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Competence Center for Research in Energy, Society and Transition

Universität Basel
Wirtschaftswissenschaftliche Fakultät

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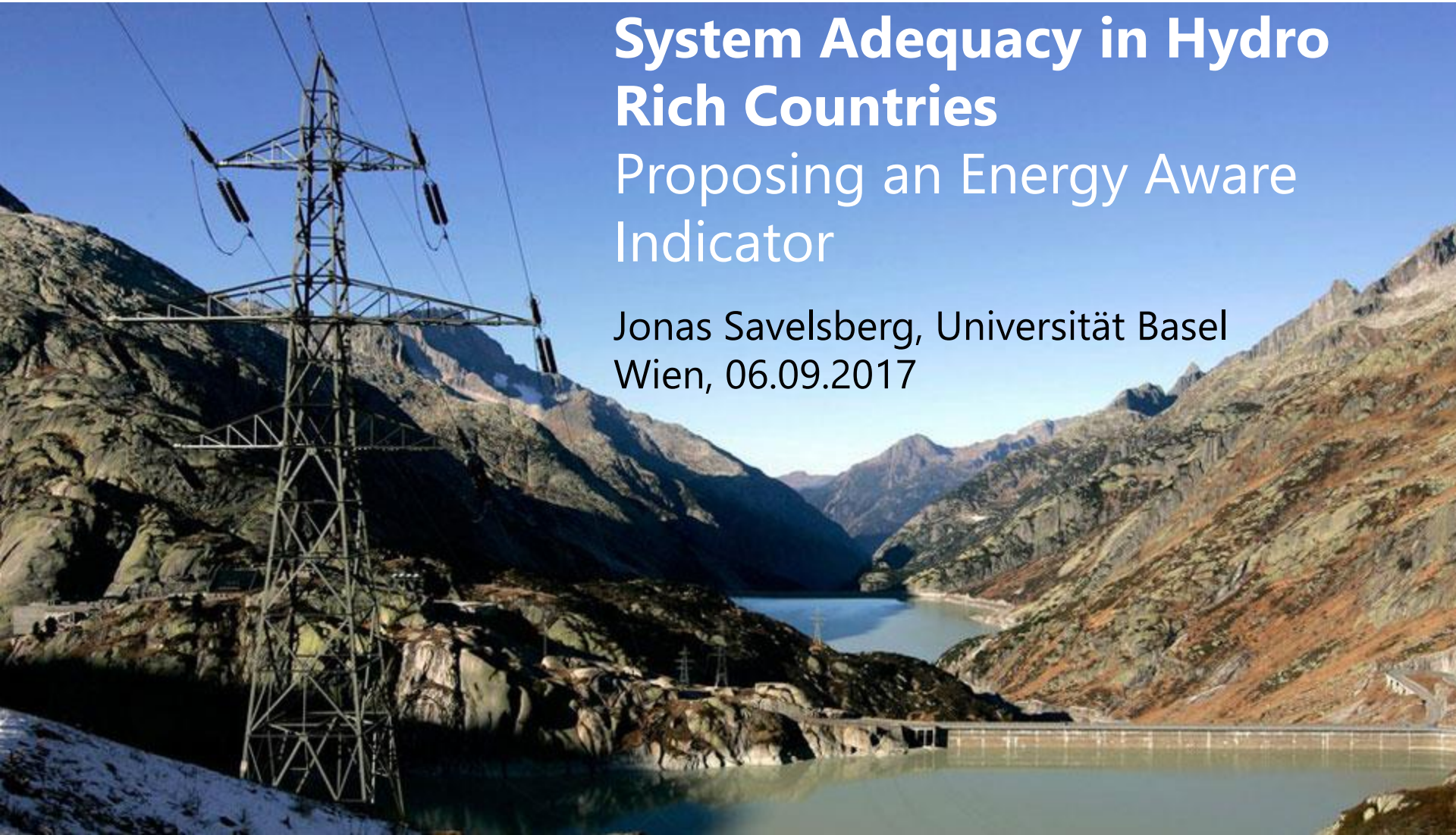

