Is self-consumption really grid-friendly?

Self-consumption business models - technical and economic challenges

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Serdar Kadam
AIT Austrian Institute of Technology

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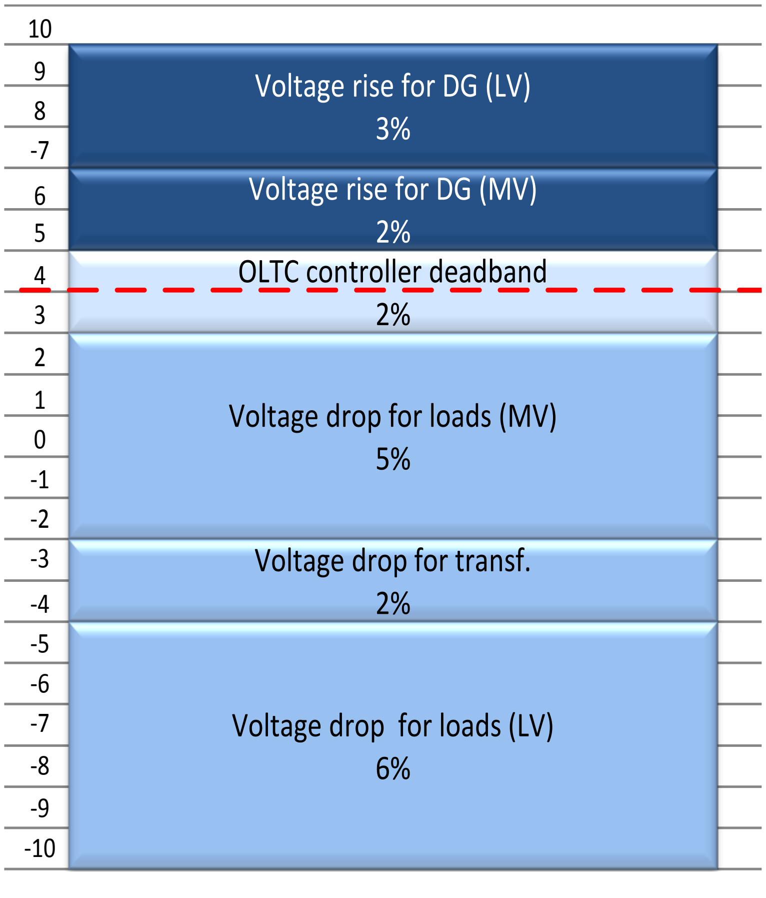
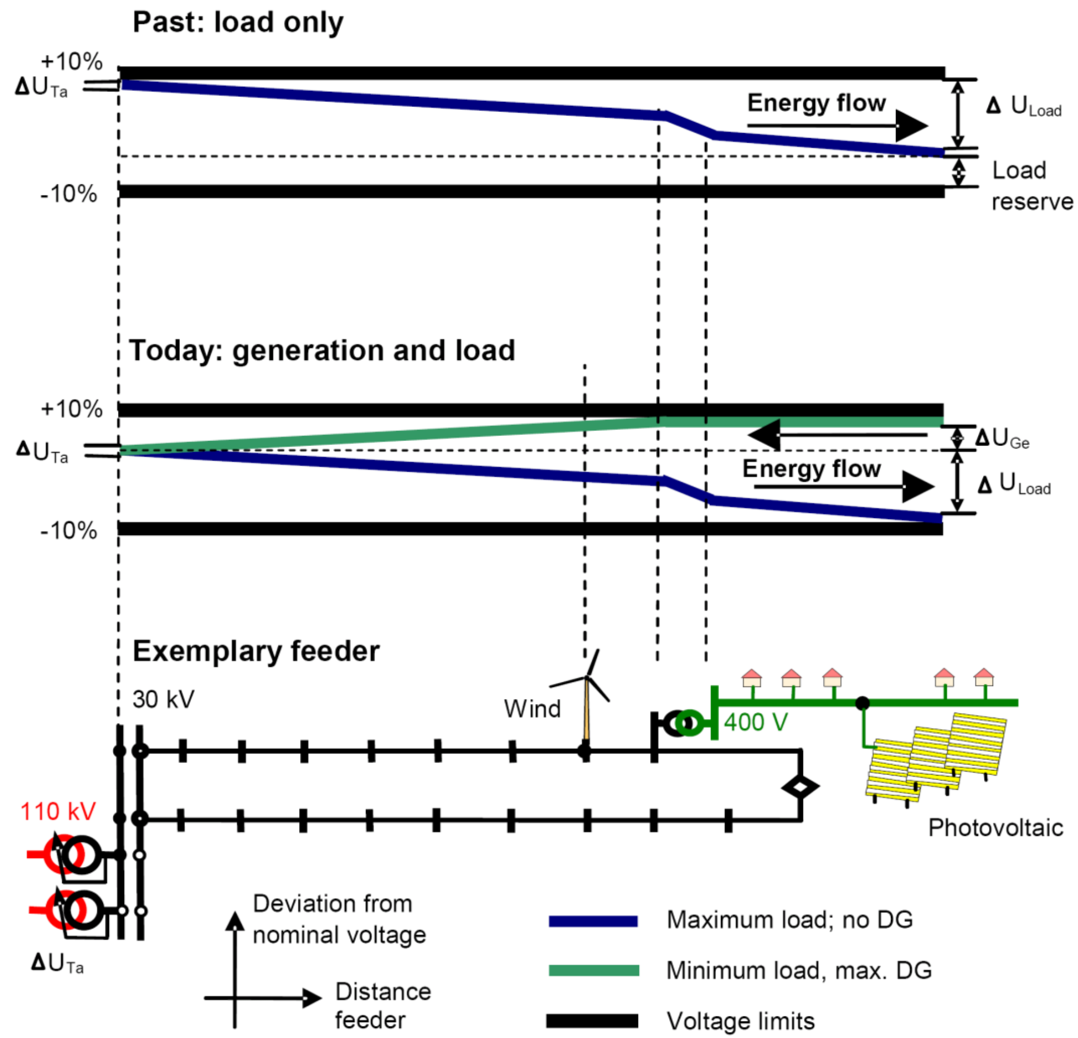
Voltage rise: one of the main technical barriers to the integration of PV





