Power Plant Control for Utility-Scale Photovoltaic Installations

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1. Monitoring, Control and Supervision

2. Control... of what? And Why?

3. Different Control Approaches

4. skytron's Power Plant Controller

Monitoring, Control and Supervision

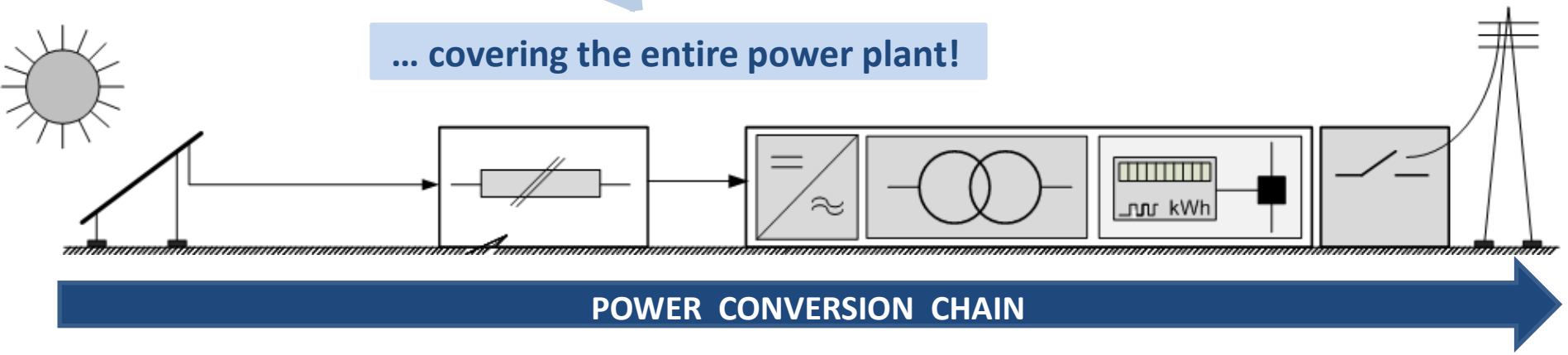
Our Job

- Monitoring
- Control
- Supervision
- Operation & Maintenance (O & M)
- Asset Management

Your Benefit

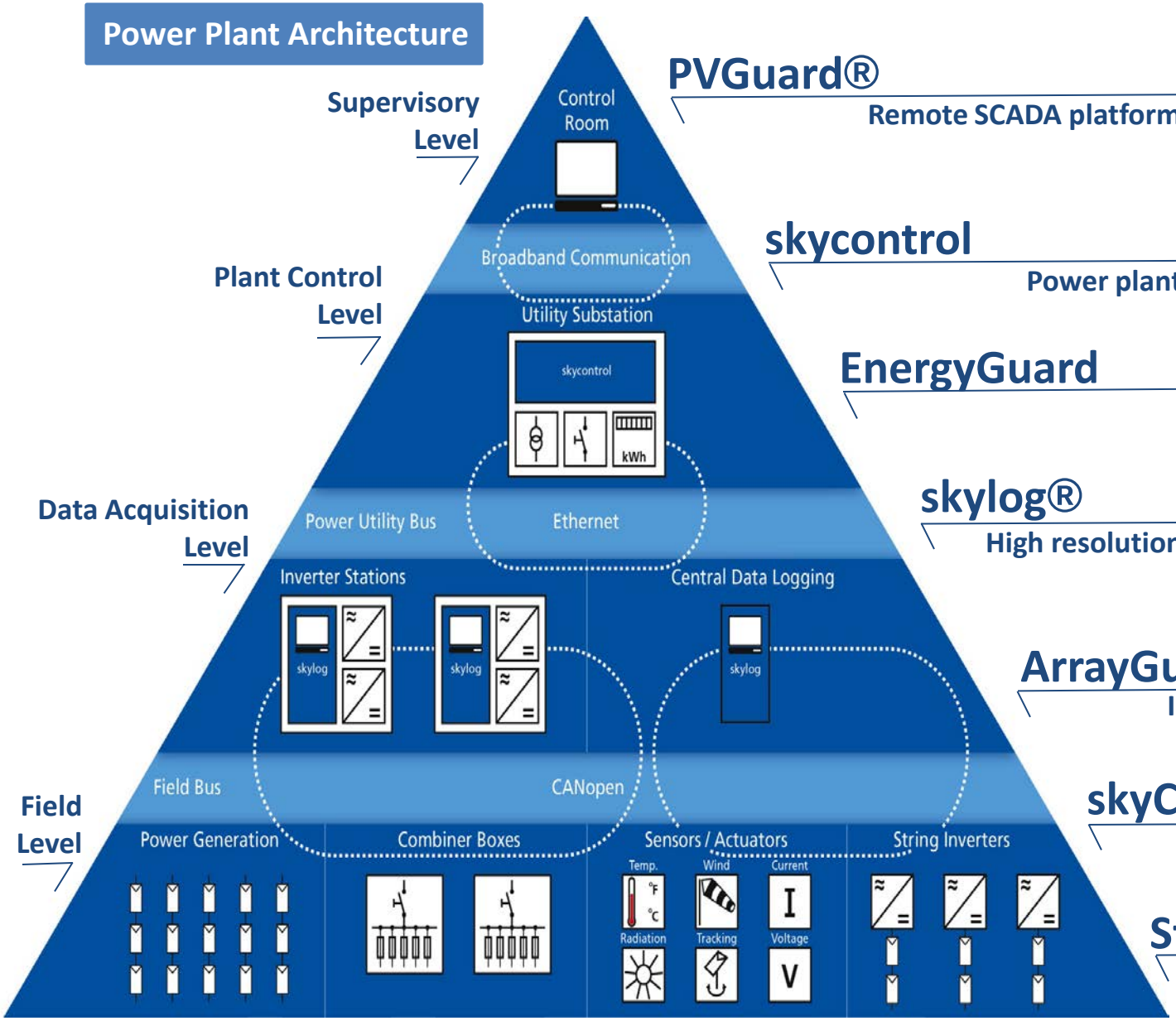
- Plant operation always “in view”
- Reduced downtimes
- Availability tracing
- Enhanced efficiency and yield
- Secured investment (ROI)

