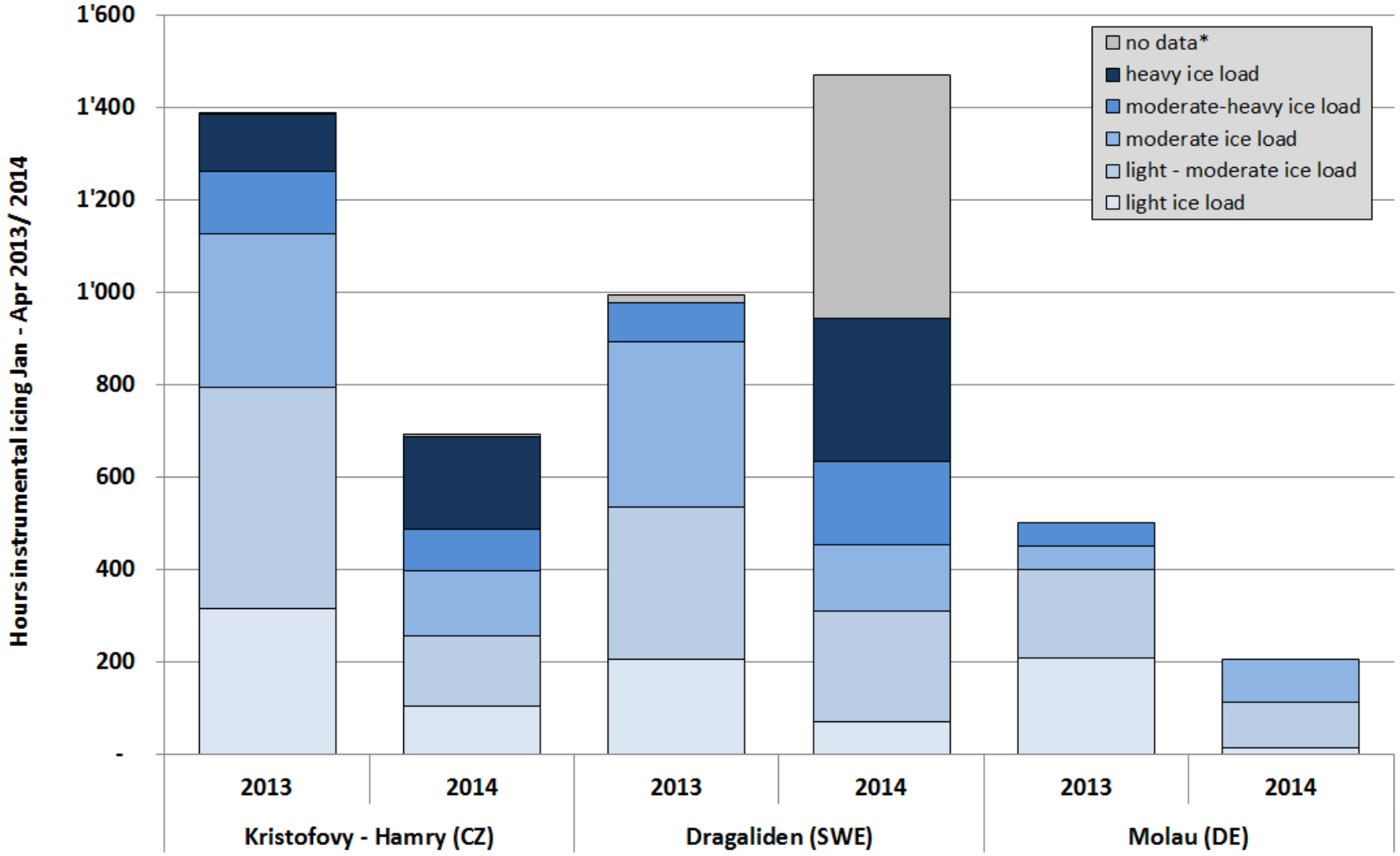
+ 3 classes for intensity

Year-to-year variability

2013 versus 2014

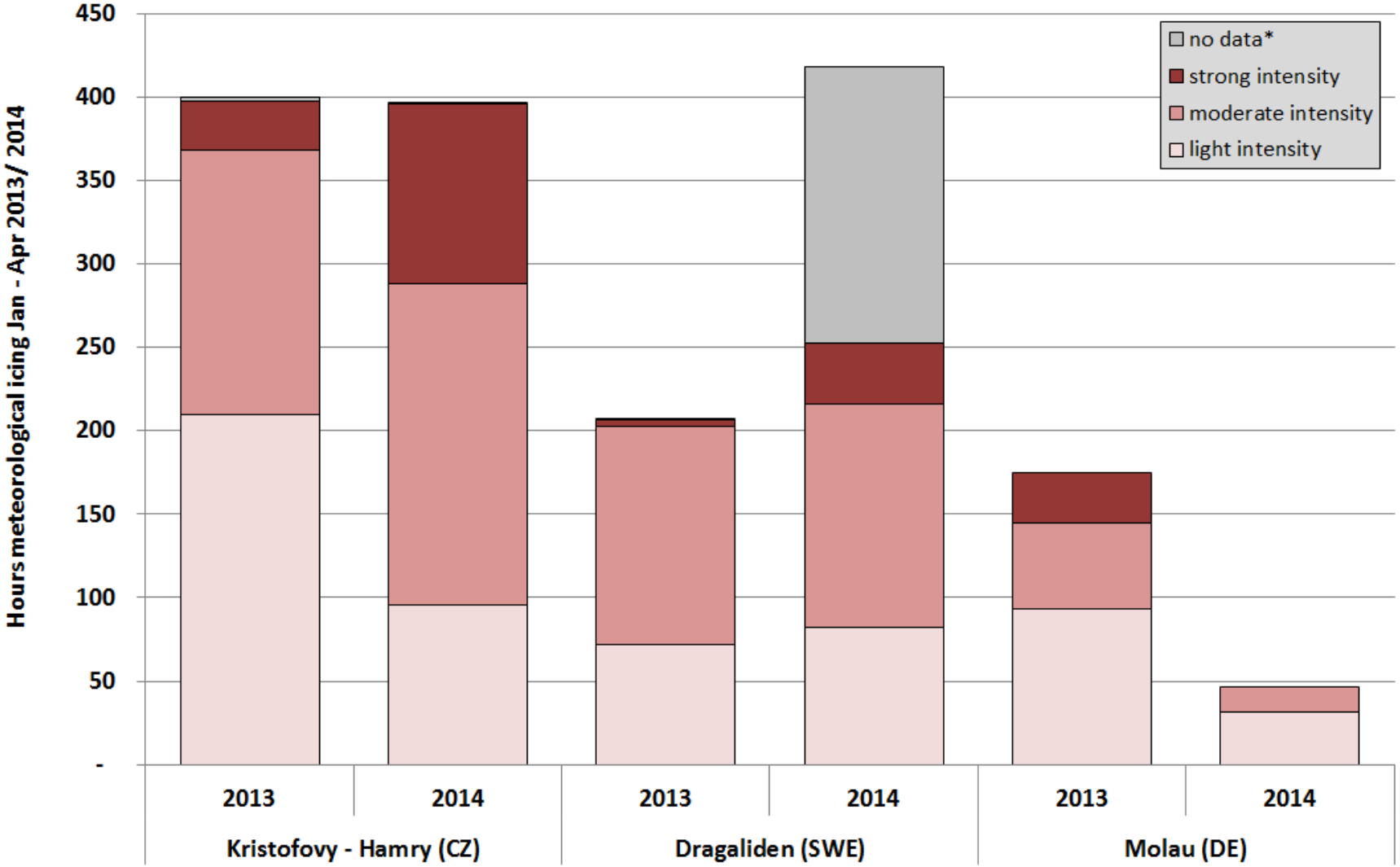
Year-to-year variability

Instrumental icing



Year-to-year variability

