BATTERIES IN RENEWABLE ENERGY SYSTEMS – CATEGORIES OF SIMILAR USAGE OF LEAD ACID BATTERIES

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- **Why to make categories?**
- **Standard evaluation report**
- **Categorization process**
- **Example**

Goal: *Introduction to the Benchmarking categorization process*

Why to make categories?

- Categories of similar usage of lead-acid batteries
- Different systems

- Differe

Operating conditions of batteries in RES vary so greatly that categories of similar operating conditions must be defined!

Standard evaluation report

- RES measured time-series data (different system, worldwide)
- Minimal data requirements
- Internet application ITHESA for processing the data

Input: - system description
- data file specification
- uploading measured time series

Output: - PDF file with processed measured data, graphical and tabular presentation

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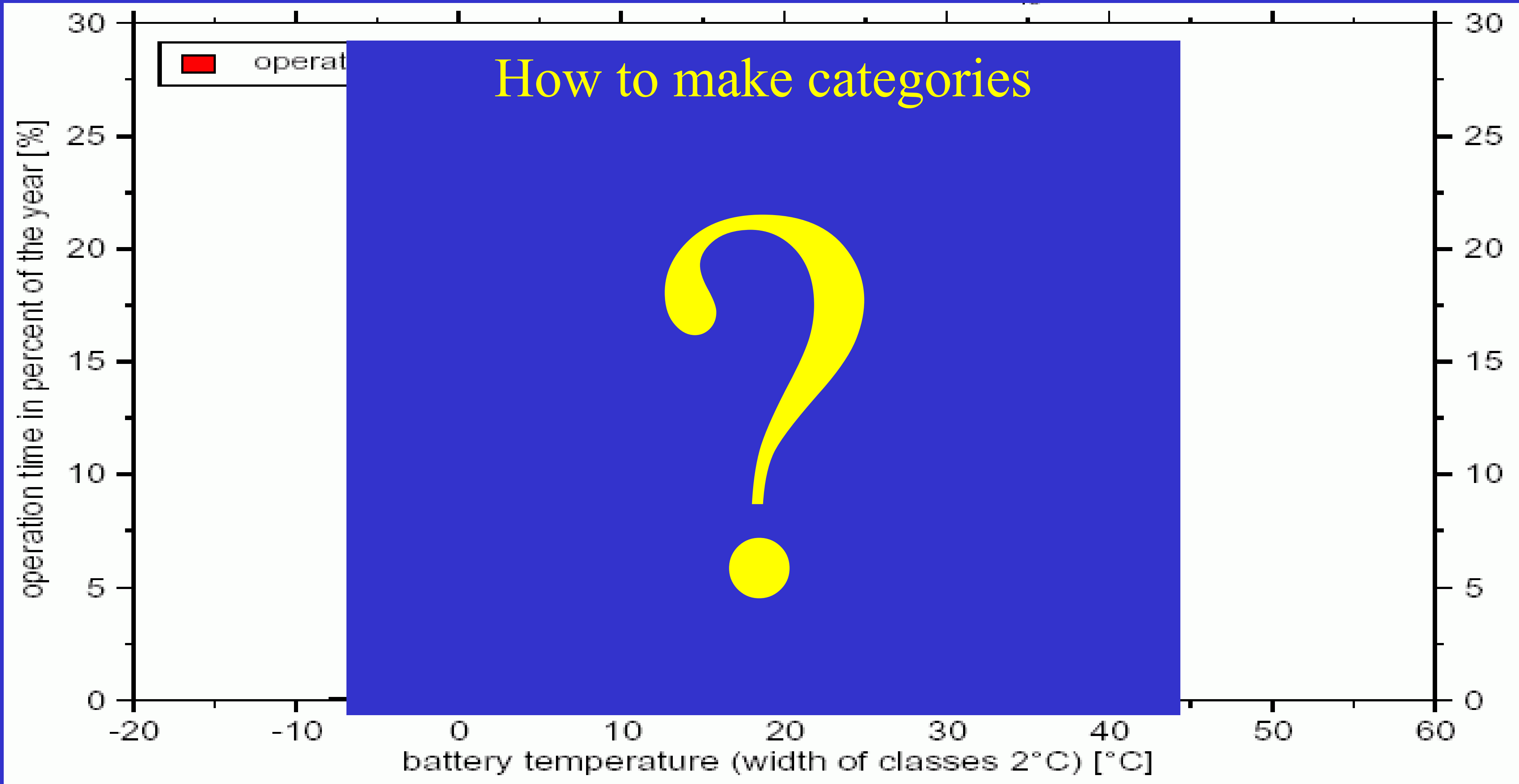
Standard evaluation report



ITHESA is a product of FhG – ISE, Freibrug.

Categorization process

Categories of similar operating conditions for batteries.

The categorization process is based on measured values from existing RES around the world.

Categorization process

Similar operating conditions lead to similar risk for aging mechanisms.

1. Grid corrosion
2. Electrolyte stratification
3. AM hard/irreversible sulfation
4. AM shedding
5. AM degradation
6. Water loss / drying out

Categorization process

An ageing mechanism risk is given by stress factors.

Thus <u>stress factors</u> were selected to define categories of similar operating conditions.

1. **Charge factor**
2. **Ah throughput**
3. **Highest discharge rate**
4. **Average time between full charge**
5. **Time @ low SOC**
6. **Partial cycling**

- **Temperature acceleration factor**
- **Low battery environmental temperature**

Intensity of the stress factors

Each stress factor is evaluated with the intensity index:

The intensity index is assigned by the means of intensity criteria.

Expert knowledge were integrated into the criteria within the project.

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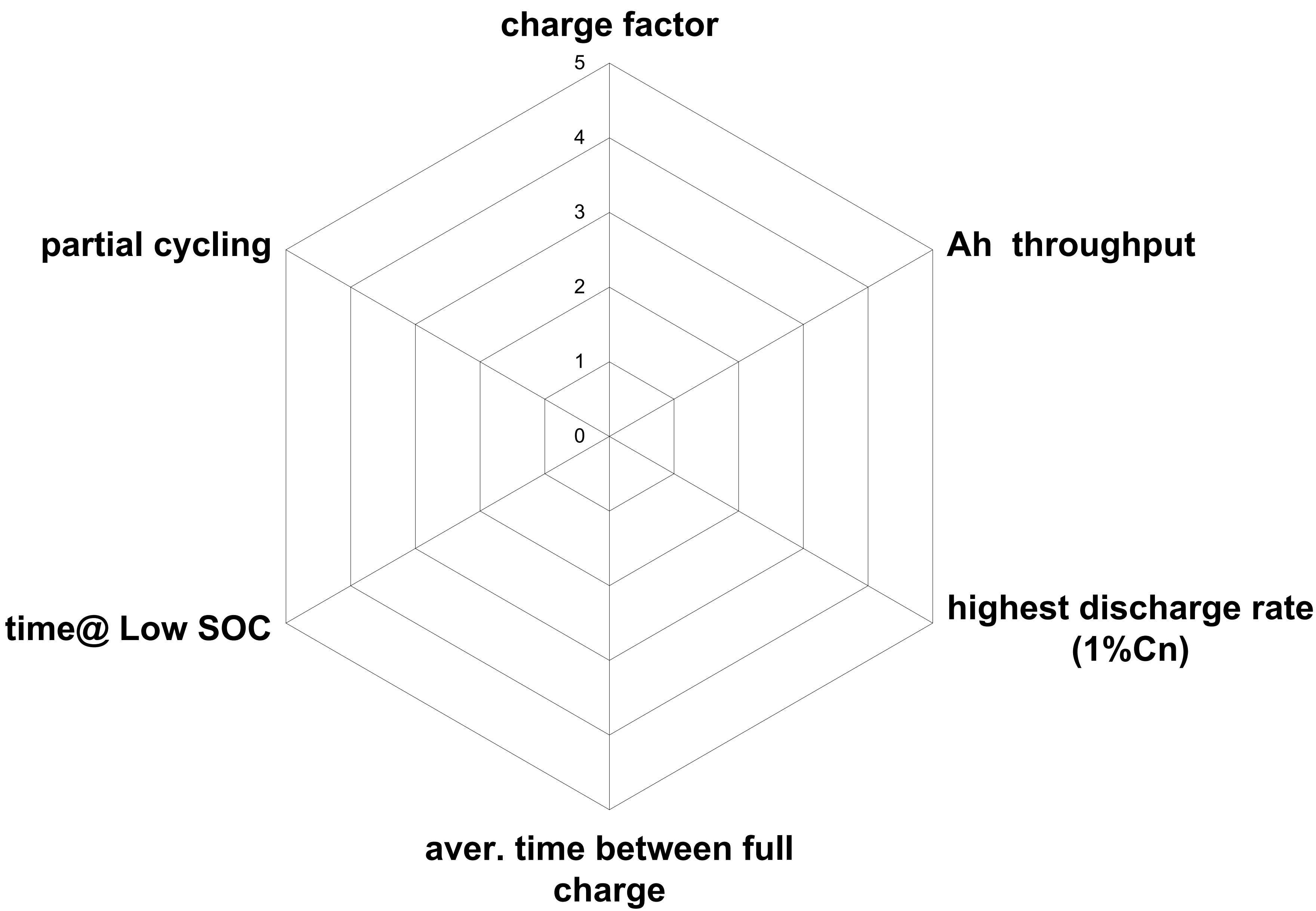
Stress factors visualization