Estimation of the voltage rise caused by PV infeed (acc. to current assessment procedures)

- Voltage rise caused by a three-phase PV infeed:

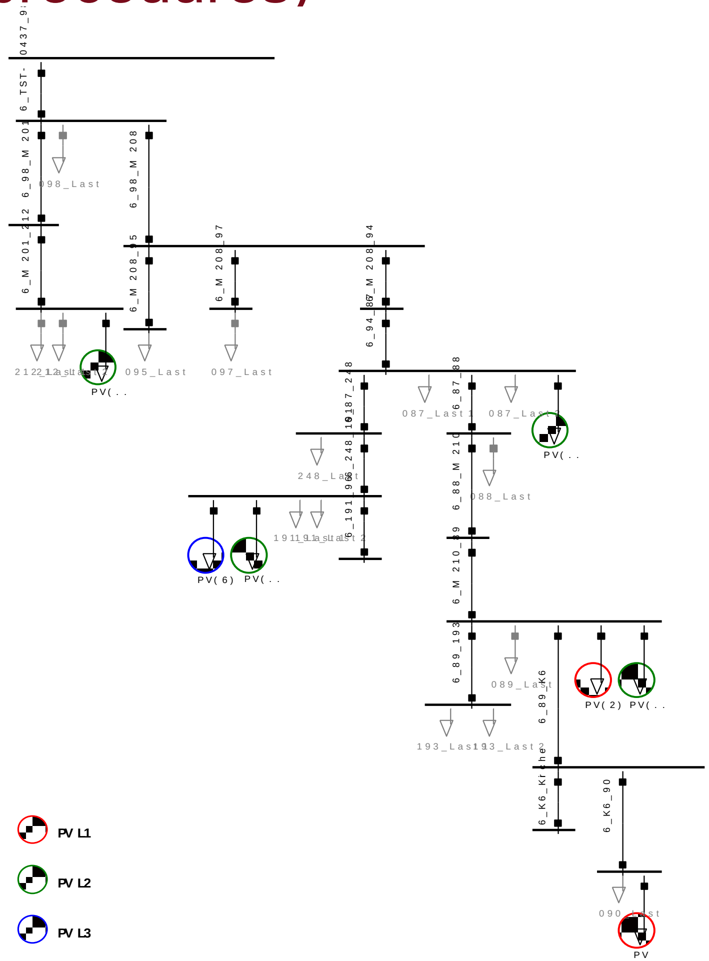
$$\Delta U \approx \frac{R \cdot P_{PV} + X \cdot Q_{PV}}{U_N^2}$$

