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Estimating energy production losses, comparison with ice detection.

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Several Wind Power Plants are today equipped with de-icing systems to minimize the risk of ice growth on the rotor blades.

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The decision to install de-icing systems is strategic and a major investment which most be taken early in the design process.

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This study shows the importants of a dedicated controll system to avoid unnecessary use of the de-icing system.

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During the winter 2008 to 2009 the icing situation and the production of a 600kW Vestas Wind Power plant was studied.

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Ice situation, power output, wind speed, humidity and air temperature was measured.

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The ice situation was measured by using two T41 Icing Rate Sensors.

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One sensor was configured to show the icing intensity and the icing rate.

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The other sensor showed the length of the icing period.

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The plants power output was compared with the plants nominal power output.

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The nominal power was calculated from the power curve of the plant and the wind speed, measured at the site.

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All Measurements During The Test Period

At high winds the measured power is higher than nominal. At low winds less.

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All Measurements During The Test Period

Is this the result of an aneometer error?

If so, the power losses due to ice is higher than given in this report.

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Severe ice (>1mm)

Total test time: 1500h January - March.

Time with severe ice	**246h**
Shut down due to low winds	**140h***

*** Losses not due to ice.**

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Severe ice (>1mm)

Total test time: 1500h January - March.

Shut down due to ice	**24h**
Reduced power	**82h**

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Case 1
Severe ice at times with high winds

Measured power is 20 - 30% lower than the nominal power.

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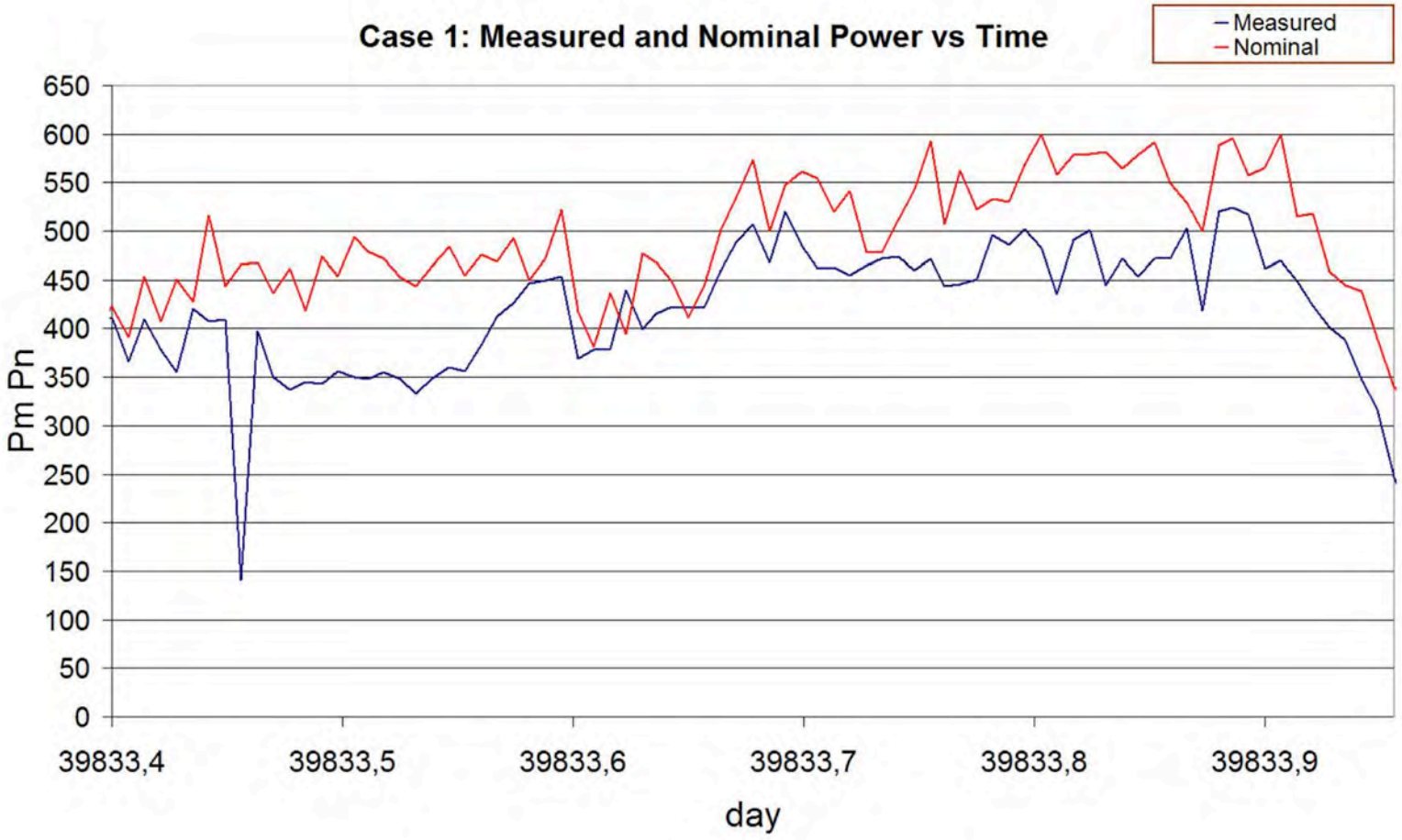
Case 1: Measured and Nominal Power vs Time
Measured
Nominal
650
600
550
500
450
400
350
300
250
200
150
100
50
0
Pm Pn
39833,4
39833,5
39833,6
39833,7
39833,8
39833,9
day