… covering the entire power plant!



Monitoring, Control and Supervision

Power Plant Architecture



PVGuard®
Remote SCADA platform for multi-vendor multi-site power plant supervision

skycontrol
Power plant controller for grid stability

EnergyGuard
Energy meter monitoring

skylog®
High resolution real-time data logging and preprocessing

ArrayGuard®
Intelligent combiner boxes

skyCONNi
Field sensorics

StringGuard®
String current monitoring

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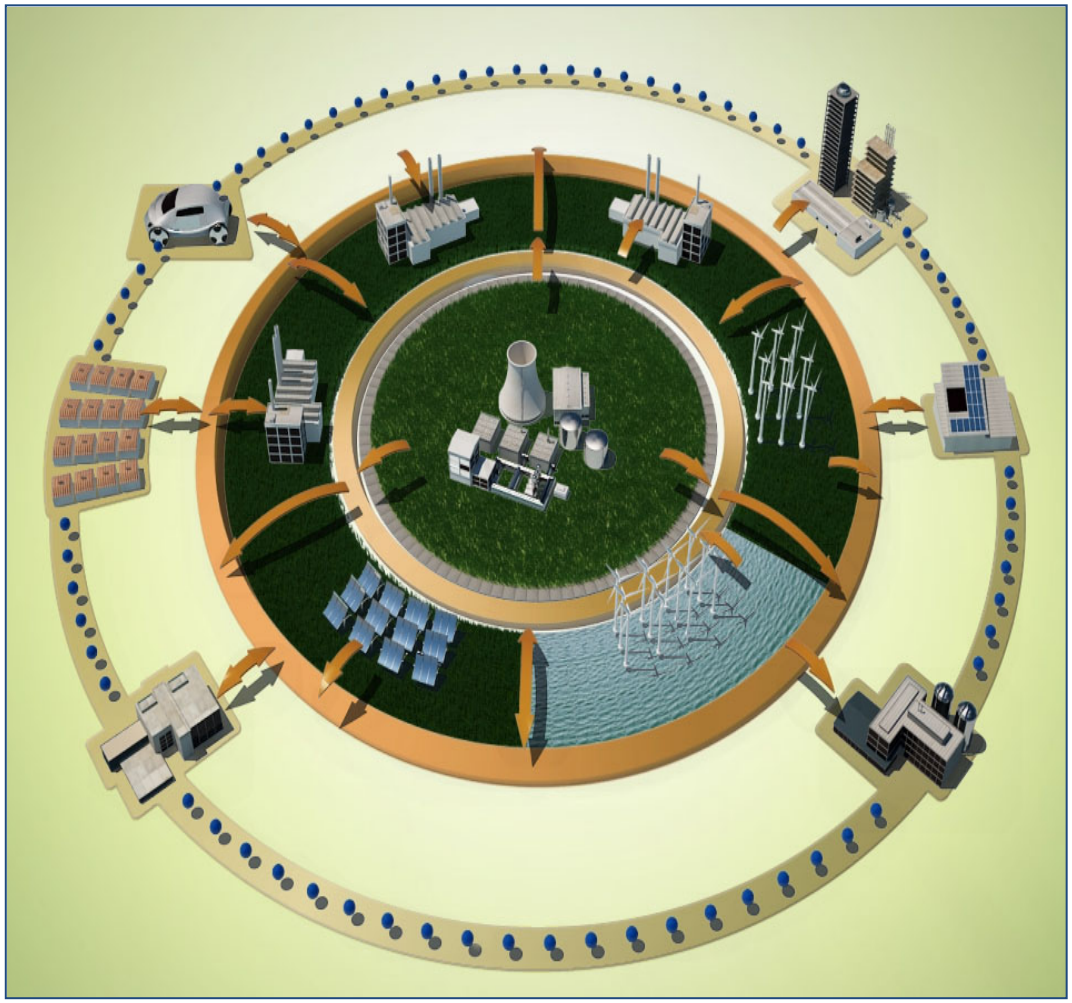
Why is Control Required?



