PROTEST -Procedures for Testing and Measuring Wind Energy Systems
Drive train case study

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SITE ASSESSMENT . WIND TURBINE ASSESSMENT . GRID INTEGRATION . DUE DILIGENCE . KNOWLEDGE . CONSULTANCY

protest

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- **Participant organisation name**

Energy Research Centre of the Netherlands (Coordinator)	ECN	NL
DEWI GmbH - Deutsches Windenergie-Inst.	DEWI	DE
Center for Renewable Energy Sources	CRES	GR
Hansen-Transmissions International	Hansen	BE
Suzlon Windkraft GmbH	Suzlon	DE/INDIA
Germanischer Lloyd Industrial Services GmbH	GL	DE
Universität Stuttgart	UStutt	DE

Total Budget appr. 2.6 Mio €, duration 2.5 years

- Motivation and Scope
- Concept and Objectives
- Approach and Work Packages
- Case Study: Drive Train
- Outlook

- EU Policy enforces use of renewable Energies
- Sizes of turbines and sizes of wind farms increase
- Reliability of turbines is a pre-requisite for economic exploitation of wind energy
- Statistics say: turbines show 2 to 5 failures per year that require attendance

Statistics say:

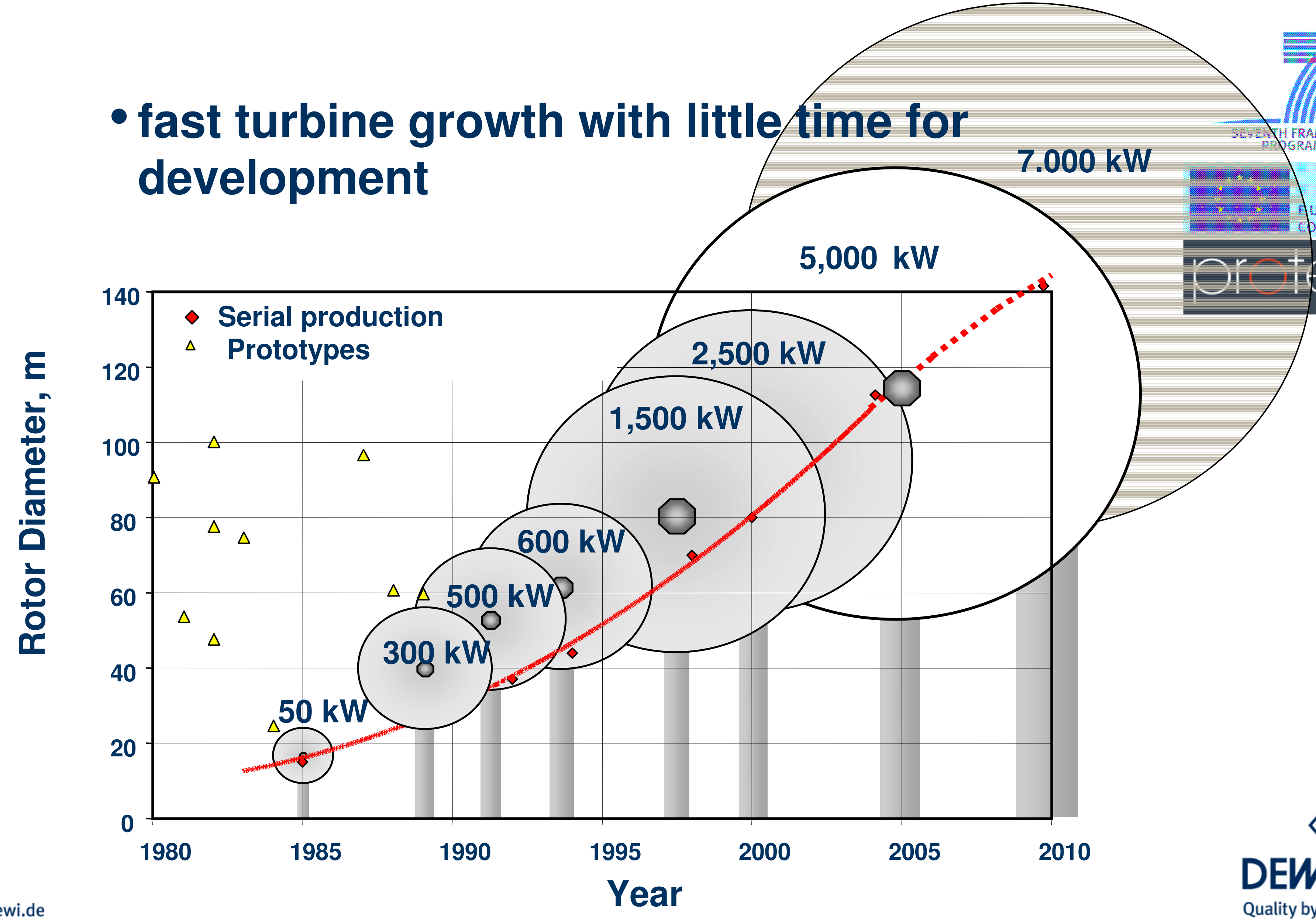
- turbines show 2 to 5 failures per year that require attendance
- and electrical components fail more often
- however: cost and downtime are governed by failures of mechanical systems

drive train, pitch and yaw systems, bearings

Reasons for such failures of mechanical systems as mentioned in studies and expert discussions:

- **lack of knowledge on loads at component level**
- **shortcomings in standard load simulation models**