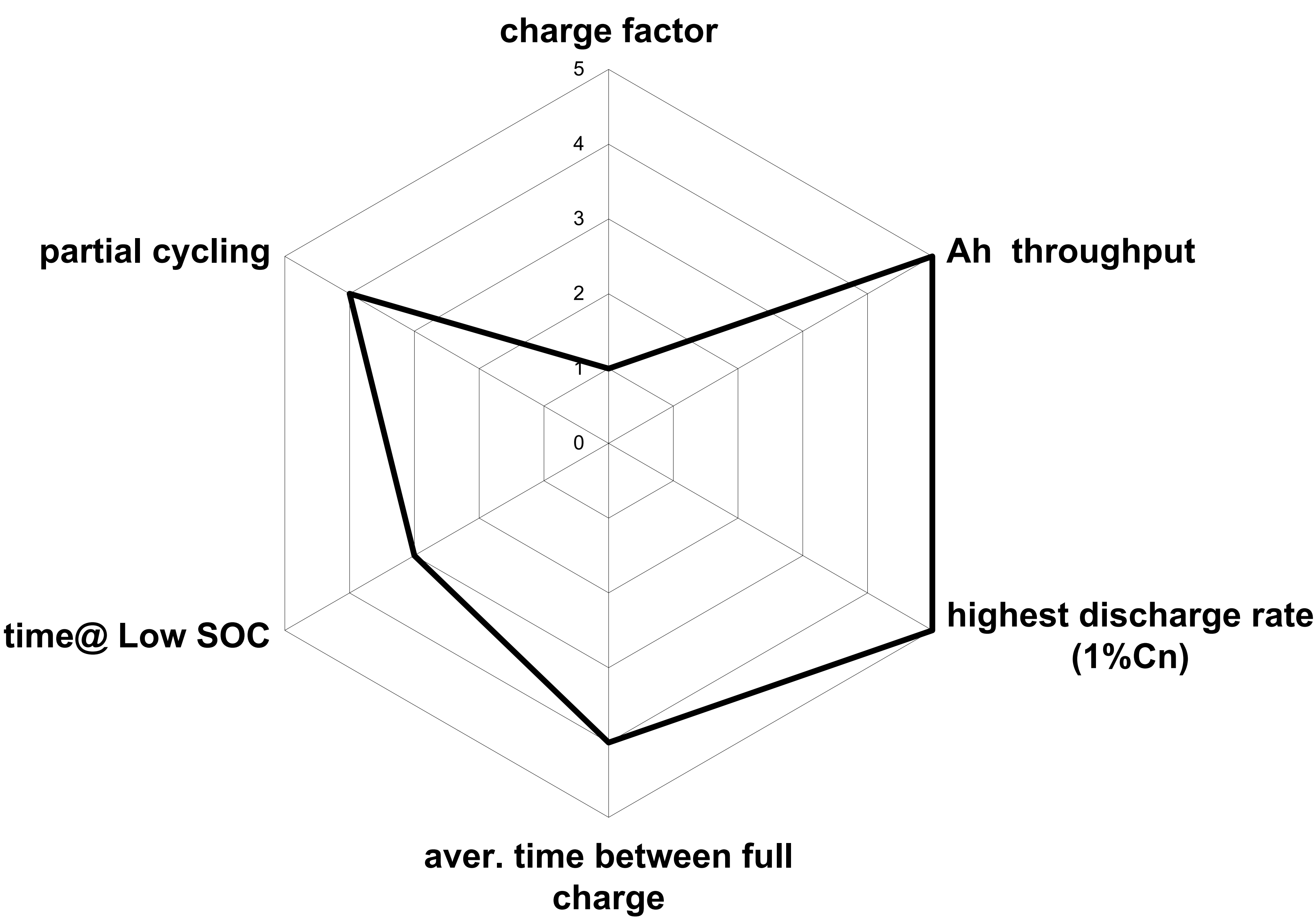
RES example: intensity evaluated stress factors

Stress factor	*Intensity*
Charge factor	**1**
Ah throughput	**5**
Highest discharge rate	**5**
Average time between full charge	**4**
Time @ low SOC	**3**
Partial cycling	**4**
Temperature acceleration factor	*3*
Low temperature	*1*