Meteorological icing

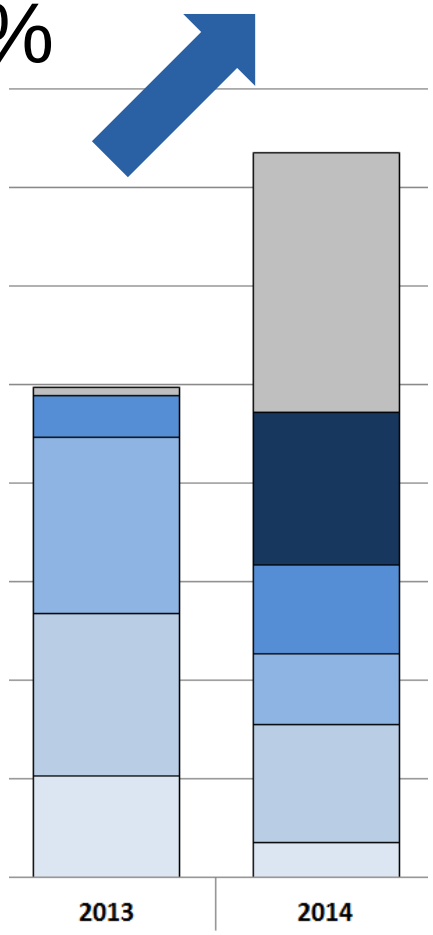


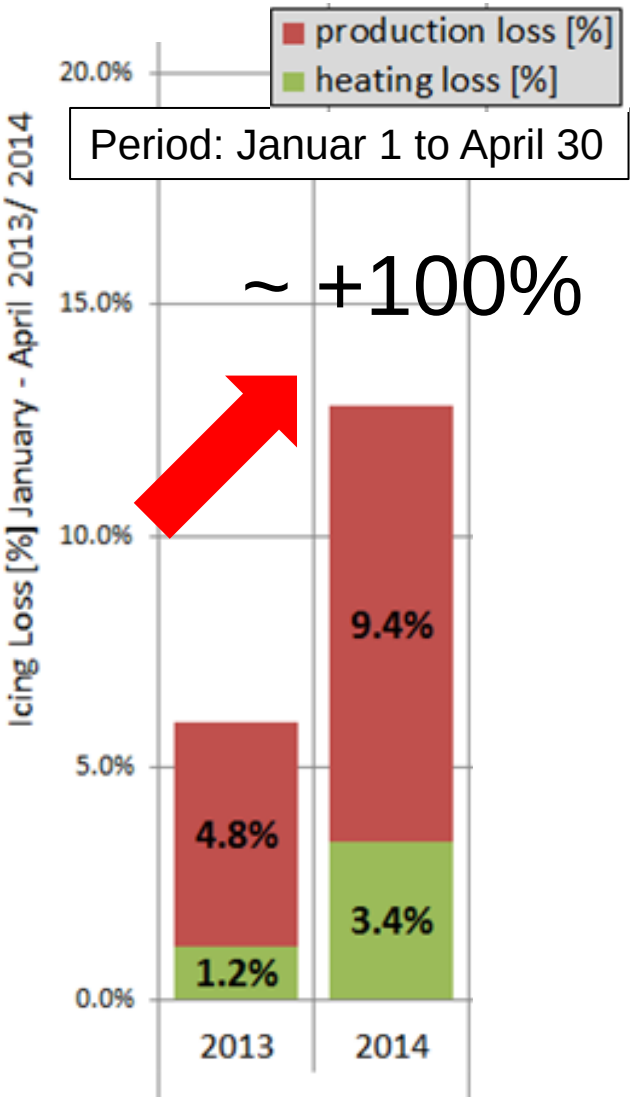
Year-to-year variability

Instrumental icing versus production loss

Dragaliden, SWE

~ +50%

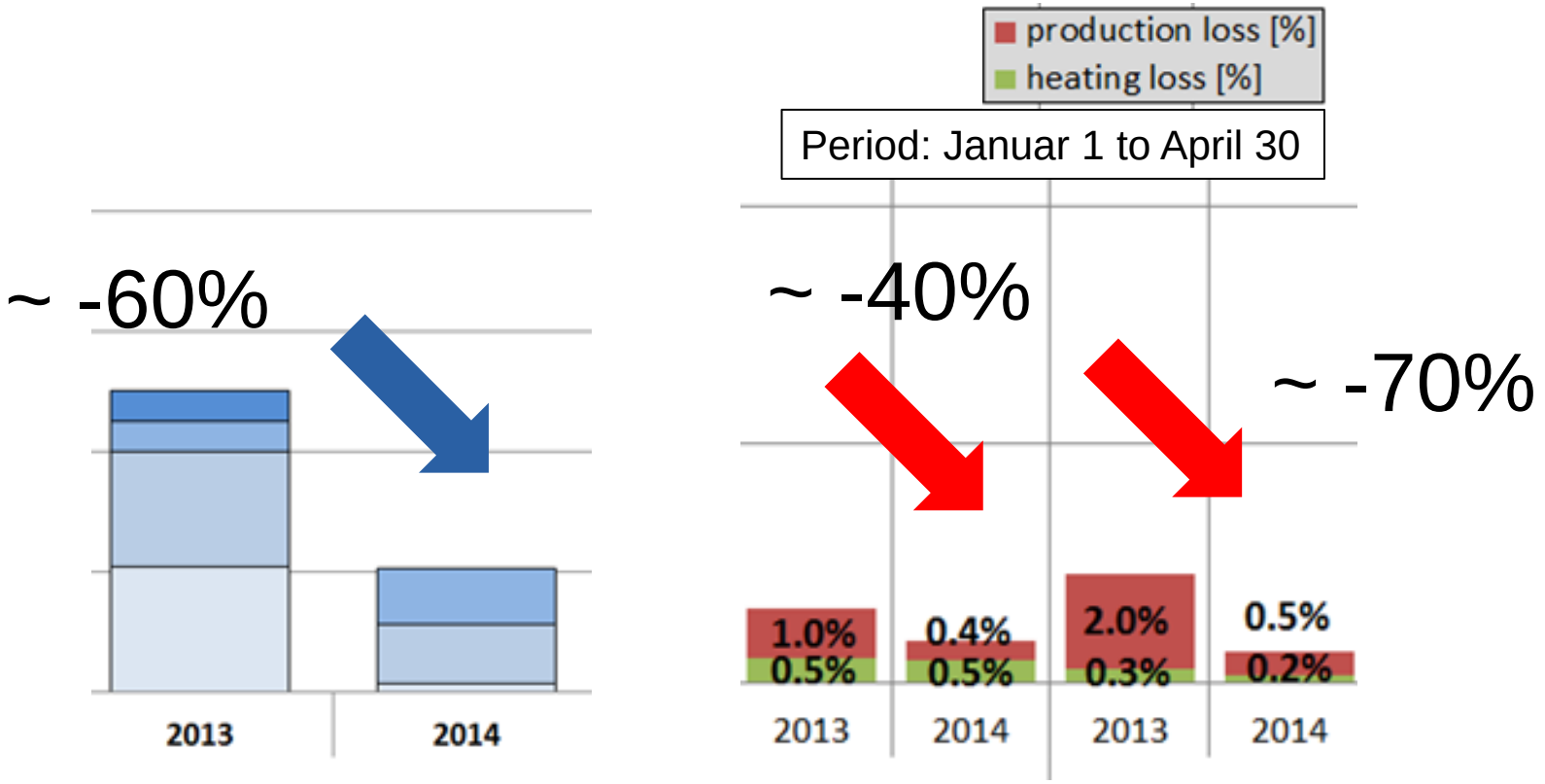