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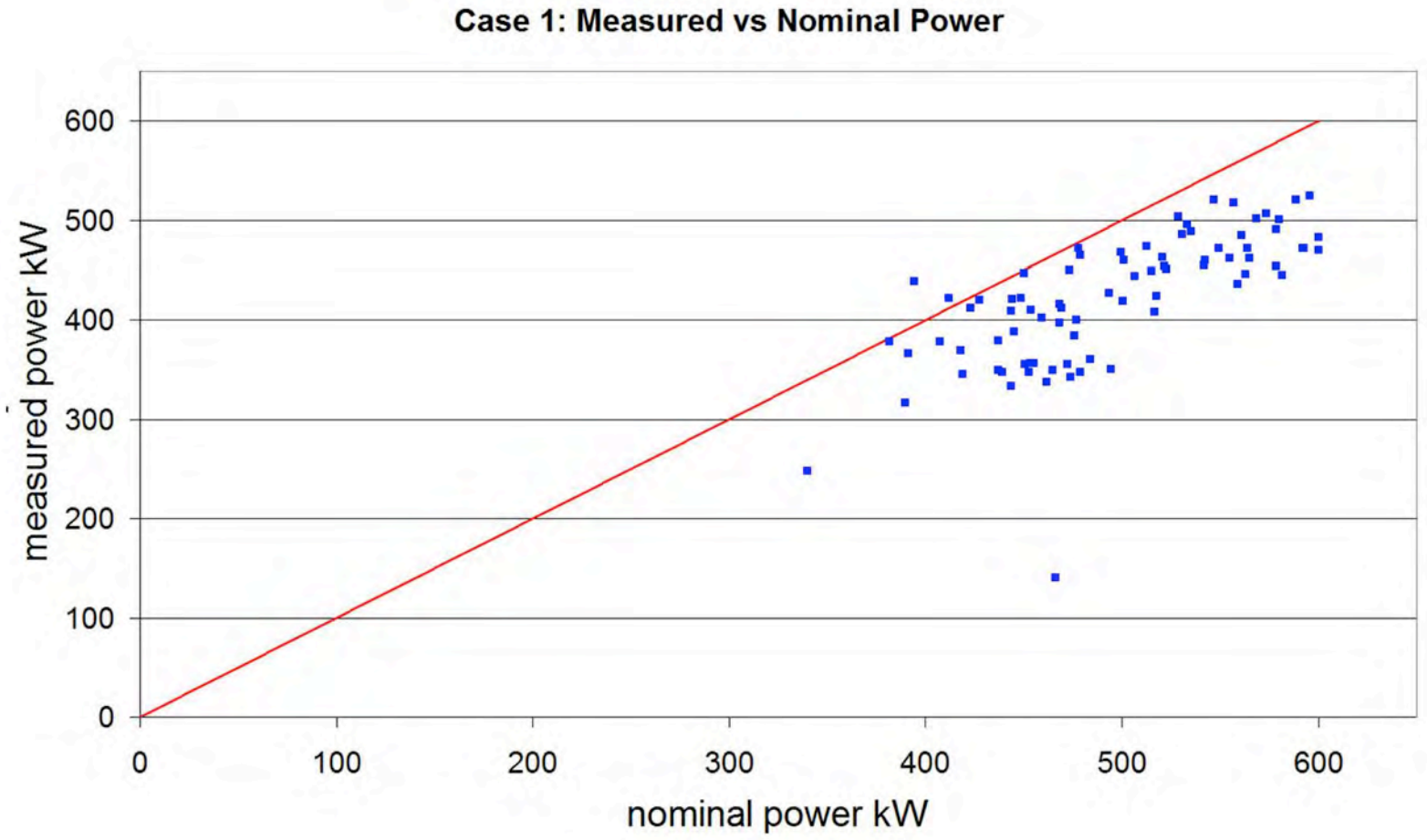
Case 1: Measured vs Nominal Power
measured power kW
nominal power kW
0
100
200
300
400
500
600