Stress factors visualization



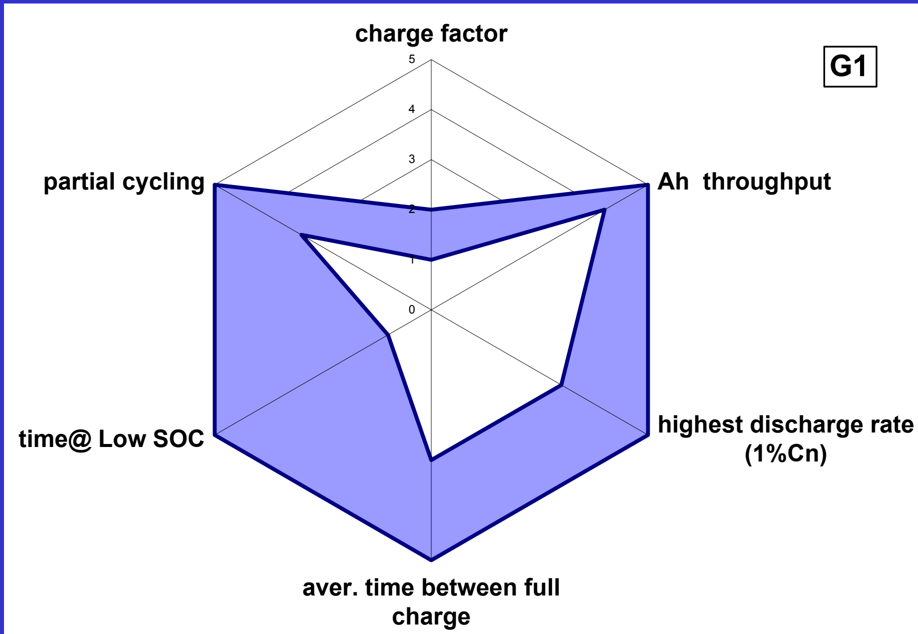
Stress factors visualization

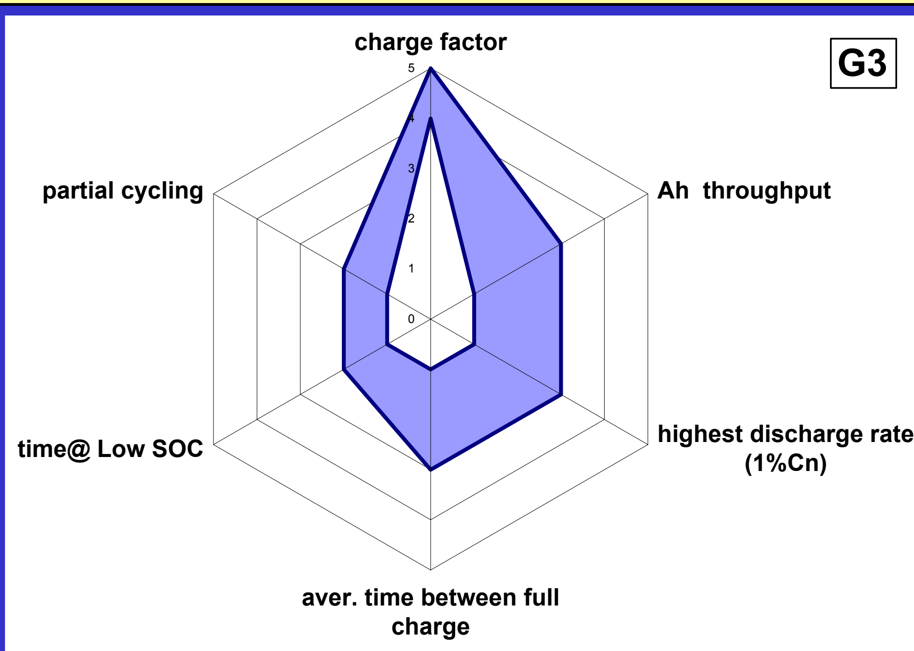


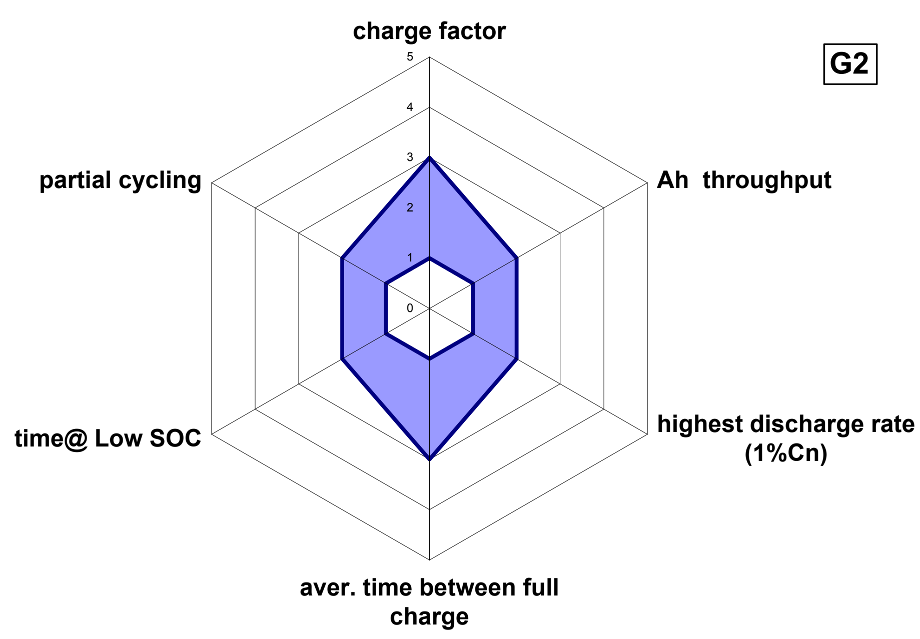
Determination of categories

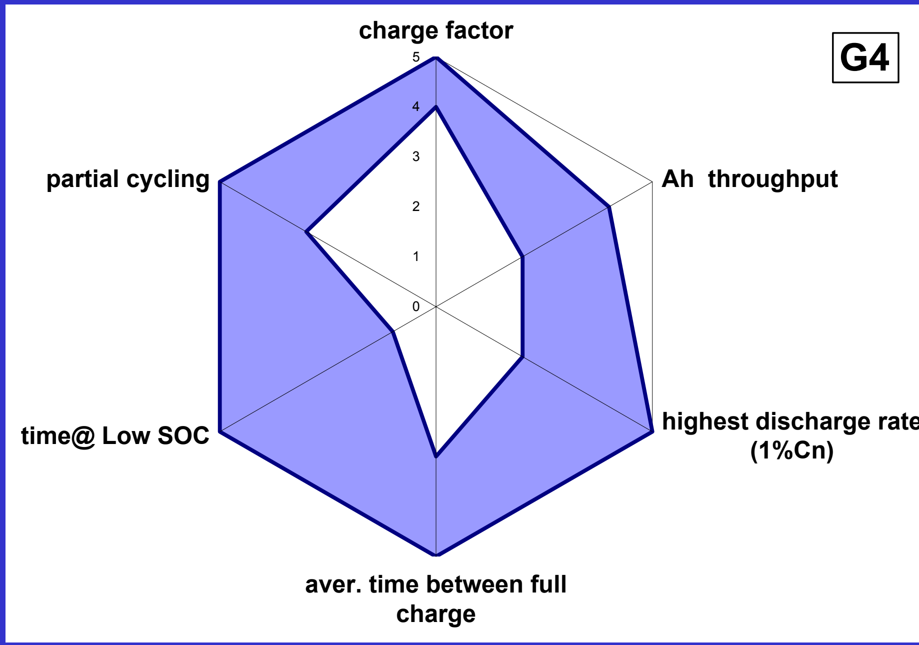
The distribution of the radar plot shapes is used for determination of categories by a visual consideration together with expert knowledge.