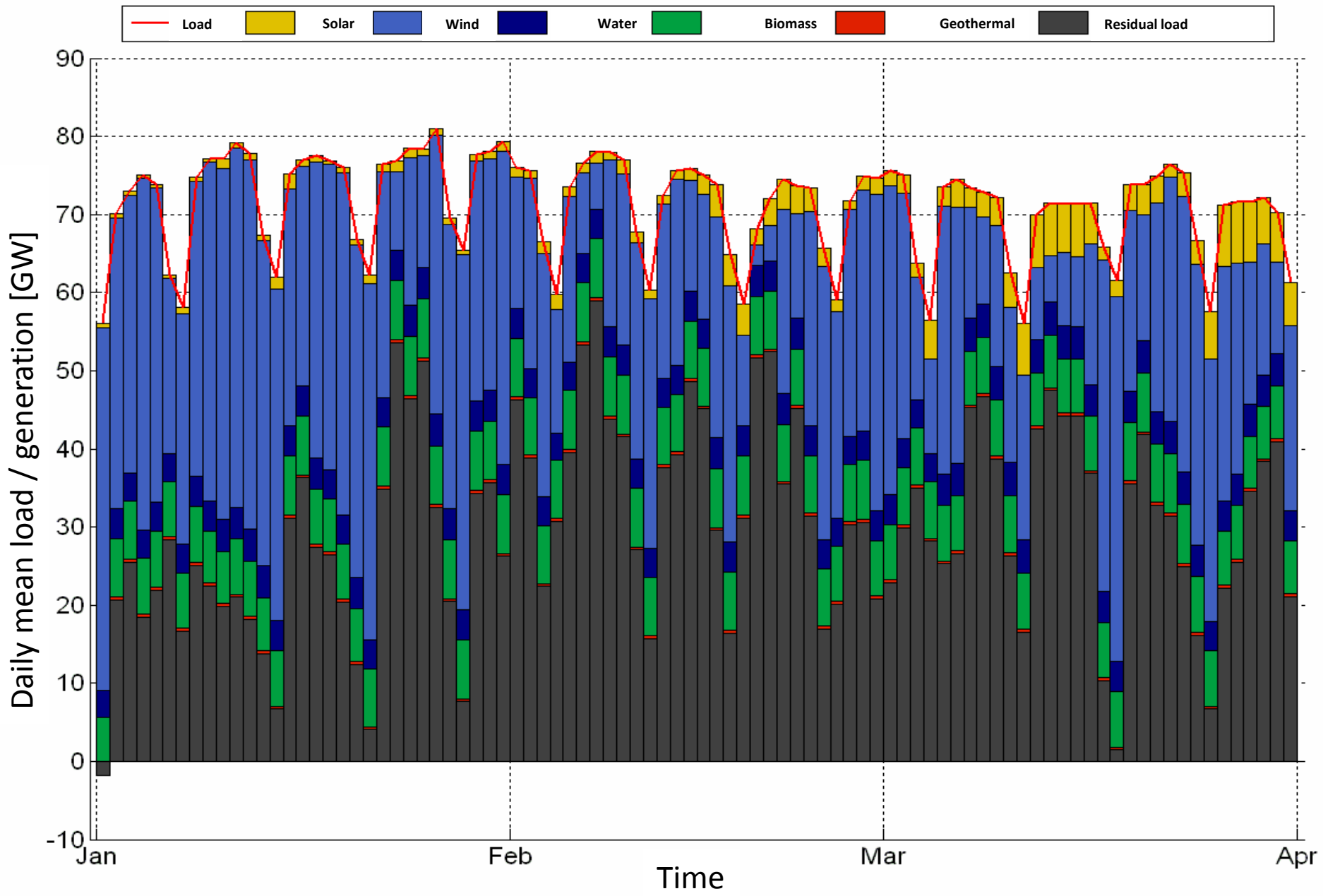
Source: Siemens AG

TODAY:

- **Distributed bulk power systems feed into an electricity grid which originally was designed for centralized, top-down electricity distribution and supply.**
- **At low-voltage and medium-voltage levels**
- **- Wind power plants**
  - Photovoltaic power plants
  - CSP power plants
  - Biogas power plants
  - Tidal wave plant
  - Geothermal plants

skytron®
pioneers of energy

The Effect Upon the Electricity Grid



Today's Electricity Grid Characteristics

- Fluctuating load profiles (day, night)
- Fluctuating energy injection by "Renewables" due to variable weather conditions
- Irregular energy injection and energy extraction in sub-grids
- Limited energy transport capacities of "historic" transmission and distribution grids
- Limited capabilities of conventional power plants to balance out those fluctuations
- Grid faults - sudden load shedding and short circuits