System Adequacy in Hydro Rich Countries

Proposing an Energy Aware Indicator

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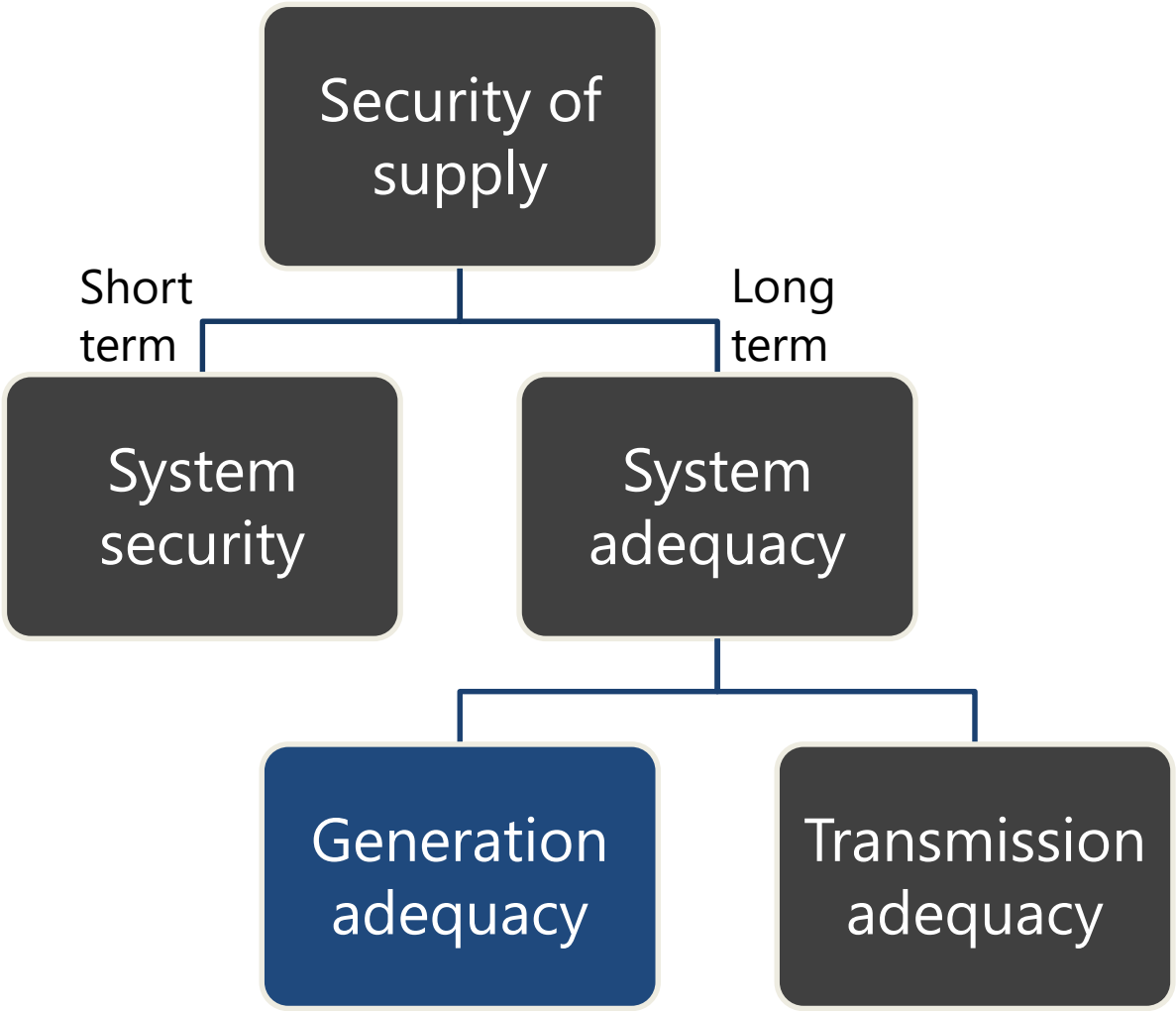
Wien, 06.09.2017

1. **Introduction**
2. **An Indicator for Hydro Rich Countries**
3. **Numerical Analysis**
4. **Conclusion**

Introduction



Introduction

- **Rising shares of vRES in Europe** have reignited the debate on system security (short-term) and **system adequacy** (long-term)
- Analysis of **System Adequacy (SA)** both on TSO and ENTSO-E level
- Most commonly used indicators **Energy Not Served**, **Loss Of Load Expectation, Loss Of Load Probability and Reserve Capacity Margin**

Introduction

- Amount of **water stored in reservoirs for electricity generation** represents a crucial determinant of system adequacy
- None of these indicators take into account the **particularities of hydro rich systems**
- **Time dimension of system adequacy** is not fully covered by indicators
- E.g. **Reserve Capacity Margin only reduced** if there is no water left in the reservoirs

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An Indicator for Hydro Rich Countries

- **Two versions** of the indicator
  - **Duration** of storage supply [hours]
  - **Buffer** of storage supply [GWh]
- **Application** of the indicator
  - Analysis of **long-term planning of investments** into storage and generation capacities
  - Identify **short-term shortages** and optimize **inter-annual storage operation**

