OPERATING EXPERIENCES WITH ANTI-ICING SYSTEMS IN NORDEX TURBINES

Winterwind 2013,
Dr. A. Löwe

NORDEX
We've got the power.

Outline

- **Introduction to Nordex**
- **Nordex Anti-Icing Option**
  - System features
  - Projects in the field
- **Performance analysis of winter season 2011/12**
  - Webcam observations
  - Icing simulations
  - Comparison of power yield

Experienced in Onshore Wind and Cold Climates

1985 Nordex founded in Denmark

1990s First **cold climate turbines** installed in China

2000 Introduction of **Multi-MW-Platform**: N80/2500

2007 First cold climate Multi-MW turbine: **N90/2500 CCV** in USA

2010 **First Anti-Icing systems** installed in Sweden (N100/2500)

2012 Largest cold climate Windpark: 34x **N117/2400 CCV** in Michigan

2013 Market Launch of Generation Delta **N100/3300** and **N117/3000**

800 MW of cold climate turbines in operation

120 MW of turbines with Anti-Icing systems in the field

Anti-Icing Option – system features

- **Continuous monitoring** of icing conditions
- The system operates **while the turbine is running**
- Heating of the **aerodynamically relevant** blade surface
- Reliable and lightweight **electrical resistance heaters**
- Based on pilot system by **VTT**

VTT Technical Research Centre of Finland

Anti-Icing Projects – Status 2/2013

2010:

4 WTGs (N100/2500 R100 CCV) in Jokkmokksliden

3 pilot Anti-Icing Systems

1 reference turbine

2011:

+ 14 WTGs in Jokkmokksliden/Storliden

+ 2 WTGs in Vårdkasen

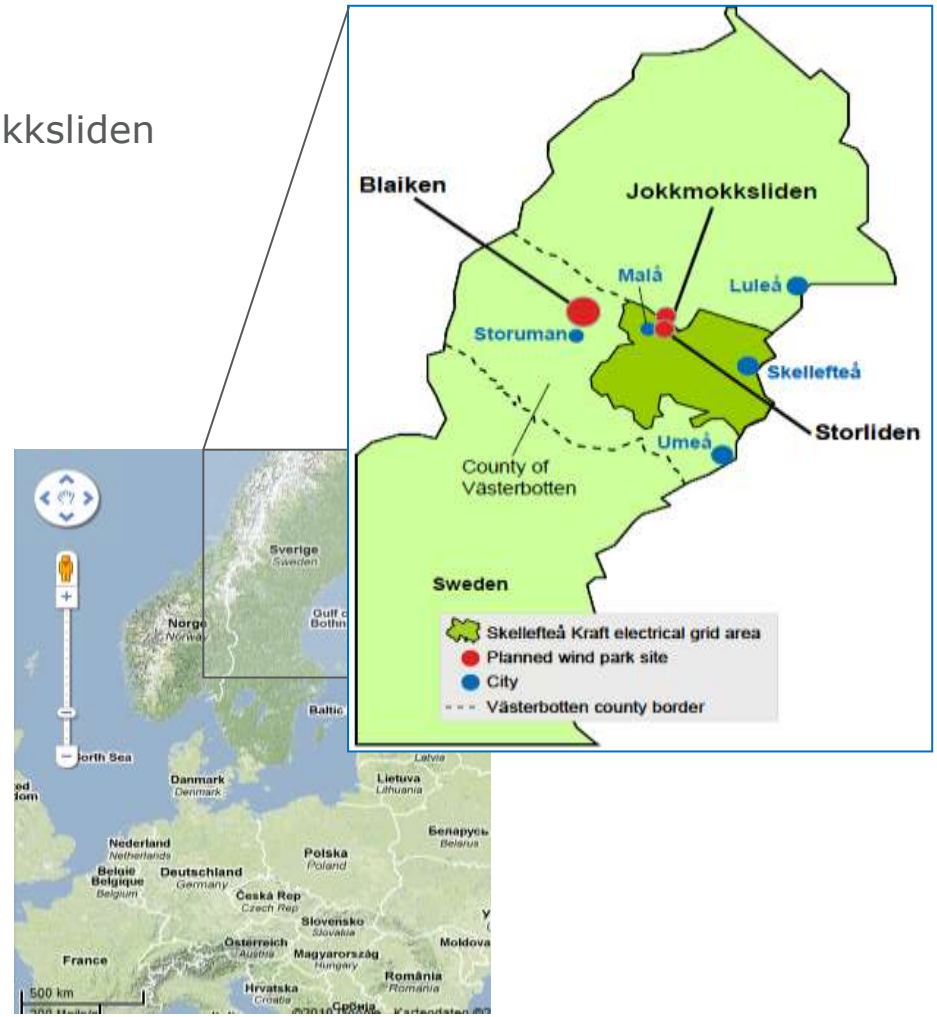
2012:

+ 30 WTGs in Blaiken

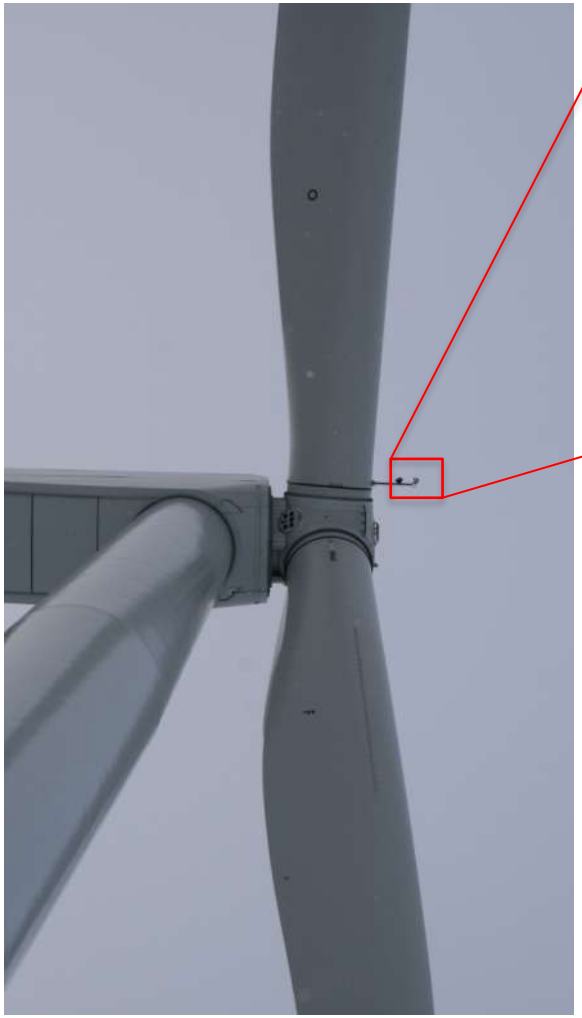
2013:

+ 30 WTGs in Blaiken

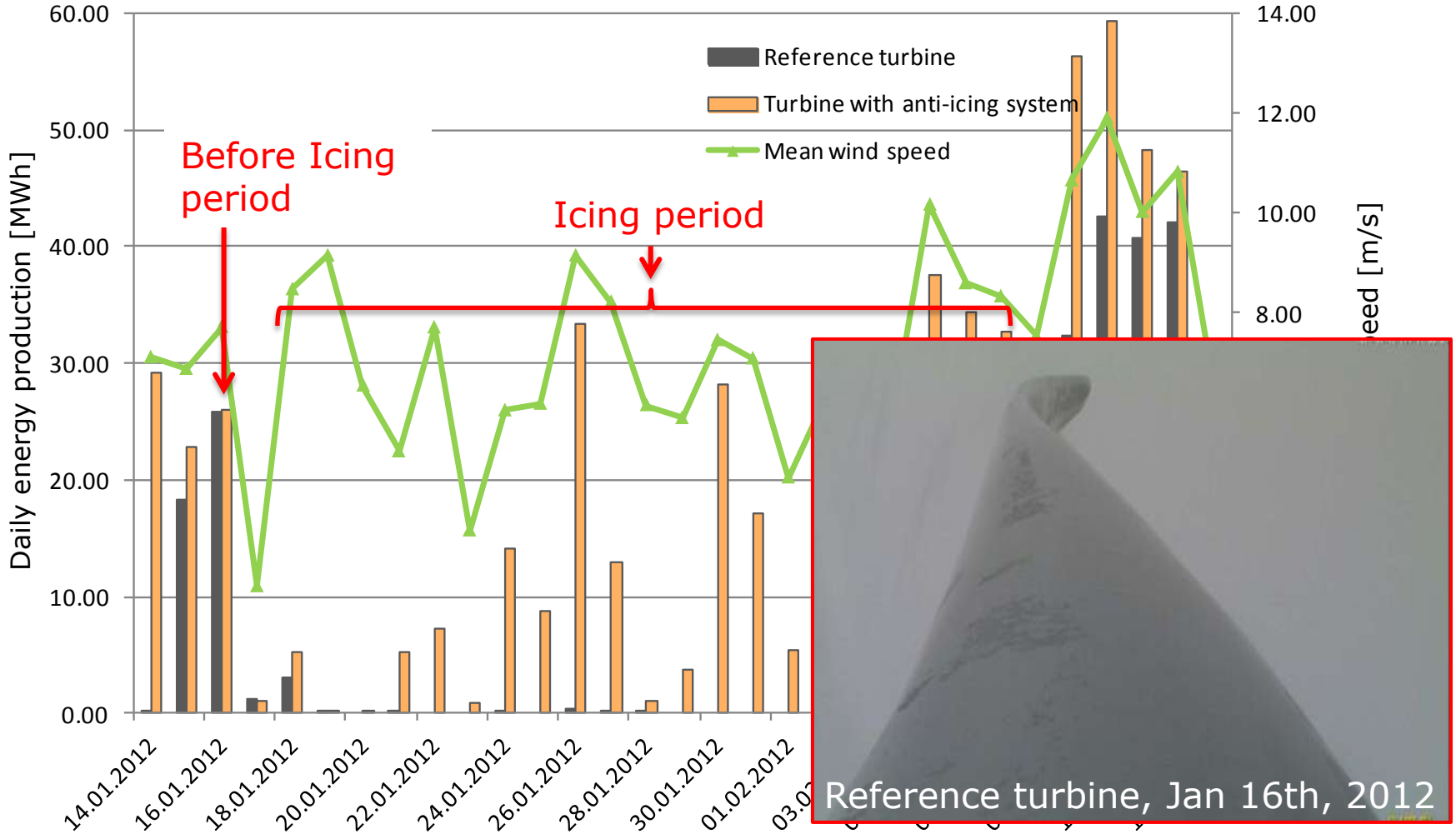
+ 1 WTG in Finland



Performance analysis – visual observation



Visual observation during icing event



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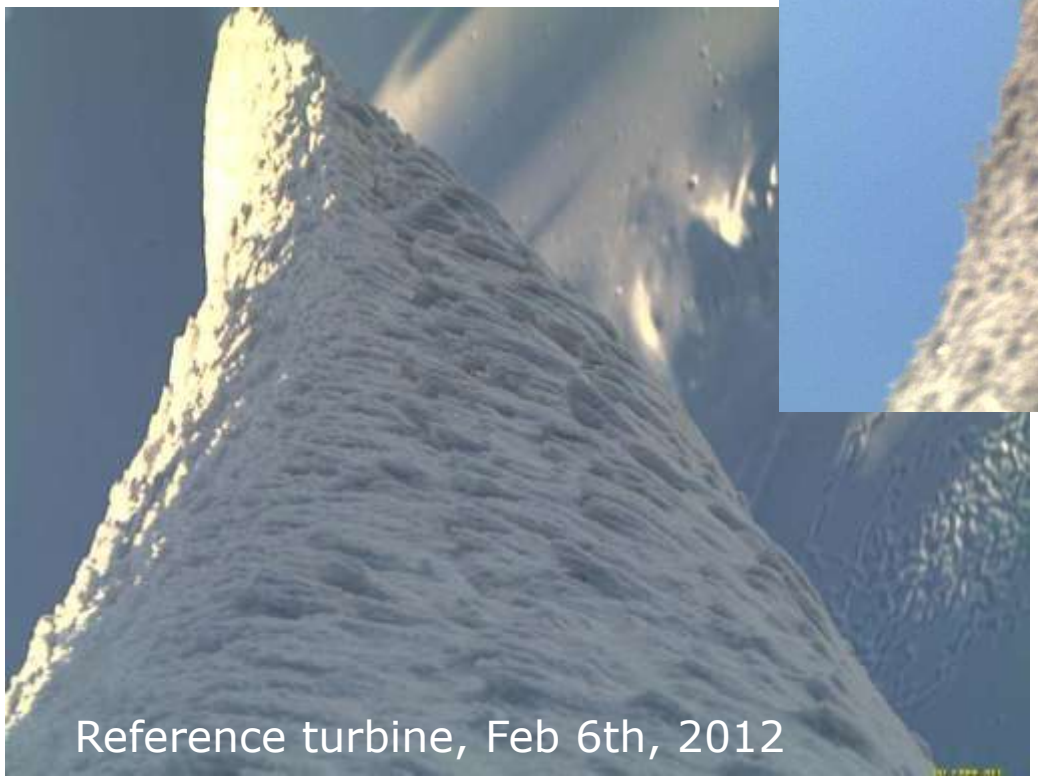


It works!