- fast turbine growth with little time for development



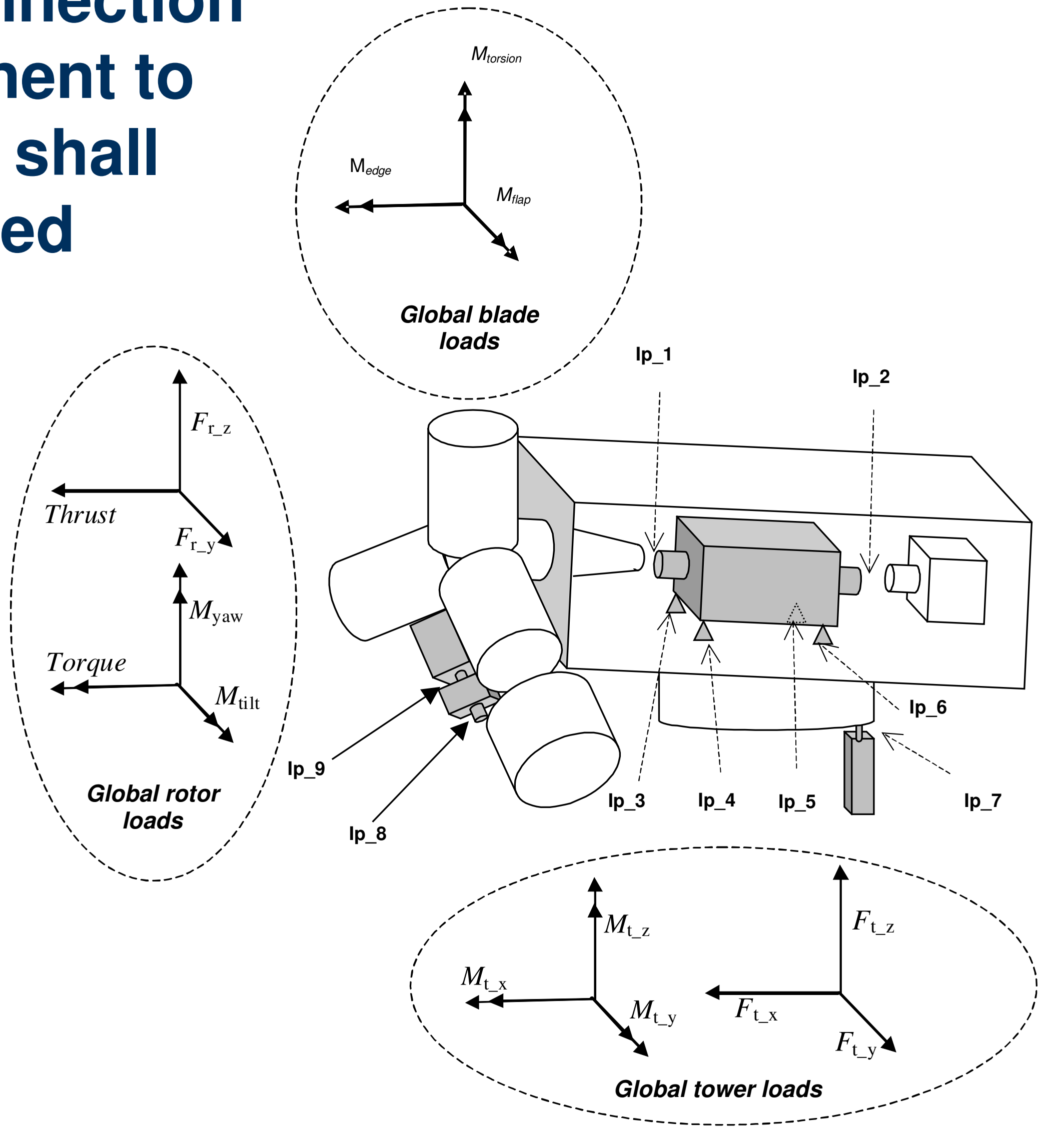
What are the answers to the problem?

- **Monitoring cannot solve the problem!**

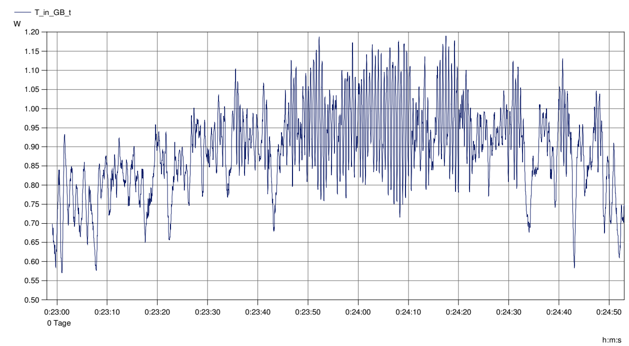
  CMS and frequent inspections will help detect failures earlier but cannot avoid failures due to unexpected loading

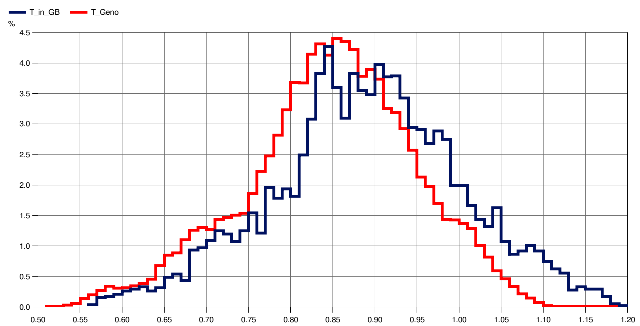
- **Design procedures for mechanical components other than blades and tower need improvement**

- **Loads at interconnection points of component to turbine structure shall be clearly specified**



- **Recommended practices on how to assess the actual loading of the component by prototype/validation testing shall be developed**





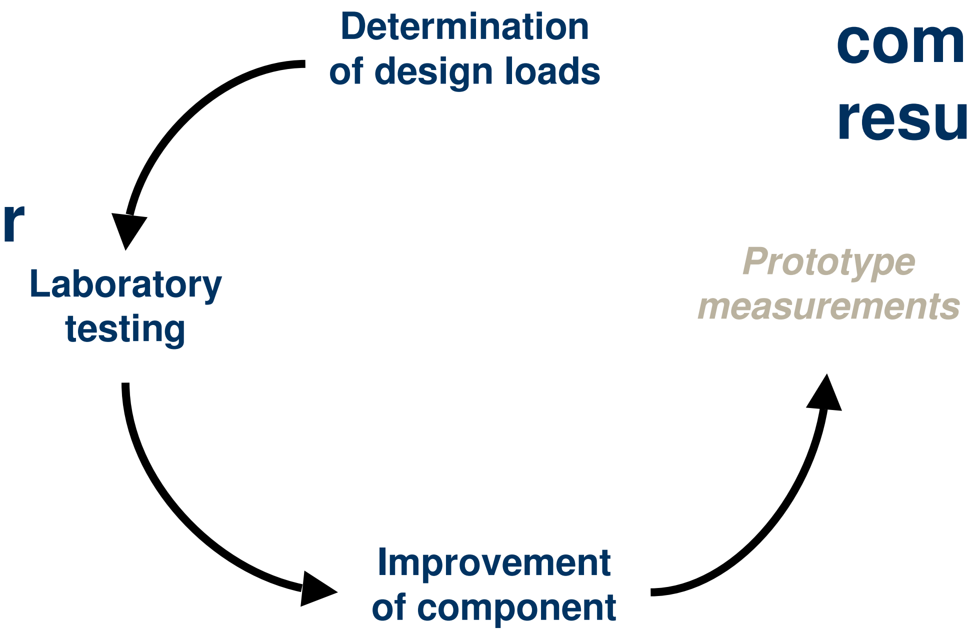
Overall Objective of PROTEST

Setting up a methodology that enables standardized specification of design loads for mechanical components s.a. drive train, pitch system and yaw system.