Year-to-year variability

Instrumental icing versus production loss

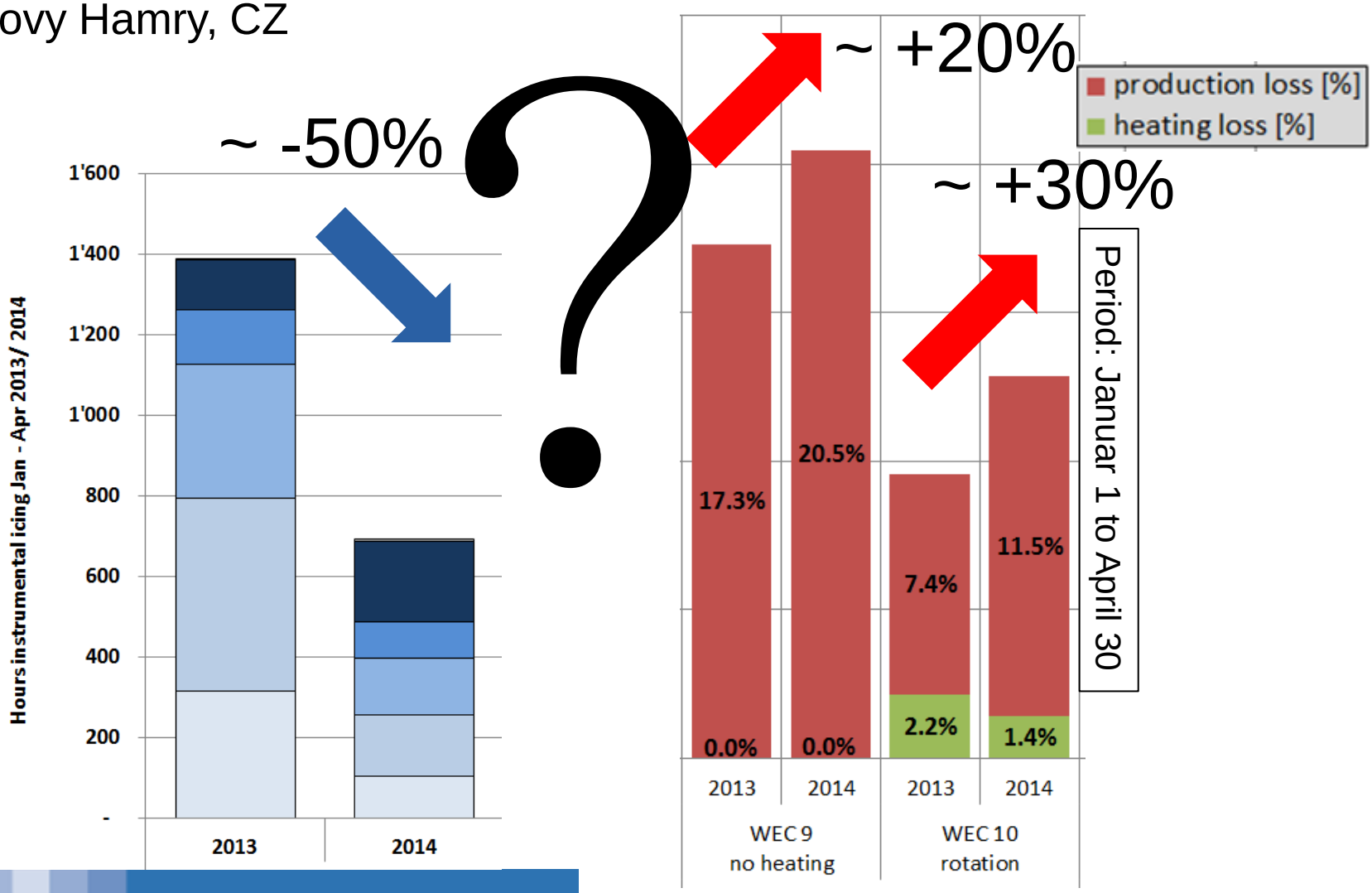
Molau, D



Year-to-year variability

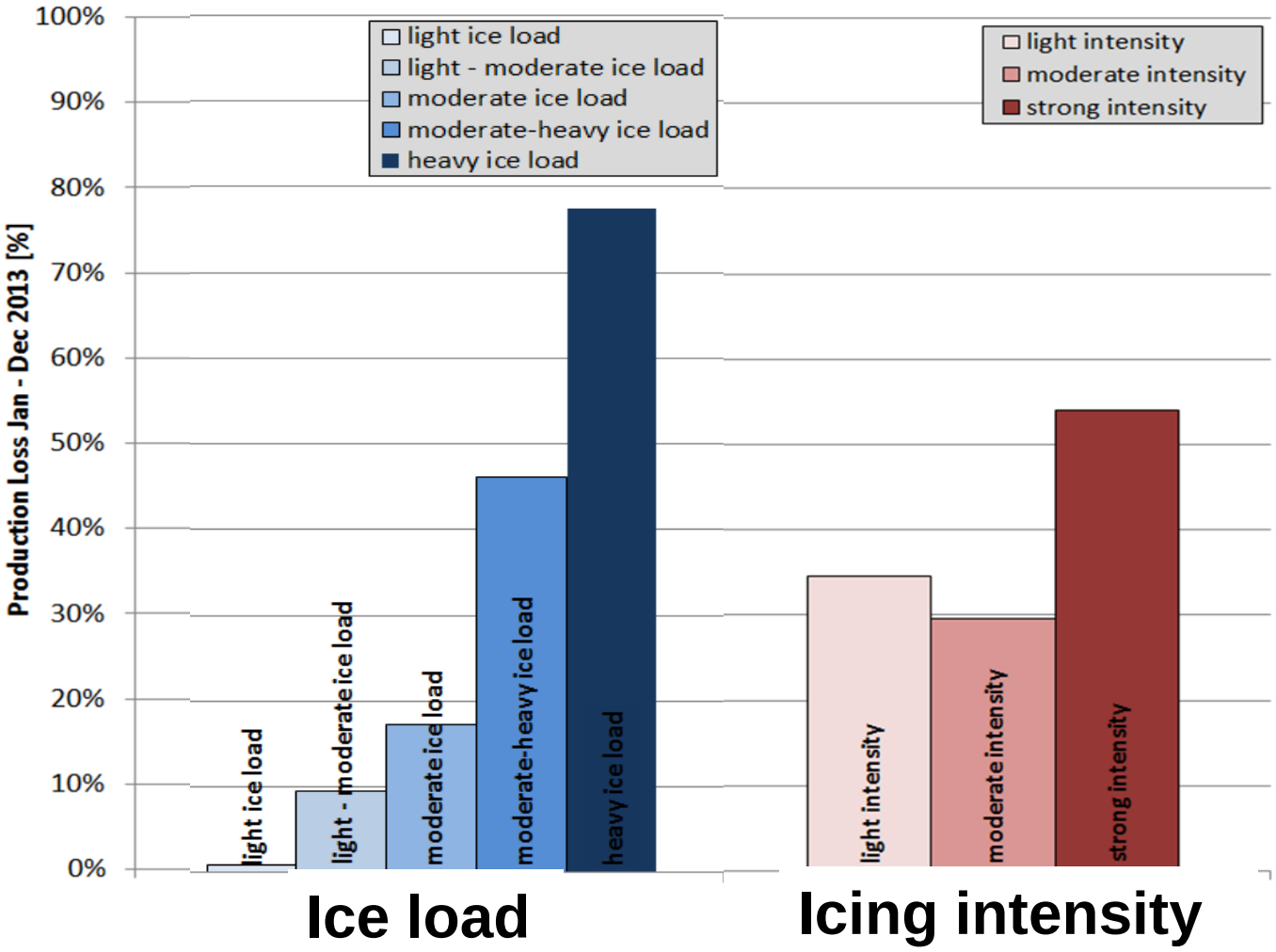
Instrumental icing versus production loss