Duration of Storage Supply

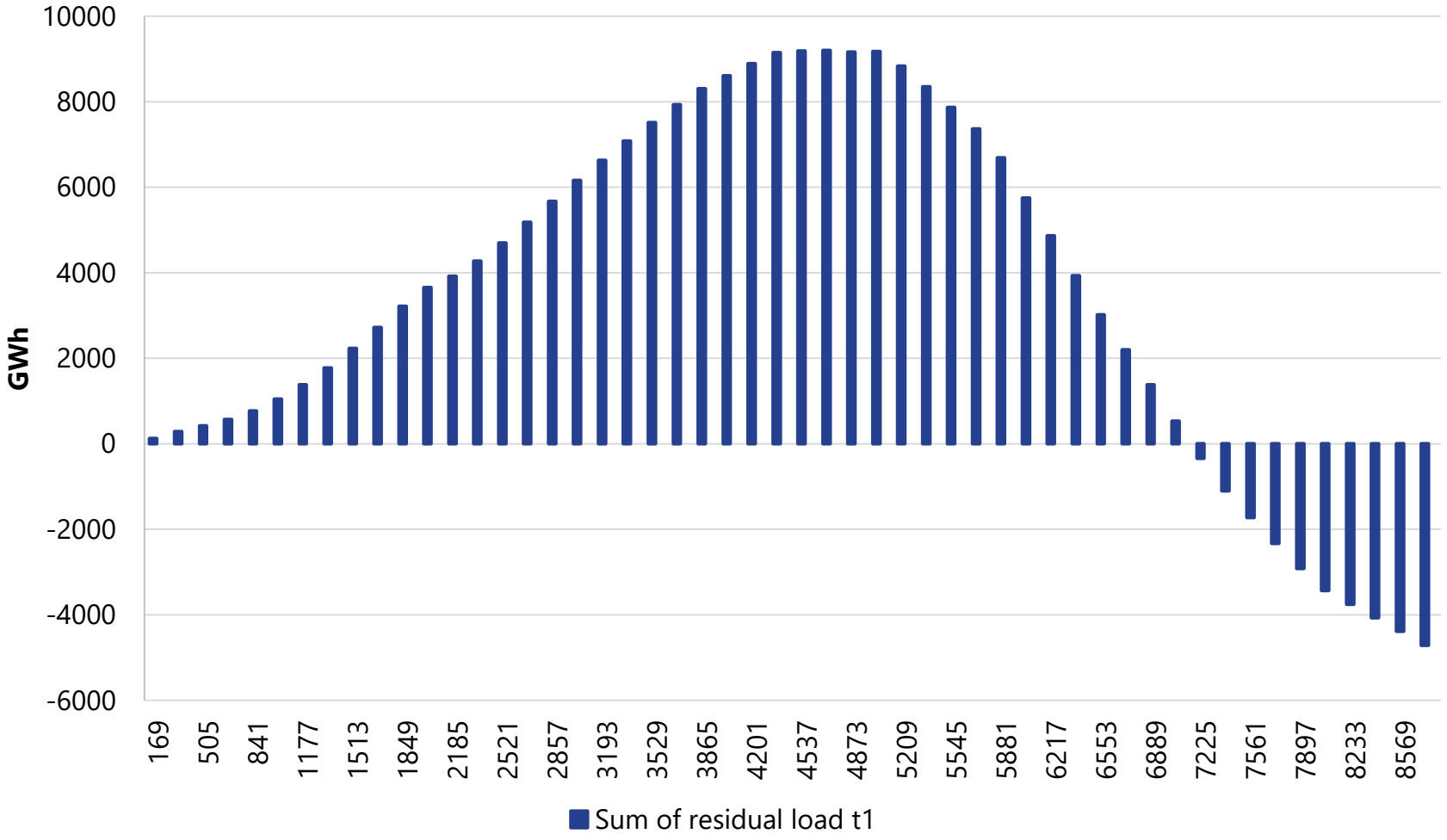
$$DSS_t = \sum_{h=t}^{T+t} g_{t,h}$$

$$g_{t,h} = \begin{cases} 1 & if\ S_t \geq D_{t,h} \\ 0 & if\ S_t < D_{t,h} \end{cases}$$

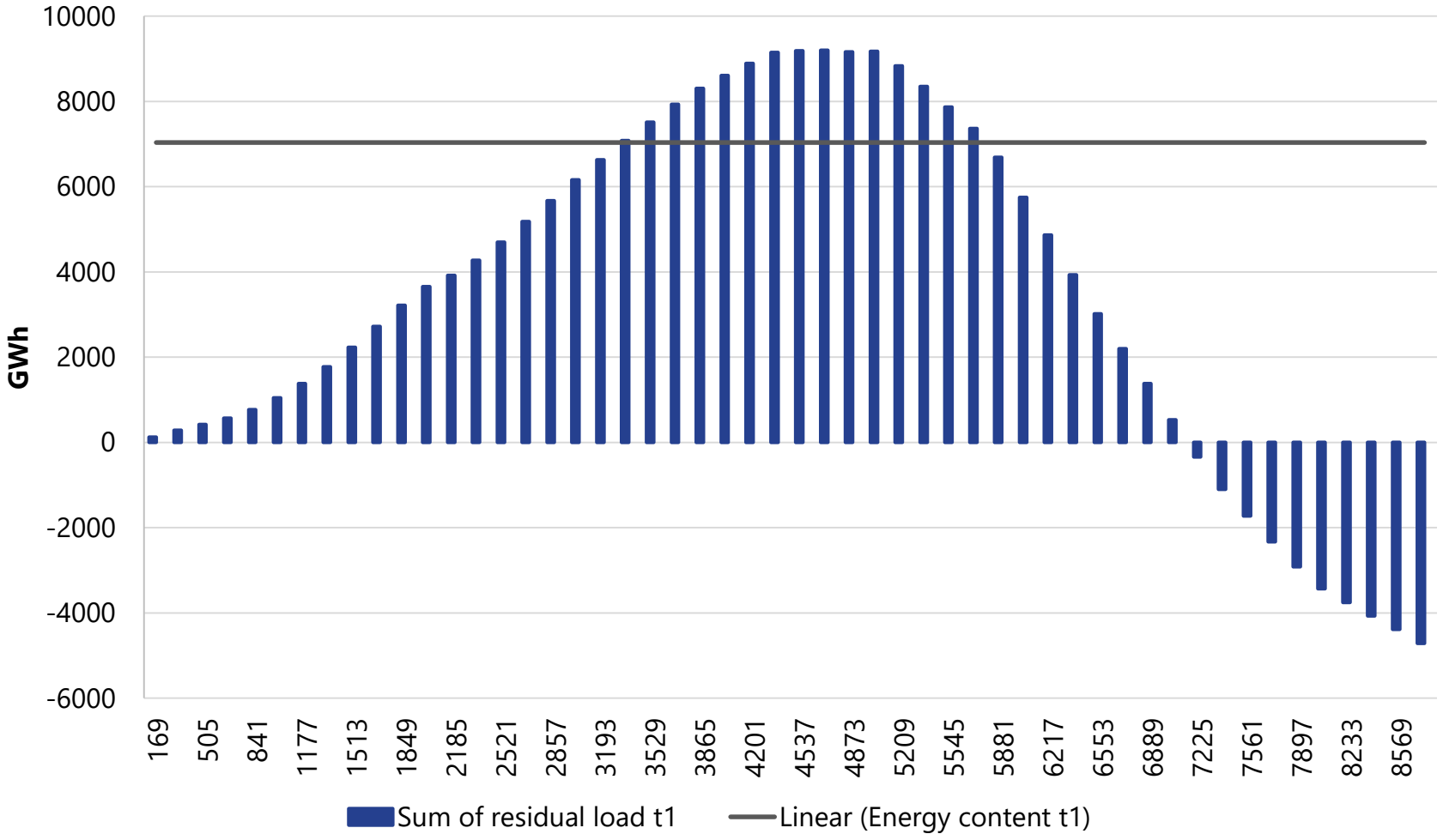
S_t = Energy content of storage in MWh in t