- Voltage rise caused by a single-phase PV infeed:

$$\Delta U \approx 6 \cdot \frac{R \cdot P_{PV} + X \cdot Q_{PV}}{U_N^2}$$

- Voltage rise caused by several single-phase PV infeeds??

➢ Assumptions are necessary: DNOs do not know to which phases the PV generators are connected:
  - Worst case: all on e.g. L1
  - Best case: ideal distribution over phases
  - “Worst-best case” or “residual unbalance” concept



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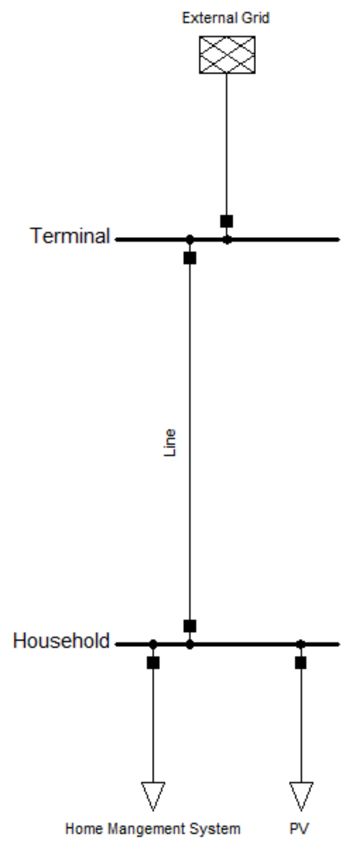
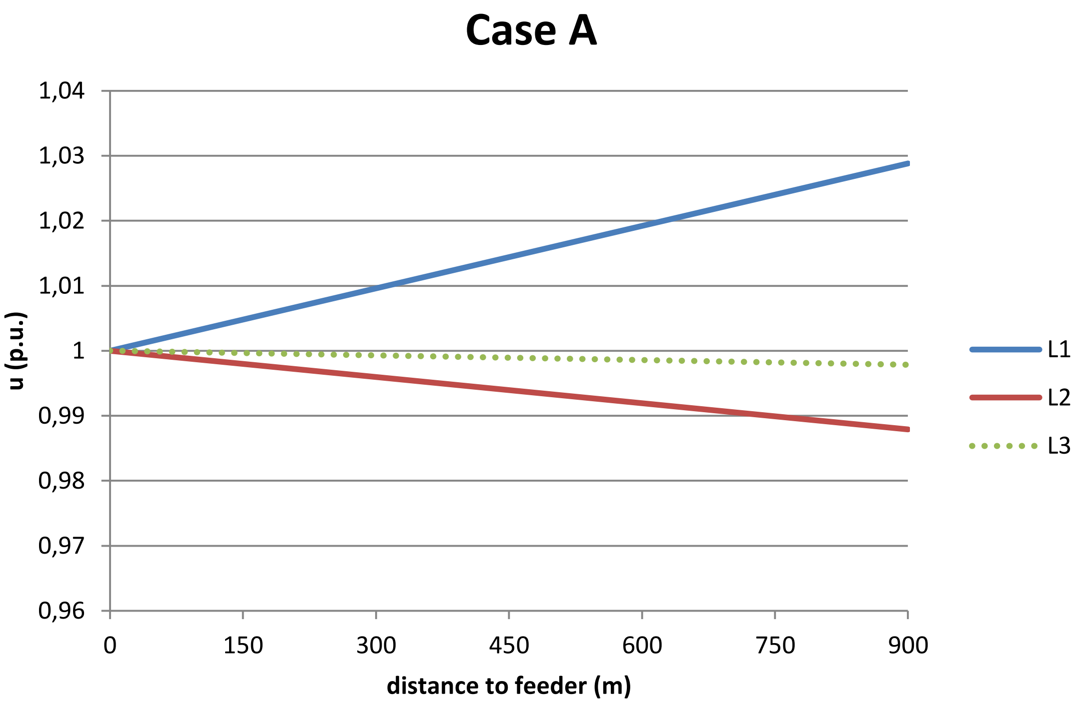
Testbook Case: self-consumption vs. physics