Determination of categories

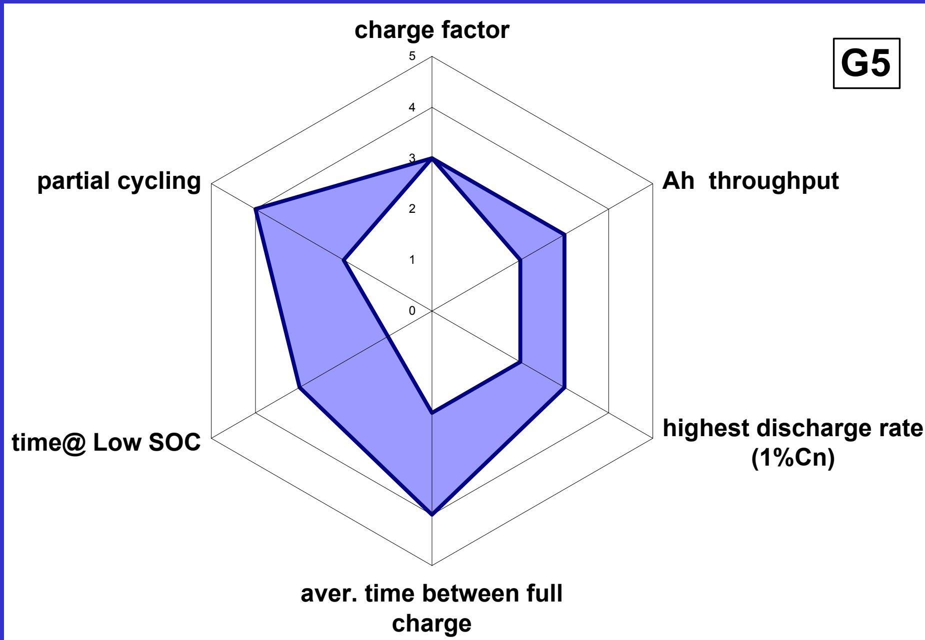


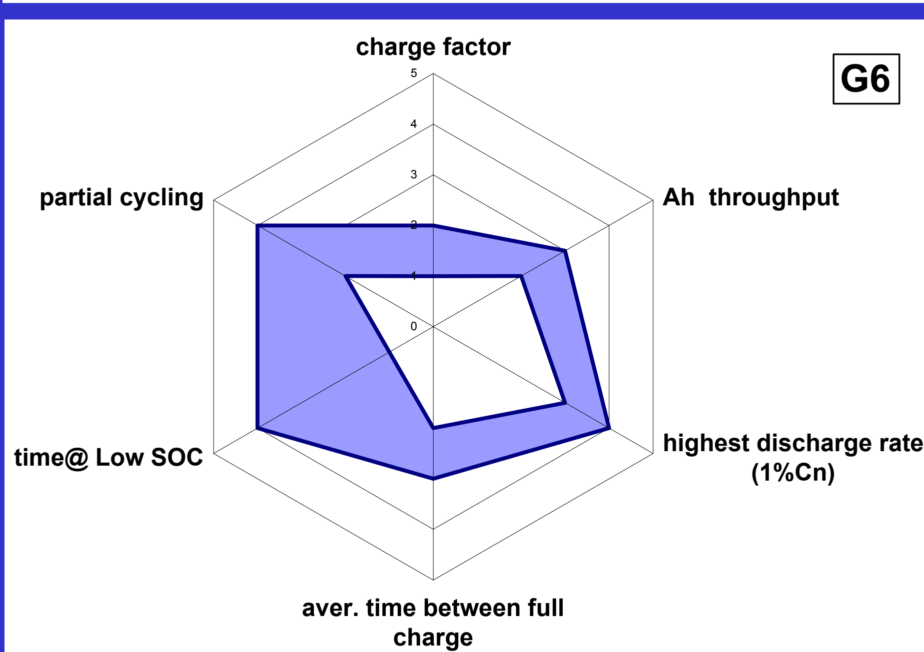






Determination of categories

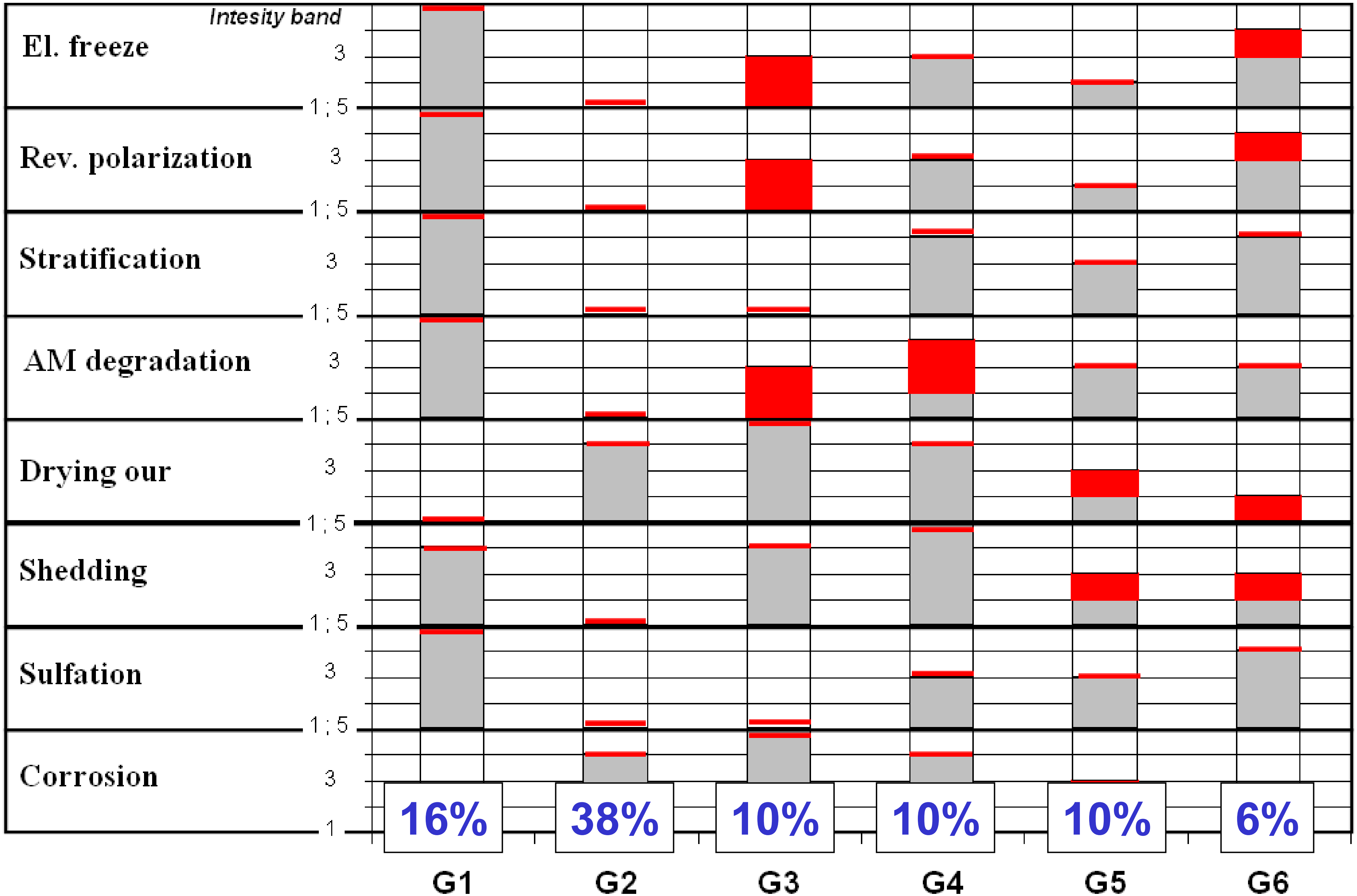




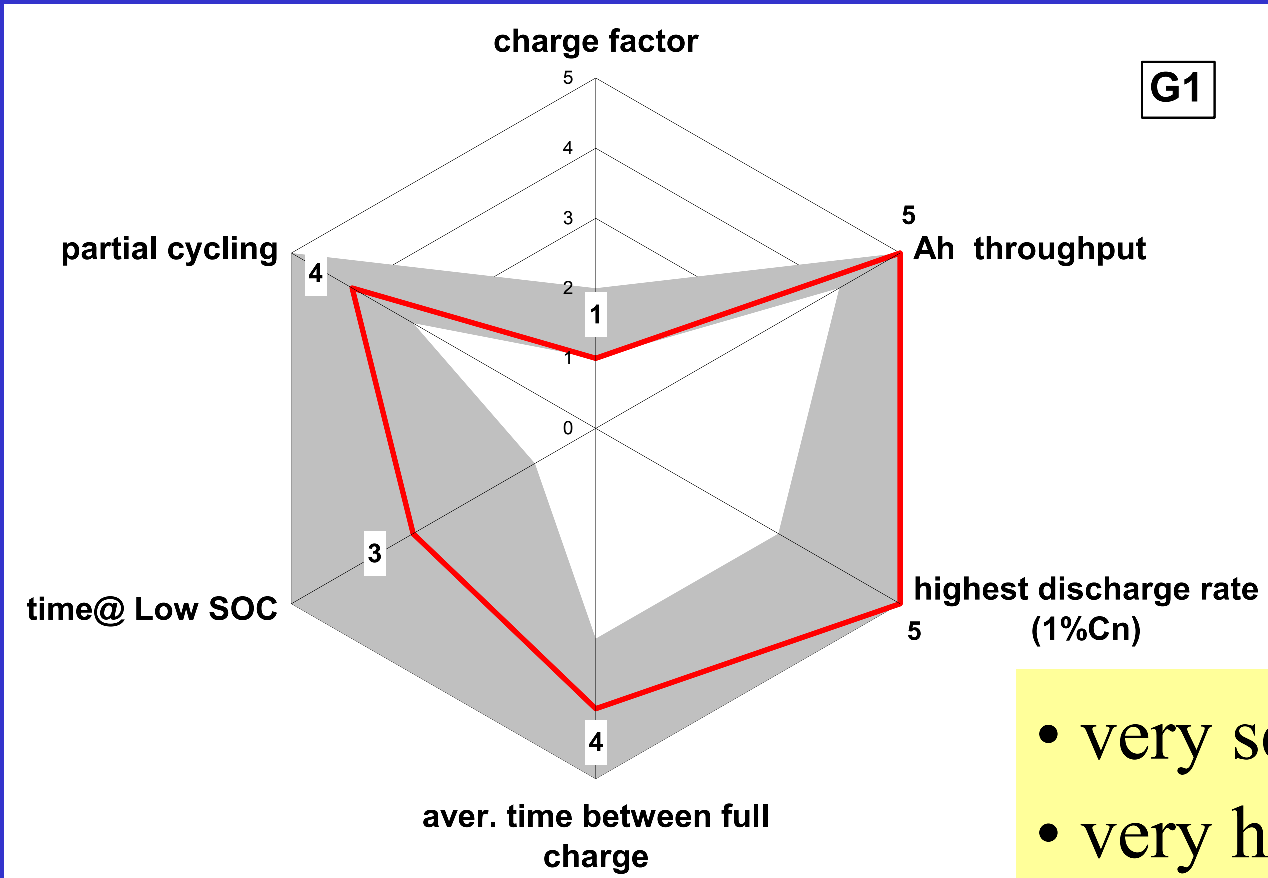
Temperature factors:

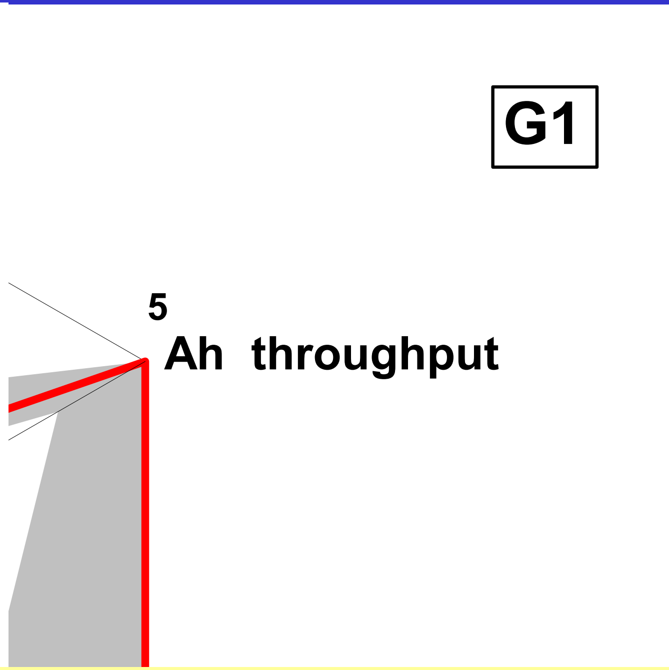
- **Temperature acceleration factor**
- **Low temperature factor**

Risk of aging mechanisms



Example of category G1

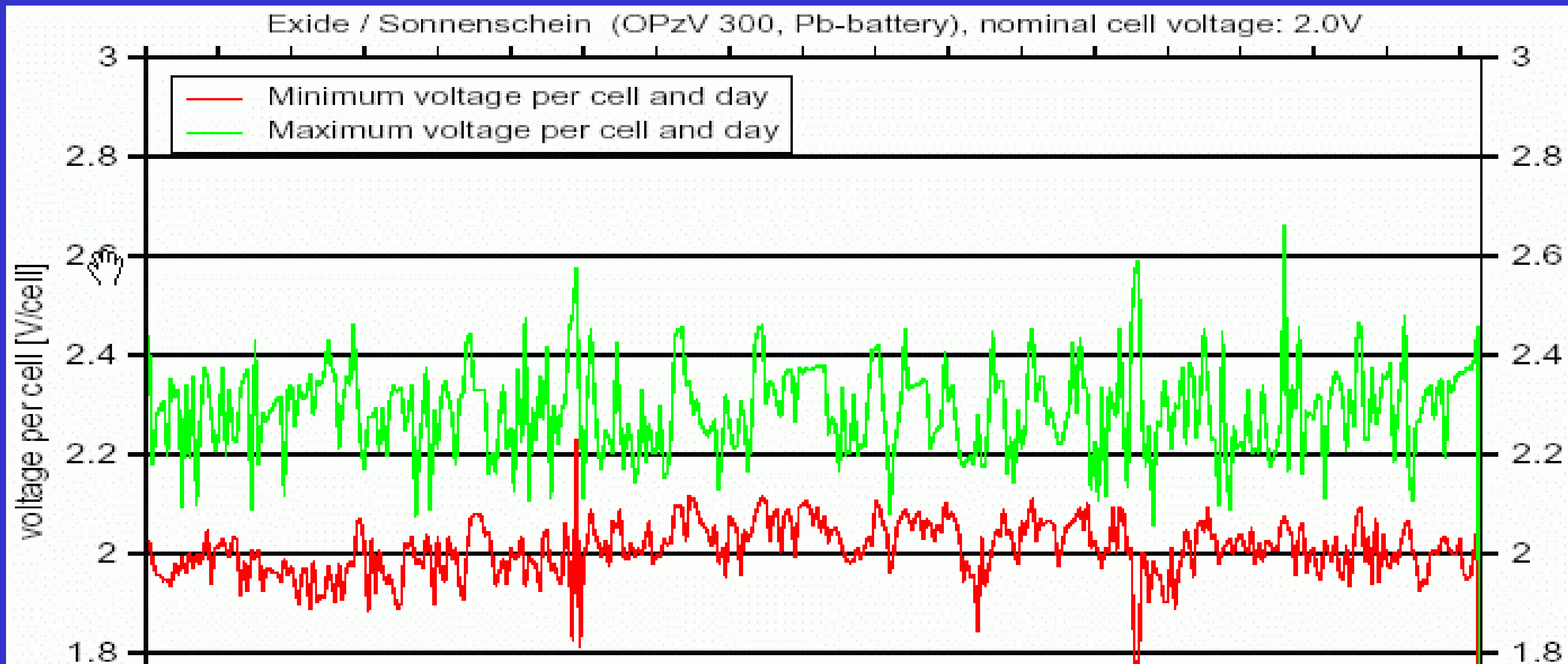




- very seldom full recharge
- very high or high Ah throughput (full cyclic operation)
- low charge factor
- PSOC operation
- very high discharge current rate

Example of category G1

Battery: 12V battery 300Ah, single cells, OPzV, gel
Battery manufacturing: Jan. 98   Installation: 1.4.1998
Monitoring period: 1999
Good thermal insulation



- max. voltage: very seldom full recharge
- min. voltage: deep discharge particularly in winter time
- over-polarization risk

