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Universität für Bodenkultur Wien

# Probabilistic Safety Analysis for Small Wind Turbines

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# Content

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- What is a Probabilistic Safety Analysis (PSA)?
- Aim of research

- Identification of risks and hazards
- Event Tree calculations
- Other factors of influence

Solvento, 2016

# Probabilistic Safety Analysis (PSA)

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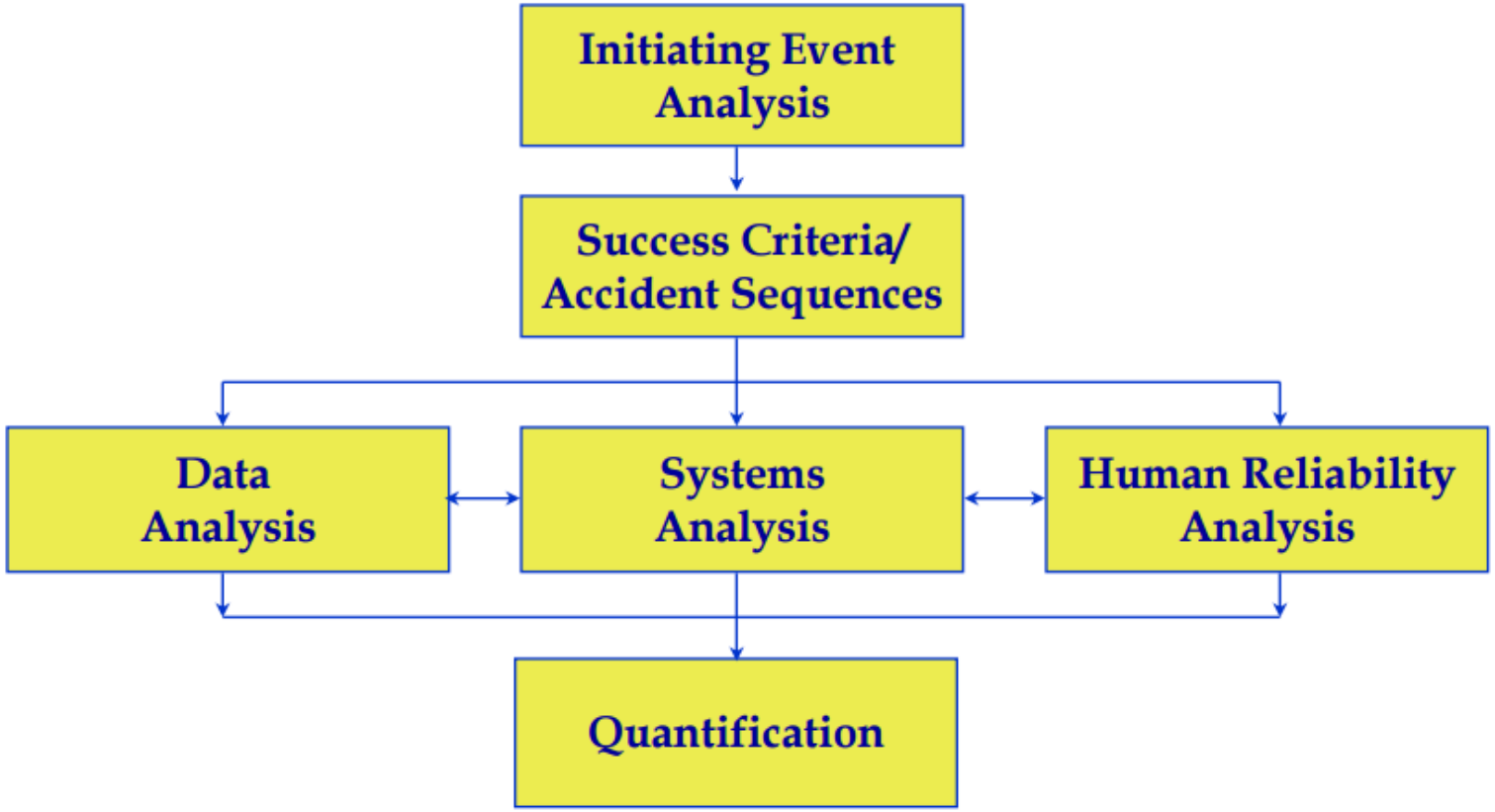
PSA gives answers to:

- What can happen?
- What are the probabilities of the scenarios?
- What are the consequences?

→ Risk frequencies will never include all influencing factors

→ Identifying weak points and shaping possibilities




Khatib-Rahbar, 2011

# Aim of Research

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- What are potential failures of SWTs, which may physically harm people in urban areas?
- How could the risks of these failures be calculated?