Kristofovy Hamry, CZ



Turbine performance footprint

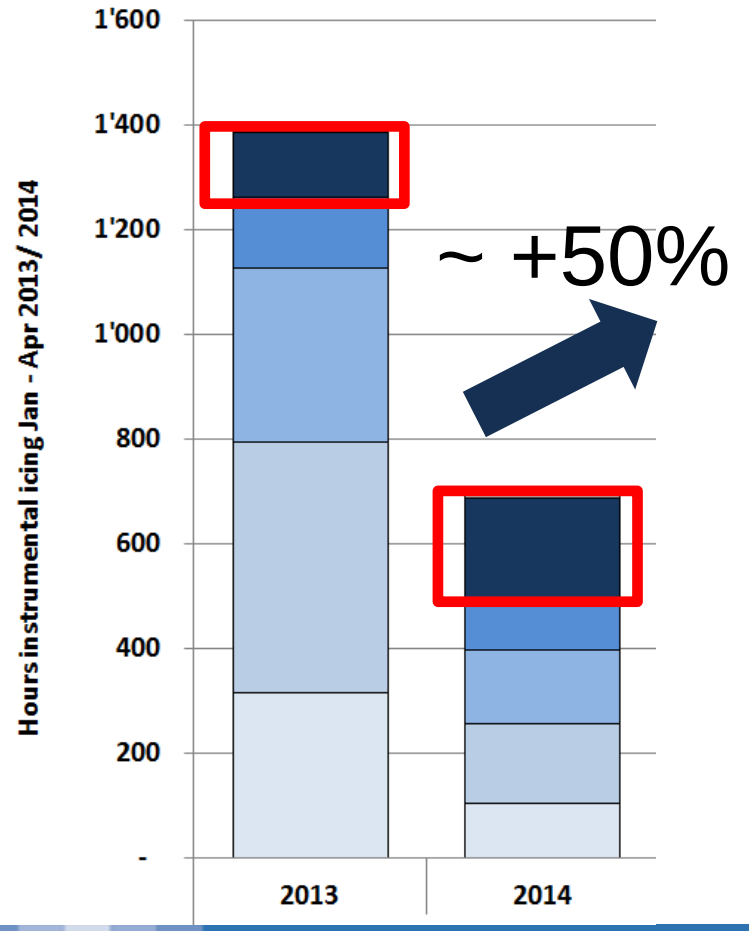
Kristofovy Hamry, CZ, heated turbine

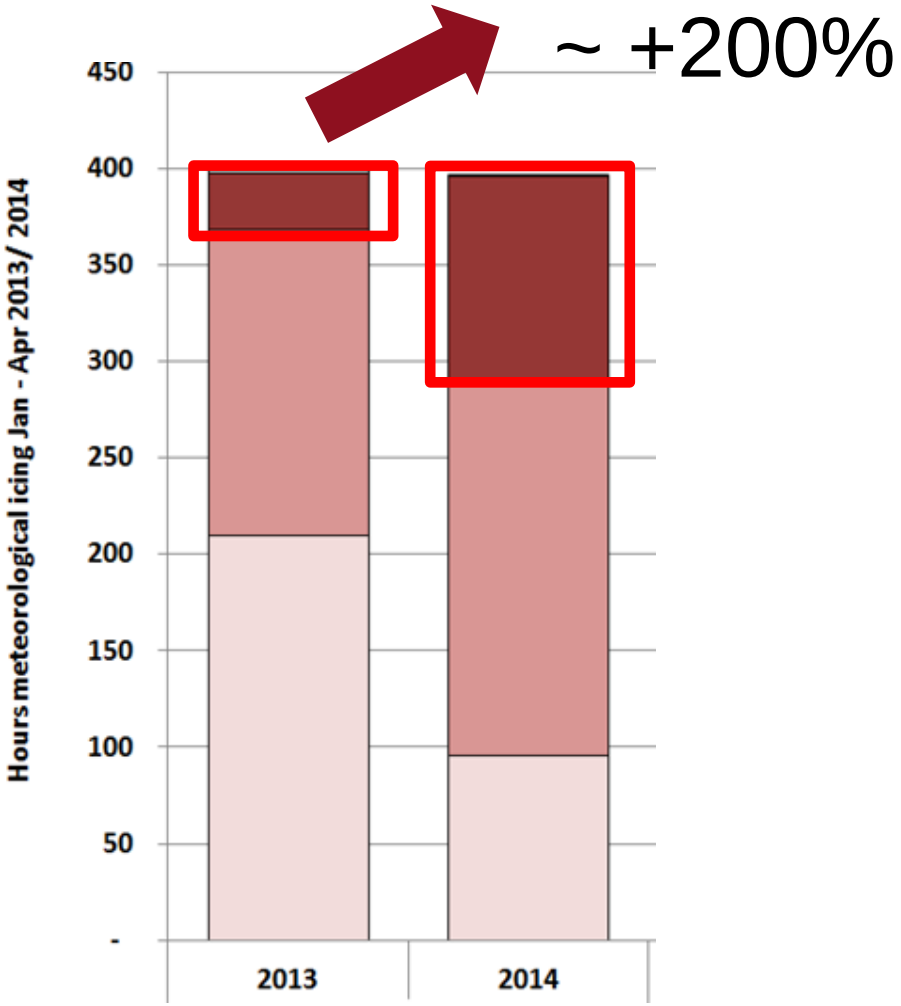


Year-to-year variability

Instrumental icing versus production loss

Kristofovy Hamry, CZ

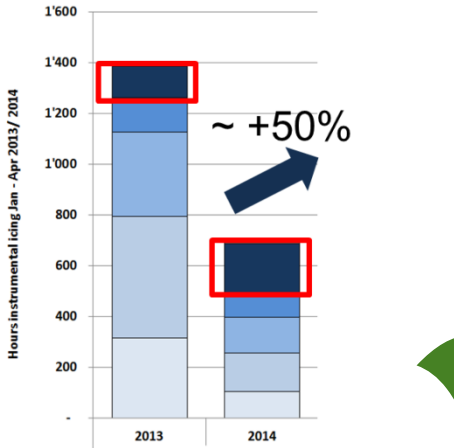


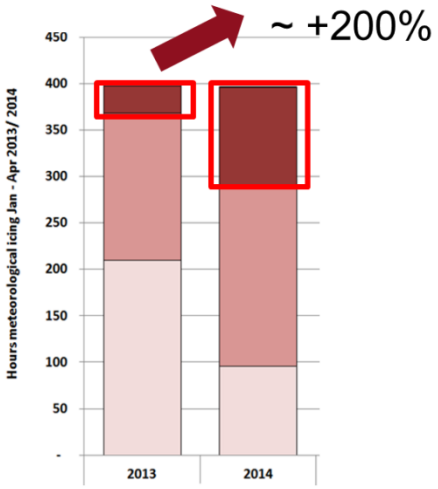


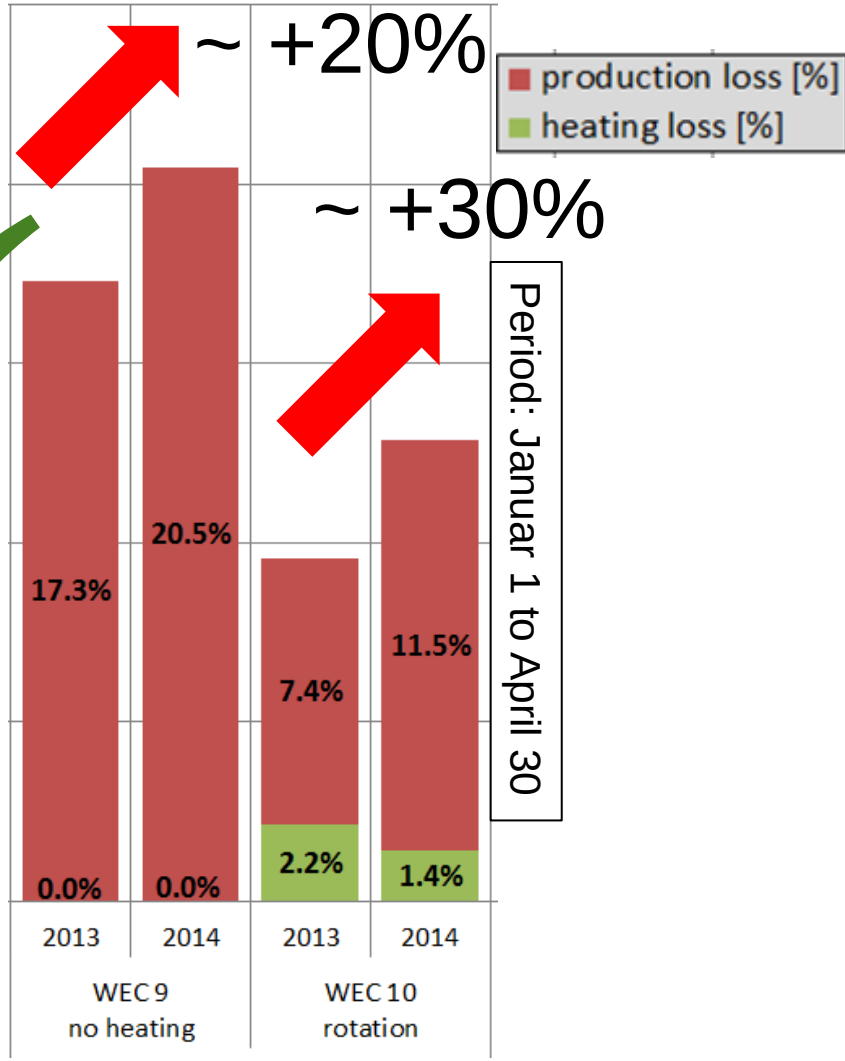
Year-to-year variability

Instrumental icing versus production loss