POWER YIELD AND ICING CONDITION

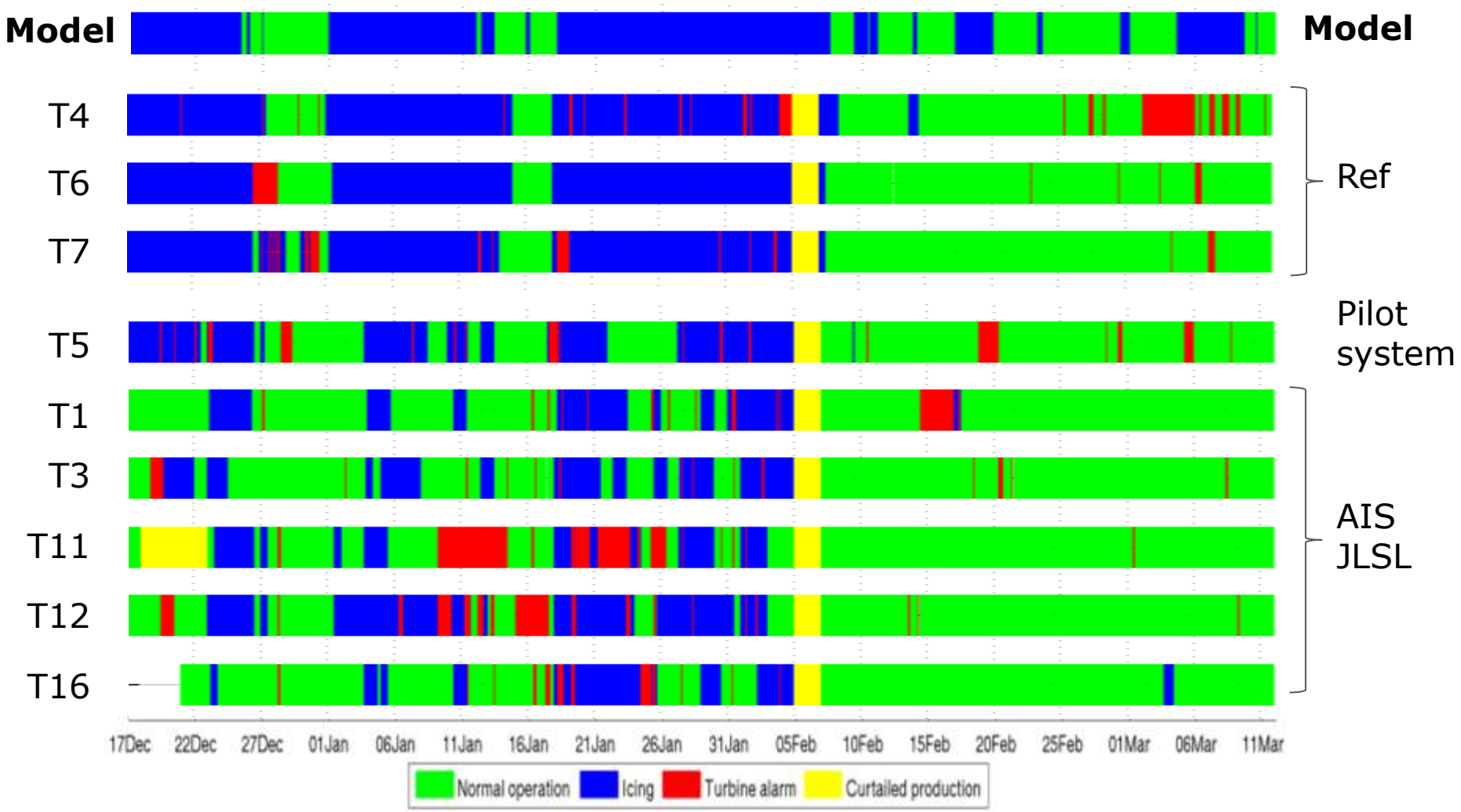
- Third party evaluation by Kjeller Vindteknikk

  - Determination of theoretical **icing times by simulation**
  - Determination of **theoretical production** P_{theor} from individually determined power curve of each turbine
  - Determination of **production losses** P_{loss} by P_{theor} - P_{real}
  - Determination of **individual turbine icing times** (manually)