To get insights into…

- Accident Sequences: From hazards to risks
- Probabilities: For initiating events and the different risks
- Identification: Opportunities to reduce the risks

# Databasis

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- **Data of 5 years and 15 turbines tested in Lichtenegg**
- 2 years of data collection of self-made turbines in Peru by Jon Sumanik-Leary
- Dialog with experts

Sumanik-Leary,2013 and Solvento, 2016

# Identifying Risks and Hazards

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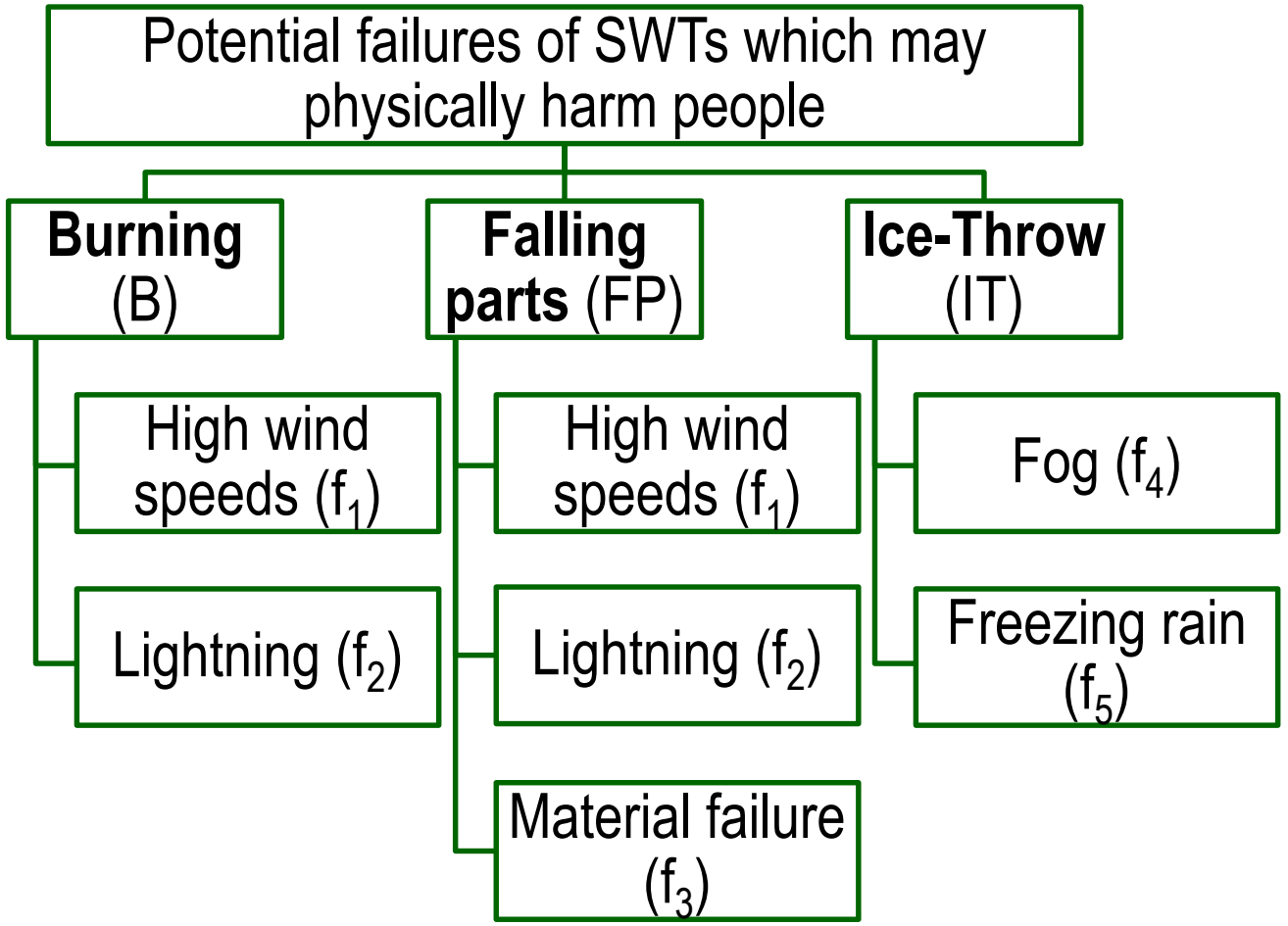
**Failure**

**Initiating Hazards**



# Frequencies of Unwanted Failures ($h_i$)

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= $\sum$ [ *frequencies of the initiating hazards (fi)*
x *probabilities of failure of the protection systems (Pi)*]

- Frequency of Burning (Bi)

$$h_B = f_1 \cdot P(B1) + f_2 \cdot P(B2)$$

- Frequency of Falling Parts (FPi)

$$h_{FP} = f_1 \cdot P(FP1) + f_2 \cdot P(FP2) + f_3 \cdot P(FP3) \cdot F1 \cdots Fn$$