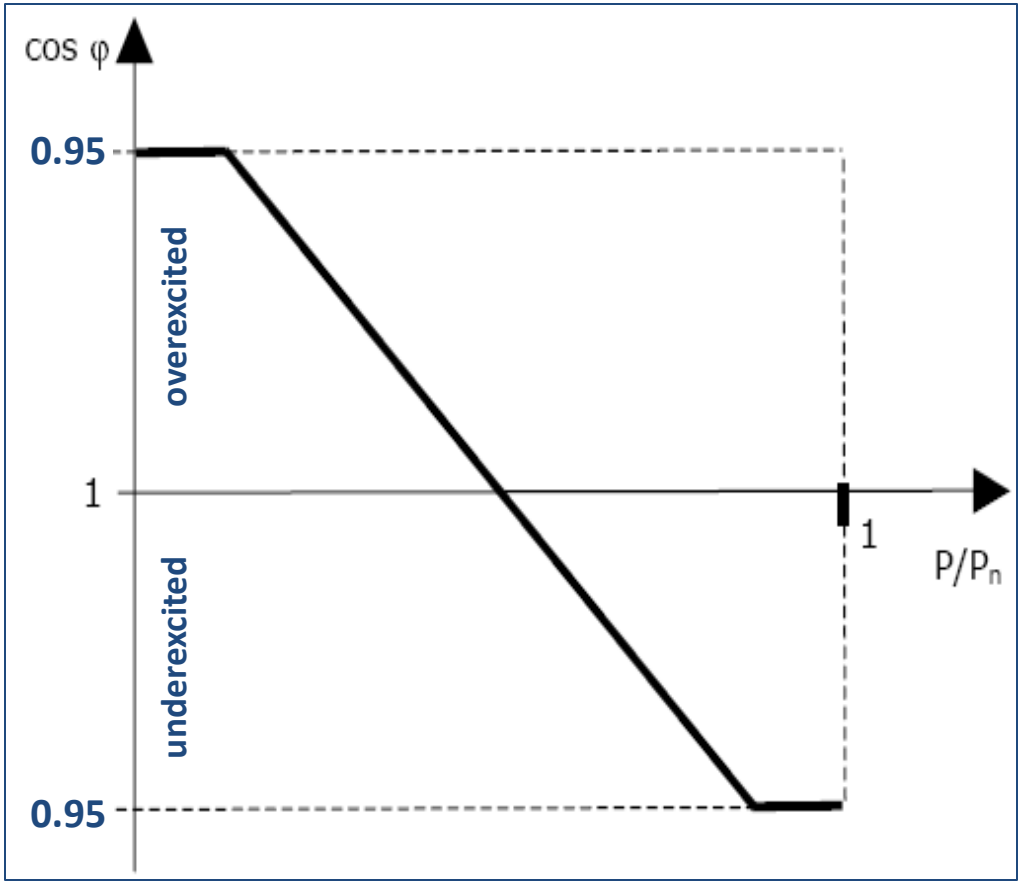
Grid security management measures

- On-demand reduction of energy injection in the event of grid overload

Decentralized grid stability measures

- Voltage support
- Injection of reactive power (cos ø)
- Frequency stability monitoring
- Fault ride through
- Provision of short circuit current (LVFRT)

Grid Stability



- **Improved grid stability thanks to decentralized grid support**:
  - Voltage support
  - Injection of reactive power
  - Frequency monitoring
- **The controllable power plant improves the grid quality**
  - either instantly, according to actual demand of power supply company
  - or according to an agreed specification

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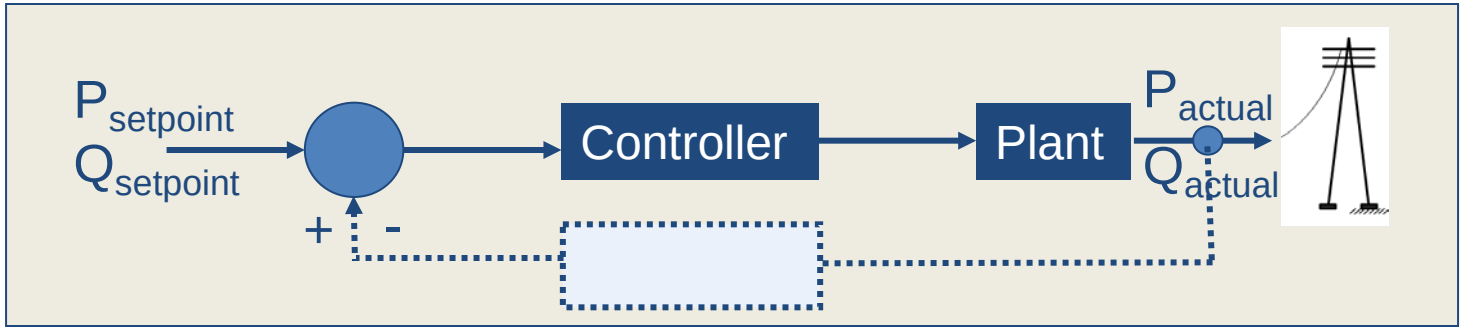
Power Plant Control: Two Approaches