Evaluation period: 17.12.11-11.3.12

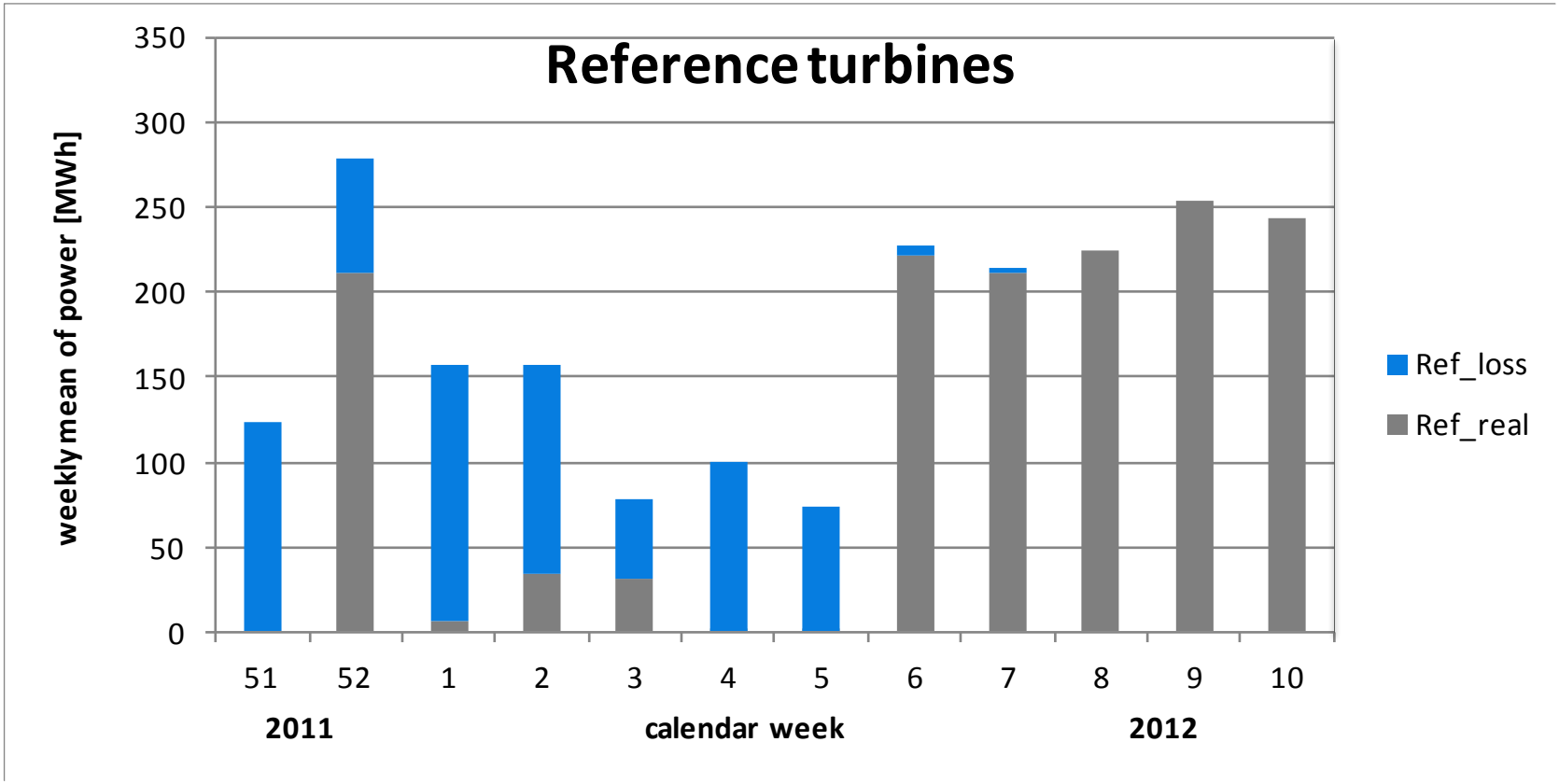
Turbine selection by commissioning date and minimum of 1800hrs availability

MODELLED AND REAL ICING PERIODS COINCIDE WELL



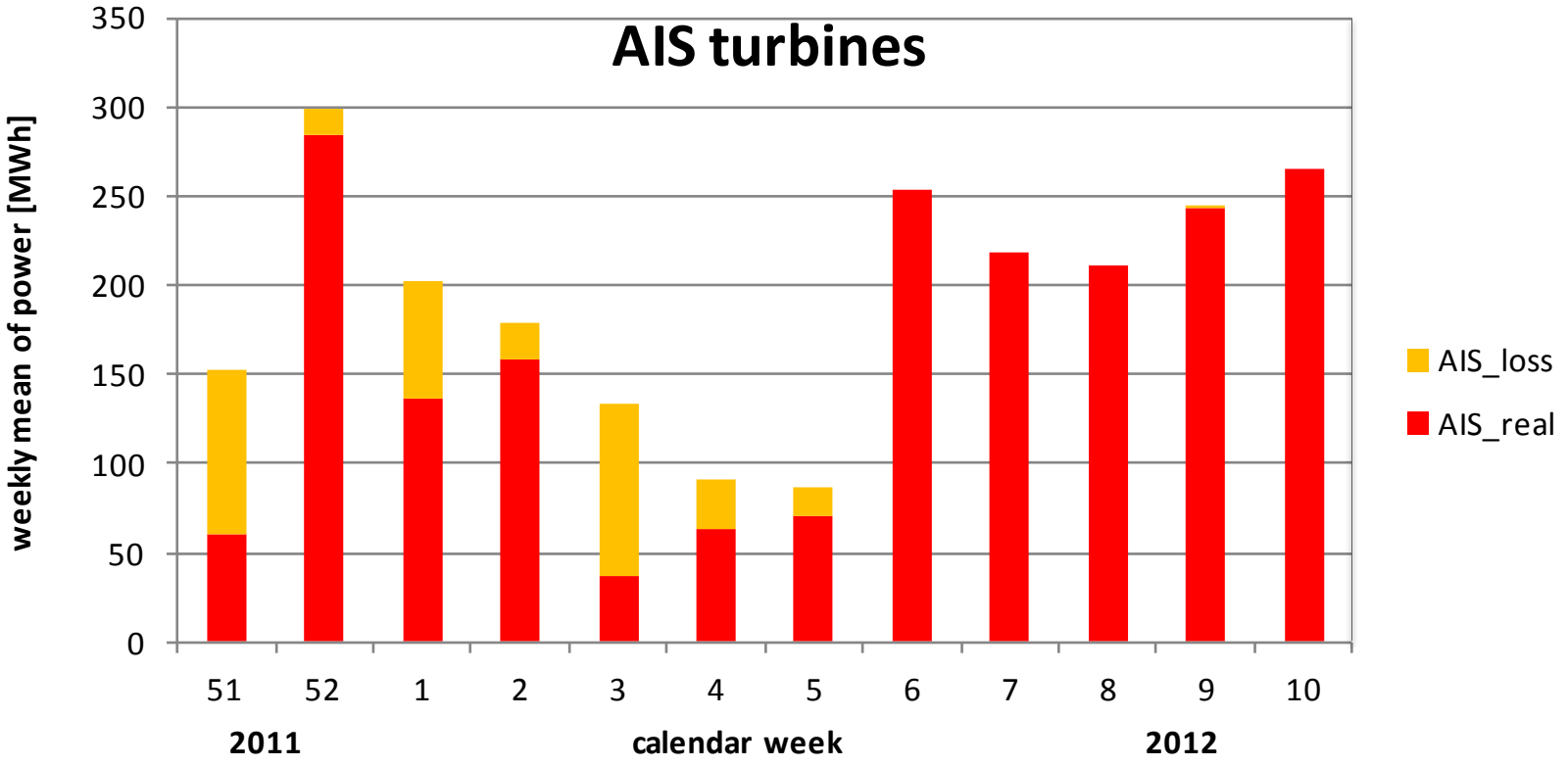
Significantly less icing induced power losses on AIS turbines