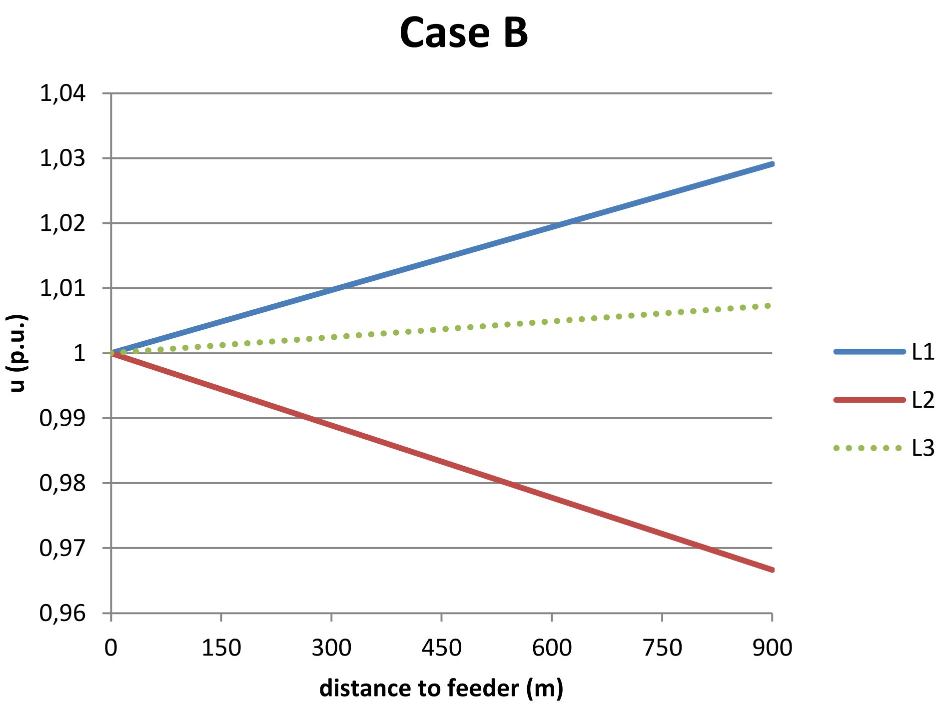
- Feeder: 900 m long
- Planning rule: e.g. 3% voltage rise allowed
- ➔ single-phase 4kWp installation tolerable



What is grid friendly self consumption?

