Parallel Session 13
Automated Control Systems for Flexibility Provision for the Heating and Electricity Sectors*

CEBC 2026, 22.01.2026

Chair: Markus Gölles, BEST, AUT

* Session organized by IEA Bioenergy
Task 44 Flexible Bioenergy and System Integration

Introduction

- **Future sustainable energy and resource supply** can only be achieved by
  - a flexible, cross-sectoral energy and resource system
  - utilizing the specific advantages of various technologies and resources

- **Special session** (organized by IEA Bioenergy Task 44)
  - discussion on providing flexibility through bioenergy technologies & hybrid bioenergy systems
  - special focus on control and automation challenges

Agenda

14:00	**Opening and Technical possibilities of flexible bioenergy technologies and systems** Markus Gölles, BEST – Bioenergy and Sustainable Technologies, Austria
14:15	**Electricity Markets, Tariffs and Supporting Schemes for Flexibility Provision – An Overview** Robert Gaugl, Institute of Electricity Economics and Energy Innovation, TU Graz, Austria
14:35	**Unlocking flexibility value through variable feed-in tariffs** David Huber, oekostrom AG, Austria
14:55	**Monetizing Bioenergy Asset‘s Flexibility on Balancing Markets** Christoph Gutschi, CyberGrid, Austria
15:15	**Interactive discussion of audience and presenters**

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BEST
Bioenergy and
Sustainable Technologies

Technical possibilities of flexible bioenergy technologies and systems

CEBC 2026, Graz, 22nd January 2026

Markus Gölles, Clemens Hollenstein, Valentin Kaisermayer, Daniel Muschick, Viktor Unterberger, Christopher Zemann

Bioenergy for provision of operational flexibility to the heating and electricity sectors

- **Providing controllable technologies to compensate volatility** of
  - most renewable energy sources
  - demands among the different sectors

- **Most existing technologies are not able to provide this flexibility**, since
  - their concepts and
  - in particular their **control strategies**

  were **not designed for highly flexible operation**

To provide the flexibility needed, **control strategies**, **able to handle strongly varying operating conditions** (load modulation) **automatically**, have to be developed

System level – scheduling of controllable producers, storages and consumers

Technology level – flexibilization of biomass conversion technologies by means of control

Technology level

flexibilization of biomass conversion technologies by means of control

Flexibilization of biomass conversion technologies

- **Potential for flexibility** provision (compensating volatility) is **only exploited in biomass boilers in heating applications**
  - due to commercial reasons (feed-in tariffs, funding schemes, high investment costs)

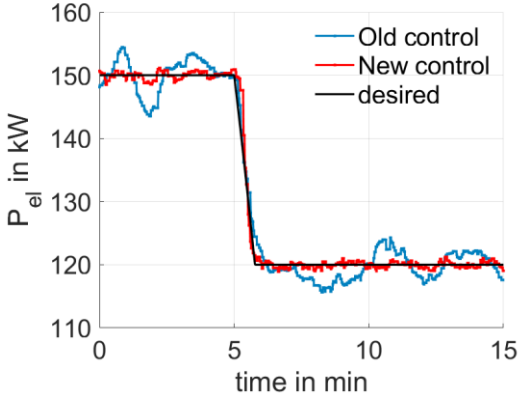
- **Control strategies currently applied do not support fully-automatic, flexible operation**
  - mainly designed for nominal (load) operation

- **Most promising & systematic approach: model-based control strategies**
  - allow targeted consideration of systems' characteristics & systematic adaptation to different plants
  - R&D for some technologies & few industrial implementations for biomass boilers

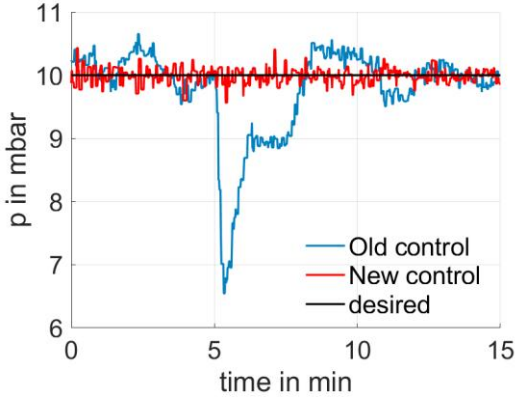
Example for technology flexibilization – fixed-bed biomass gasification CHP plant

Step-wise load change from 150 kWel to 100 kWel (-33%) within less than 2 min
(nominal capacity: 300 kW_{th} and 150 kW_{el})

electric power produced

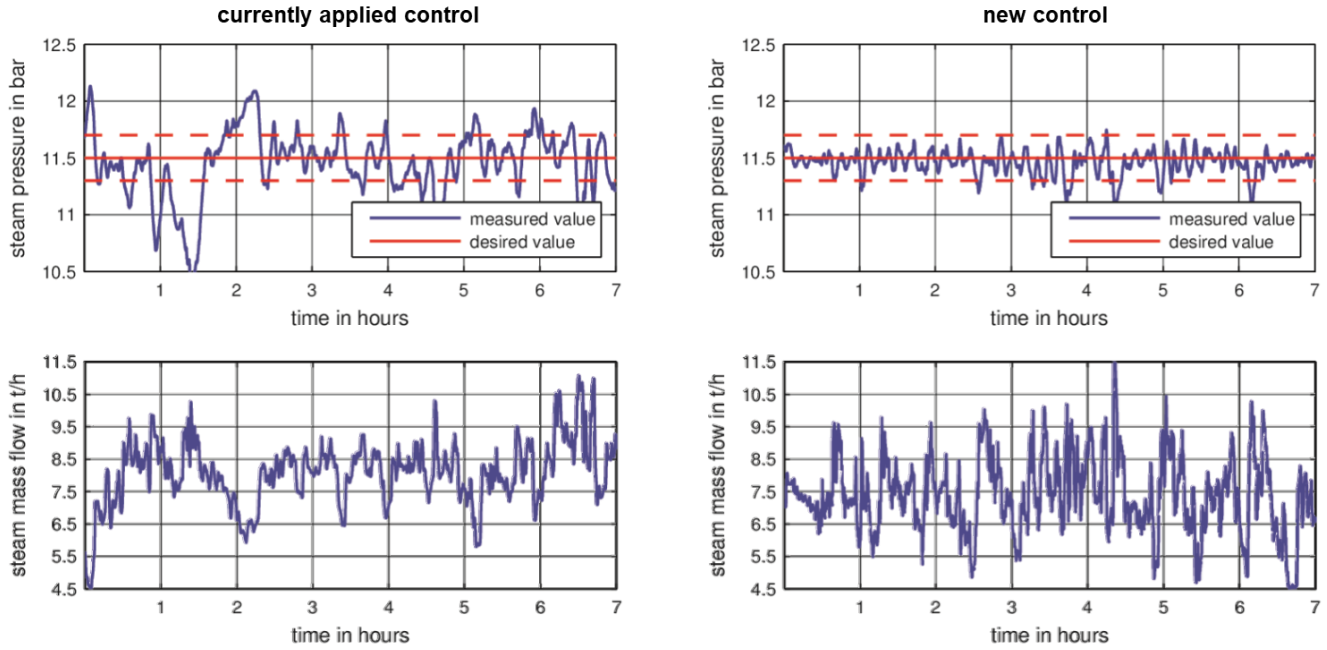


pressure level prior venturi mixer



Fixed-bed biomass gasification CHP plants are very suitable to provide flexibility to the electricity sector

Example for technology flexibilization – grate furnace providing saturated steam to dairy industry



A relevant part of the flexibility in steam production, currently provided by natural gas, **could get provided by biomass combustion**

Flexibilization of biomass conversion technologies
Interim summary

Appropriately controlled biomass conversion technologies can provide flexibility to many applications

Biomass conversion technologies are part of a larger multi-energy systems
→ Appropriate scheduling of all technologies in system is necessary