- Frequency of Ice-Throw (ITi)

$$h_{IT} = f_4 \cdot P(IT4) + f_5 \cdot P(IT5)$$

$F_i$= influencing factors

# Probabilistic Risk Calculation

**Event Tree (example B1)**

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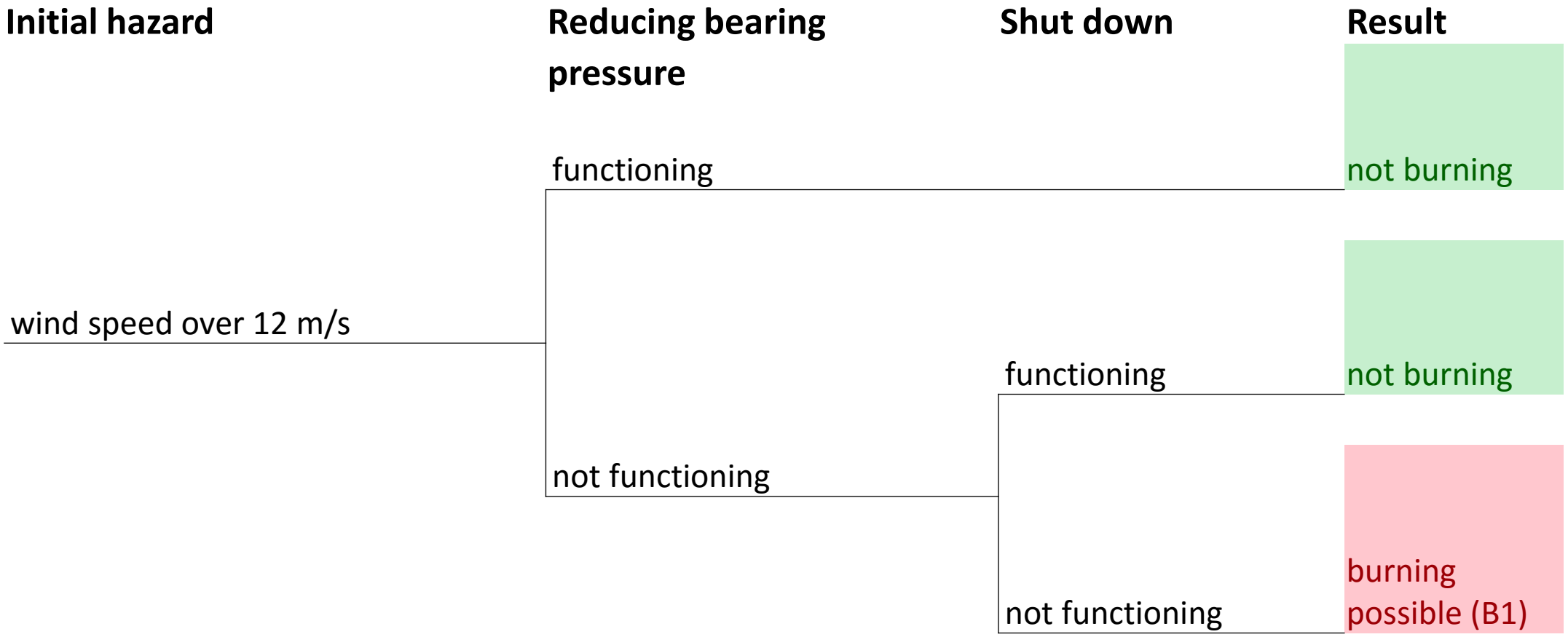

# Test of Independence

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Problem: Different installations and turbines have different probabilities of material failure

→ Which criteria are influencing the material fault-frequencies?

→ Test of independence: Chi$^2$ or Fisher's exact test

$$h(material\ fault) = f_3 \cdot P(FP3) \cdot F1 \cdots Fn$$

$$F = \frac{faults\ observed}{faults\ expected}$$

# Testing Criteria ($F_n$)

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Criteria tested:

- Vertical or horizontal axis
- Certification
- Nominal capacity

Criteria to test:

(with more data available)

- Vibration isolator
- Tower originally belonging to turbine
- Installed by manufactures

# Example of test of independence

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- Is certification having an influence on fault frequencies?

| Criteria: Certification | | Experiences (Full load hours) | Observed faults | Expected faults |
|---|---|---|---|---|
| 1 | Yes | 172138 | 2 | 3,2 |
| 2 | No | 202618 | 5 | 3,8 |
| | Total | 374756 | 7 | 7 |

→ P-value of Fisher's Exact Test for Count Data = 0.3397

→ Certification does not have a significant influence on fault frequency

→ No influencing factor ($F_{certification}$) added

# Outlook

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- Determine the frequencies of the initial hazards ($f_1$...$f_5$)
- Develop Event Trees for three different turbines
- Identify criteria influencing material faults

→Calculate the risks for the failures *burning*, *falling parts* and *ice throw* for three different turbines under the topographic conditions of Lichtenegg

→Detect weak points and shaping possibilities

# Contact

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