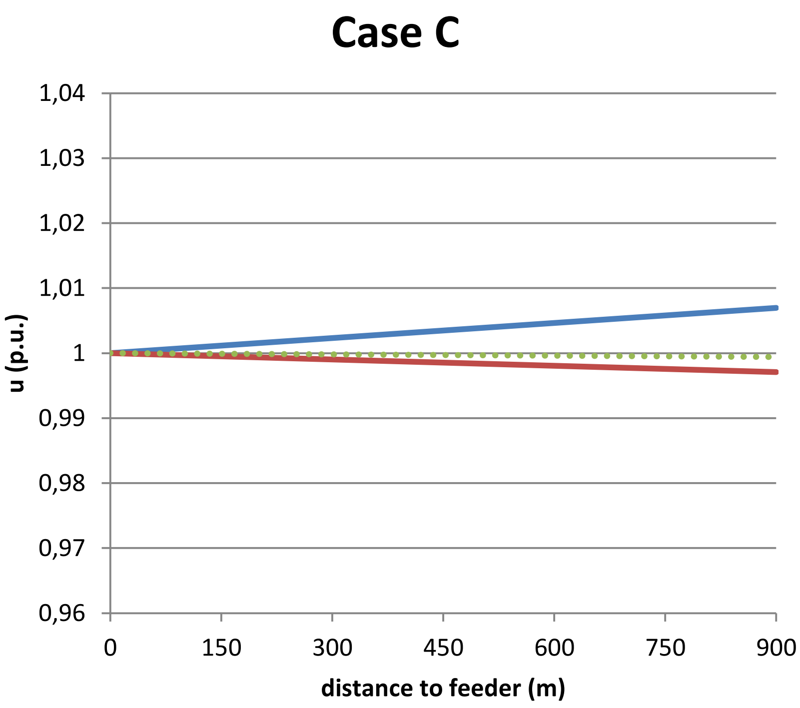
PV on L1 and 3kW load on L3

- Feed-in to grid and consumption from grid simultaneously!



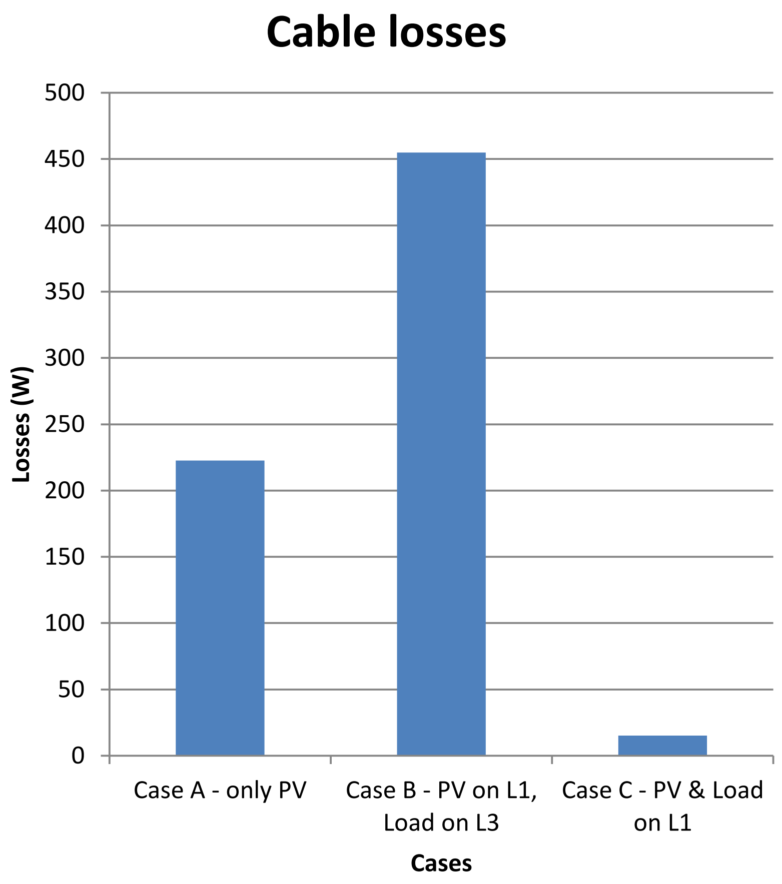
PV and 3kW load on L1

- **Grid friendly** self consumption



Effects on cable losses

- Case A: feed-in to an overlying network causes also losses
- Case B: **Unbalanced** consumption and production: **increased losses**
- Case C: Physical **self-consumption**: significantly **lower losses**
- From the metering point of view, **self-consumption** is **identical** in case B and case C.