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Case 2
Severe ice at times with low winds

Suspected aneometer failure due to ice.

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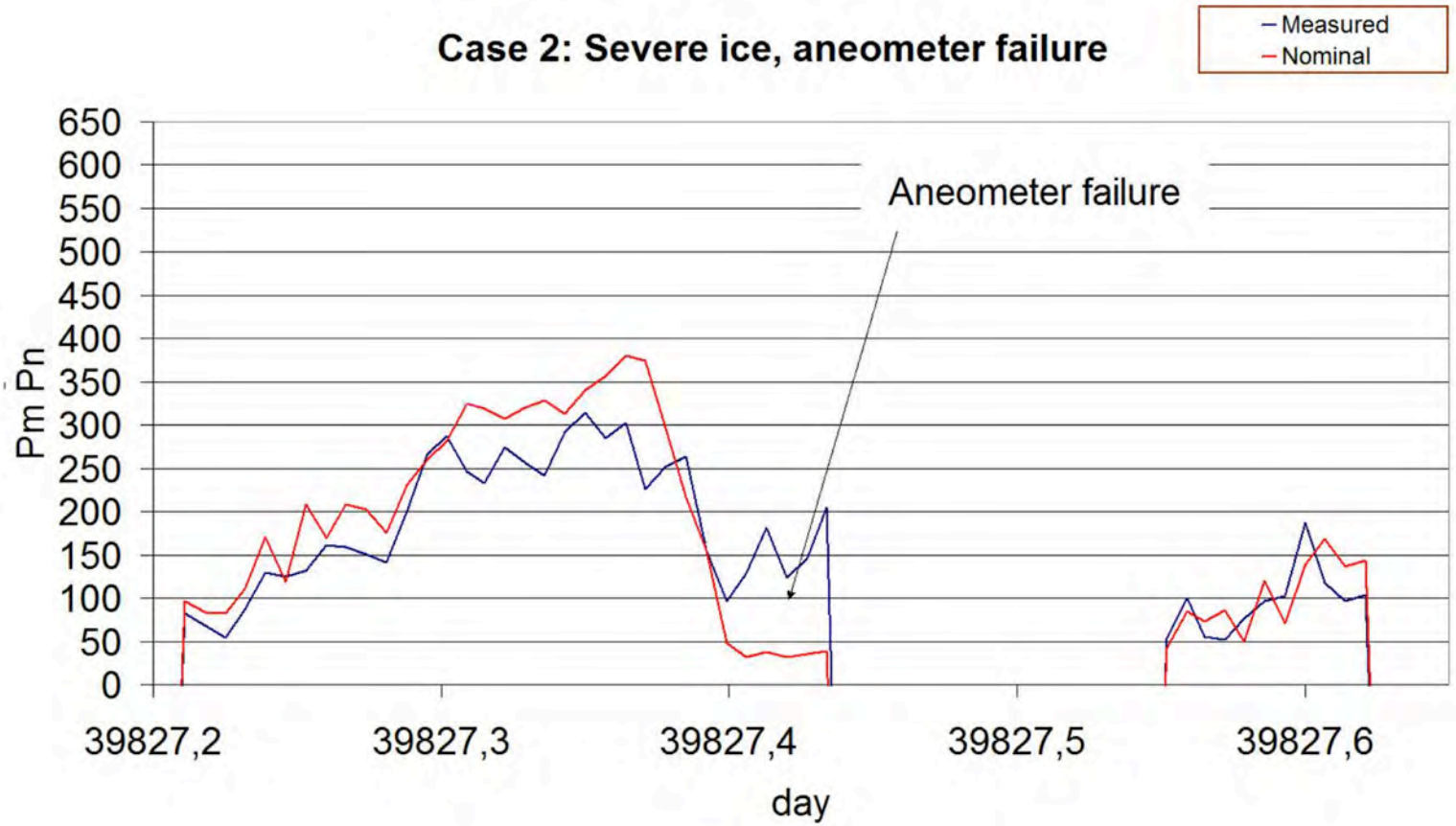
Case 2: Severe ice, aneometer failure
Measured
Nominal
Aneometer failure
Pm Pn
650
600
550
500
450
400
350
300
250
200
150
100
50
0
39827,2
39827,3
39827,4
39827,5
39827,6
day