System level

scheduling of controllable producers, storages and consumers

Requirements for scheduling (supervisory control)

optimal operation
(efficiency, CO_2 emissions, …)

→ **optimization-based**
ensures optimal operation of the system
by targeted utilization of the different technologies

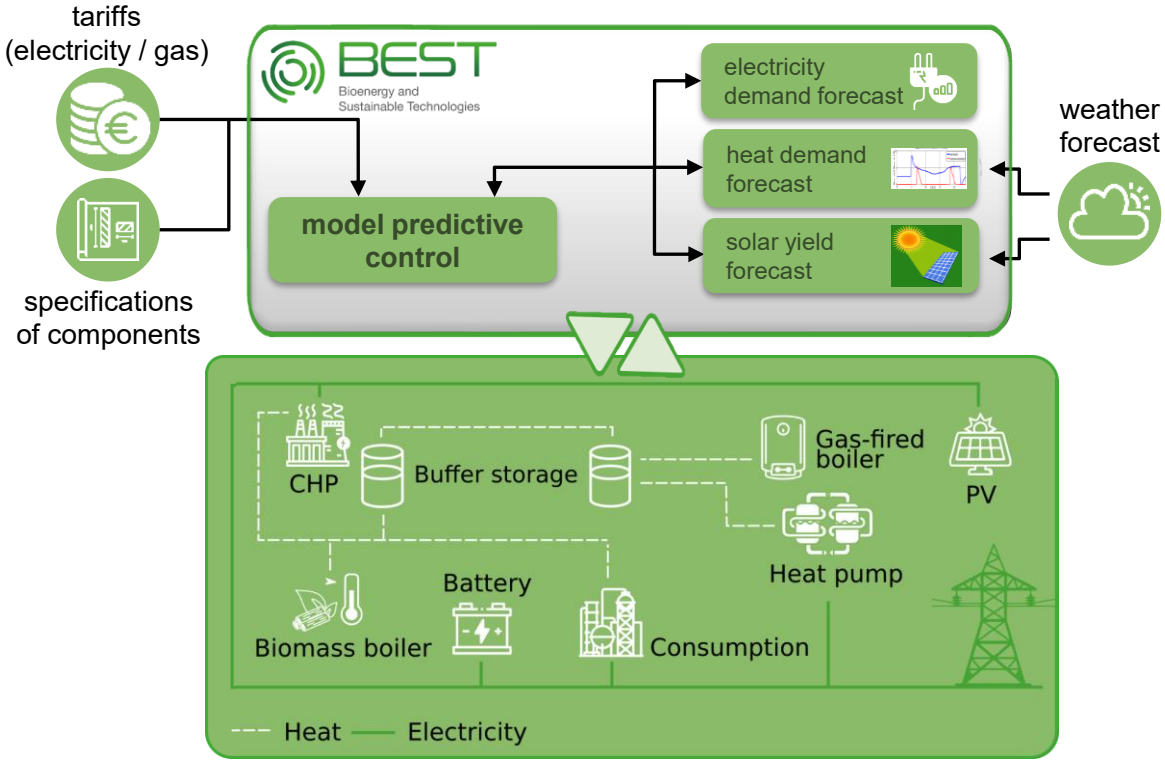
volatility
of production and consumption

→ **predictive**
integration of weather and price forecasts
calculation of forecasts for yields and conspumptions

variation range
of the configurations

→ **modular**
automatic (re)formulation of the optimisation problem
based on the specifications of the components

Modular, predictive, optimization-based supervisory control of multi-energy systems



Software framework suitable for many applications

Residential buildings

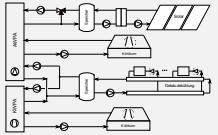
Energy management for increased comfort and efficiency

EEG / BEG

Synchronisation of individual production and consumption

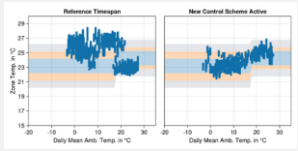
Solar thermal systems

Solar cooling, process heat, district heating



Buildings / quarters

Heating and cooling ad increased comfort and efficiency



District heating

Heating supply of entire cities with hundrets of consumers

Comerce and industry

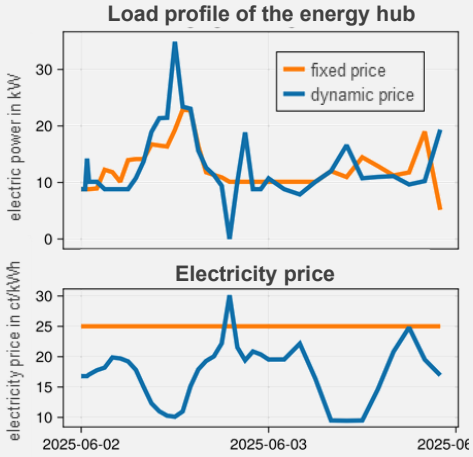
Control of energy production, storage and consumption

Many applications could provide flexibility for the electricity sector

How can we utilise these flexibilities?

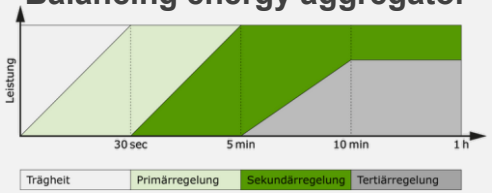
Dynamic electricity prices

Time shift of consumption and production



Participation in intraday trading

Balancing energy aggregator



© A1 Energy Solutions

Virtual Power Plants

© Next Kraftwerke

Flexibility for distribution grids

Austrian Initiatives by APG Flex-Hub / Stromausgleich Österreich

Stromausgleich Österreich

© APG

What exactly are the options here, how do the interfaces look like, …?

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Electricity markets, tariffs and supporting schemes for flexibility provision

An Overview

Robert Gaugl
Institute of Electricity Economics and Energy Innovation, TU Graz

22.01.2026

Where can you sell electricity?

Austria: the practical “routes to market”

Support-backed off-take

- Feed-in tariff
- EAG market premium + direct marketing (your plant sells to the market, support tops up to a reference value).

Bilateral sales (OTC / PPA)

- Long-term or medium-term contracts directly with a counterparty (utility, trader, corporate). Price can be fixed or indexed.

Wholesale spot markets

- Day-Ahead auction and Intraday trading (continuous / auctions) for physical delivery in price zone AT.

Balancing services (“Regelenergie”)

- Provide reserve capacity and balancing energy via APG tenders (often via an aggregator / VPP).

Because biomass can ramp and schedule, it can combine (“stack”) energy-market revenues with flexibility revenues (balancing services, intraday optimisation).

Who does what?

Key roles you need to connect to the markets

Physical trading needs a balancing group ("balance group") and a Balance Responsible Party (BRP).

Biomass plant

Physical generation + metering
(15-min schedules are common in market processes)

Balancing group / BRP

Portfolio balancing, nominations, imbalance risk & settlement

Markets

OTC / PPA • EPEX spot
Forward/futures • Balancing tenders

APG (Austrian Power Grid; TSO)

Runs the control area and procures balancing reserves (FCR, aFRR, mFRR).

APCS (Austrian Power Clearing and Settlement AG)

Balance group coordinator and imbalance settlement responsible; passes balancing energy costs via imbalance settlement.