Summary text book example

- Self-consumption is not necessarily positive in terms of:
    - **Network constraints**
    - **Losses**
    - **Loading**
    - **Voltage**

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2. Textbook Case: self-consumption vs. physics
3. 3kWp case study in a real network (simulation)
4. Results
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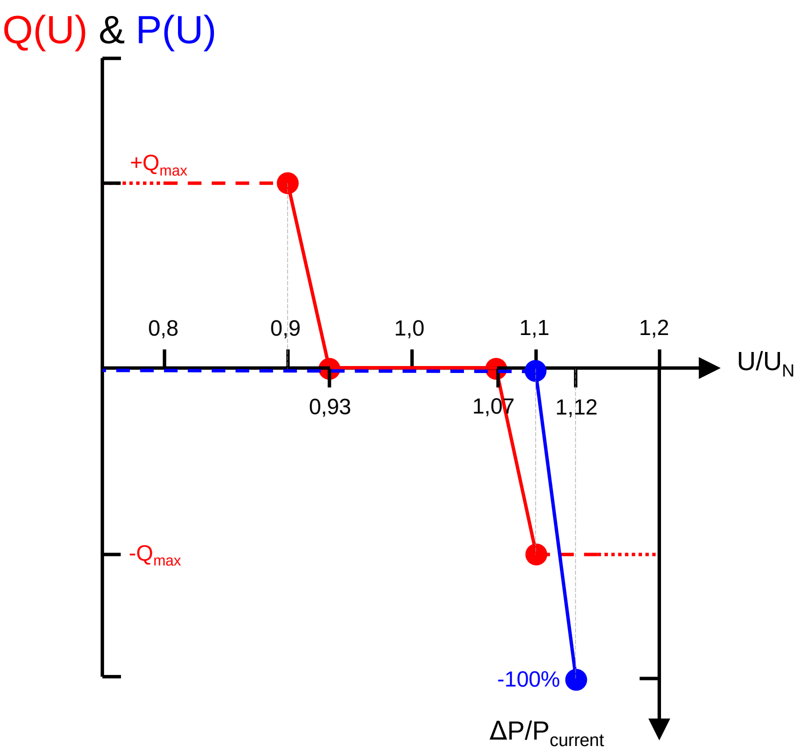
Case Study

Real network with a high PV penetration scenario

- Volt/VAr & Volt/Watt control
- 3kWp per roof (90kWp in total)
- Analysis of energy curtailment and financial impact