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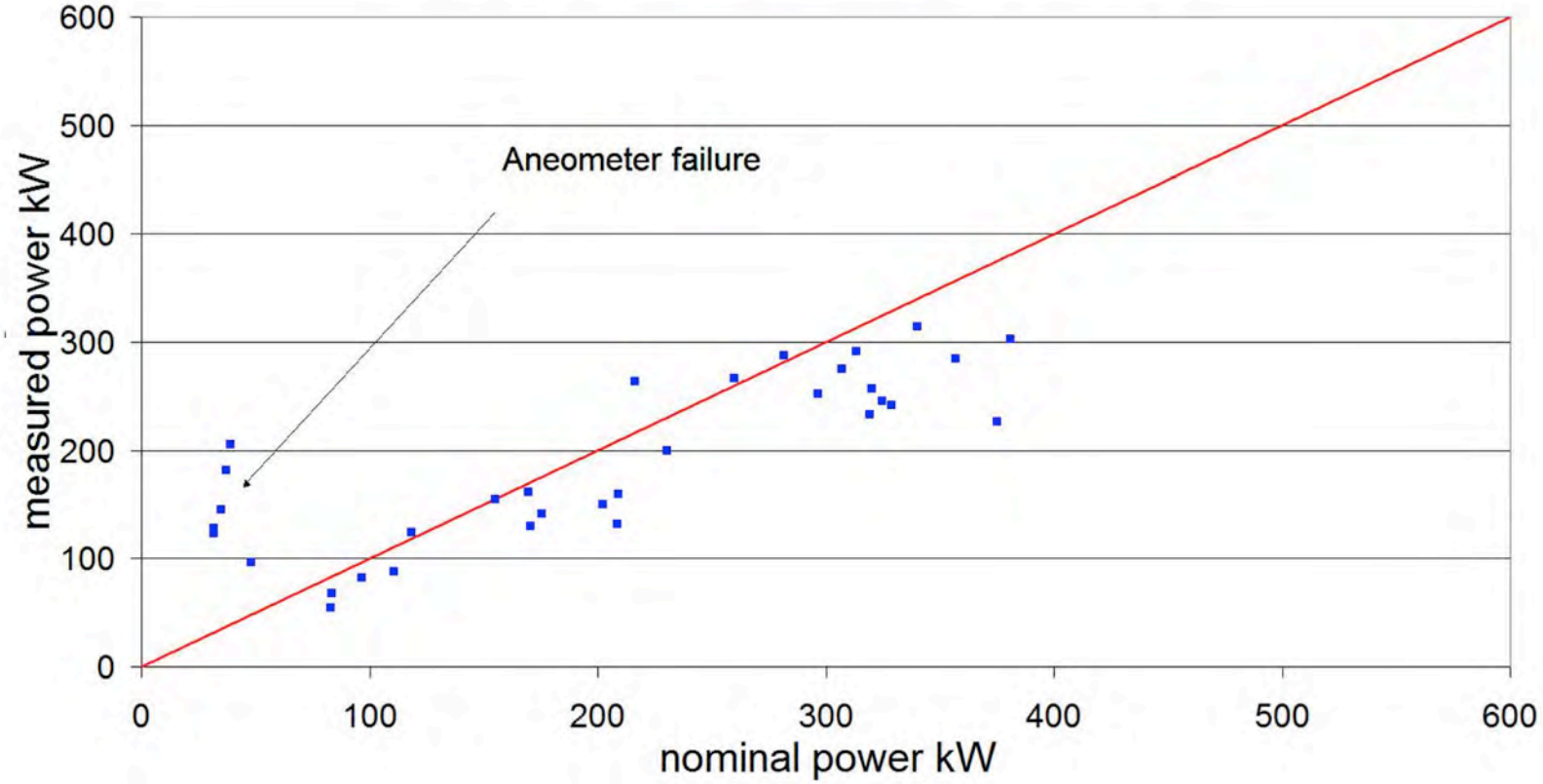
Case 3 Severe ice, aneometer failure