$D_{t,h}$ = Cumulated residual load in MWh from t to h

Duration of Storage Supply



Duration of Storage Supply



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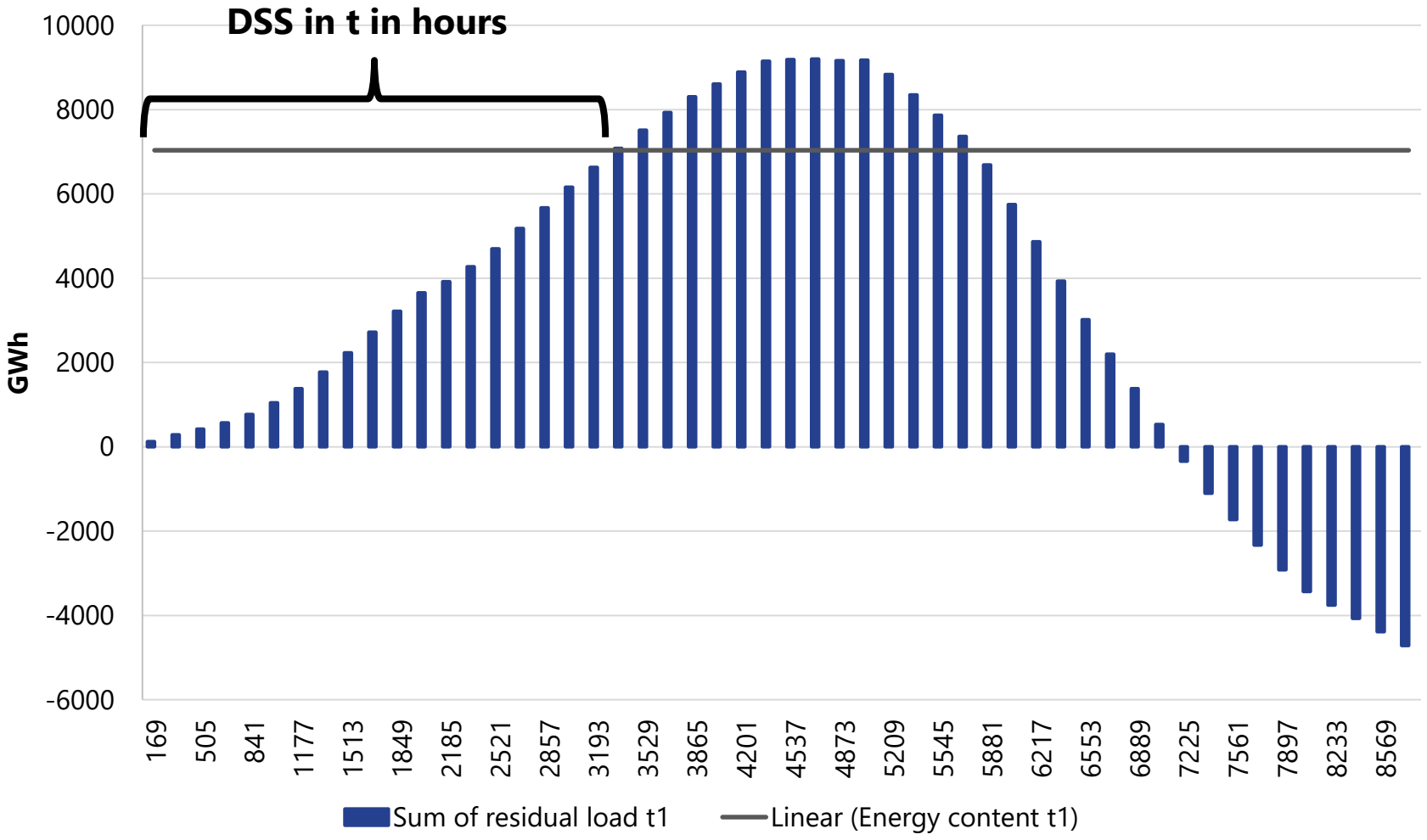
Duration of Storage Supply