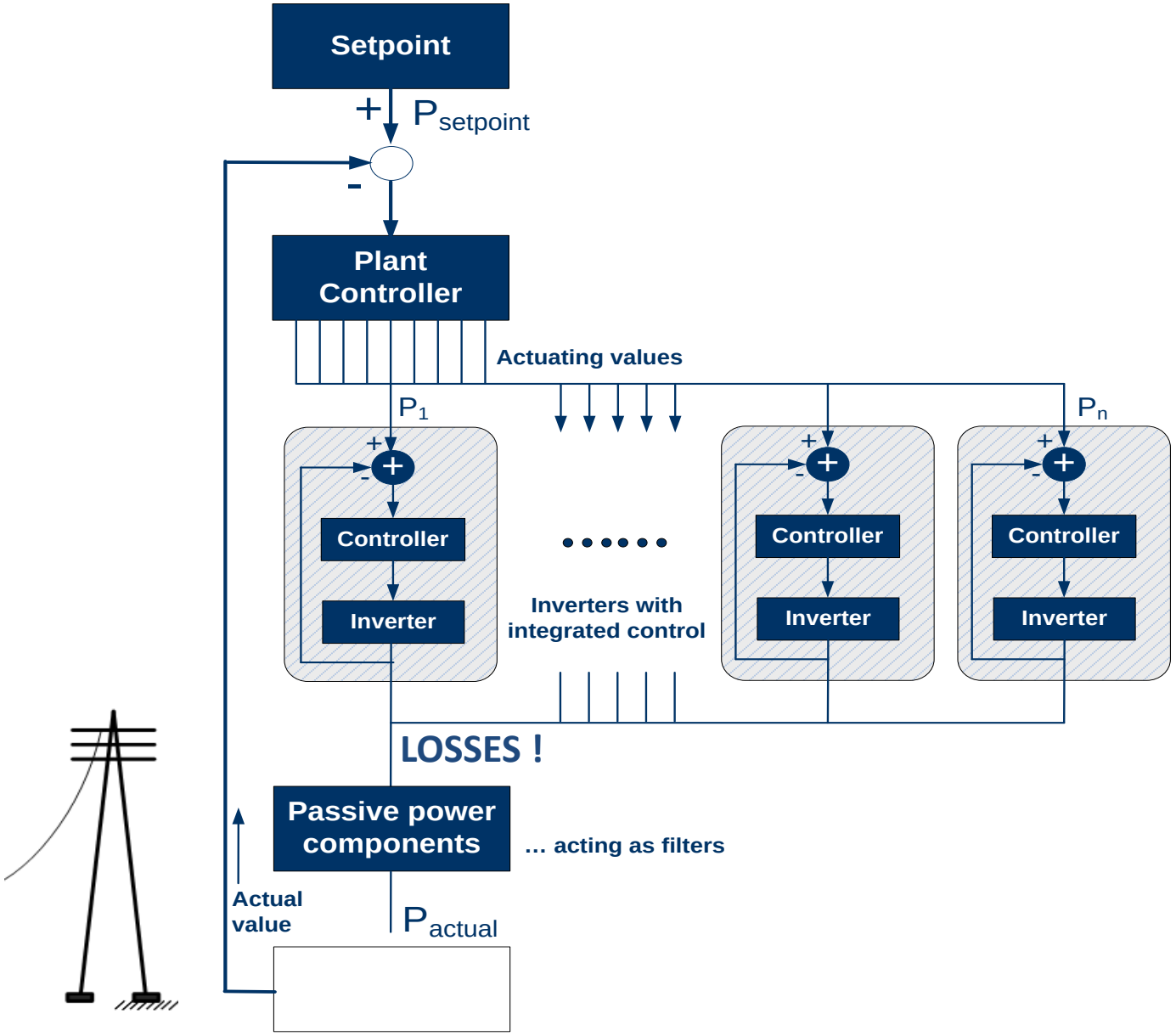
Inverter Level

- Typically open-loop control
- Feedback of actual value P, Q ?
- Actual value pick-up at injection point: LV
- Integration in SCADA system possible?

Plant Level

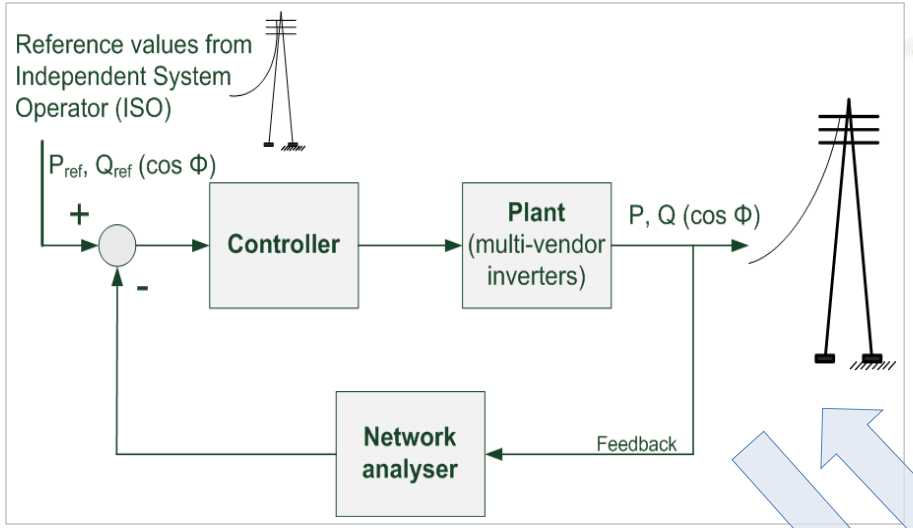
- Closed-loop control
- Feedback of actual value P, Q: Yes
- Actual value pick-up at injection point: LV, MV, HV
- Integration in SCADA system possible? Yes

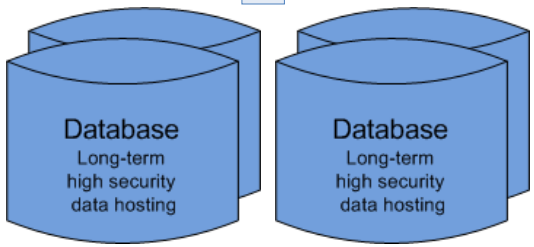
skytron's Approach: Power Plant Controller