Kristofovy Hamry, CZ







Intermediate summary

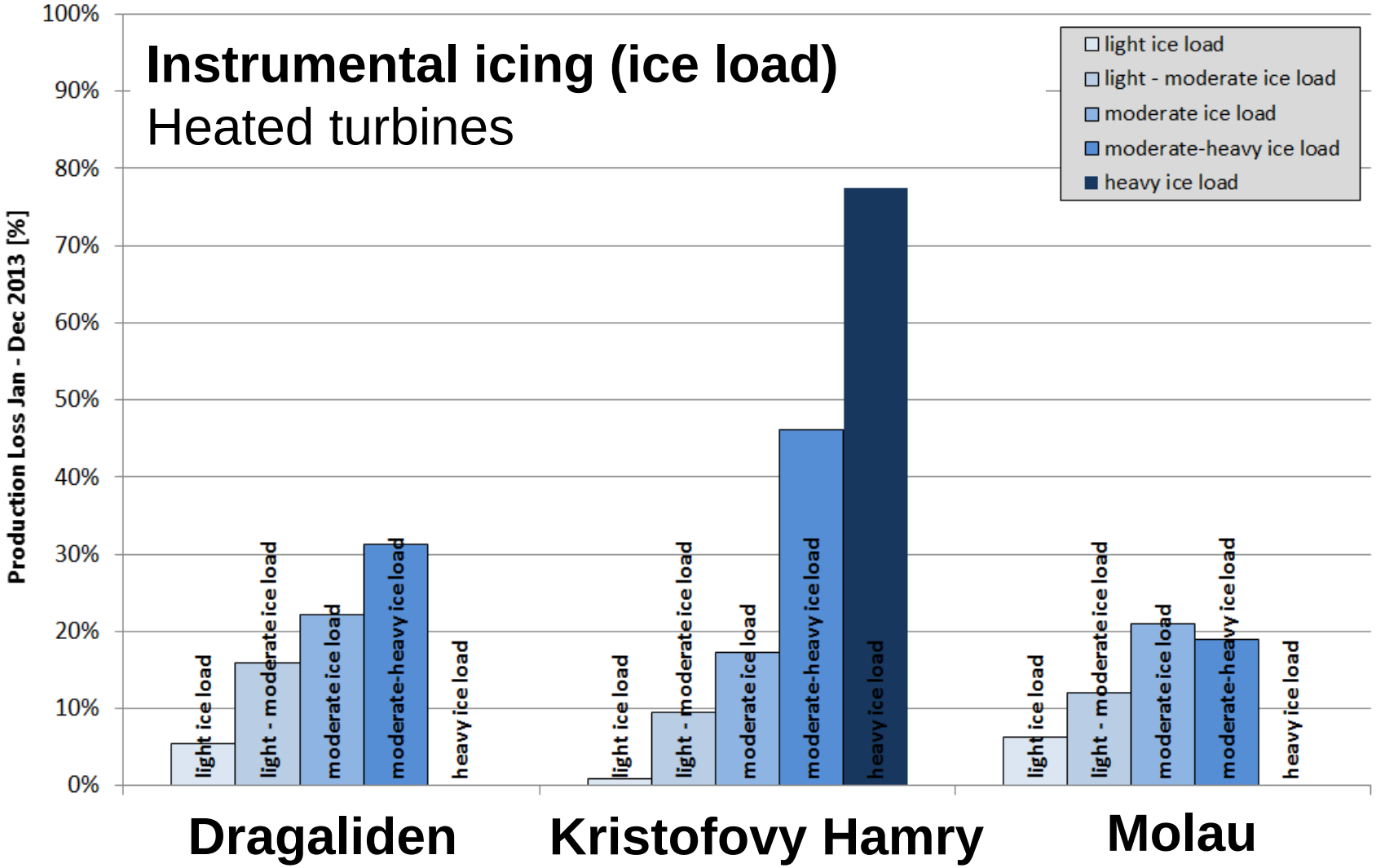
- Icing conditions **differ significantly from year to year**
- Power losses differ significantly from year to year
  → not necessarily in line with the **overall icing frequency**
- Information on **meteorological and instrumental icing is not sufficent** to fully describe turbine performance
- Turbine performance is strongly dependent **on ice load and icing intensity**