Buffer of Storage Supply

$$BSS_{a,t} = S_t - L_{a,t}$$

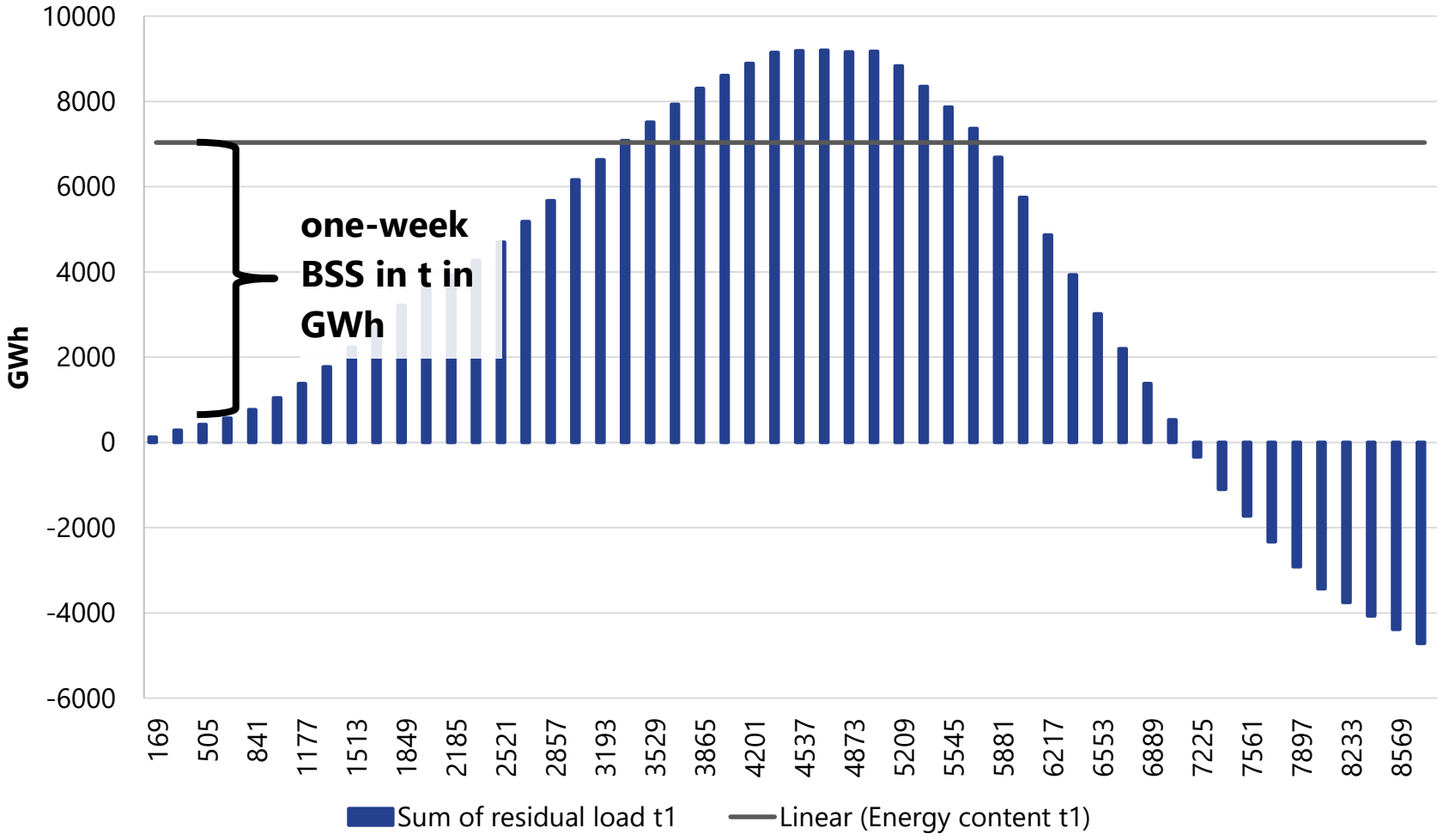
$$L_{a,t} = \sum_{h=t}^{t+a} R_h$$

S_t = Energy content of storage in MWh in t

$a = Target\ self-sufficiency\ timeframe\ in\ hours$

$R_t = Residual\ load\ in\ MWh\ in\ t$

Buffer of Storage Supply



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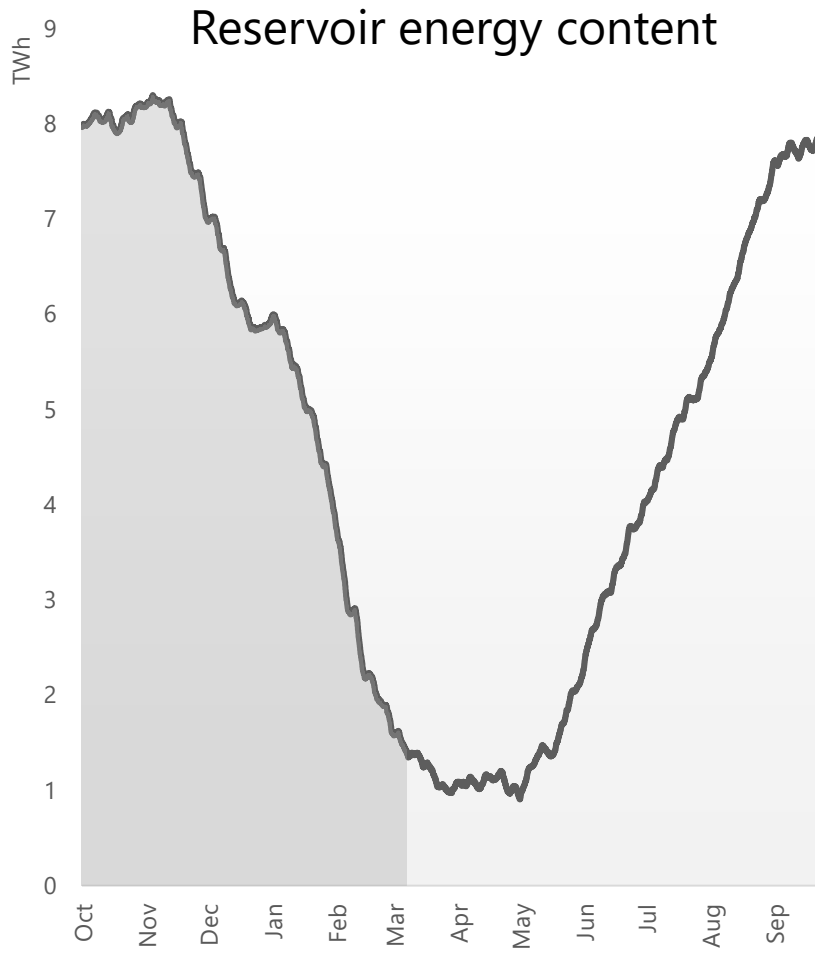
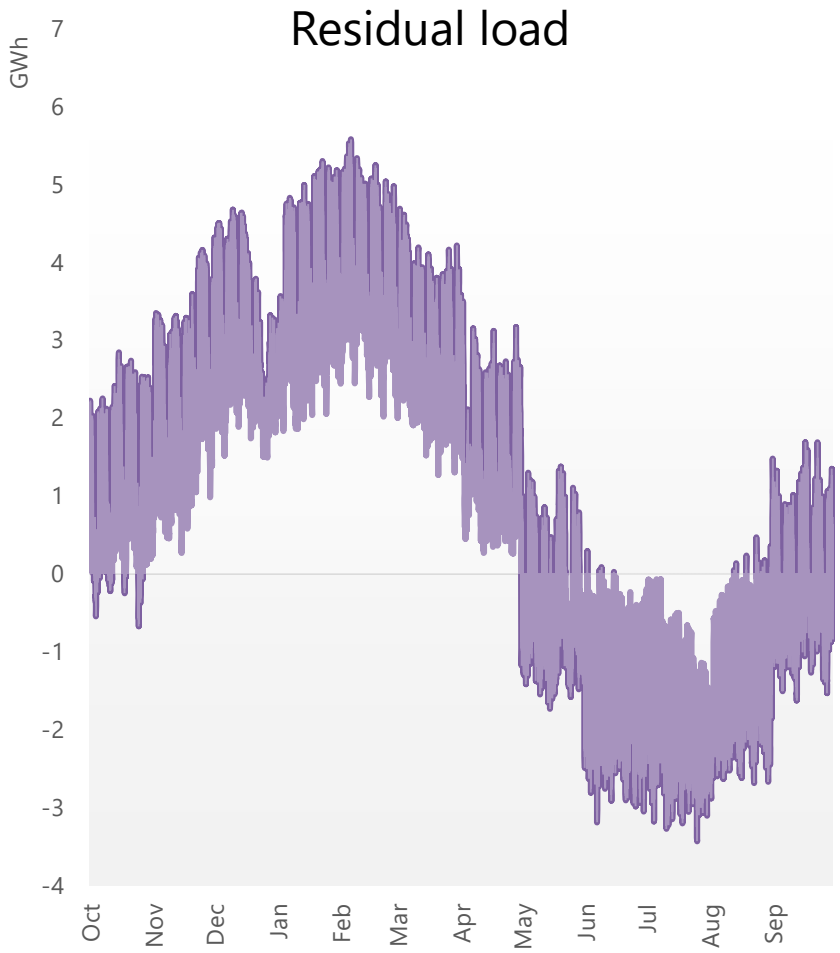
Duration of Storage Supply (DSS)