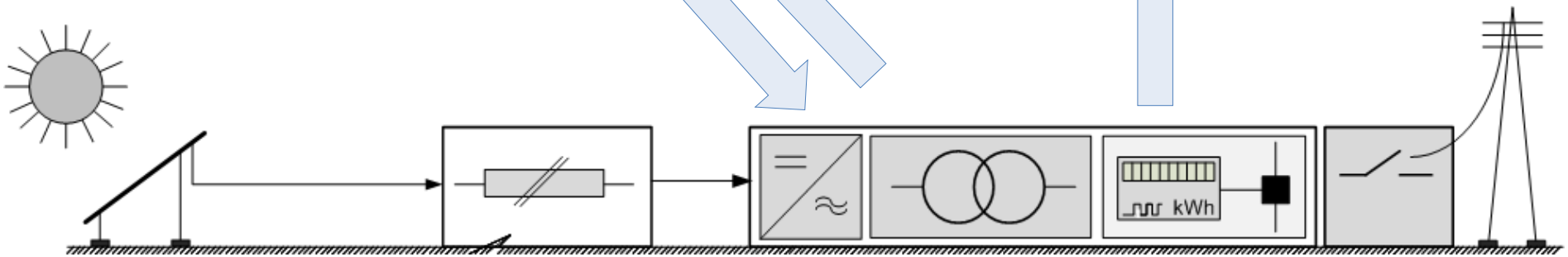


Monitoring, Supervision … … and Control

SYSTEM INTEGRATION







Generation | Field Monitoring | Inversion | Transformation | Grid Connection