Turbine performance footprint

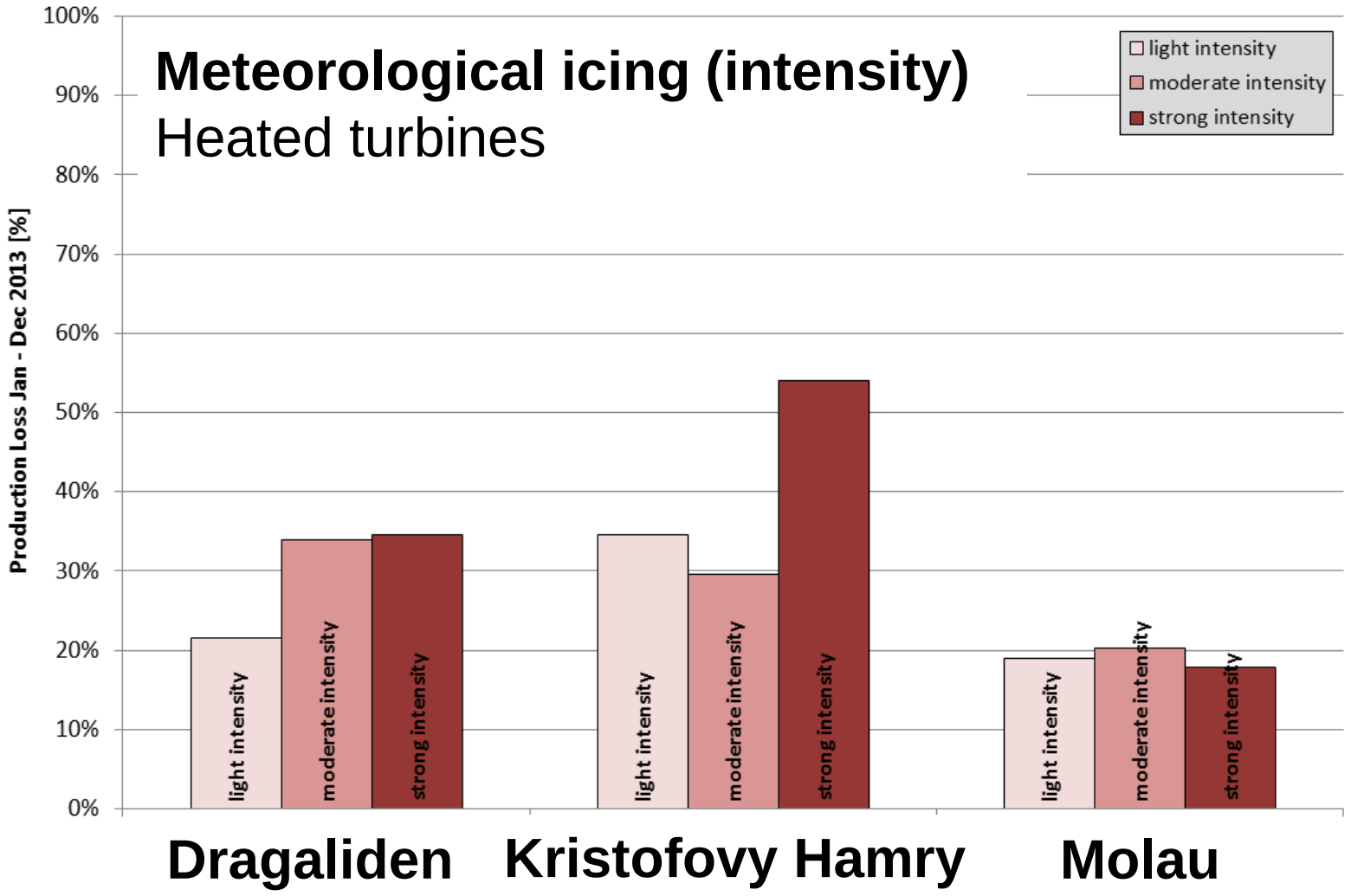
Describes the **average production loss** for a specific turbine for **different classes of ice load and icing intensity**