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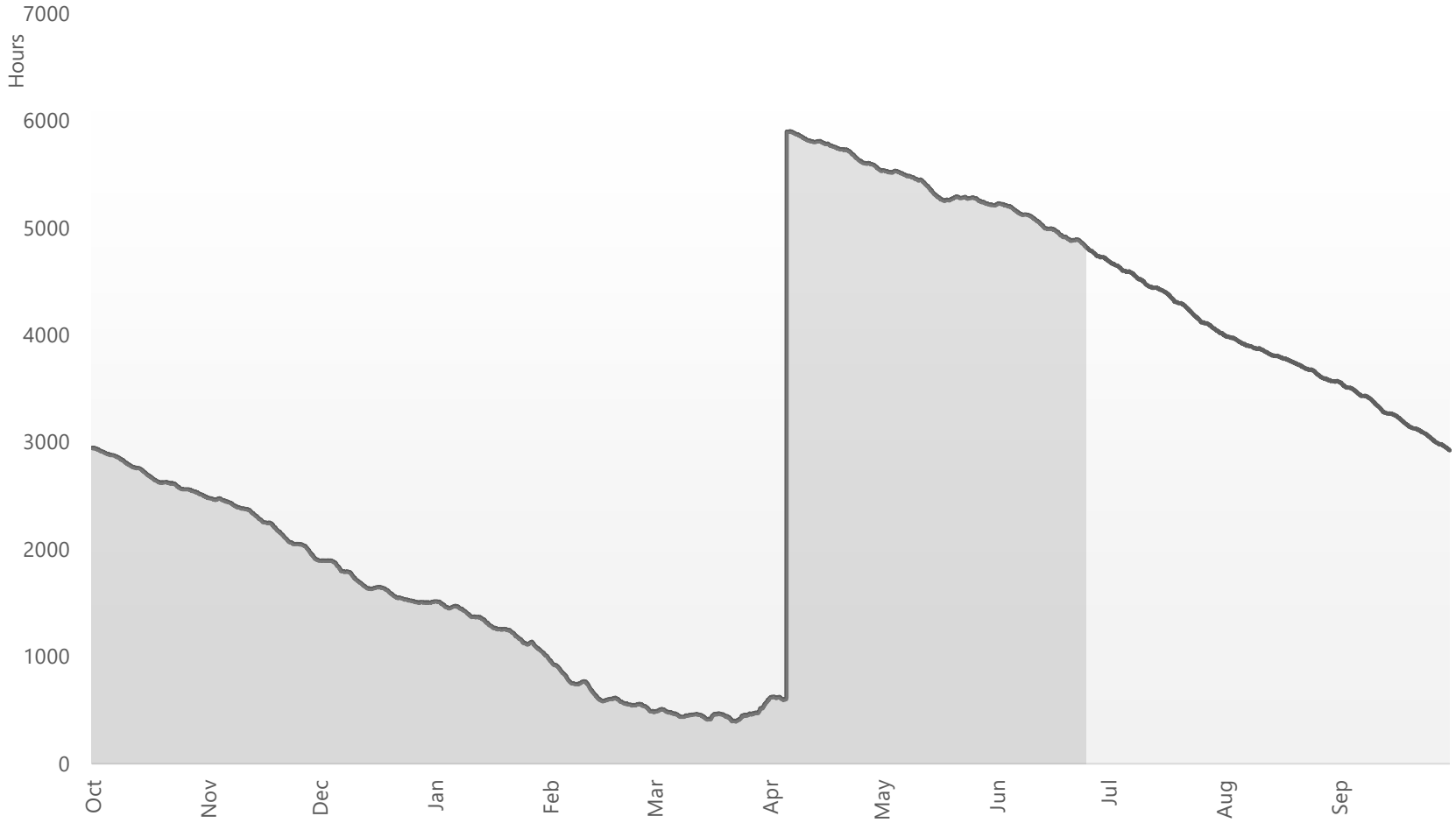