Electricity exchange

Long-term and short-term

Different products are traded on the exchange, which vary based on the duration of delivery:

Long term

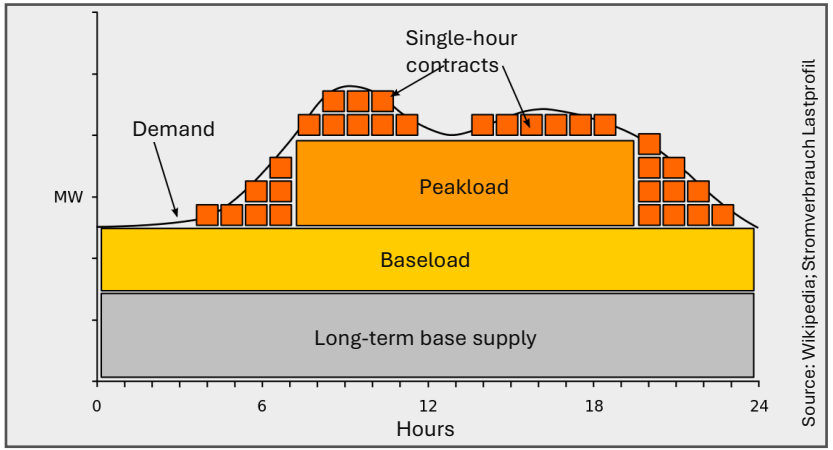
Futures /Forwards

- Long-term contracts are concluded with **durations of several years**, ensuring basic supply over an extended period.
- The primary **focus** here is usually **not on physical delivery** (i.e., electricity supply), but rather on **financial hedging** against future price developments on the spot market.

Short term

Spot market

- Spot market deals with electricity quantities available for s**hort-term** delivery.
- Quantities are either purchased
  - one day before physical delivery (**day-ahead market**) or
  - on the same day (**intraday market**).



Spot markets: day-ahead & intraday

EPEX SPOT for the AT price zone

Spot markets optimise physical delivery for the next hours or day and are the reference for many index prices.

Day-Ahead (DA)

- Single daily auction for **delivery the next day**.
- **Traded blocks**
  - **Hourly blocks** (Mostly)
  - Baseload blocks
  - Peak load blocks (8:00 a.m. – 8:00 p.m.)
  - Others
- Used to lock in an initial schedule.

Intraday (ID)

- **Trading closer** to **real time** to update schedules.
- Main use cases: **forecast errors**, outages, price spikes, negative-price avoidance.
- Traded blocks
  - **15-minute & hourly blocks** (Mostly)
  - Larger blocks also possible (base and peak load)
- For flexible plants: “sell when prices are high, reduce when low”.

Spot trading is physical delivery. Your BRP must nominate schedules and carries imbalance risk if actual generation differs from nominations.

How is flexibility monetised?

Two big buckets: trading value + system value

Flexibility = ability to change output (up/down) at the right time, reliably.

A Energy-market value

- **Shift generation** to higher-price hours (DA/ID optimisation).
- **Avoid negative prices** or curtail when marginal value is low.
- Reduce imbalance costs by following nominations more closely.

B Balancing (Regelenergie) value

- **Capacity payment:** Get paid for keeping reserve capacity available.
- **Balancing energy payment:** Get paid when activated.
- **Requires prequalification** and operational performance.
- Often accessed through a **VPP / aggregator**.

Fuel, heat demand (for CHP), minimum run times, and maintenance constrain flexibility — but even "partial flexibility" can be valuable if it is predictable and automatable.

The Austrian market premium (EAG)

Sliding premium: top-up between “strike” and market reference

Under the EAG, renewable generators (including biomass) can receive a “floating (sliding) market premium”.

What the plant must do

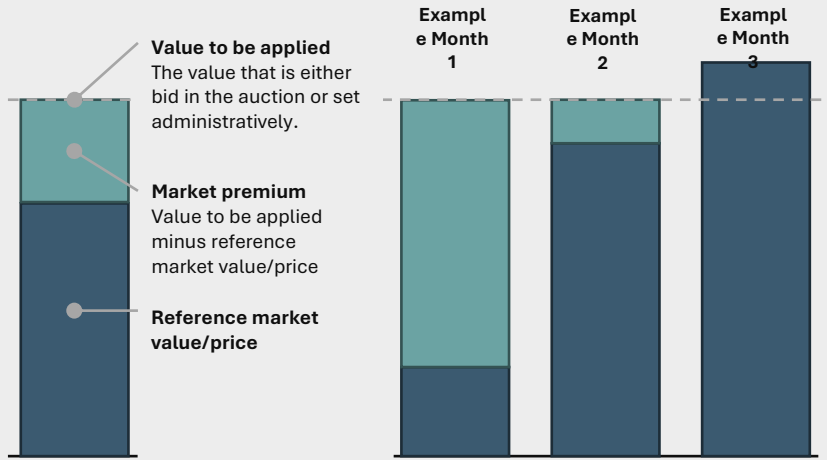
- Sell electricity to the market (“**direct marketing**”).
- **Meet metering and reporting rules** in the support contract.
- Typically awarded via competitive tenders (technology-specific).

What this changes (vs FIT)

- You get market **price signals** (incentive to produce in valuable hours).
- Support reduces downside when market prices are low.
- **Revenue** becomes “**market price + premium**” rather than a fixed tariff.

Concept (as described by the ministry):

Market premium (ct/kWh) = “value to be applied” (azW) – reference market value (price)



Dynamic feed-in tariffs (index-based)

A commercial product - not the same as a subsidy

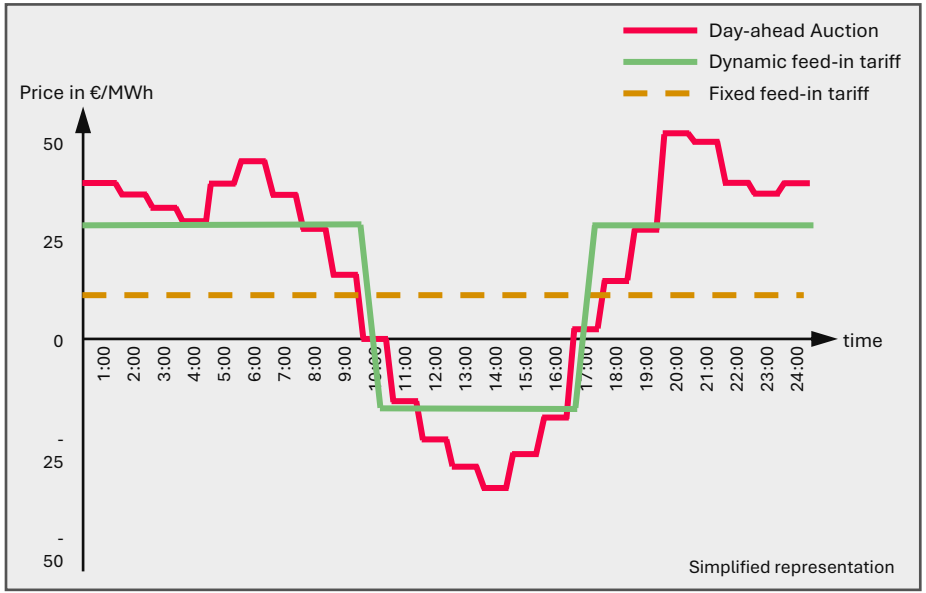
“Dynamic feed-in” = remuneration follows a market index (often Day-Ahead spot), typically minus a supplier spread.

Why it exists

- **Simple**: no trading desk needed
- Transparent index reference
- But: you carry **spot price volatility** (and often a spread)

What it means

- **Possibility** to **earn more compared** to **fixed feed-in tariff**
- **Works best** for **dispatchable power plants** or for non-dispatchable plants combined with storage
- **Follow** the **price signal**



You will hear more about it in the presentation of Mr. David Huber (oekostrom AG).

FIT vs Market Premium vs Dynamic Feed-in

Same word “tariff”, very different economics

Feature	Feed-in tariff (FIT)	EAG market premium	Dynamic feed-in tariff
Price exposure	Low (fixed tariff)	Medium (market+ top-up)	High (market-indexed)
Who sells electricity?	OeMAG off-take (support scheme)	Generator (direct marketing)	Supplier/utility contract
Incentive to react to prices	Weak	Strong(er)	Strong
Typical use case	Legacy/regulated support	Main EAG support route	Commercial offer for smaller plants

Market premium and dynamic feed-in both expose you to market prices; the difference is that the market premium is a subsidy top-up defined by law, while dynamic feed-in is a purely commercial indexed contract.