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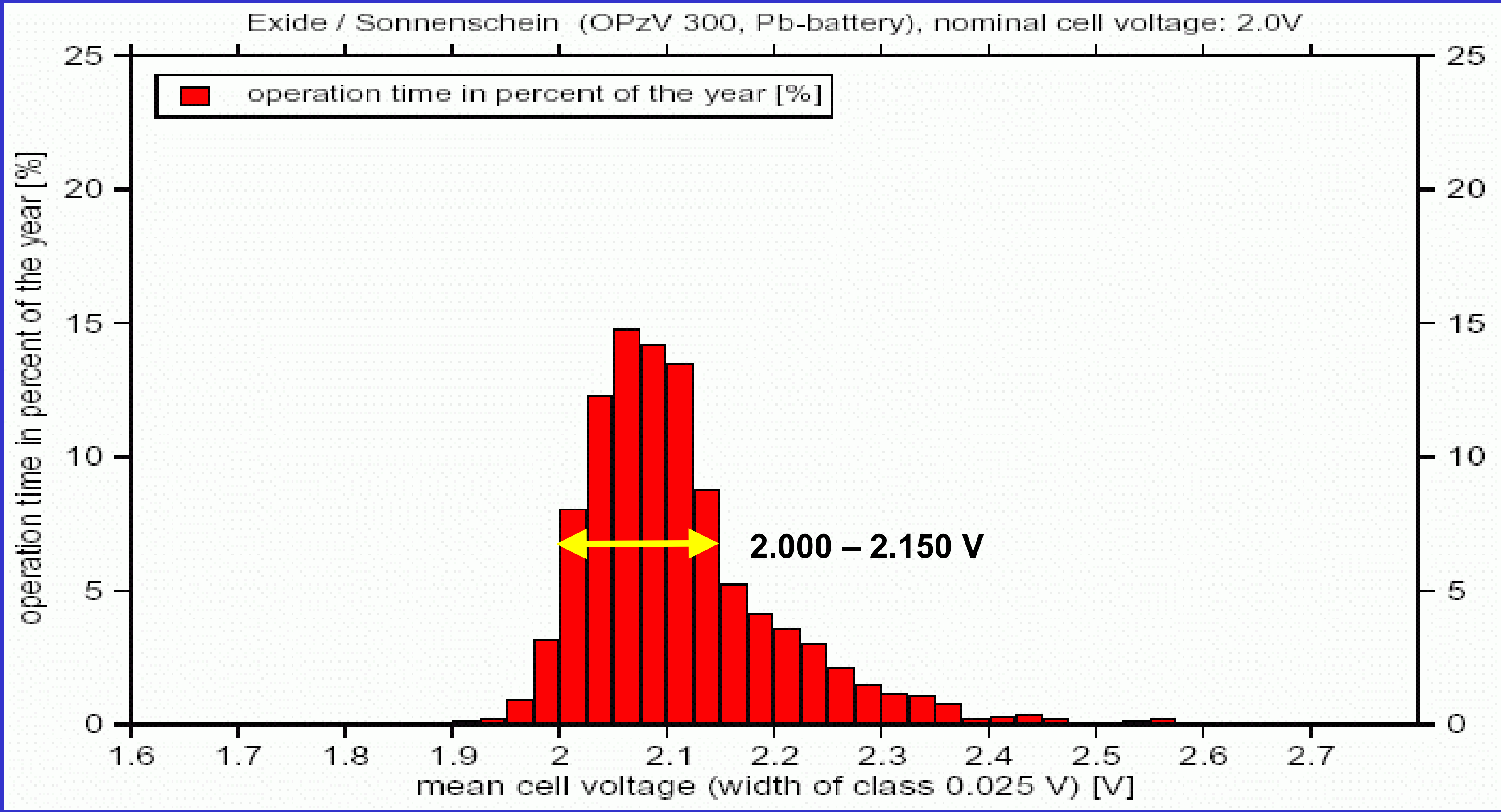
Example of category G1



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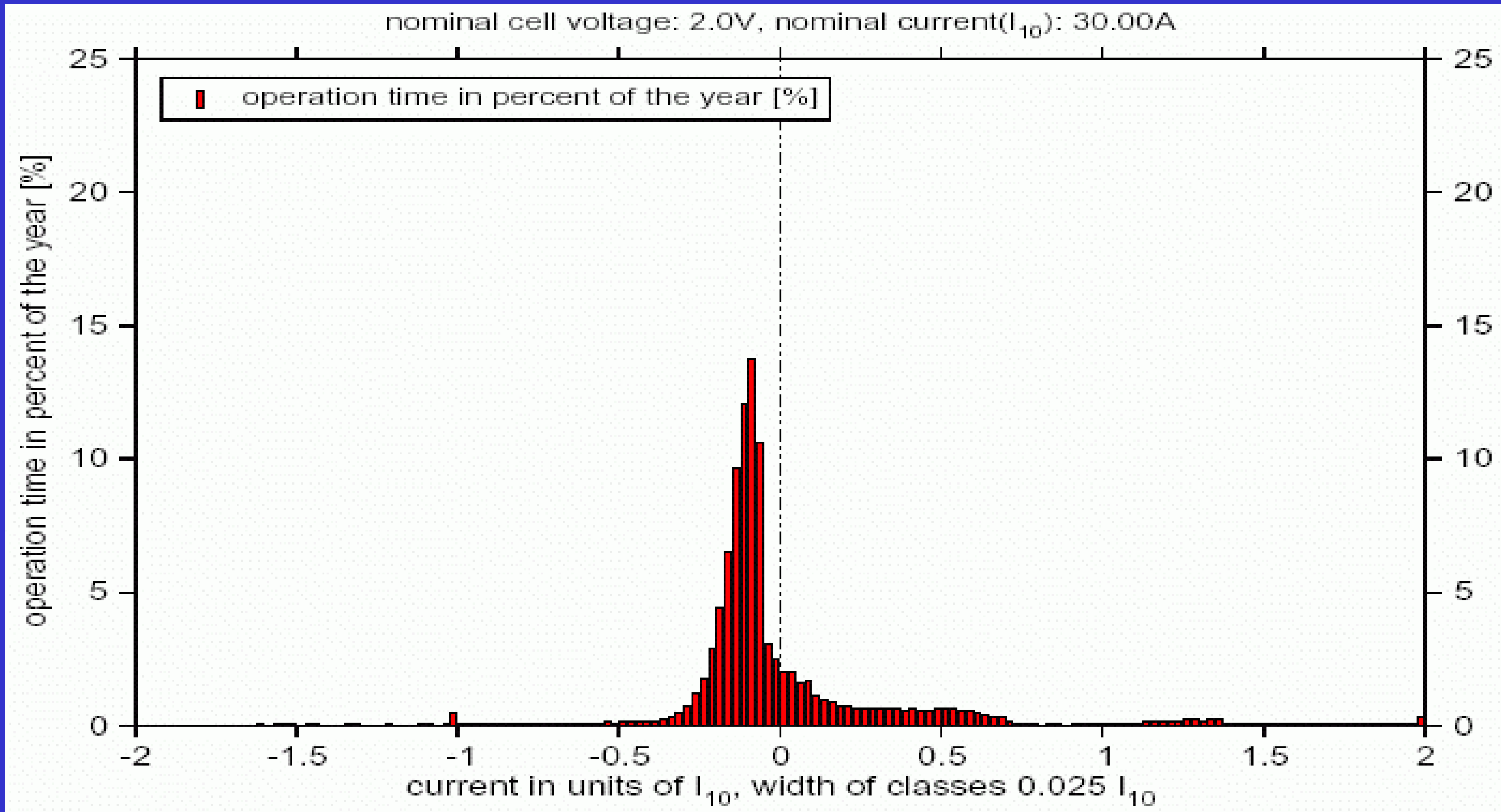

- max. voltage: very seldom full recharge
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- high power operation