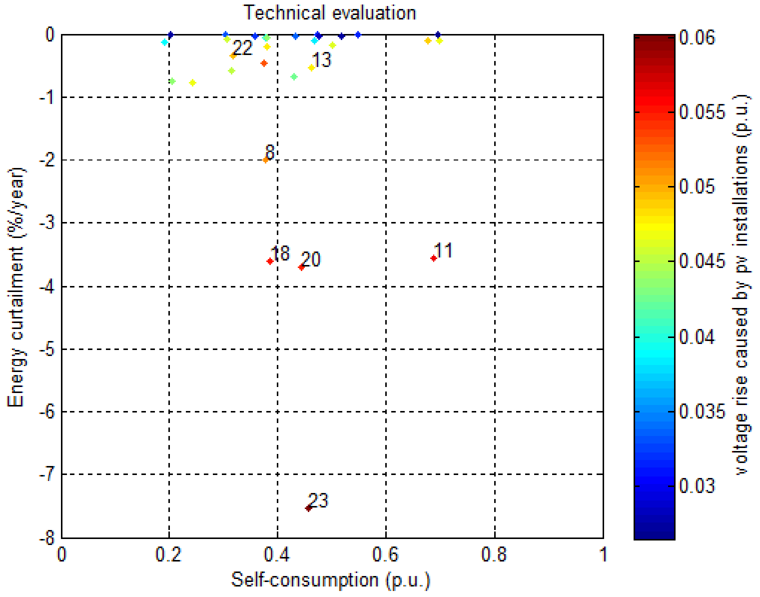
Voltage dependent control strategy

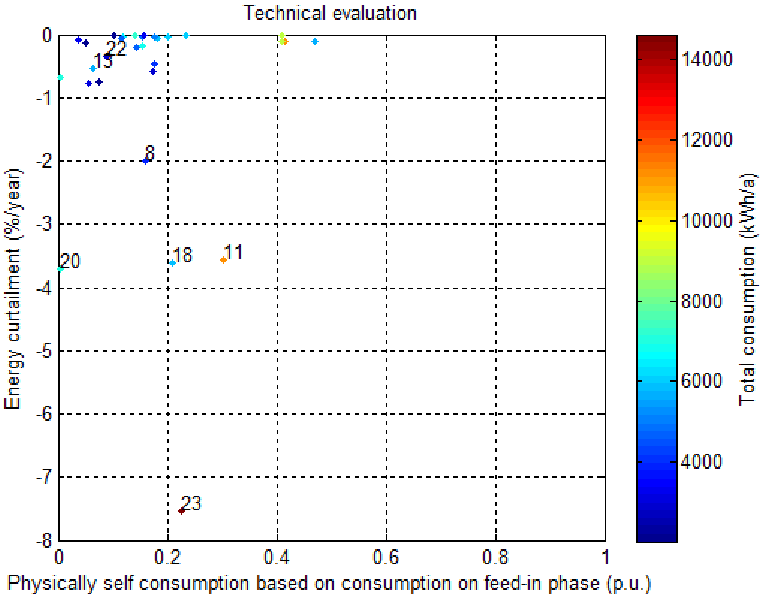
- Q(U) Reactive power control to decrease voltage rise (e.g. 1.07-1.1 p.u.)
- P(U)-control to **avoid disconnection of inverters** and comply with regulatories e.g. u<1.1 p.u.
- **➔ Increased Hosting capactity**



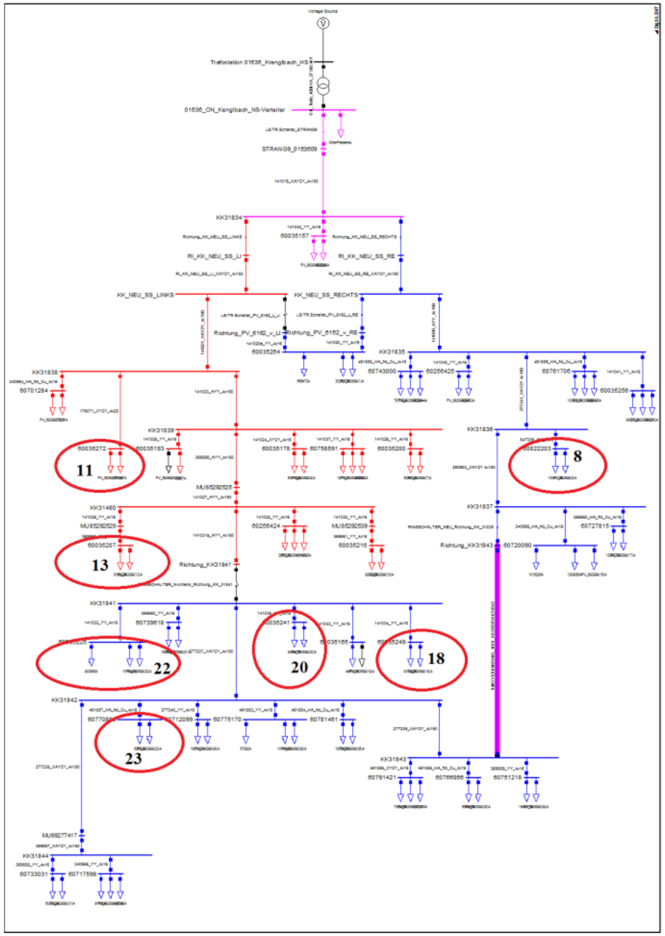
Study case results: 3kWp on roof scenario