Guidance on how to derive loads at interconnection points.

Guidance communicate results

Guidance for lab testing



Guidance for validation testing

Approach and Work Packages

- **Assessment of common practice**
  State-of-the-art-Report WP1
  Questionnaires WP2 & 4
  - assessment of load cases and design drivers
  - assessment of measurement procedures

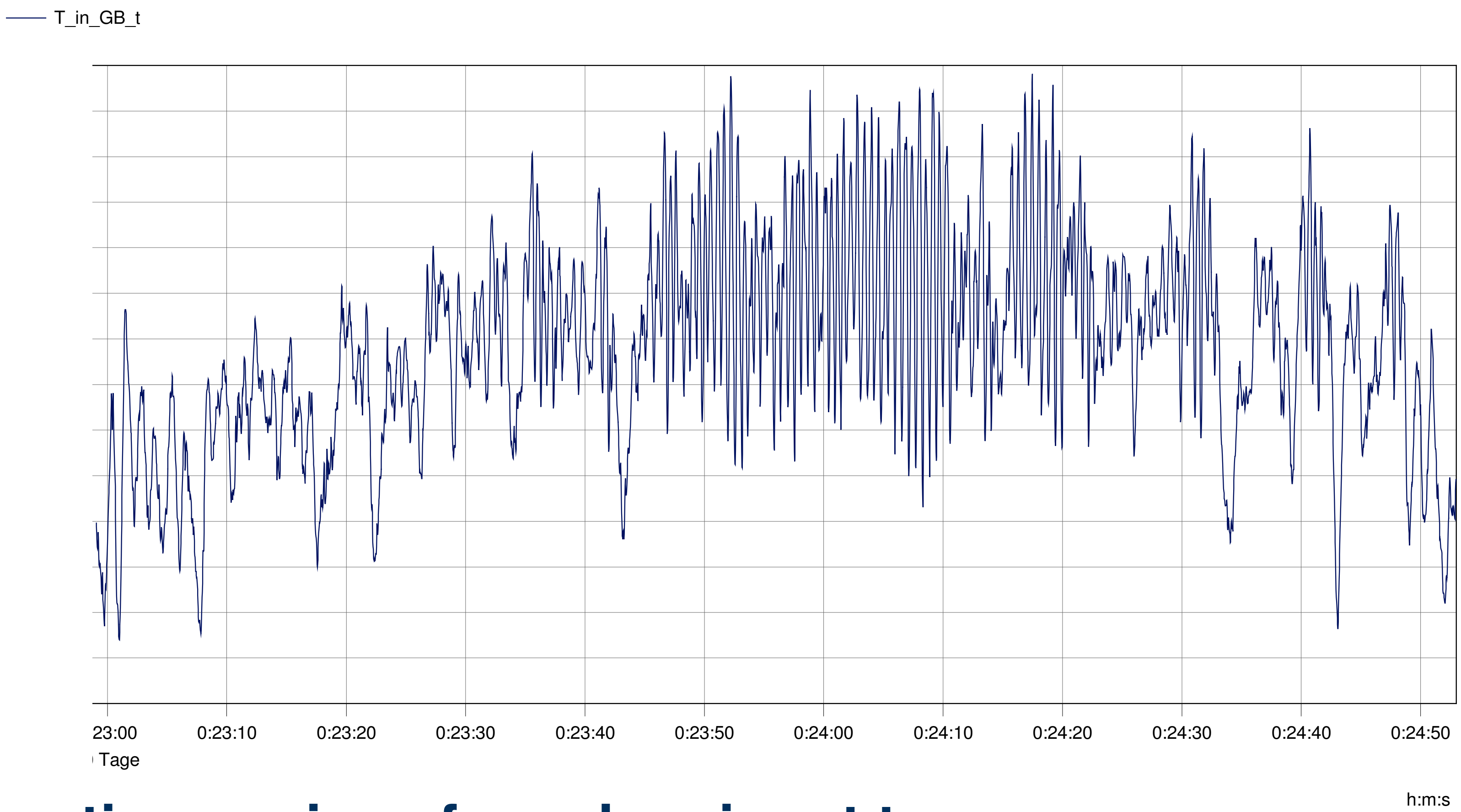
- **Find white spots and bottle necks & draft procedures**
- Definition of how to report loads at interconnection points WP3
- Prototype measurement definition WP4

- **Application of draft procedures of WP 1-4 in case studies:**
  - **Case study on drive train loads WP5**
    SUZLON, HANSEN, DEWI
  - **Case study on pitch system loads WP6**
    ECN, CRES
  - **Case study on yaw system loads WP7**
    ECN, CRES