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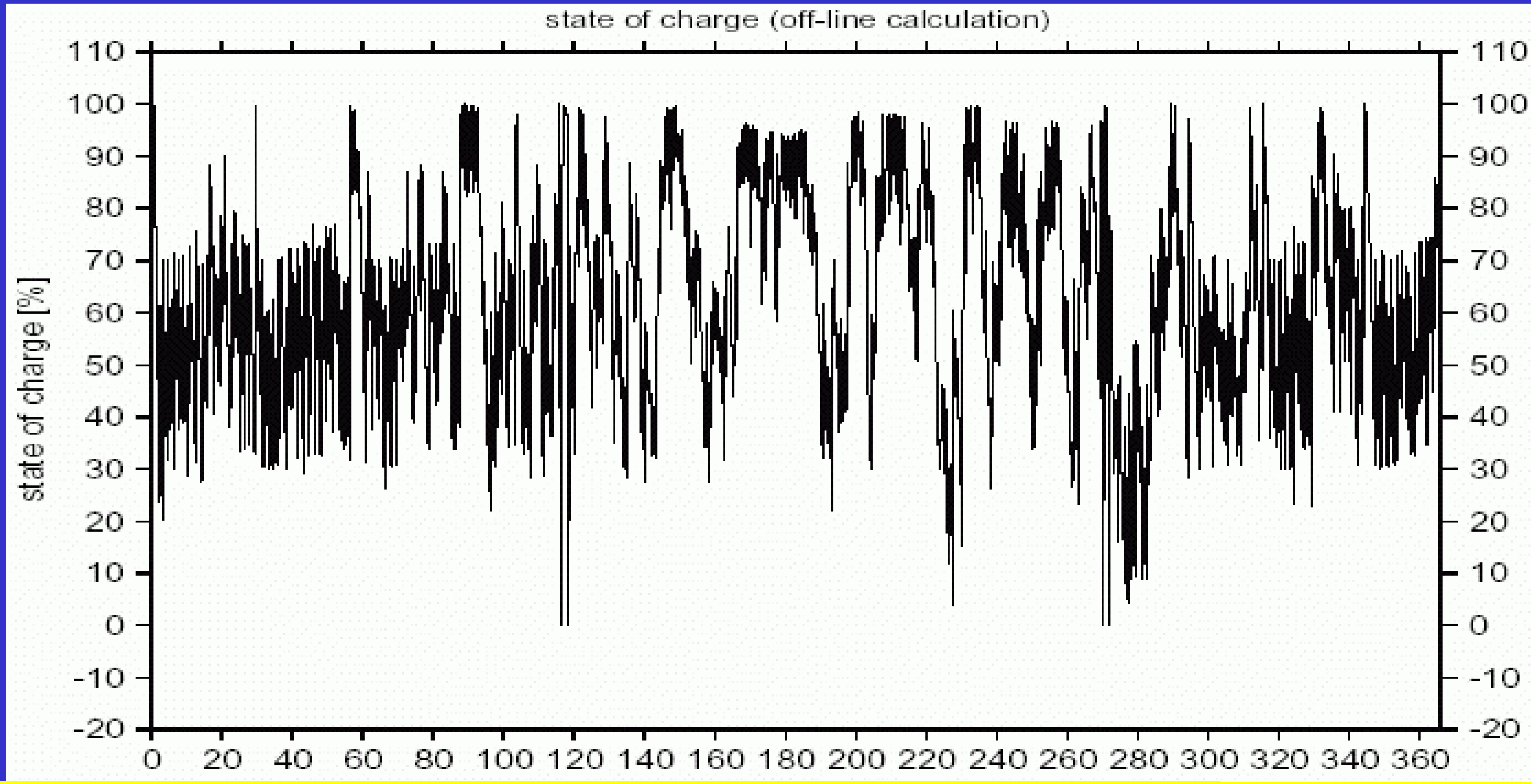
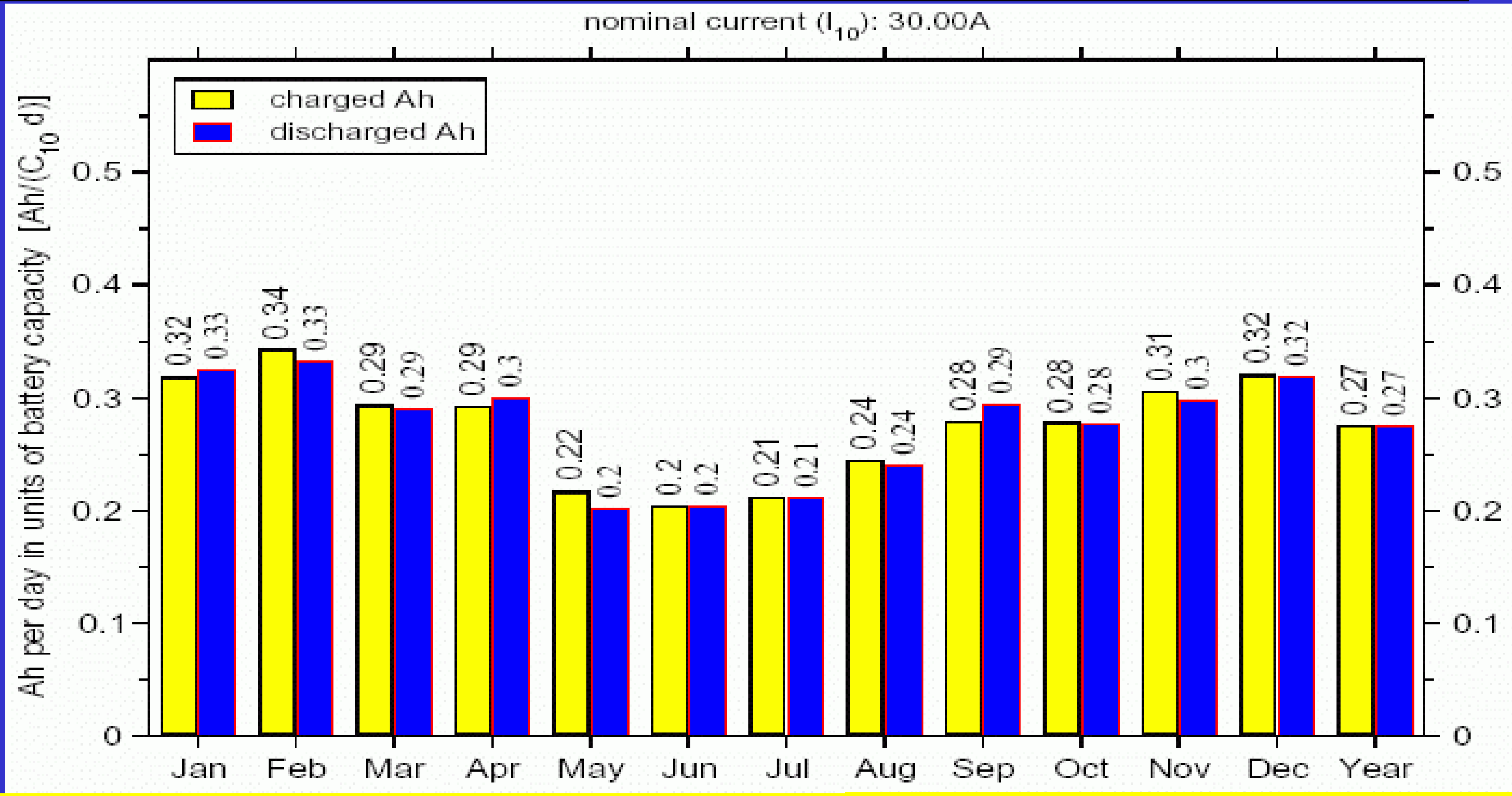