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Case 3
Light Ice

Often the measured power is higher than the nominal.

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Case 3
Light Ice

Is this due to the light ice making the rotor blades smoother?

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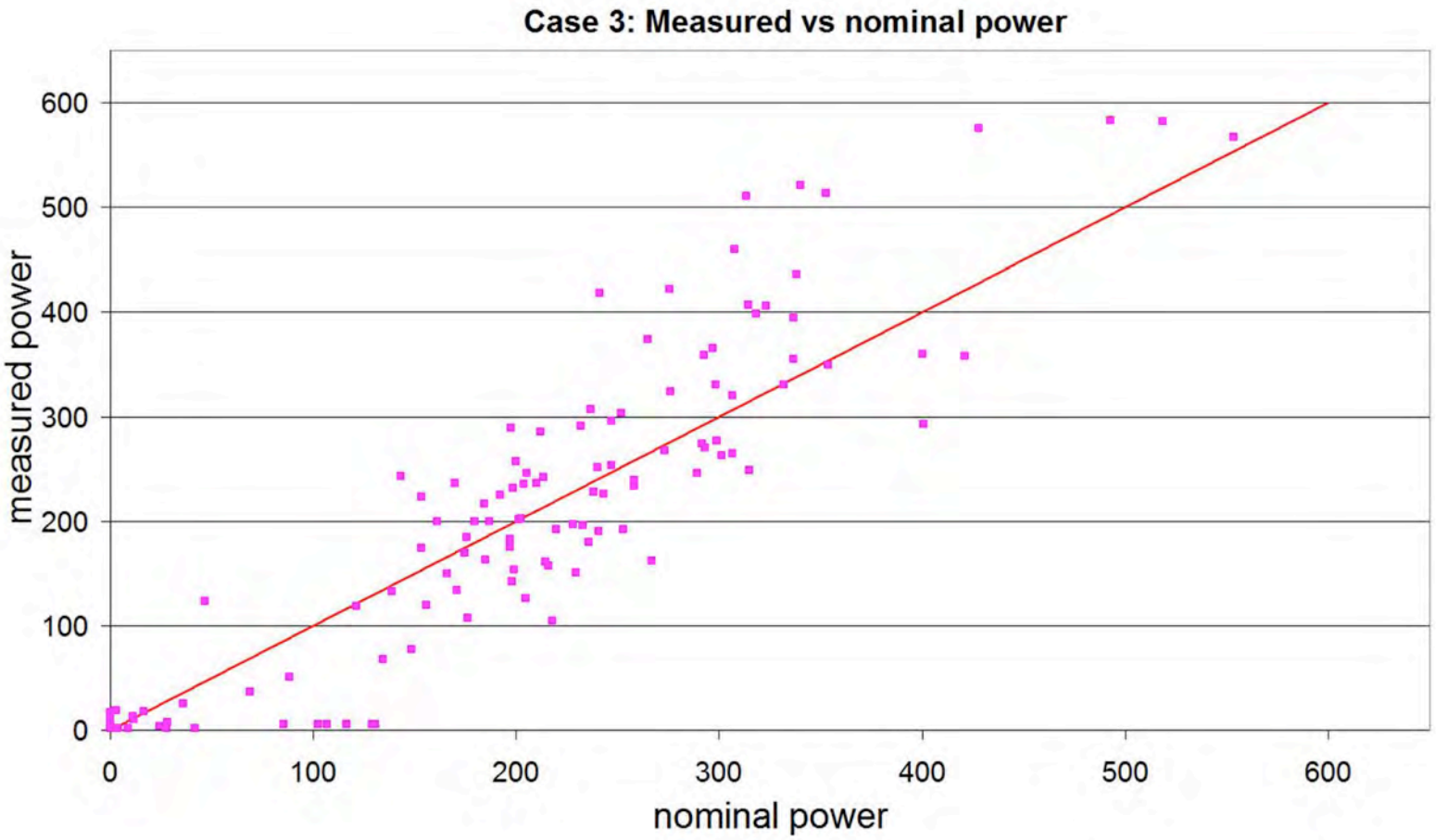
Case 3: Measured vs nominal power
measured power
nominal power
0
100
200
300
400
500
600