Virtual power plants (VPPs) & aggregators

Pooling assets to access markets and balancing services

You will hear more about it in the presentation of Mr. Christoph Gutschi (CyberGrid).

Balancing energy ("Regelenergie")

What is it

Balancing energy keeps system frequency stable and resolves short-term imbalances.

FCR *Frequency Containment Reserve*	aFRR *automatic Frequency Restoration Reserve*	mFRR *manual Frequency Restoration Reserve*
▪ Very fast response ▪ Procured via tenders ▪ Stabilises frequency immediately	▪ Automatic activation ▪ Capacity + energy remuneration ▪ Restores frequency after initial containment	▪ Manually activated ▪ Capacity tender + energy tender ▪ Covers larger/longer deviations

Balancing markets typically remunerate (1) reserved capacity (availability) and (2) activated balancing energy.
Participation in APG tenders requires technical prequalification and contracts.

You will hear more about it in the presentation of Mr. Christoph Gutschi (CyberGrid).

Decision matrix

Options to market a biomass plant

Decision factor	Market premium (EAG) (+ direct marketing)	Dynamic feed-in tariff (index contract)	VPP / aggregator (portfolio optimisation)	Balancing energy (FCR/aFRR/mFRR)
Revenue driver	Market sales + premium top-up vs reference market value	Indexed payout (e.g., spot index +/- spread)	Arbitrage/optimisation across DA/ID, imbalance, sometimes ancillary markets	Capacity payment (availability) + energy activation payment
Price risk	Medium (exposed to market; premium reduces downside)	High (direct index exposure)	Variable (often shared via contract; depends on scheme)	High for activation; capacity is contracted but performance penalties apply
Effort & complexity	Medium: needs scheduling, balancing group, HKN handling, reporting	Low–Medium: contract simpler, still needs metering & settlement	Low–Medium for plant: outsource trading/optimisation; higher contracting diligence	High: prequalification, telemetry, test procedures, availability obligations
Technical requirements	Standard metering; forecasting & nomination processes	Standard metering; index settlement	Remote control / data exchange typically required	Fast response, telemetry, controllability; APG prequalification
Best fit when…	You want support + market signals; can handle direct marketing	You prefer simplicity and accept market-index risk	You want to outsource trading and capture more value from dispatchability	You have reliable, dispatchable flexibility and can meet strict requirements

Questions

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Decentralized. Digital. Flexible.

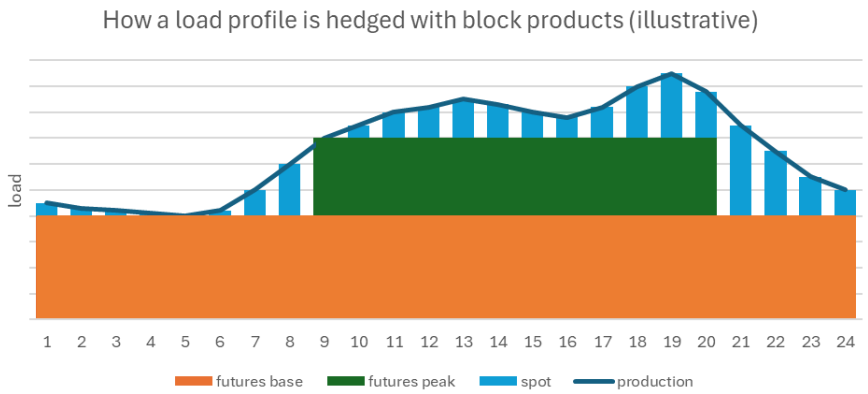
Unlocking flexibility value through variable feed-in tariffs.

David Huber
Short-term & flexibility trading – expert in system integration

CEBC2026 | Session 13: Automated Control Systems for Flexibility Provision | Graz, 22 Jan 2026

From profile to market value: hedging a load profile with block products

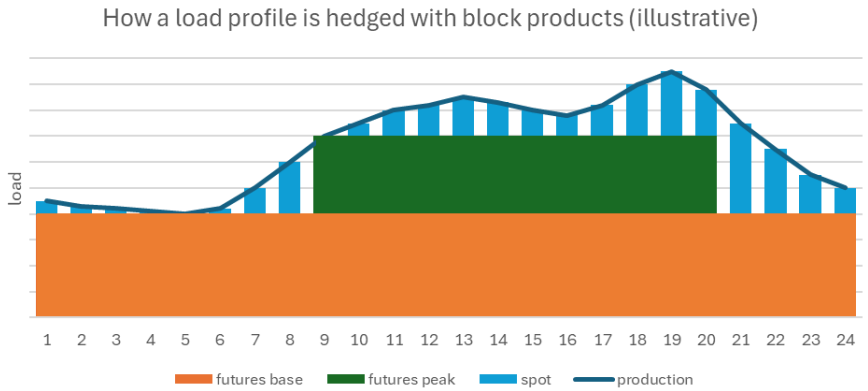
We convert a volatile quarter-hourly profil into a structured hedge: Baseload + Peakload, with the remaining gaps settled on Spot.

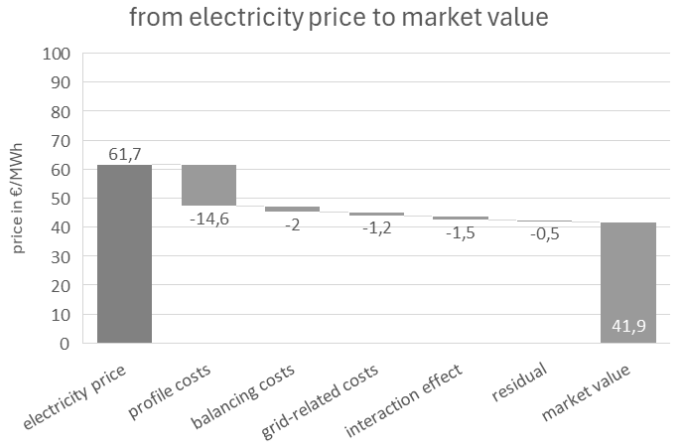


- baseload futures (00–24) hedge the “minimum” demand that is present every hour
- peakload futures (08–20) cover the systematic daytime uplift
- the remaining volume is the residual: handled via day-ahead / intraday procurement in 15 minutes resolution.
- the better the forecast & flexibility, the smaller the residual and the lower the balancing exposure.

From profile to market value: how your profile defines the market value

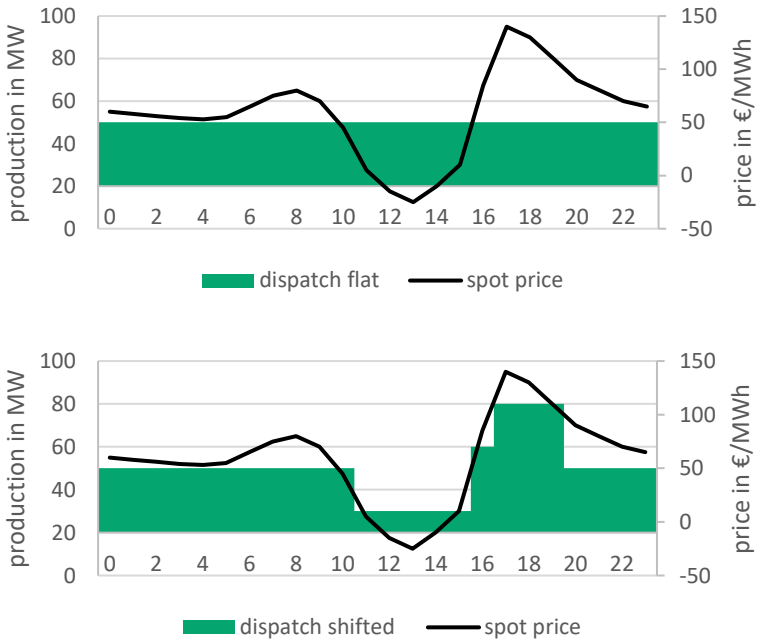
The value of generation is not the average price—it's the capture price minus risk & service costs.