- Heating in operation
- Heating in standstill
- No heating

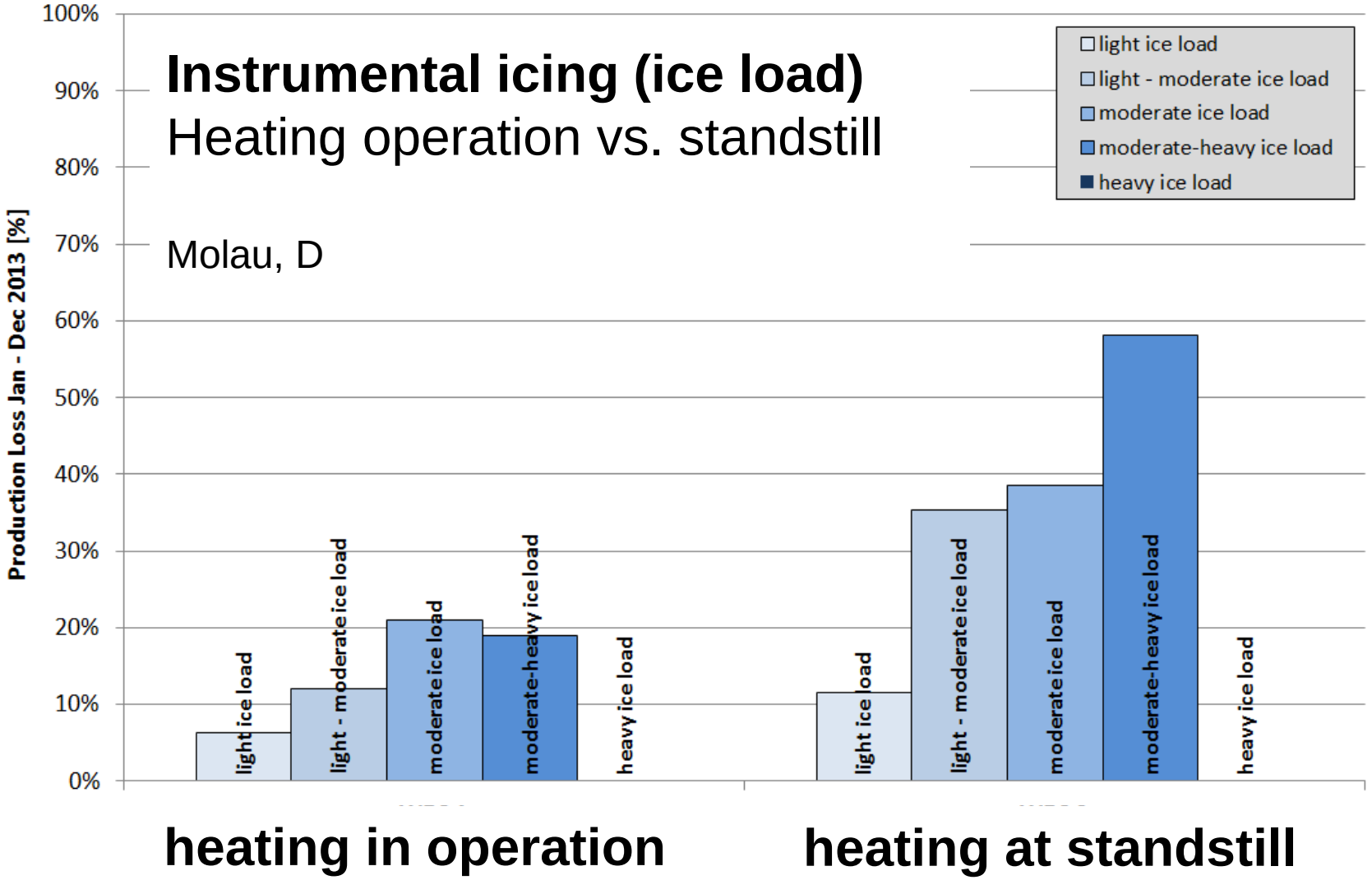
Turbine performance footprint



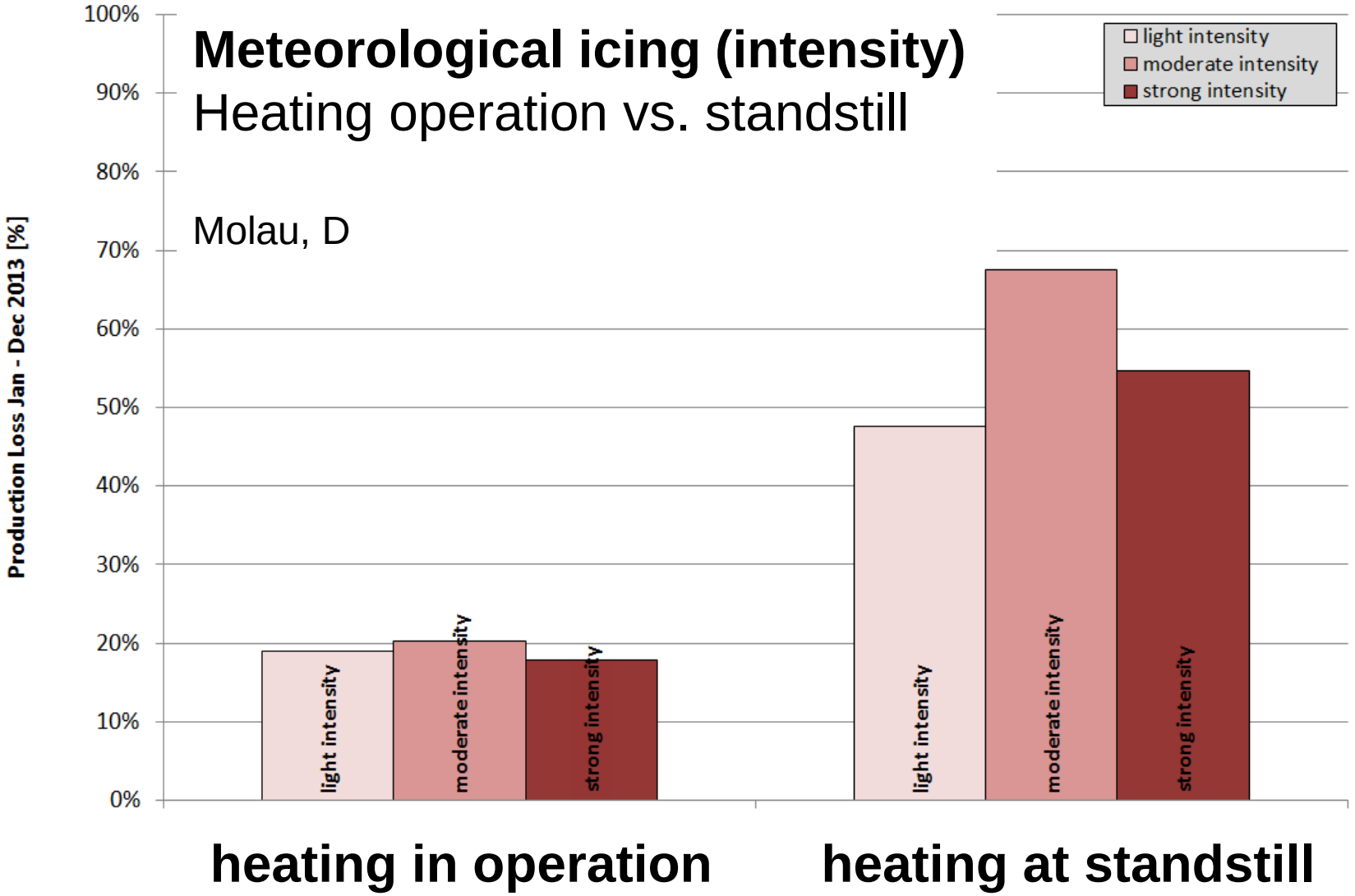
Turbine performance footprint



Turbine performance footprint



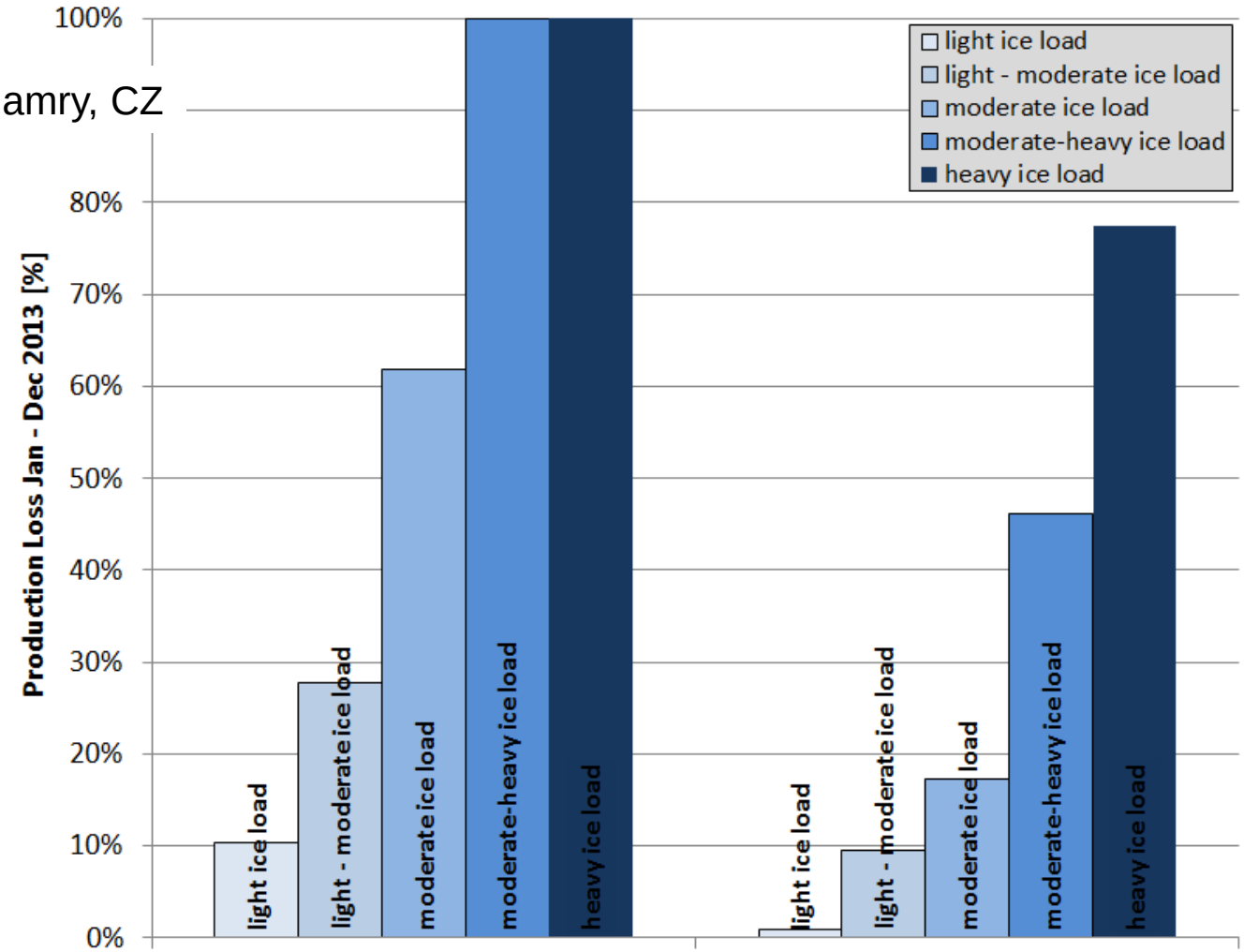
Turbine performance footprint



Turbine performance footprint

Instrumental icing (ice load): Heating vs. no heating

Kristofovy Hamry, CZ



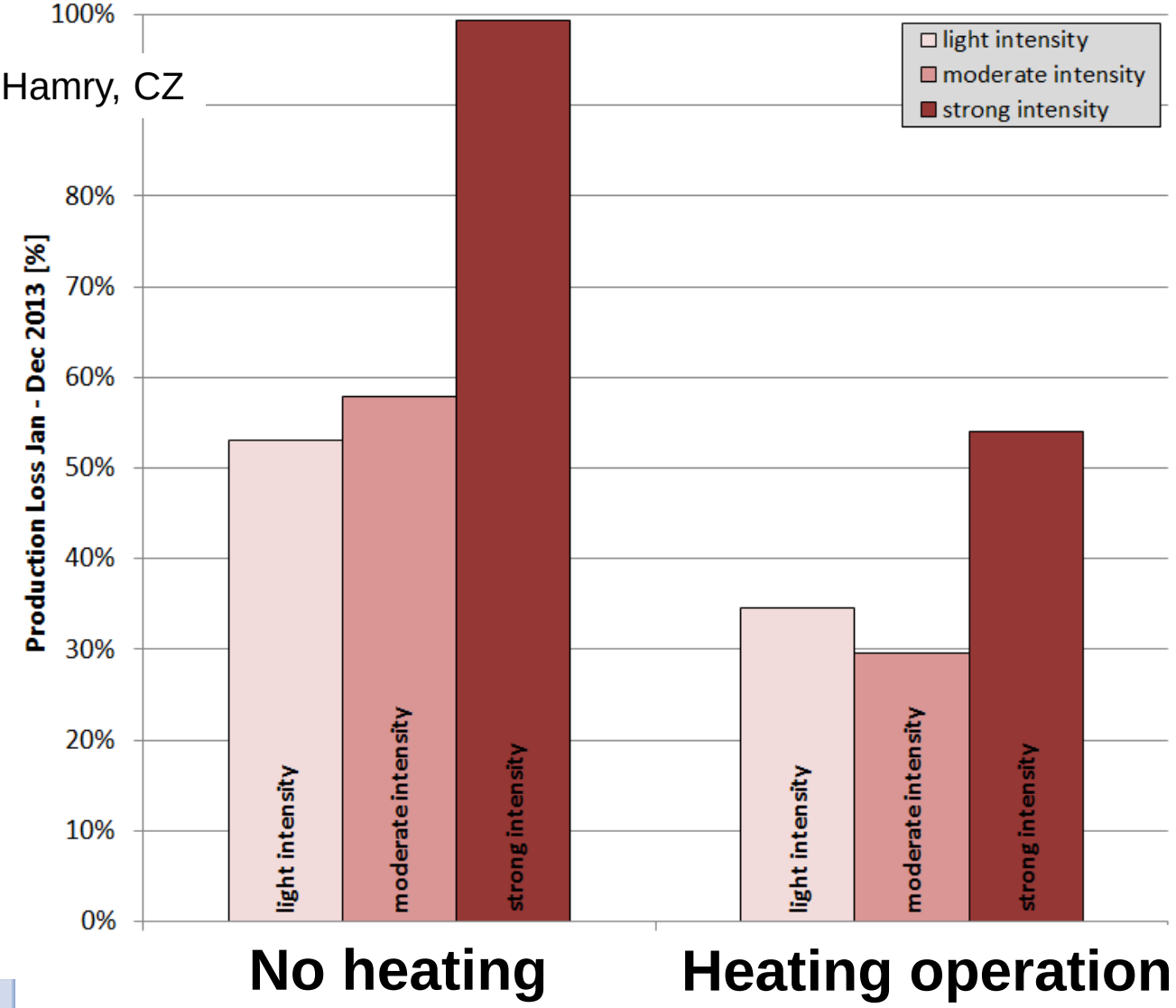
No heating

Heating operation

Turbine performance footprint

Meteorological icing (intensity): Heating vs. no heating

Kristofovy Hamry, CZ



Final summary

- Icing conditions **differ significantly from year to year**
- Power losses differ significantly from year to year
  → not necessarily in line with the **overall icing frequency**
- Information on **meteorological and instrumental icing is not sufficent** to fully describe turbine performance
- Turbine performance is strongly dependent **on ice load and icing intensity**
- The **turbine performance footprint** is quite consistent for **same operation mode at different sites** (light to moderate icing)
- **Local icing conditions** need to be assessed in detail
  → **ice load & icing intensity** classes
- A turbine performance footprint **is required for all turbine types** to quantify the power losses and to **compare turbine types**
- **More field data** required to set up **average performance footprint**


Thank you for your attention!
Meteotest
Aill na Searrach
Hauguil
Helm
Västan
Östan
Suchowej
Galerne
Noroet
Wisperwind
Föhn
Böhmwind
Hallstatt
Jinovec
Bise
Drévent
Joran
Ora
Höllentäler
Krowotenwind
Tramuntana
Furiani
Austru
Karajo
Košava
Bora
Gallego
Criador
Cierzo
Bochorno
Cers
Chouillère
Mistral
Marin
Garbé
Xaloc
Libeccio
Jugo
Garbin
Gornjak
Vardarac
Oštro
Xaroco
Poniente
Terral
Levante
Marocco
Foraño
Grecale
Melte