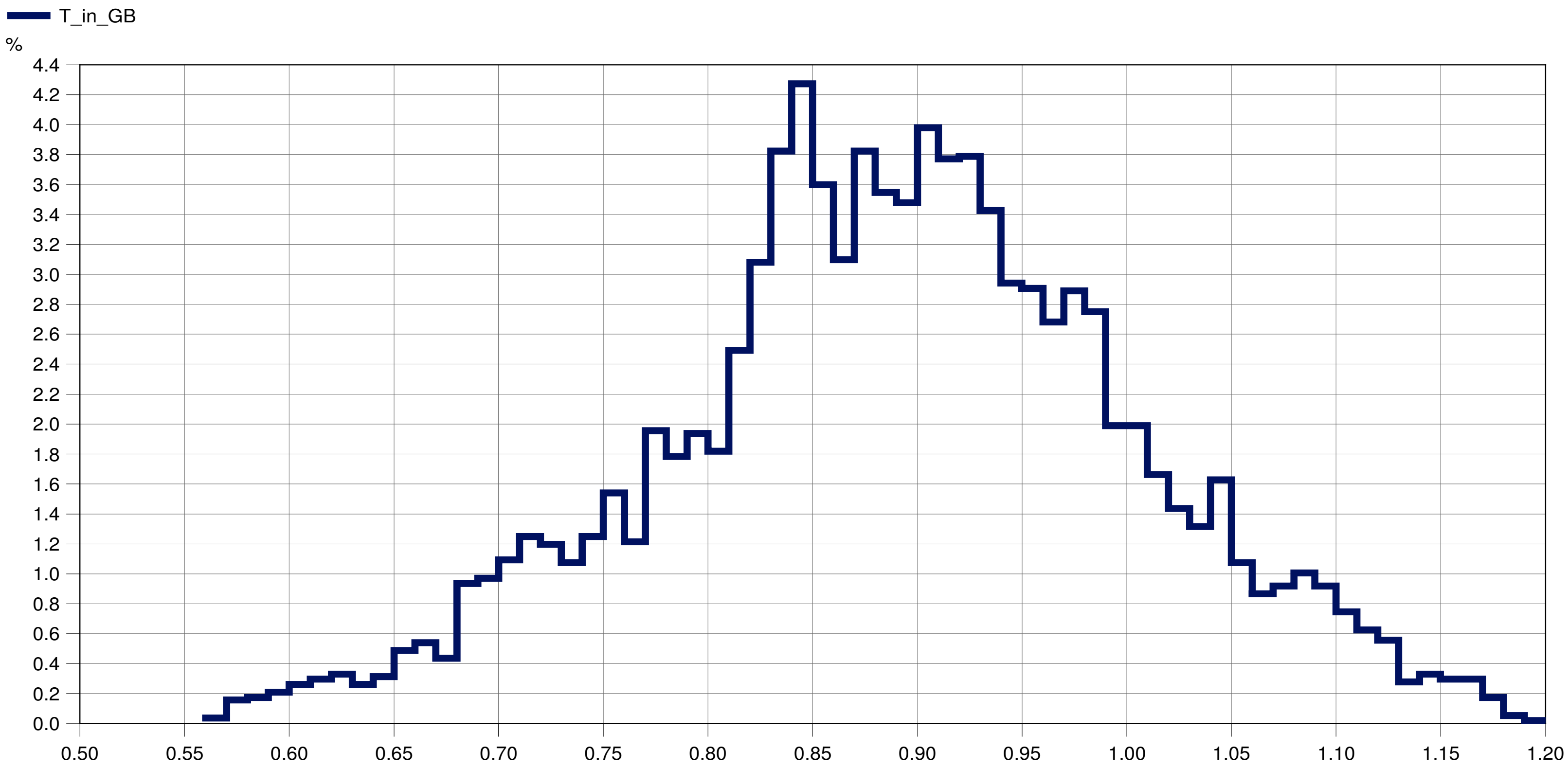
- Measurements are carried out by SUZLON/HANSEN/DEWI at a SUZLON S82-1.5MW turbine in India
- Gearbox of Hansen Transmissions
- In addition to the "standard" measurement campaign in accordance with IEC 61400-13, the signal list is expanded: additional signals, which are of special relevance for the drive train

- **loads on the main shaft:**
  bending loads
  torque
- **torque on the high speed shaft**
- **rotational speed levels:**
  high speed shaft
  intermediate speed shaft
  main shaft
- **rotor position**
- **axial displacement of**
  high speed shaft,
  intermediate speed shaft and
  low speed shaft

- **displacement of the gearbox in the nacelle**
- **temperatures:**
  outdoor
  ambient
  air flow (cooler input & output)
  bearings high speed shaft
  bearings intermediate speed shaft
  oil sump
  oil in cooler & at manifold
- **oil pressures:**
  in front of / behind the mechanical pump at the manifold