- more constant output -> higher market value
- dispatchable generation (e.g., biomass/CHP) typically achieves top values
- volatile output tends to trade at a discount — flexibility and predictability reduce it.

From market value to variable feed-in tariffs: making flexibility payable



- same energy, different value: both schedules deliver e.g. 1,200 MWh/day, but not in the same hours
- revenue uplift from shifting: + ~€ 13,000 /day by reducing output during low/negative-price hours and increasing it in high-price hours
- capture improvement: + ~€ 11 /MWh purely through better timing
- why variable tariffs matter: a spot-/DA-indexed feed-in tariff makes the market value transparent and directly rewards flexible operation
- We can turn the price signal into an executable dispatch

NEO – Next Generation Energy Optimization

What NEO does?

- cloud-based optimization solution for supply-side management and demand-side management
- converts tariffs / market prices into asset dispatch plans under real constraints
- executes via VPP control (setpoints/schedules) while local safety logic remains in place

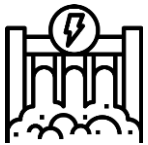
Inputs

- Forecasts (generation/consumption, weather-driven signals)
- Market data (day-ahead / intraday prices, tariff curve)
- Real-time telemetry (P_{actual}, status, availability)
- Constraints (min/max, ramp rates, SOC/water/heat constraints)

Outputs

- Optimized schedule / setpoints (per asset and time interval)
- Clear “dispatch intent” that operators can audit and override
- Reporting basis for performance evaluation (uplift vs baseline)

Biomass CHP



Hydropower

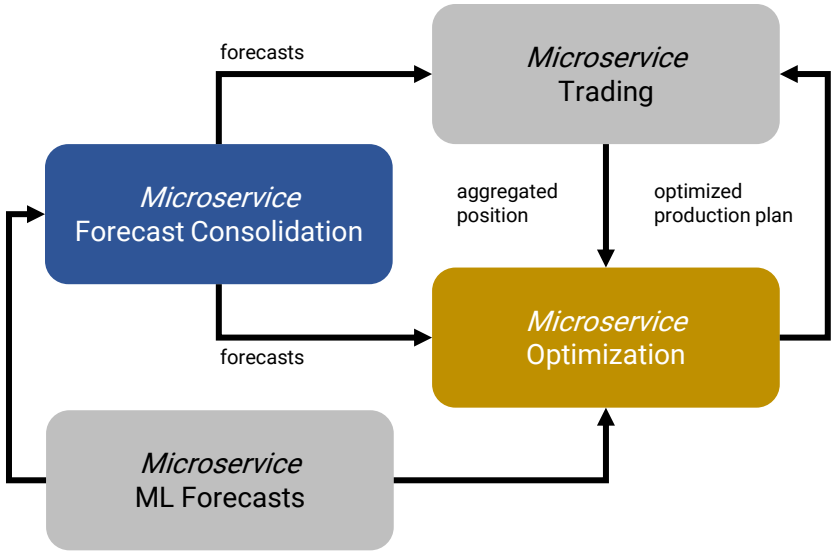
source: flaticon

Battery Energy Storage Systems (BESS)

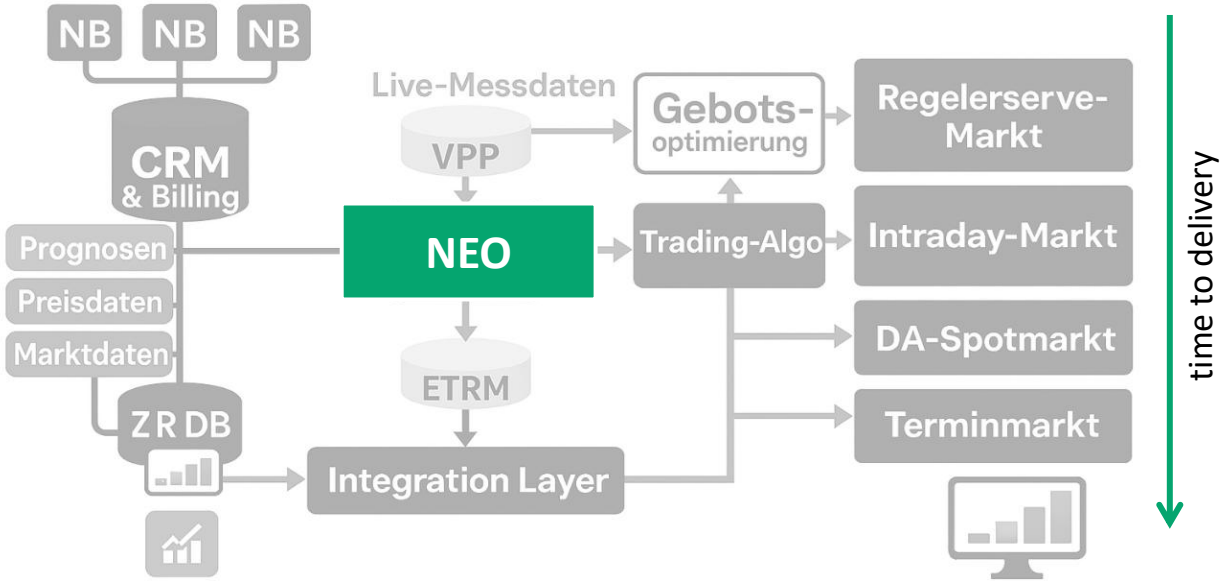
NEO system architecture

Core idea: Cloud-based, modular platform for connecting decentralized renewable assets and converting market price signals into dispatch commands.

- Cloud-native microservice design for **scalability and resilience**
- Separation of concerns: forecasting → optimization → trading interface → control
- CI/CD pipeline for fast iteration and secure deployment
- Standardized asset types (hydro, biomass, battery, …) via standardized protocols (IEC 104, Modbus TCP/IP, MQTT)
- End-to-end encryption (OpenVPN) and role-based access for cybersecurity



NEO integration into the overall context of energy trading



Operating concept of the market optimization microservice

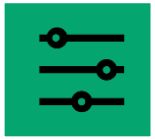
plant

Ingest data streams from production and consumption via the VPP

Formulate an optimization problem with constraints

cloud

Repeating cycle every few minutes



Dispatch via VPP; monitor deviations and apply safe fallback

Optimize revenues and generate a schedule (rolling horizon)

source: flaticon

Interfaces & on-site requirements

Purpose: Enable automated, safe dispatch by translating a variable feed-in tariff into plant setpoints.

Ingest
Plant -> VPP (required signals)

Dispatch
VPP -> Plant (control signals)

- Direct protocol integration: existing RTU via IEC 60870-5-104 or Modbus TCP/IP (others by agreement) using OpenVPN
- Bidirectional control: “oekobox” gateway with OpenVPN (encrypted VPN over public cellular)

source: flaticon

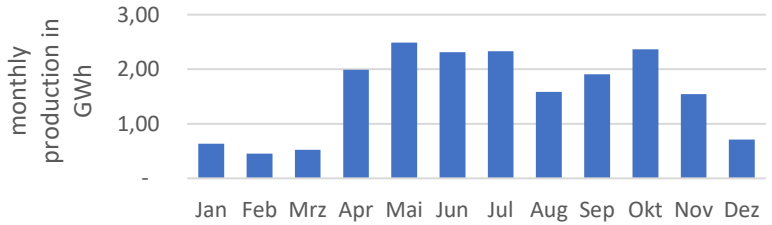
Case study: Hydroelectric plant w/ reservoir

