Intelligent Grid Management of DC Grids in Production

Verbundvorhaben: DC-Industrie – Intelligentes offenes DC-Netz in der Industrie für hocheffiziente Systemlösungen mit elektrischen Antrieben
Requirements for an intelligent grid management

Tasks of grid management

Expansion levels of grid management

Control concepts
The motivation for intelligent grid management is diverse

Potentials of Ultra-Efficient Power Distribution in Industrial DC grids:

**Installation Potentials**
- Lower wiring
  - Decentralized device arrangement: up to 95% less wiring
- Lower errors and service costs
- Space reduction of control cabinets
- Increasing the modularization of machines

**Energetic Potentials**
- Lowering conversion losses
  - approx. 10% due to elimination of conversion points
- Use of regenerative energy (12%)
  - Use immediately: about 90
  - Save: about 9%
  - Reloading: approx. 1%
  - Heat up: only in emergency cases

**Availability Potentials**
- Higher plant availability
  - Short grid failure: approx. 98% increase in availability
- Reduction in costs by avoiding damages to the system
- Peak power reduction

**Technical Equipment Potentials**
- Lower device costs
  - Up to 20% due to the elimination of power electronics Increase
- Efficiency of system components
  - Small dimensioning: approx. 60% potential savings
  - Elimination of redundancies: approx. 30% potential savings
The requirements for grid management can be divided into four areas

Requirements for grid management:

- **Operation**
  - When supplying several machines via a DC system, a secure supply must be ensured.
  - As little control as possible during operation
  - Energy flexibility: The energy supply must follow production

- **Planning procedure, configuration and reconfiguration**
  - Rescheduling / additions need to be as easy and flexible as they are today (with AC)
  - Self-configurable or configurable with as less effort as possible
  - Stations can change step by step in the life cycle of the plant
  - Communication should be as low and effortless as possible

- **Requirements for durability & reliability**
  - Energy Management: No power failures due to additional ICT

- **Economic and ecological efficiency**
  - Energy savings > 10% (compared to today, no recuperation)
  - Making external energy demand more flexible is an important goal
Agenda

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The tasks of grid management go beyond the simple energy supply

Tasks that are realized by grid management:

- Production Planning
- Resource Management: Maintenance & Service, Planning & Projecting
- Quality of the Supply: Supply Reliability, Defined Interface
- Grid Stability: Maintaining of the grid operation, Error Handling
- Optimized Operational Management: Monitoring, Consumption Optimization
Agenda

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## Expanded levels of grid management

<table>
<thead>
<tr>
<th>Communication</th>
<th>Information exchange</th>
<th>basic combination</th>
<th>decentralized group regulation</th>
<th>Extended decentralized group control</th>
<th>central grid control</th>
</tr>
</thead>
<tbody>
<tr>
<td>none</td>
<td>-</td>
<td>irregular</td>
<td>Decentralized control via voltage-current control characteristic (characteristic-based control)</td>
<td>Decentralized group control + optional adaptation of the voltage-current control characteristic (characteristic-based control) by a grid manager</td>
<td>Central control - A grid manager specifies setpoints</td>
</tr>
<tr>
<td>Fieldbus communication (real time)</td>
<td>Fieldbus communication (non-real-time)</td>
<td>none</td>
<td>none</td>
<td>Optionally via fieldbus communication (non-real-time)</td>
<td></td>
</tr>
<tr>
<td>Information exchange</td>
<td>-</td>
<td>voltage band</td>
<td>voltage band</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>
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## grid subscriber in the DC grid

<table>
<thead>
<tr>
<th>Role</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Producer</td>
<td>Provision of energy</td>
</tr>
<tr>
<td>Prosumer</td>
<td>Optimized management</td>
</tr>
<tr>
<td>Consumer</td>
<td>Value-adding or necessary, not value-adding</td>
</tr>
<tr>
<td>DC-branch</td>
<td>Power flow control through fault management: Detecting and correcting / isolating occurring fault conditions</td>
</tr>
<tr>
<td>Sensor</td>
<td>Additional status detection of the DC-BUS</td>
</tr>
</tbody>
</table>
Characteristic-based control for decentralized grid management

- The load balancing takes place in the expansion stage, decentralized as well as extended group control via a characteristic-based control.

- Every active device implements this regulation.
  - The active device realizes a quasi-stationary current-voltage characteristic at the DC bus connection terminal.
  - The characteristic-based control is set via interpolation points.
  - All power sources operate as voltage controlled current sources.
Exemplary application of the characteristic based control

Feed-in current of PV system and mains supply depending on the load current:
Decentralized grid management in plants

Diagram showing the integration of various components into a grid system, including AC grid, Storage, Switch, Measuring device, DC/AC Inverter, DC/DC Converter, Motor, DC source, AC source, AC load, DC load, AFE, Rectifier, and BUS.
Conclusion and outlook

- The requirements for grid management were declared.
- The tasks of grid management have been defined.
- Four stages of grid management have been defined.
- Initial studies show that the functionality of the control system, prioritization and thus first economic optimization with characteristic curves are possible.
  - Further investigations with regard to the stability will be carried out.
  - The grid management will be implemented in demonstrators.
Thank you for your attention!