POWER CHAIN

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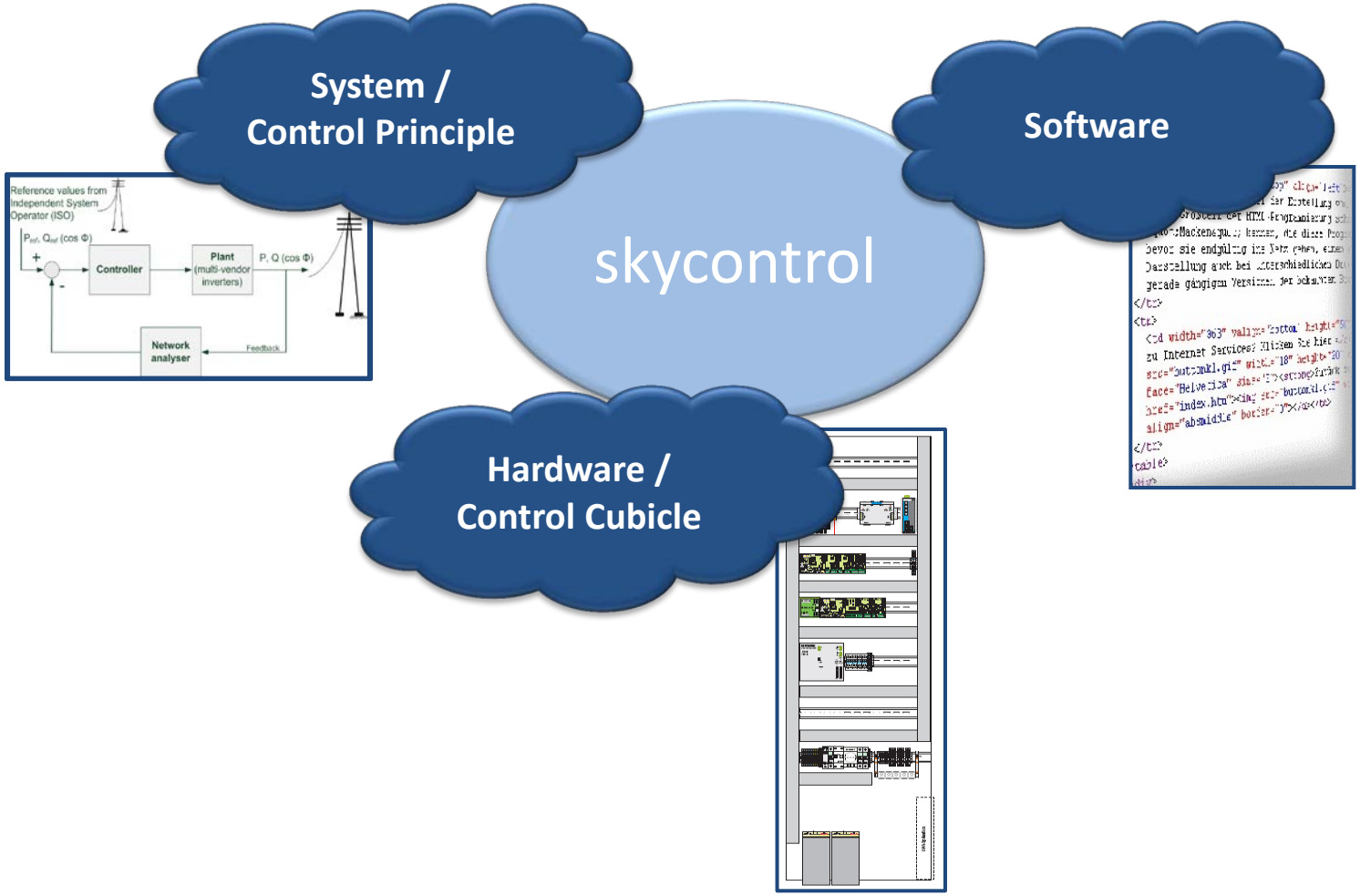
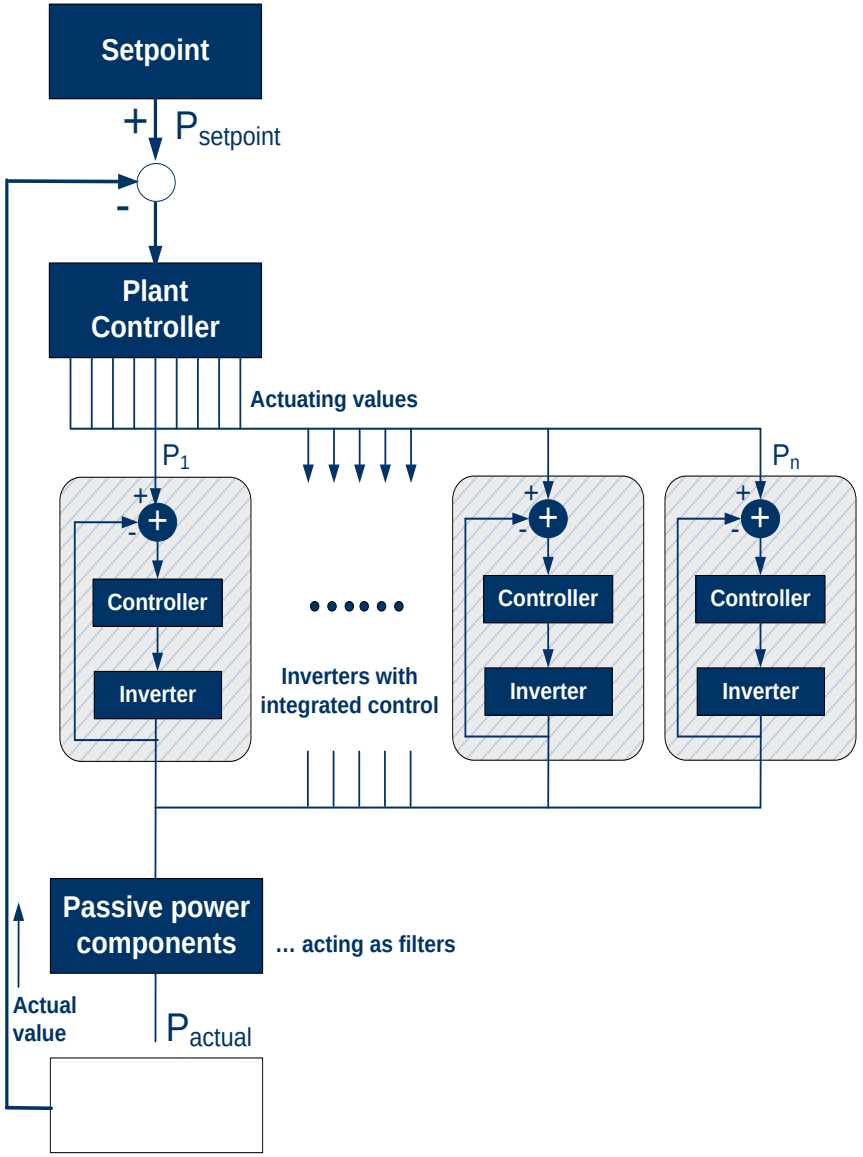
skytron's Power Plant Controller: skycontrol