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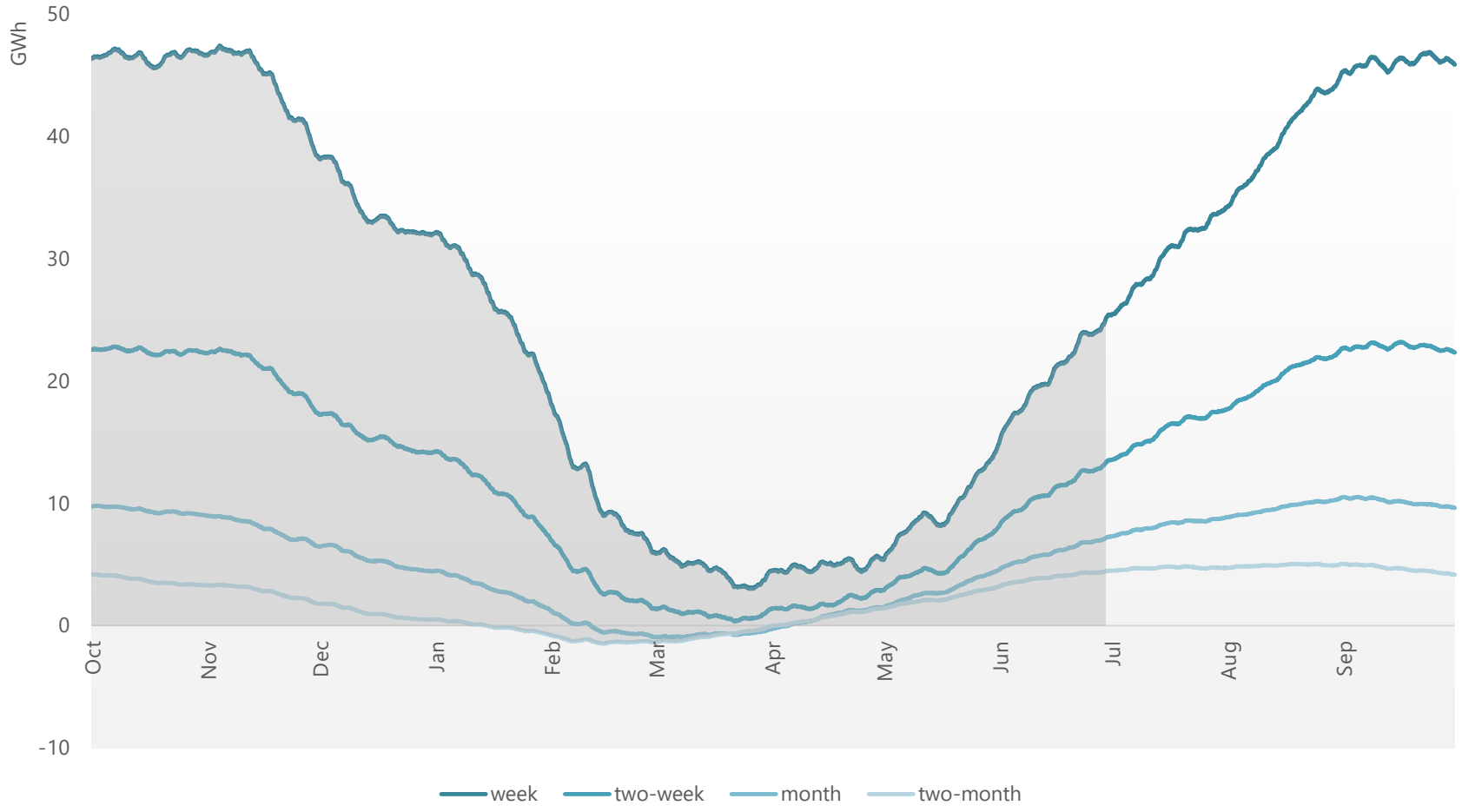