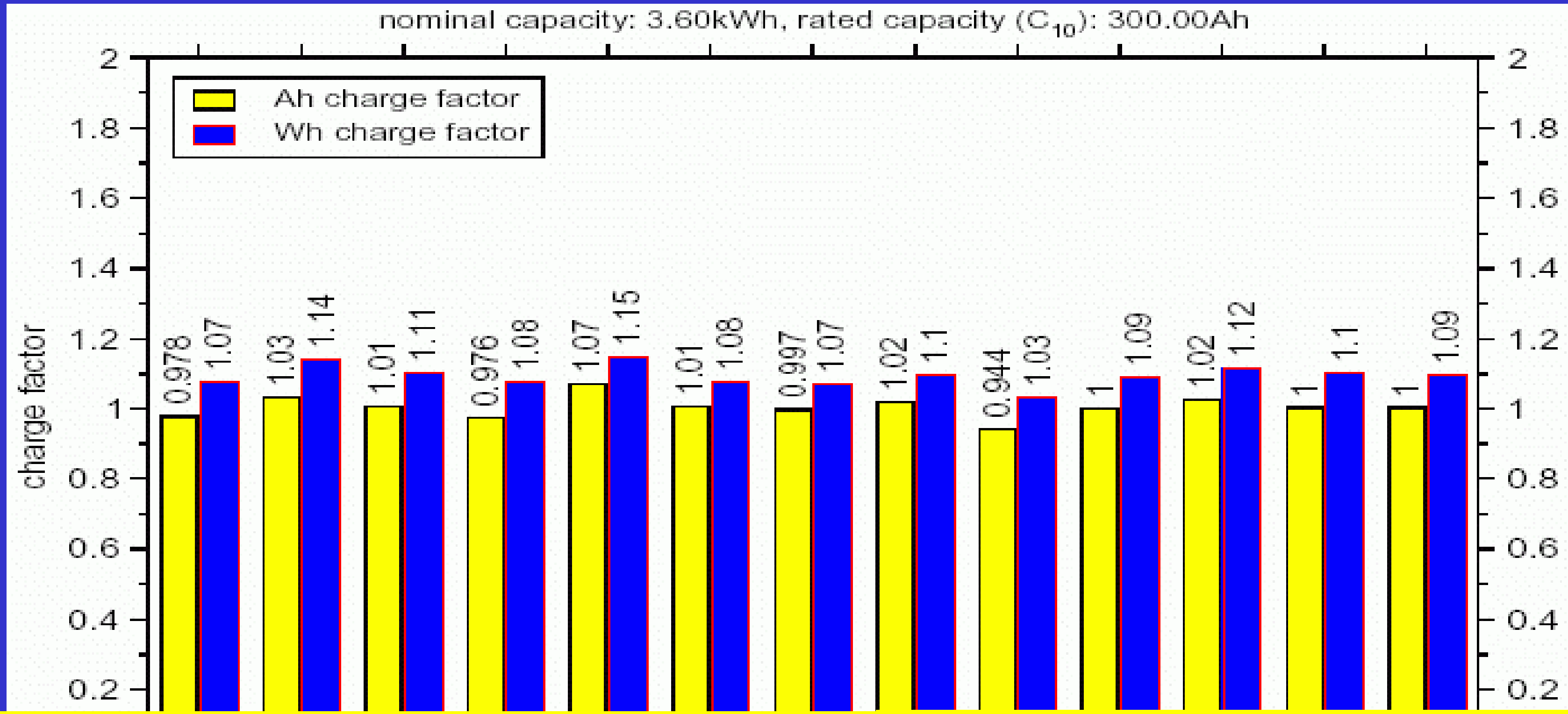
- max. voltage: very seldom full recharge - more frequent in summer
- min. voltage: deep discharge particularly in winter time <35%SOC
- over-polarization risk
- PSOC operation
- high power operation
- lower Ah discharge in summer

Example of category G1



- max. voltage: very seldom full recharge - more frequent in summer
- min. voltage: deep discharge particularly in winter time <35%SOC
- over-polarization risk
- PSOC operation
- high power operation
- lower Ah discharge in summer - 21%C_n ; in winter ~ 31%C_n

Example of category G1



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- very low charge factor

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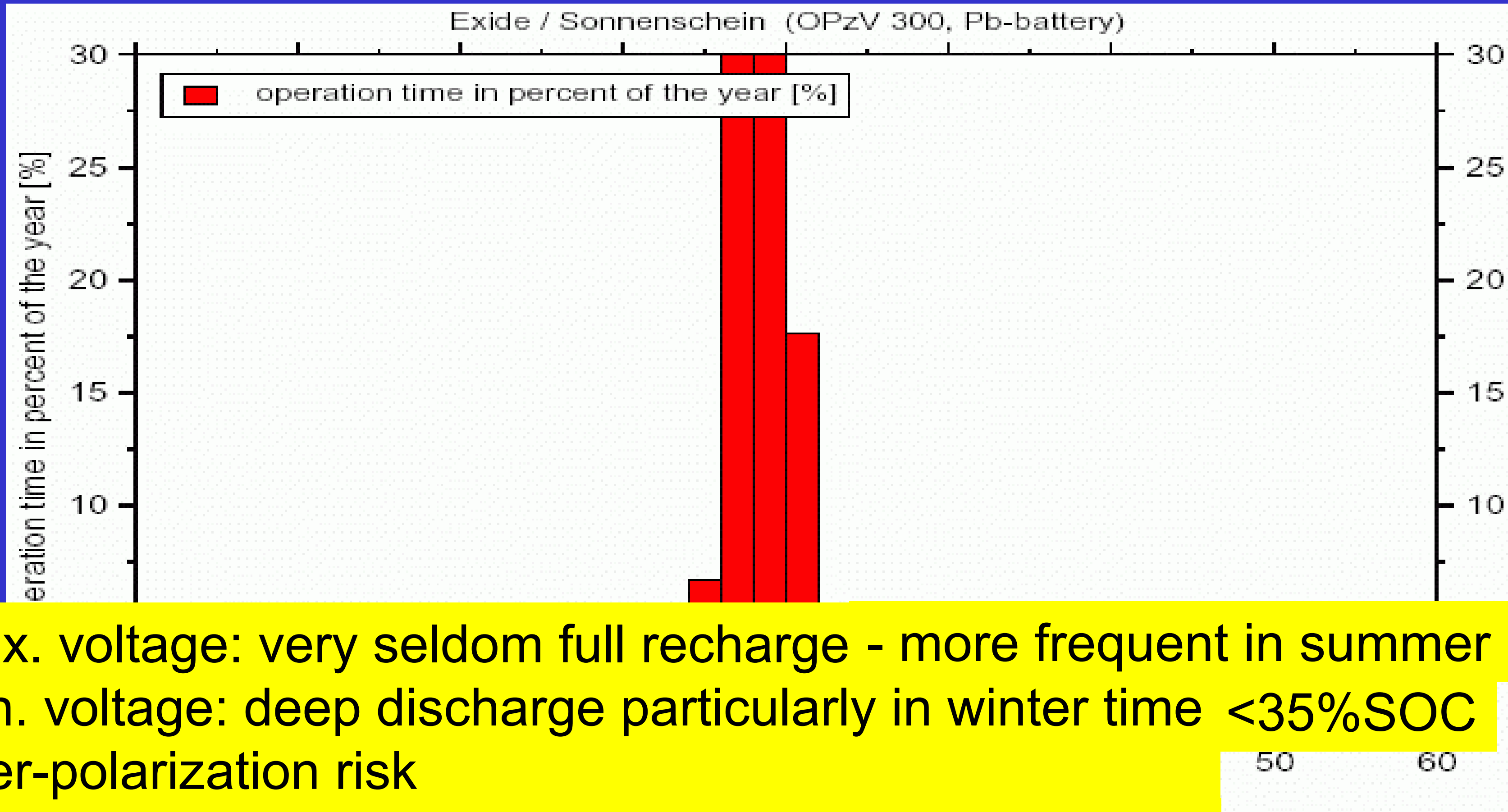

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- optimal temperature, no envir. condition for electrolyte freeze

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- PSOC operation
- high power operation
- lower Ah discharge in summer - 21%C_n ; in winter ~ 31%C_n
- very low charge factor
- optimal temperature, no envir. condition for electrolyte freeze

Very HIGH risk of:

⇨ hard/irrev. sulfation

⇨ electolyte stratification

⇨ AM degradation

⇨ over-polarization risk

HIGH risk of:

⇨ AM shedding

In low envir. temp.:

Battery heat insulation is important due to

⇨ very high risk of electrolyte freeze

⇨ very high discharge current

Conclusion

- 6 categories were defined
- climatic conditions are considered
- categories have different risks of aging mechanisms
- 90% of available datasets could be classified
- categorization can be done by automatic tool
- visualization enables to make recommendation & overview RES system

Conclusion

- New category may be implemented by expert
- Missing an existing category due to a lack of data

Thank you for your attention!

Acknowledgement

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