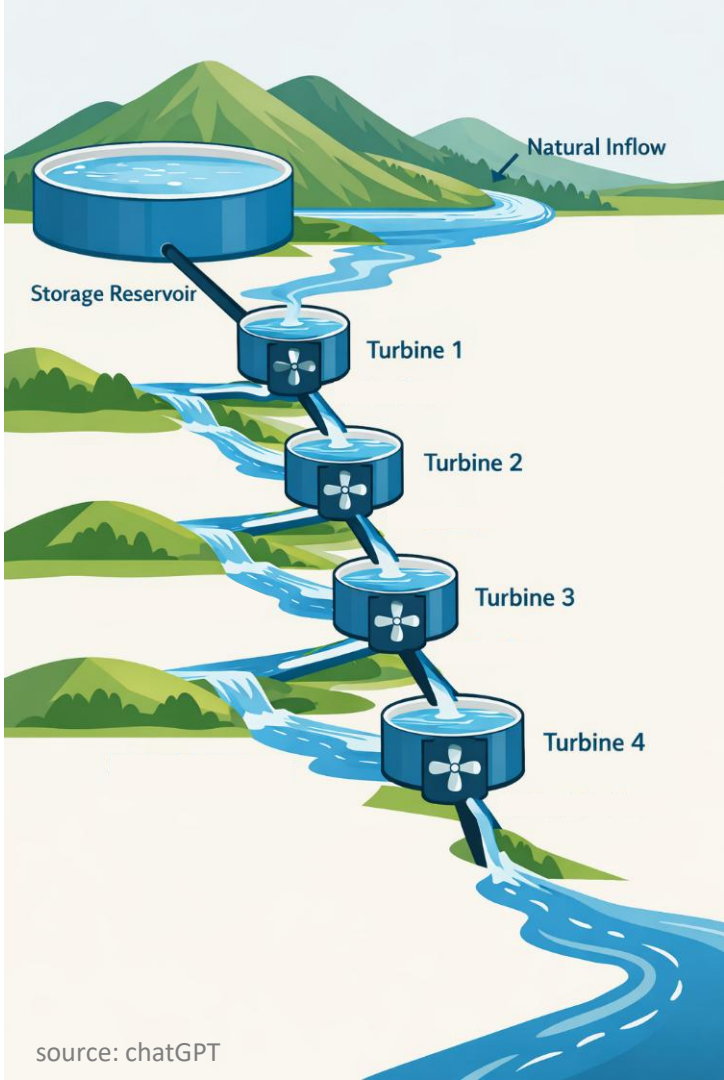
Public utility setup

- local energy supplier with multiple generation and consumption facilities
- annual demand approx. 20 GWh

Technical unit

- multiple turbines with a cumulative output of 4.2 MW
- 7-million-liter water reservoir at the top level
- annual production of approx. 20 GWh
- reservoir enables time-shifting without changing annual energy volume





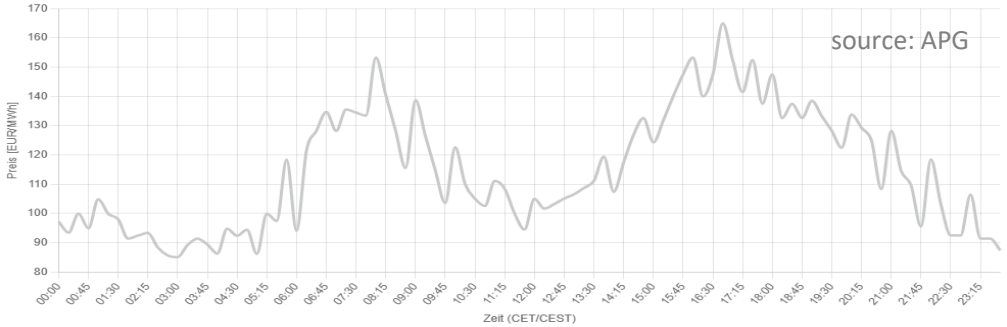
source: chatGPT

Operation of the hydroelectric power plant to maximize spot revenues

Value creation

- Automated end-to-end process completely replaces manual planning
- Economically optimal timetable creation for own and external assets

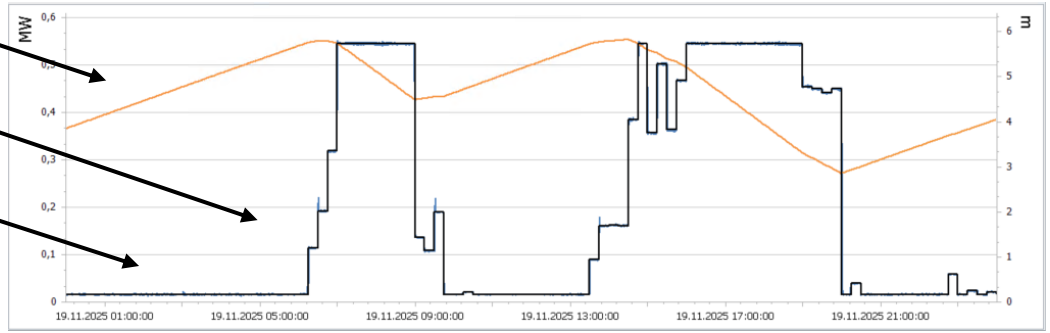
Day-ahead spot price EXAA 10:15



state of charge in m

turbine load set in MW

turbine load actual in MW



Value creation from the optimization of flexible assets

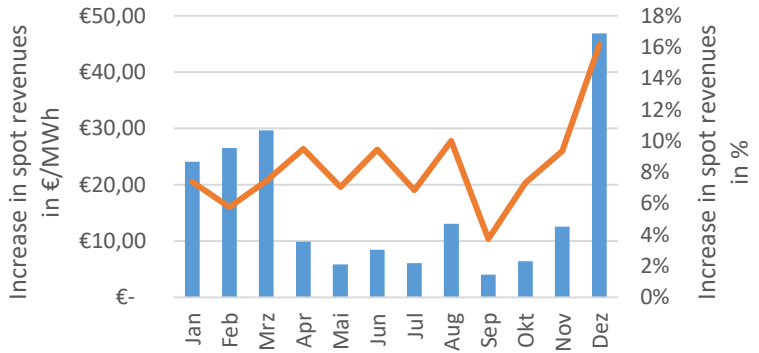
KPI: +8.3% spot-market revenue uplift (≈ €11/MWh) with the same amount of energy sold

How value is created

- Price signal → optimization → automated dispatch

Key value drivers

- Shift generation to high-price periods
- Reduce exposure to negative prices
- Constraint-aware scheduling (min/max, ramps, SOC/reservoir/heat)
- Reduced manual operation through remote dispatch & monitoring



Lessons learned & outlook

Lessons learned

- data first: reliable metering + availability signals are the main value driver
- constraints decide: realistic limits (min/max, ramps, storage/heat) make dispatch executable
- people & process matter: transparency, override, and clear responsibilities enable adoption

Outlook

- portfolio co-optimization: dispatch across assets + positions to maximize capture and reduce risk
- faster onboarding: standardized connectors + KPI reporting to accelerate rollout

Q&A

For a clean, safe, and independent energy future for all!