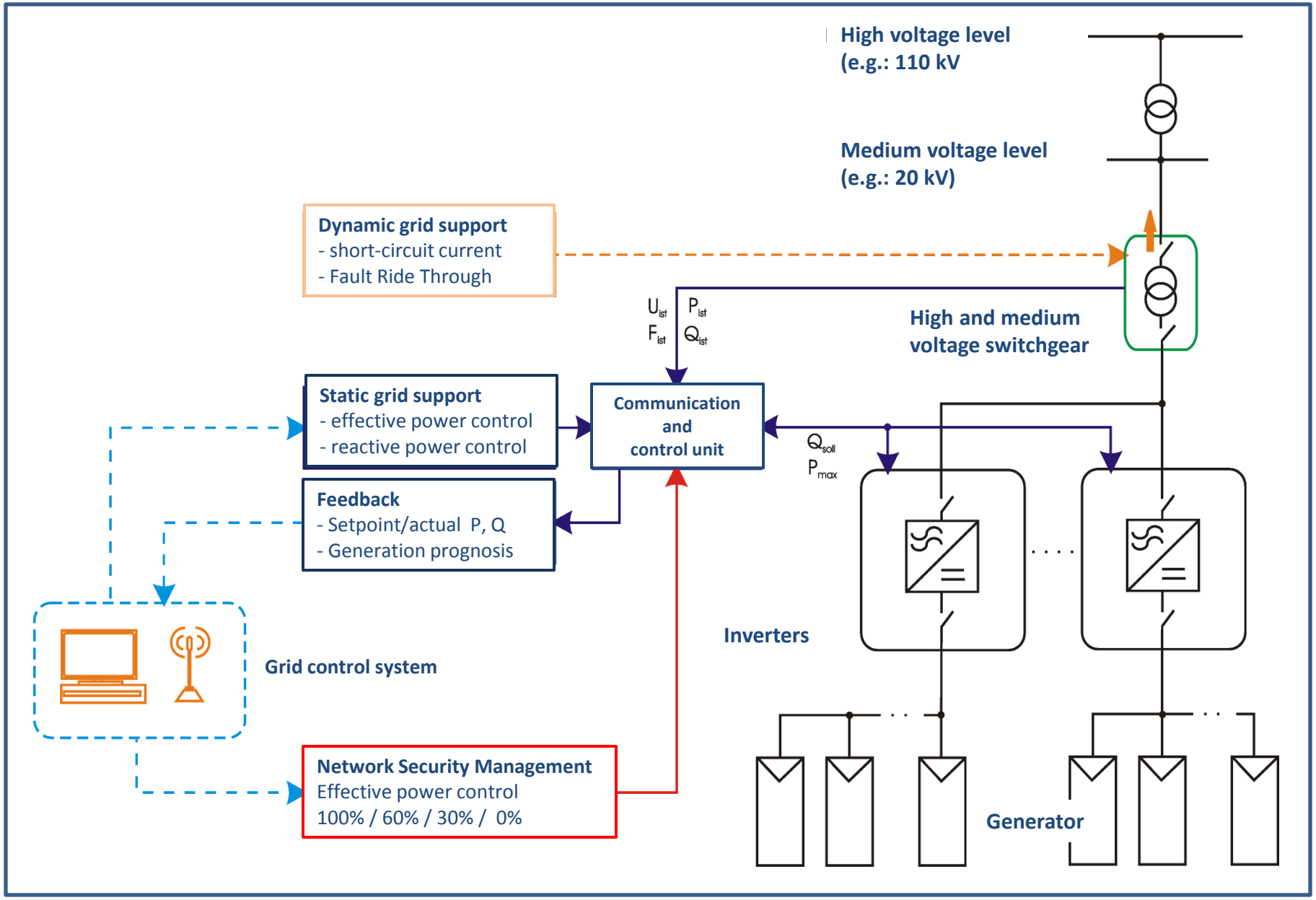


Characteristics and Control Parameters

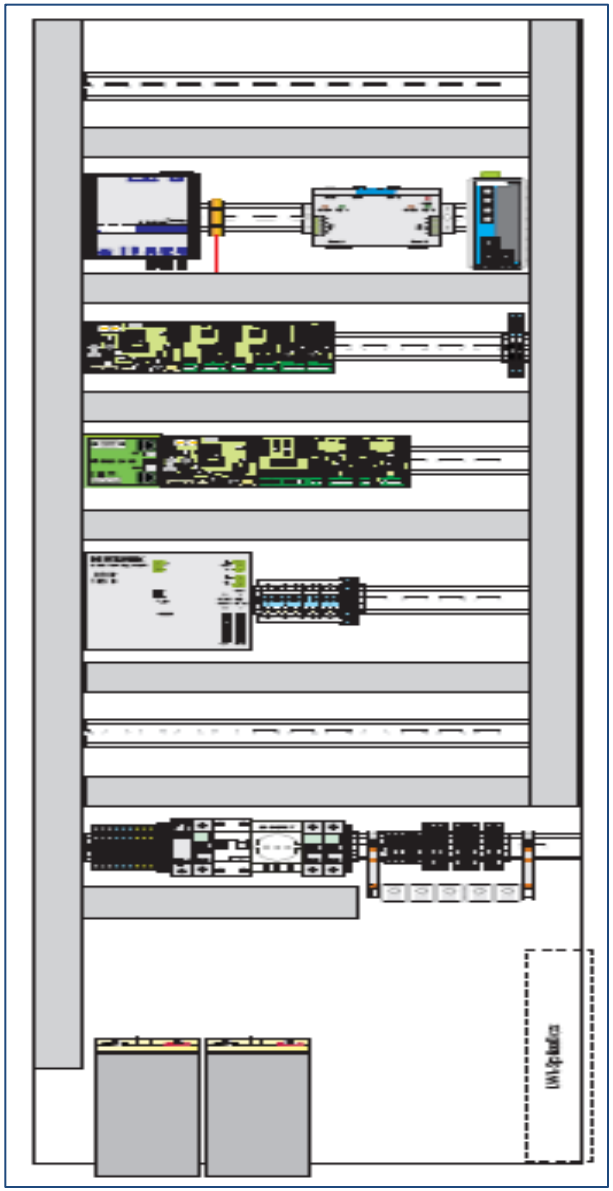


- **Genuine closed-loop control**
- **Feedback of actual values at grid injection point at medium or high voltage level**
- **Grid parameters:**
  - effective power P
  - reactive power Q
  - grid frequency f
  - grid voltage V
- **Effective power control**
  (NSM – Network Security Management)
- **Reactive power compensation**
- **Reactive power injection**
  (grid support function)

skycontrol: The Control Principle



skycontrol: The Hardware



- **Different-size cubicles, depending on required**
  - control features
  - housing
  - interfaces

- **Customized to suit**
  - interfaces specified by power supply company
  - mounting space available
  - layout and configuration of PV power plant
  - required functional scope

- **skycontrol**
  - is NOT a standard power plant controller
  - is a plant control system – adjusted to customer

skycontrol: The Functional Scope

Functions	Setpoint inputs:
Network Security management (NSM)	• Discrete switching signals (0%, 30%, 60%, 100%) • Analog signals (4 to 20 mA, 0 to 10 V) • Digital interfaces (MODBUS, BACnet)
Effective Power Control	• Discrete switching signals (0%, 30%, 60%, 100%) • Analoge signals (4 to 20 mA, 0 to 10 V) • Digital interfaces (MODBUS, BACnet) • Characteristic working curve of grid frequency → P(f)
Reactive Power Control	• Agreed value, fixed • Discrete switching signals (cos ϕ: -0.9, -0.95, 1, +0.95, +0.9) • Analog signals (4 to 20 mA, 0 to 10 V) • Digital interfaces (MODBUS, IEC 60870) • Characteristic working curve of effective power → Q(P) • Characteristic working curve of reactive power → Q(V)
Integration of System Protection Signals	• Grid injection enable • Emergency OFF / Fast trip • Inverter control in the event of MV / HV switch-off

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