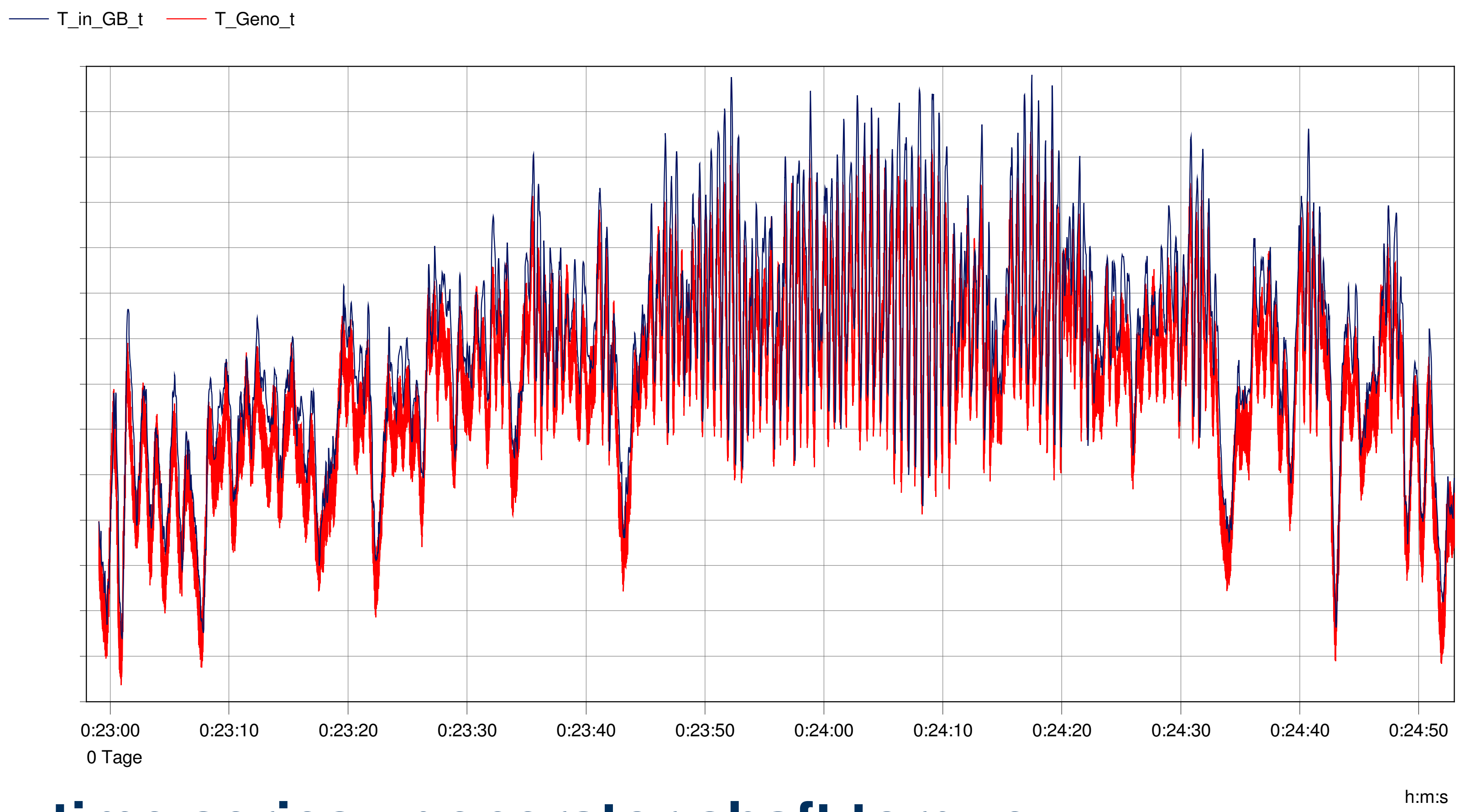


time series of gearbox input torque

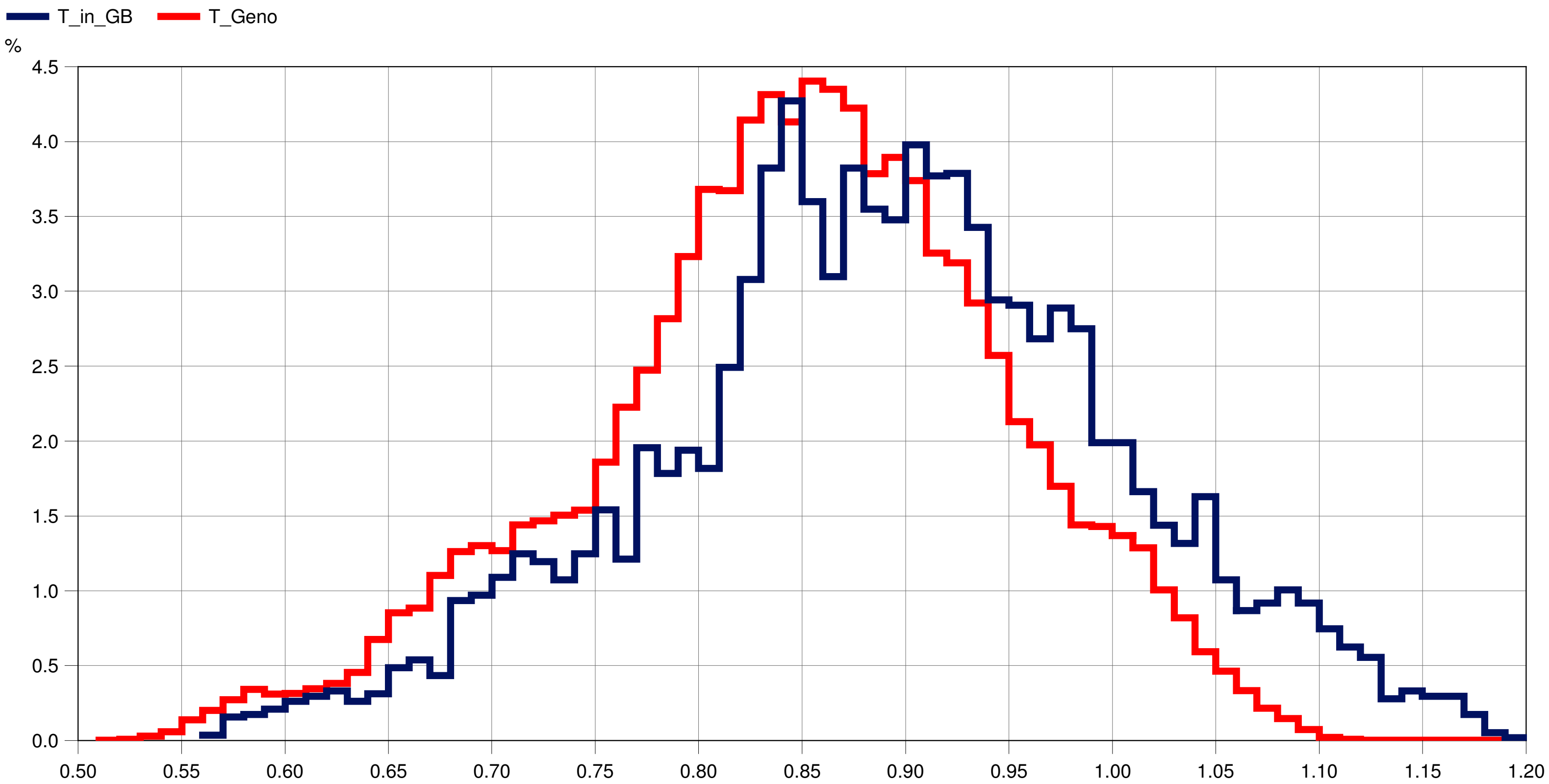


derivation of torque LDD of gearbox input shaft

(LDD = Load Duration Distribution)