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Agenda

14:00	**Opening and Technical possibilities of flexible bioenergy technologies and systems** Markus Gölles, BEST – Bioenergy and Sustainable Technologies, Austria
14:15	**Electricity Markets, Tariffs and Supporting Schemes for Flexibility Provision – An Overview** Robert Gaugl, Institute of Electricity Economics and Energy Innovation, TU Graz, Austria
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15:15	**Interactive discussion of audience and presenters**

CyberGrid

Monetizing Bioenergy Asset‘s Flexibility on Balancing Markets

8th Central European Biomass Conference CEBC 2026

Graz, January 22nd, 2026

Christoph Gutschi, Head of Product

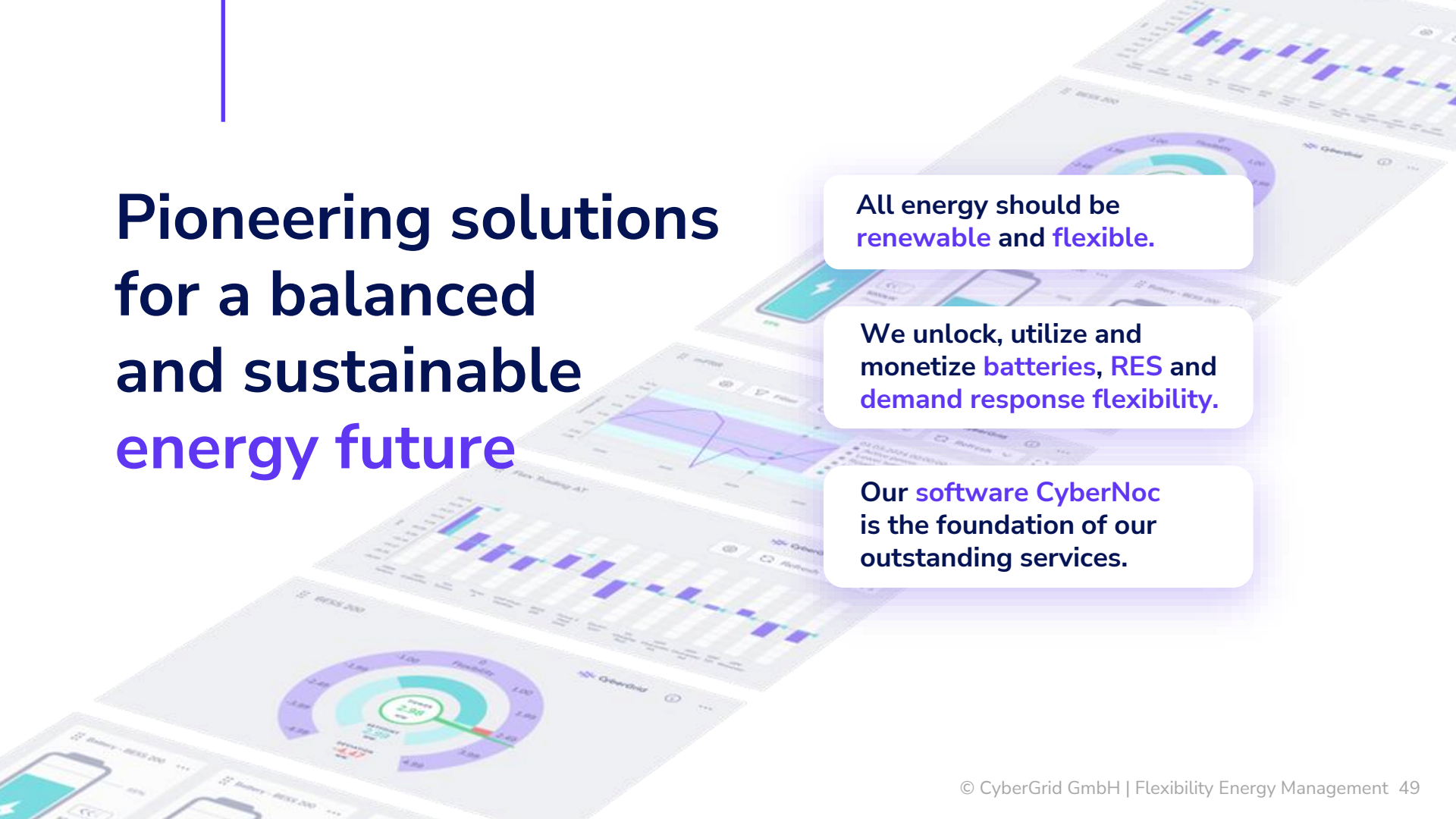
CyberGrid GmbH

Pioneering solutions for a balanced and sustainable energy future

All energy should be renewable and flexible.

We unlock, utilize and monetize batteries, RES and demand response flexibility.

Our software CyberNoc is the foundation of our outstanding services.