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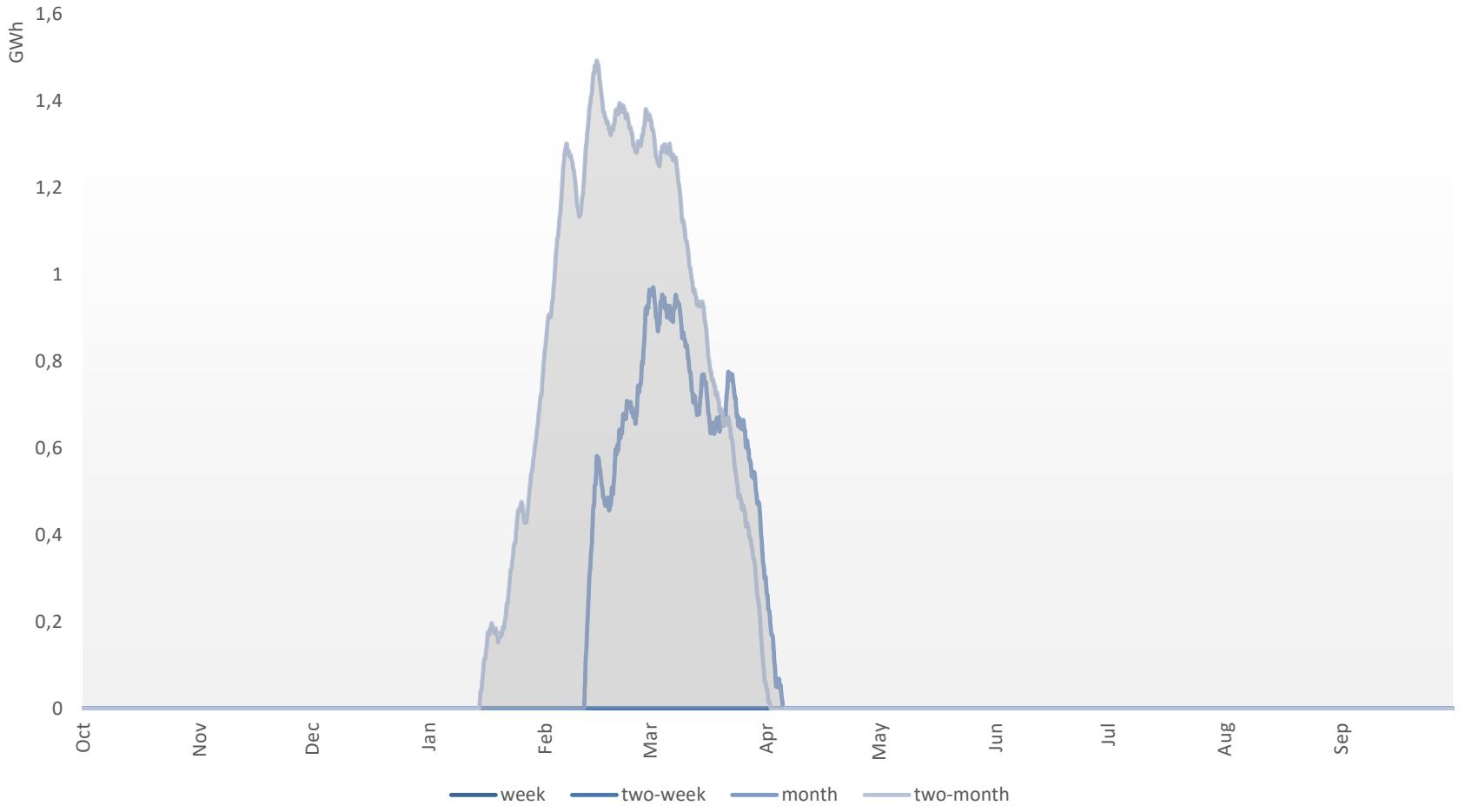
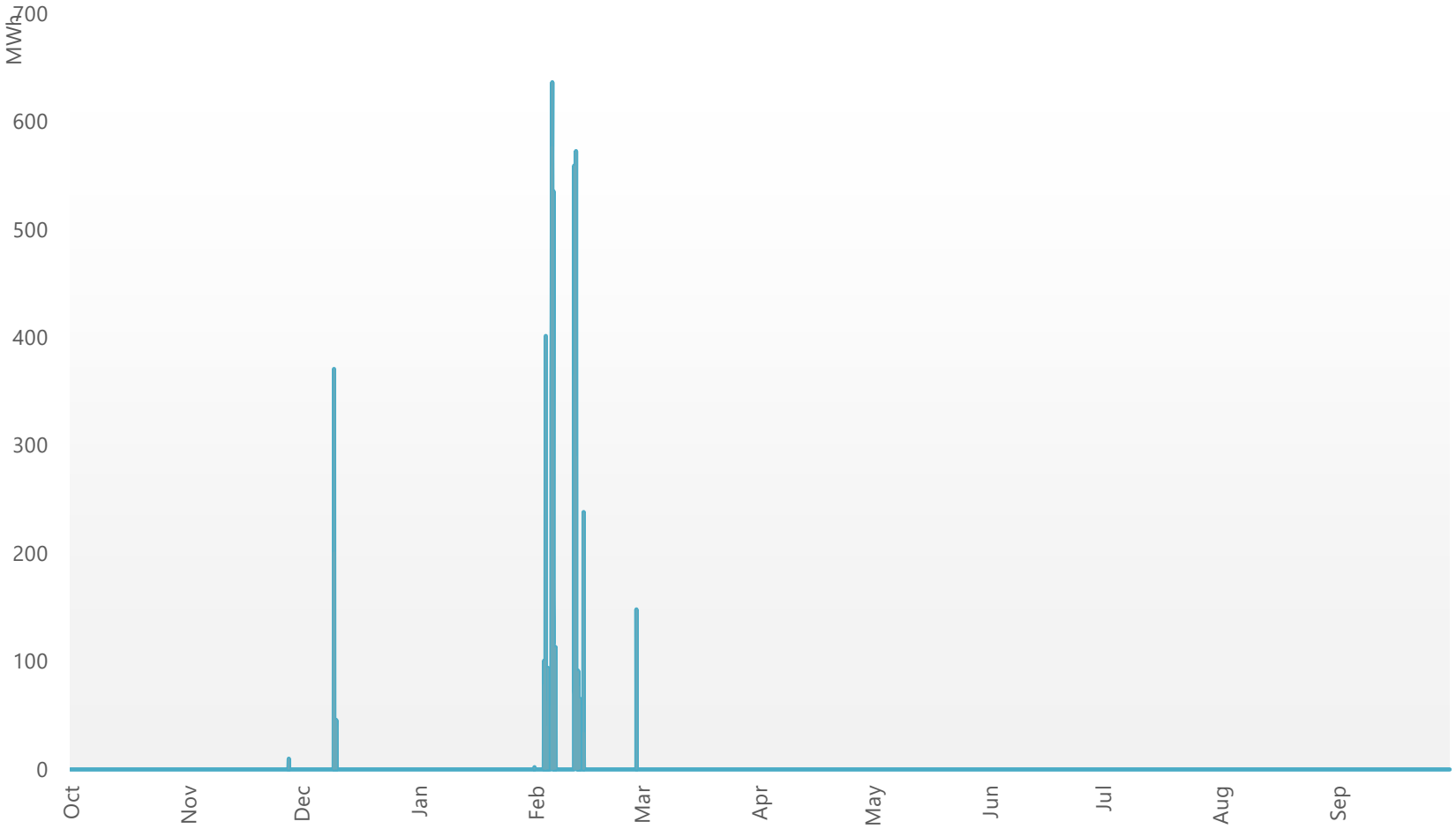


Comparison to Loss of Load (LOL)



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Conclusion

- Our indicators **complement exististing indicators** for system adequacy
- Indicators show **time dimension** and **severity of situation**
- Underlying assumption of **national autarky in extreme situations**
- Indicator also **valid for analysis of other storage systems** in case of supply interruptions

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