time series - generator shaft torque



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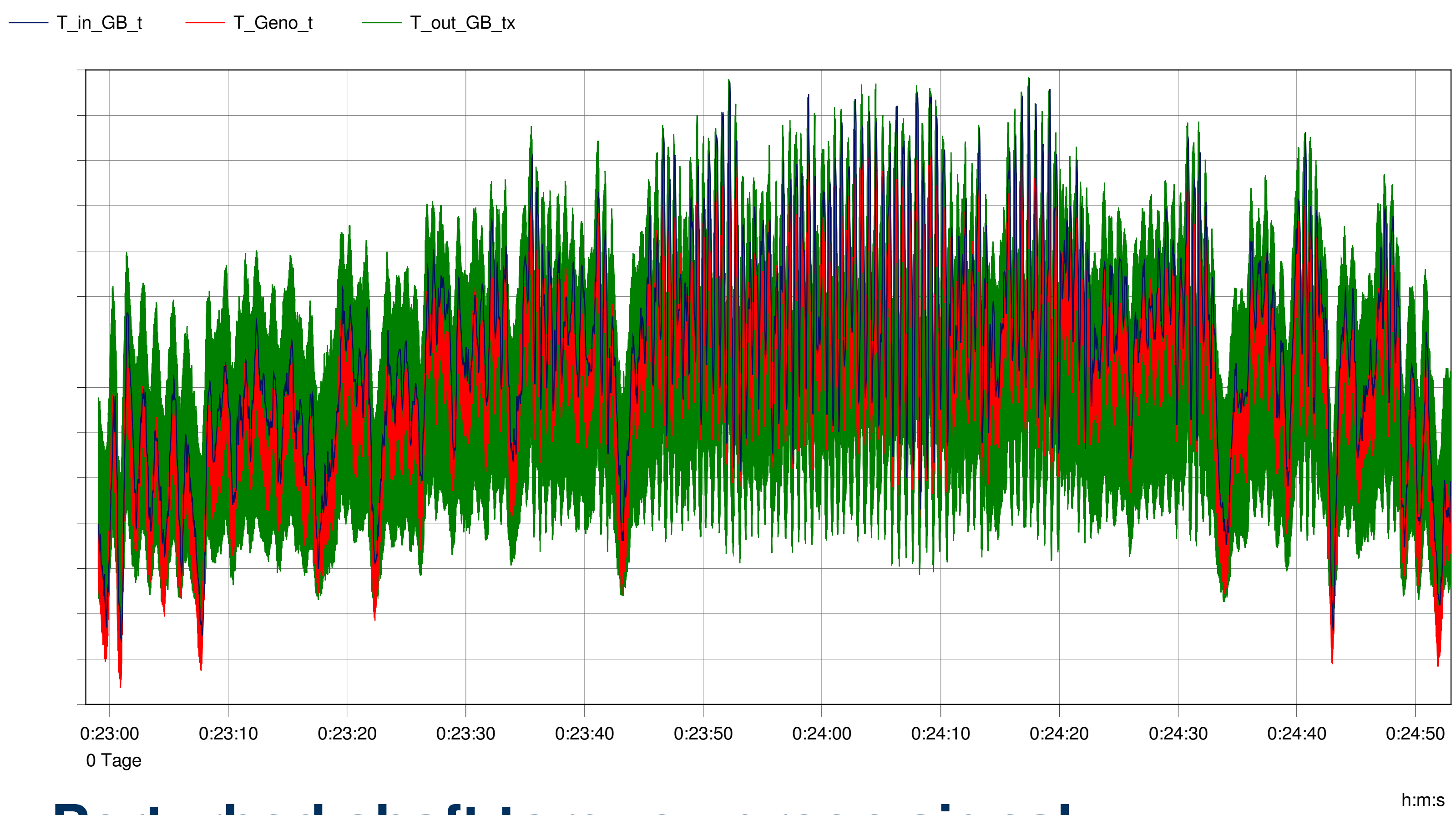
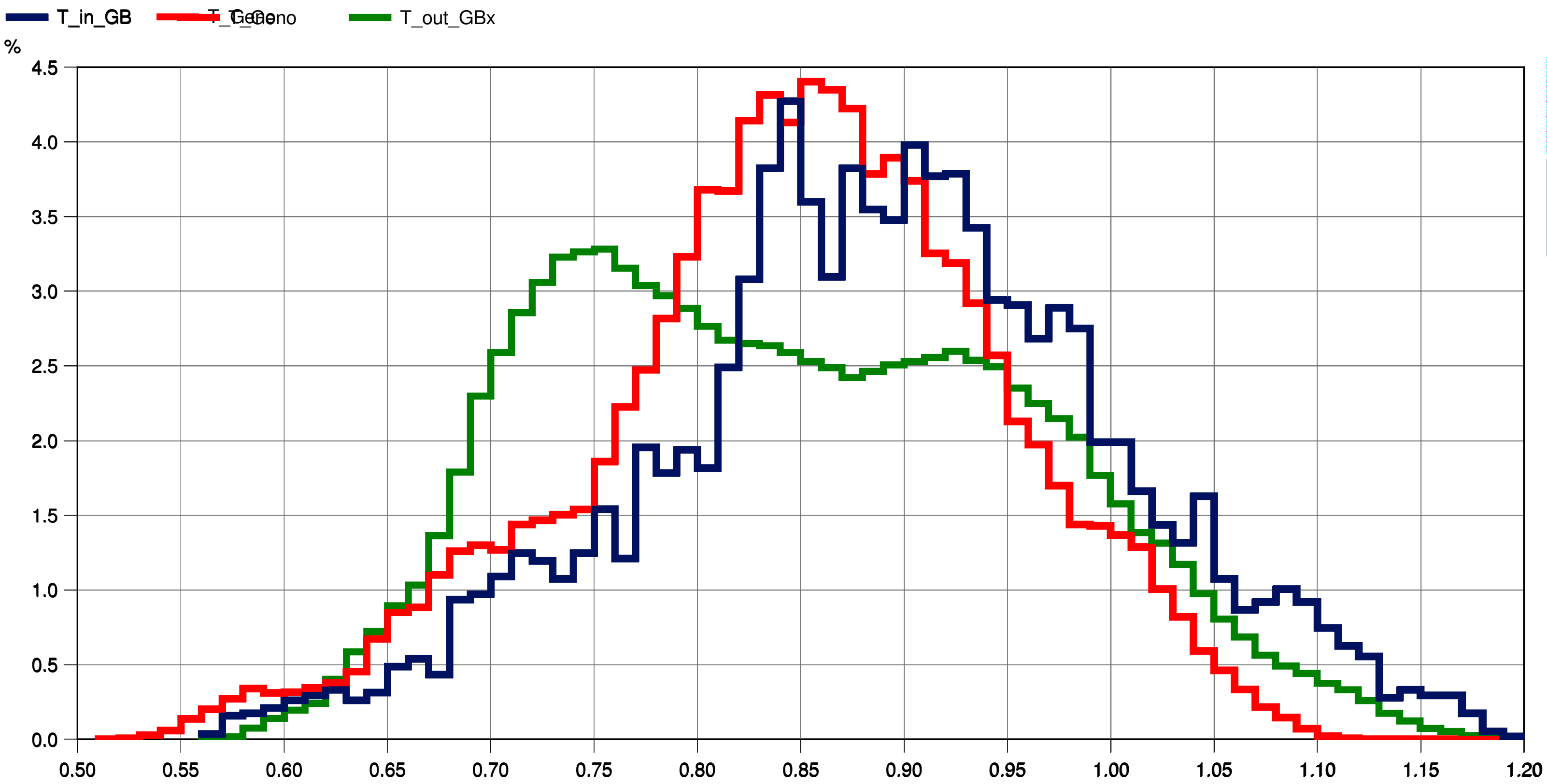