self-consumption total over ϕ vs. physical self-consumption

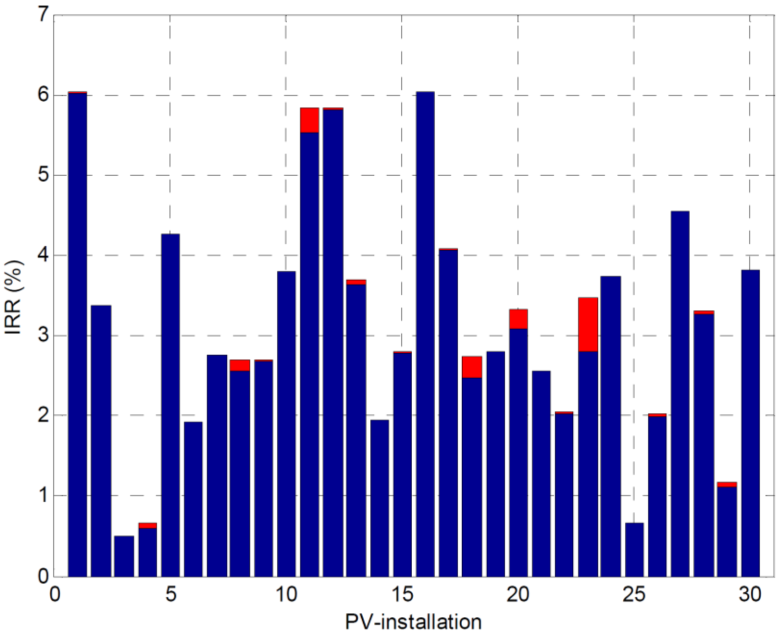




Study case results: location and profitabilty



Impact of the power curtailment on the Internal Rate of Return



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Results

- Through the voltage control (Q(U) and P(U)), the hosting capacity could be increased **significantly** (>40%)
- Relation between self-consumption rate and power curtailment more complex than in textbook case! Impacting factors:
  - network topology
  - distribution of the installations (load & PV) **along feeder** and **among phases.**
- The **individual local situation** only plays a **minor role** compared to the overall power-flow
- Ensuring a **high self-consumption** at one particular installation does not necessarily means that the impact on the network (e.g. voltage rise) is low and that curtailment can be avoided.
- Situation could be even **worsen** with **storage-based systems**.

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Conclusion

- **Status-quo metering (total over Φ)**
  - **Does not consider unbalance**
  - **High self-consumption "on average" is good enough to maximise profits**
  - **Performance of Smart Grid solutions depend on overall network situation**

- **Physics behind network planning**
  - **Phase unbalance plays a critical role:**
    - **hosting capacity reduced by 6! (voltage rise and neutral conductor loading)**
    - **Network losses ➔ in case of unbalance**
  - **Network constraints must be met for 100% (or 95%) of the time.**
  - **Understanding of grids to increase hosting capacity**

➔ **It is not only about physics, network tariff-structure must be discussed:**

- **producers / consumers / prosumers / prostomers**
- **kWh/kW-based tariff (or A/phase)**
- **tax, RES-support, … issues**

➔ **Grid-friendly tuned Home Management Systems can reduce curtailment and increase hosting capacity**

➔ **A trade-off between wallet-friendliness and grid-friendliness can be found ☺**

AIT Austrian Institute of Technology

your ingenious partner

Serdar Kadam
Energy Department
Electric Energy System
serdar.kadam@ait.ac.at | www.ait.ac.at

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