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Conclusions Control System

It is important that the de-icing system is not used unnecessary, i.e. when ice is not present.

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Conclusions Control System

Unnecessary use of de-icing entails energy losses and may reduce the rotor blades lifetime.

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Conclusions Control System

Use of meteorolgical data, depending on criteria's (January - March).

Criteria: Ice is assumed if humidity is >95% and air temperature <+1°C

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Conclusions Control System

Use of meteorolgical data, depending on criteria's (January - March).

Criteria: Ice is assumed if humidity is >95% and air temperature <+1°C

Criteria satisfied, no ice **122h**

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Conclusions Control System

Use of meteorolgical data, depending on criteria's (January - March).

Criteria: Ice is assumed if humidity is >95% and air temperature <+1°C

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Conclusions Control System

Use of meteorolgical data, depending on criteria's (January - March).

Criteria: Ice is assumed if humidity is >95% and air temperature <+1°C

Criteria not satisfied, ice present 114h

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Conclusions Control System

Use of power losses (January - March)

Criteria: Ice assumed if power loss is more than 15%

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Conclusions Control System

Use of power losses (January - March)

Criteria: Ice assumed if power loss is more than 15%

Criteria satisfied, no ice **423h**

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Conclusions Control System

Use of power losses (January - March)

Criteria: Ice assumed if power loss is more than 15%

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Conclusions Control System

Use of power losses (January - March)

Criteria: Ice assumed if power loss is more than 15%

Criteria not satisfied, ice present 65h

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Energy losses due to ice (over a one year period).

Losses during shut down caused by severe ice **1 %**

(Not incl. time with low winds).

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Energy losses due to ice (over a one year period).

Losses due to severe ice **1-2%**

(Not incl. time with low winds).

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Energy losses due to ice (over a one year period).

Losses due to medium ice **1-2%**

(Not incl. time with low winds).

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Energy losses due to ice (over a one year period).

Total loss	**4-5%**

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Energy losses due to ice (over a one year period).

Value of losses in a 2-2,5 MW plant, at today's prices

22–25k €

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Energy losses due to ice (over a one year period).

Other sites may produce greather losses.

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Thank you for your attention!

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