Perturbed shaft torque - green signal



derivation of torque LDD of perturbed shaft torque

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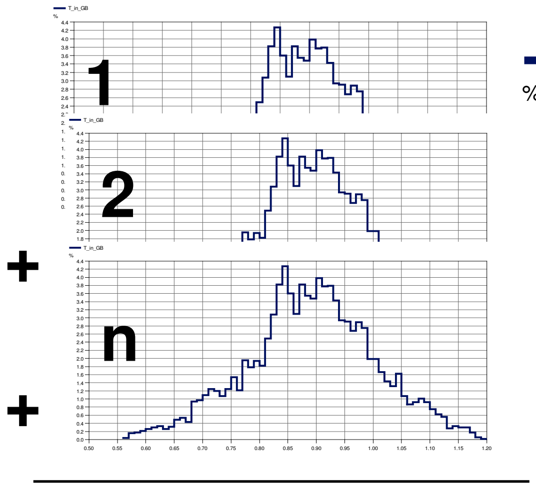
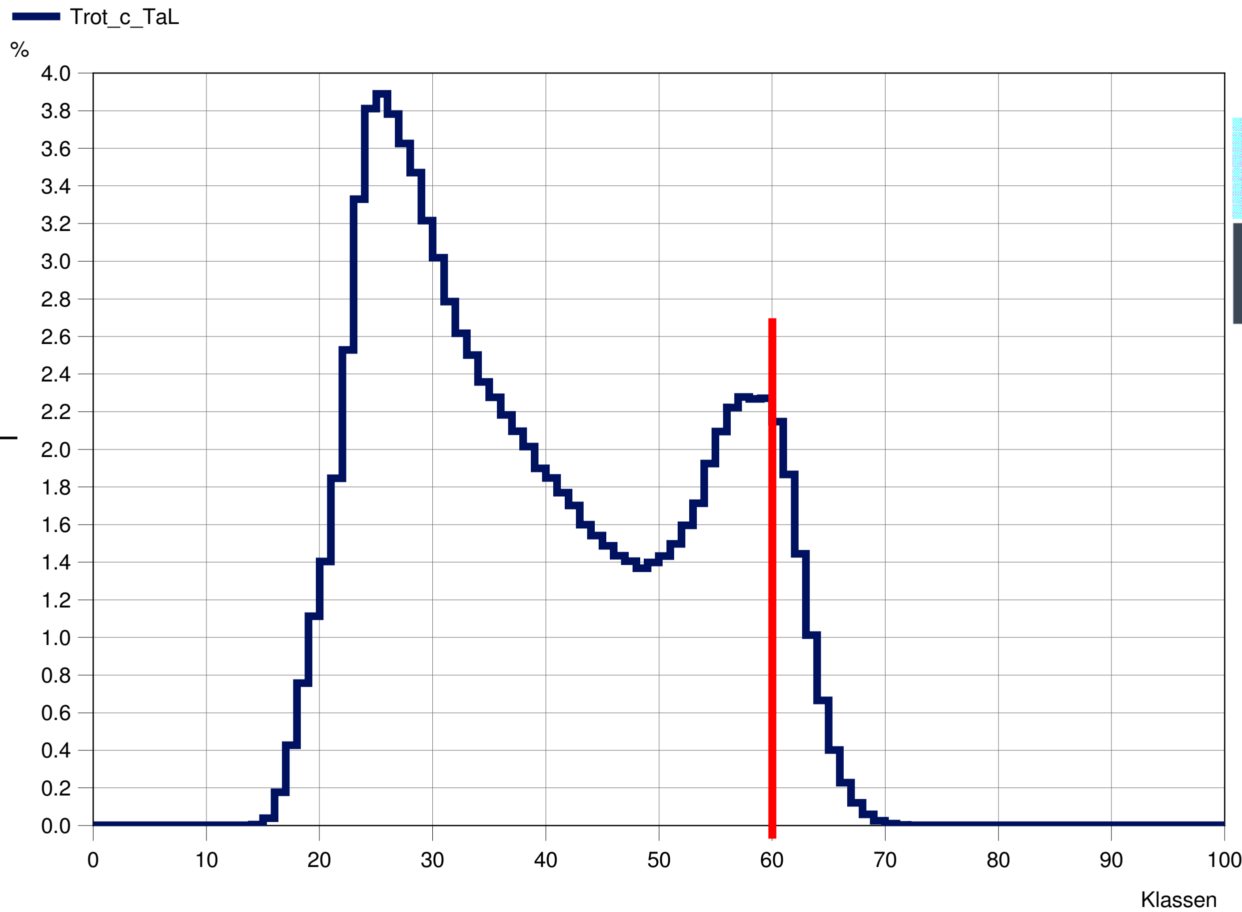
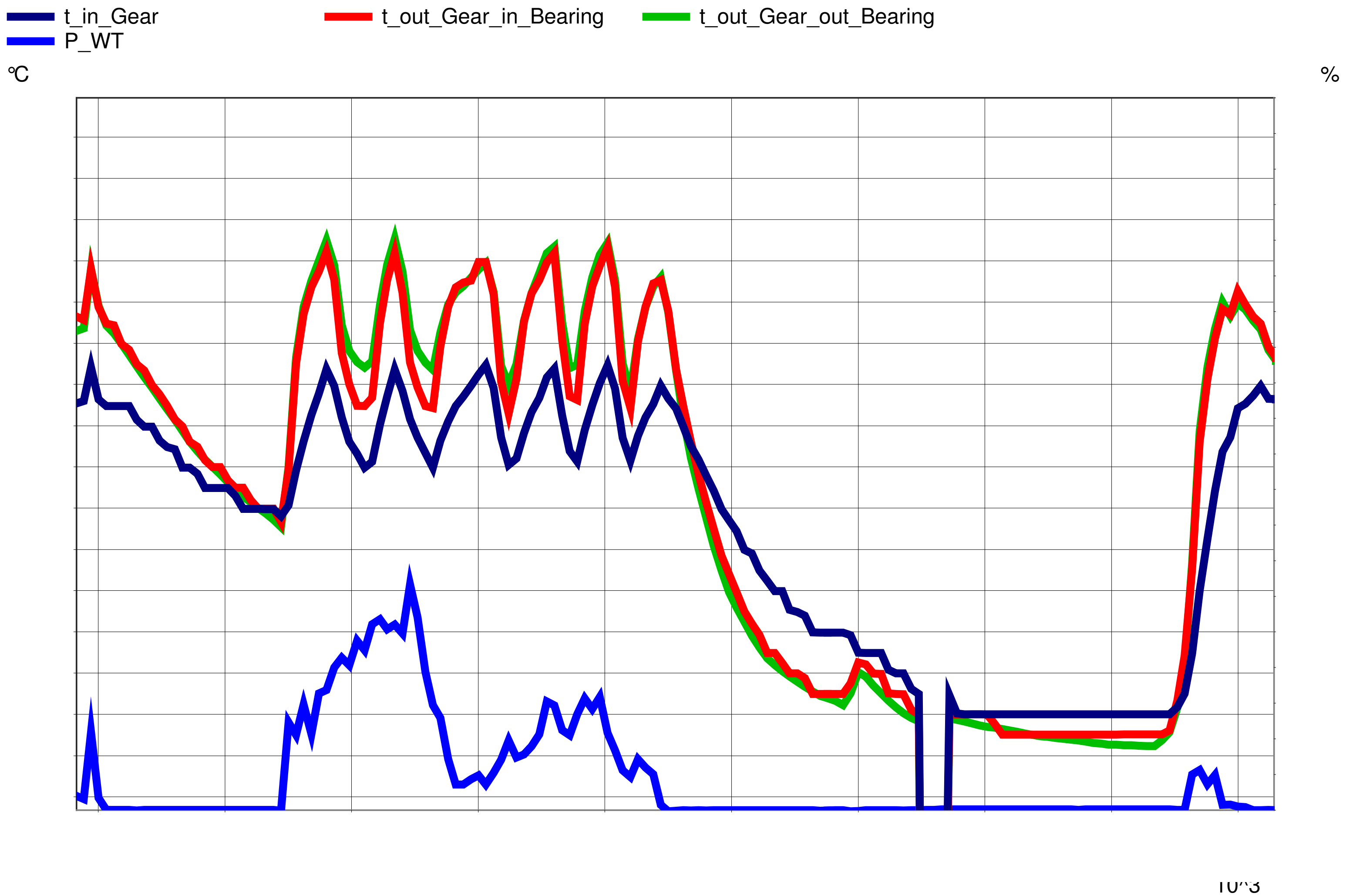