LOSSES OF TURBINES WITHOUT ANTI-ICING SYSTEM



Season 2011/12, mean of references	CW 51- CW10
Power production	1440 MWh
Power losses due to icing	695 MWh

LOWER LOSSES WITH ANTI-ICING SYSTEM



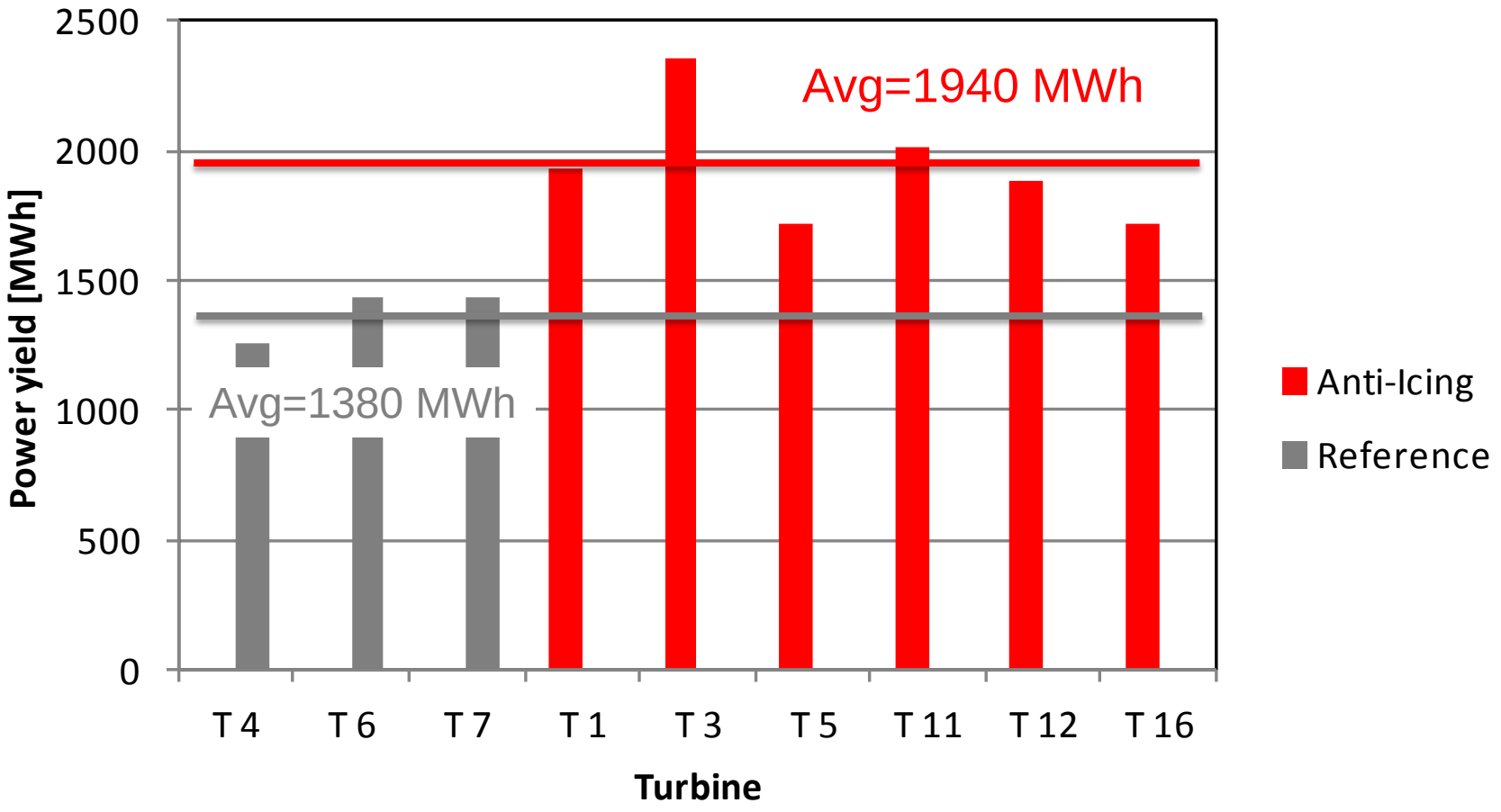
What happened in CW1 and CW3?