Service life LDD = weighted accumulation of individual 10-min-LDD's



temperatures, here: 10-min-statistics

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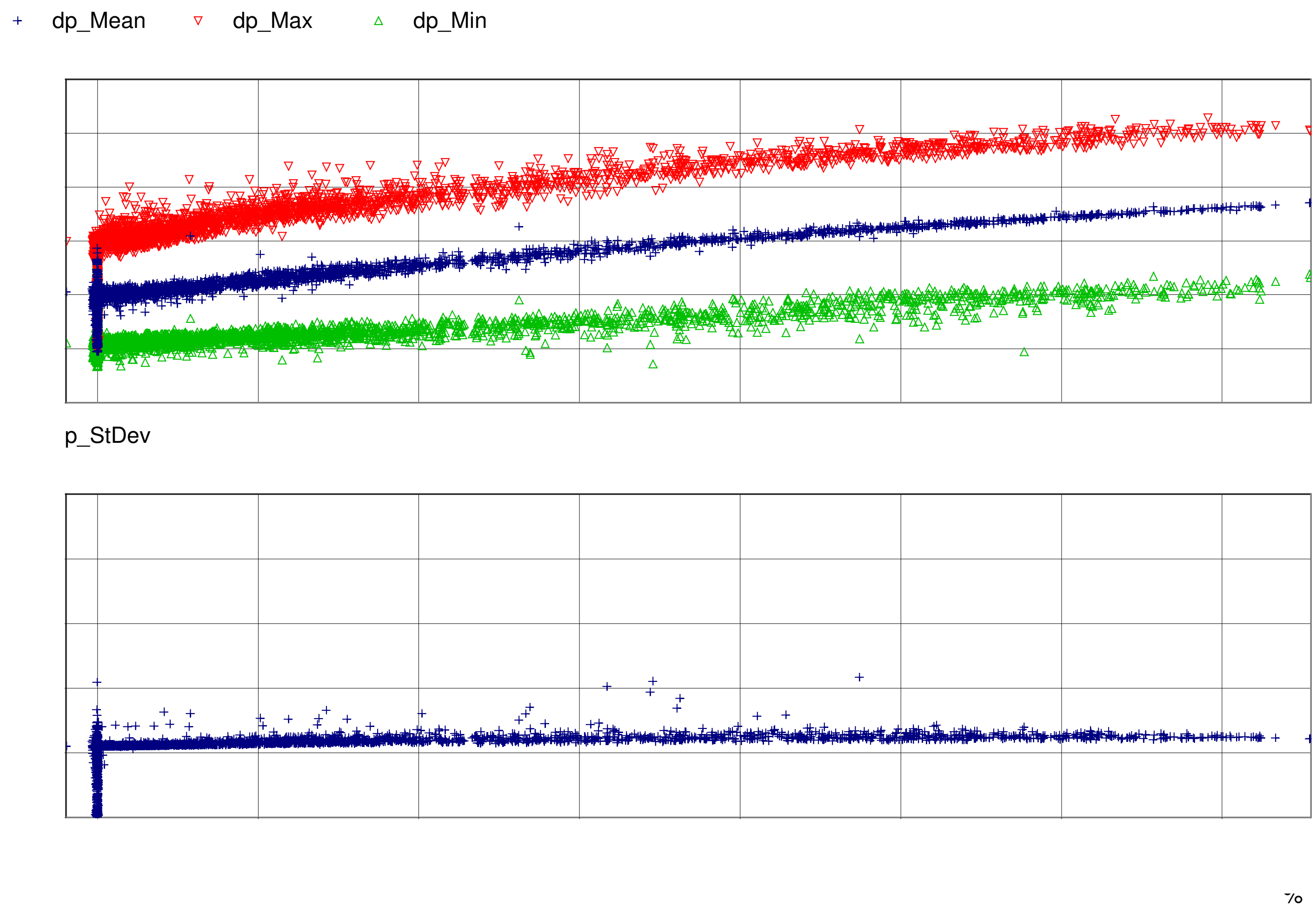

displacements, here: 10-min-statistics

- Multi-body simulations are carried out by University of Stuttgart / SUZLON to establish global loads and loads at interconnecting points
- comparison of design loads to measurements
- Feed-back on procedures as defined under WP3 and WP4

- Case study ongoing

- improvement of setup
- next campaign planned for December 2008

Thank you for your attention!