Improvement potential:

CW1: sensing of icing condition

CW3: heating parameter settings

TOTAL PRODUCTION



On average **560 MWh higher production with Anti-Icing Option** compared to reference turbines from CW51-CW10

SUMMARY

- **Performance analysis shows**
  - **Prevention of ice** on blades with Anti-Icing Option
  - **Potentials for improvement** identified
  - Significant **production gain** due to Anti-Icing Option

Nordex provides turbines with an efficient Anti-Icing System

QUESTIONS?

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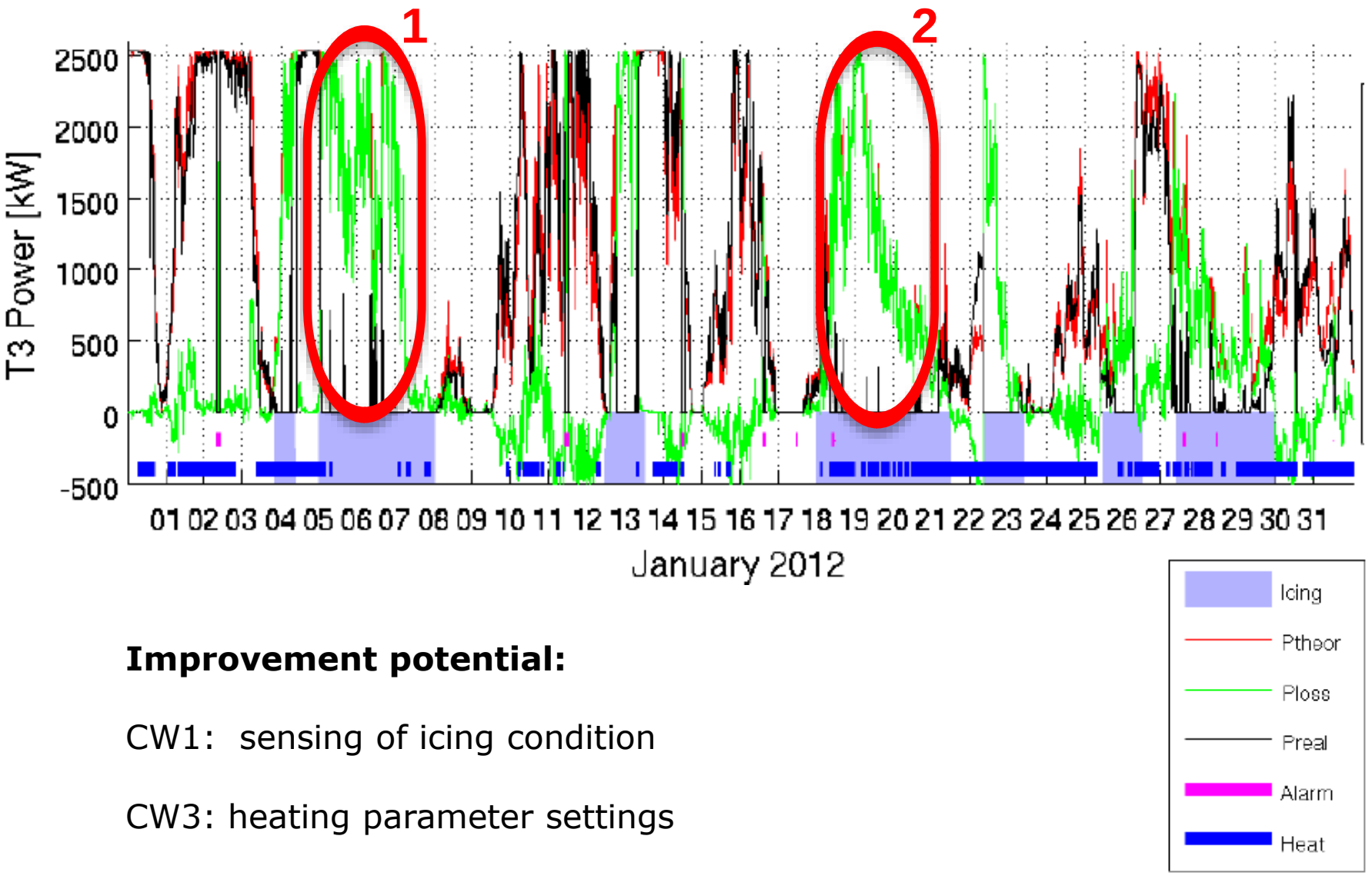
NORDEX
We've got the power.

Backup

TIMES SERIES OF POWER PRODUCTION

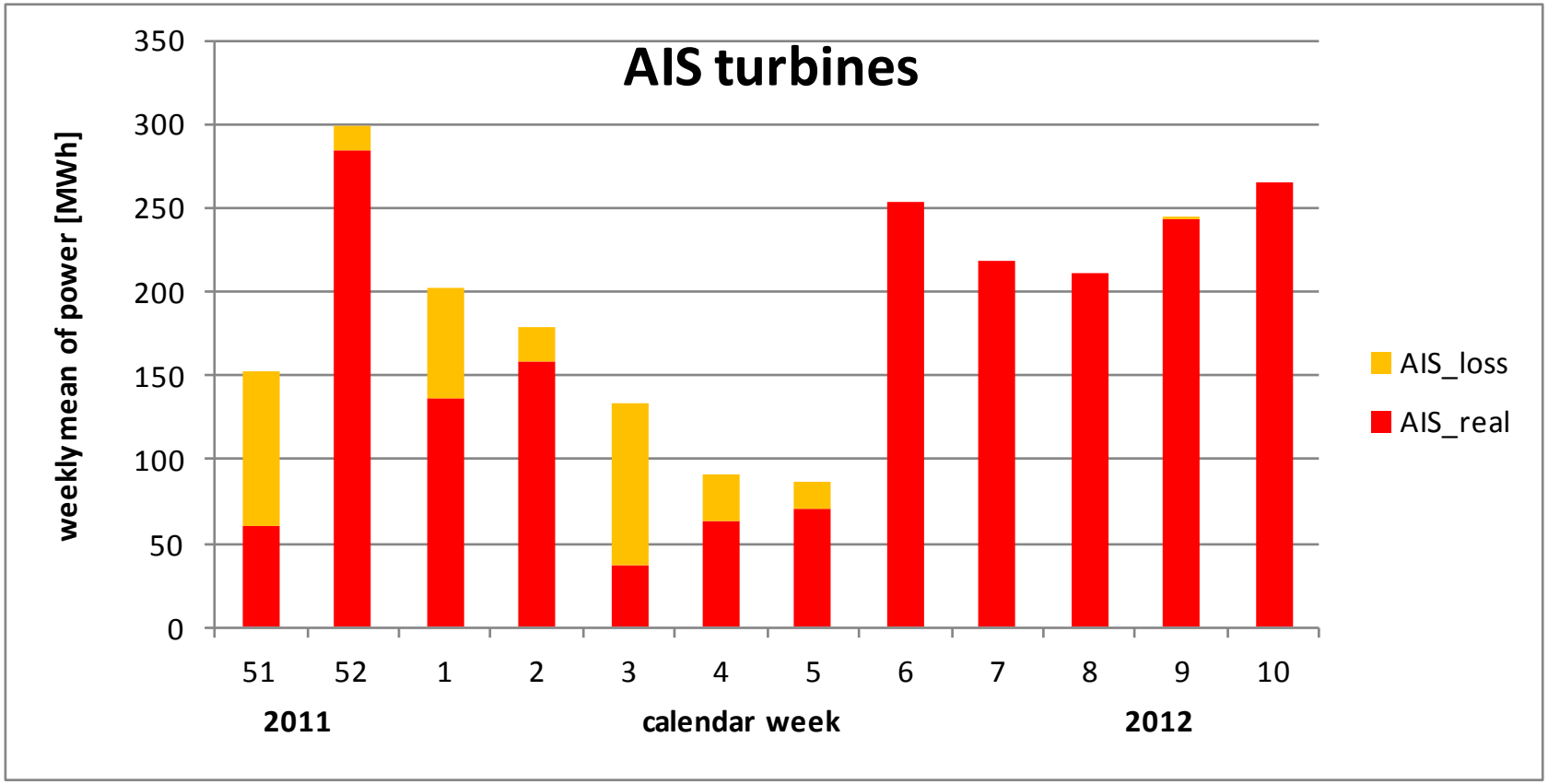


Improvement potential:

CW1: sensing of icing condition

CW3: heating parameter settings

POTENTIAL FOR FURTHER IMPROVEMENTS



Season 2011/12, mean of AIS turbines	CW 51- CW10
Power production	2000 MWh
Power losses due to icing	338 MWh