Power Exchange
TSO-markets

CyberNoc

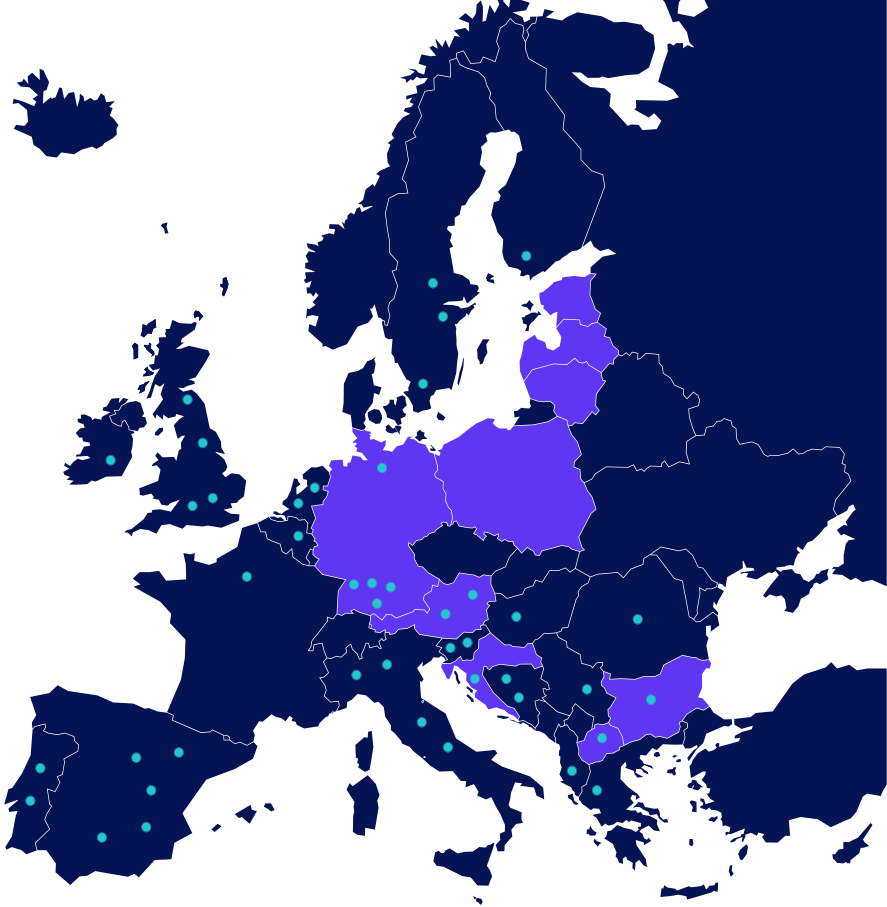
Service for industry

Flexibility Trading

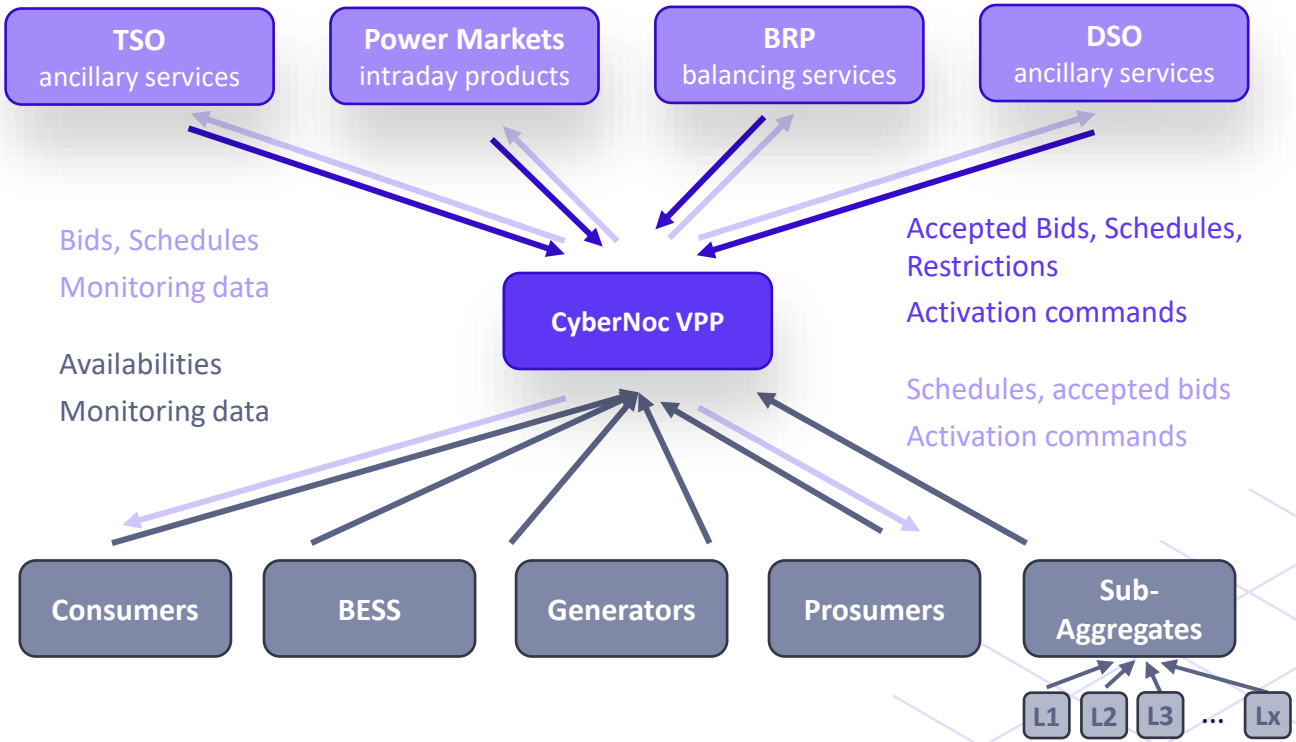
Service for utilities

Software as a Service

Flexibility Customers

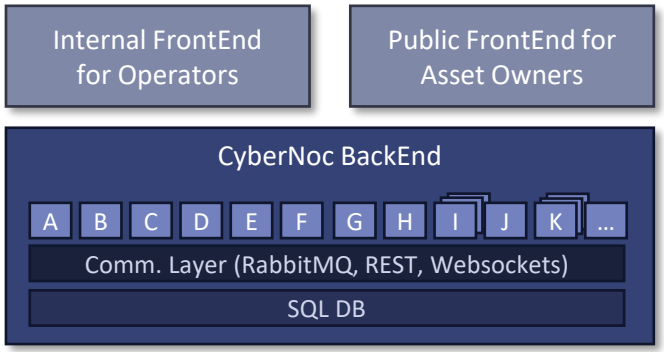


Virtual Power Plant Basics

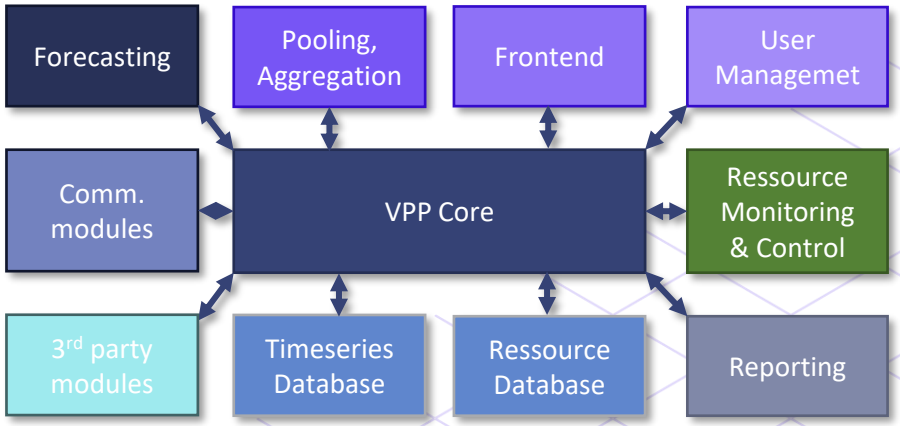


Modular Software Architecture

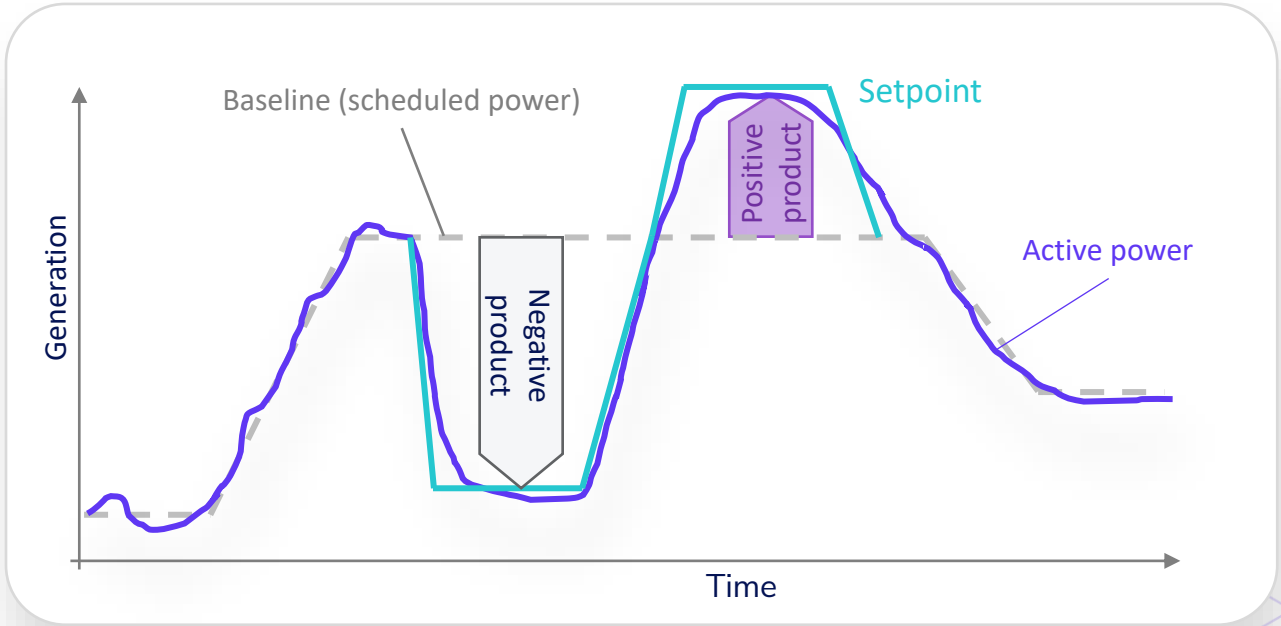
- cyberGRID's Virtual Power Plant has a modular design based on microservice architecture, simplifying upscaling and integration of 3rd party services and increasing performance.



Backend: Kubernetes based microservice architecture



What is Flexibility?

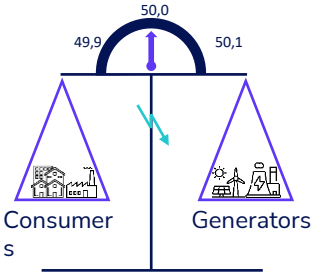


Requirements:

- Predictability
- Availability of power and energy
- Controllability
- Fast ramping
- Accurate control

Balancing Services Overview

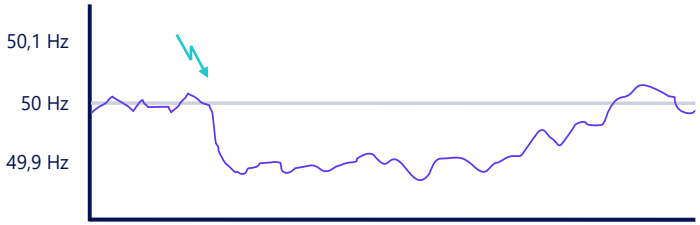
Balancing generation & consumption

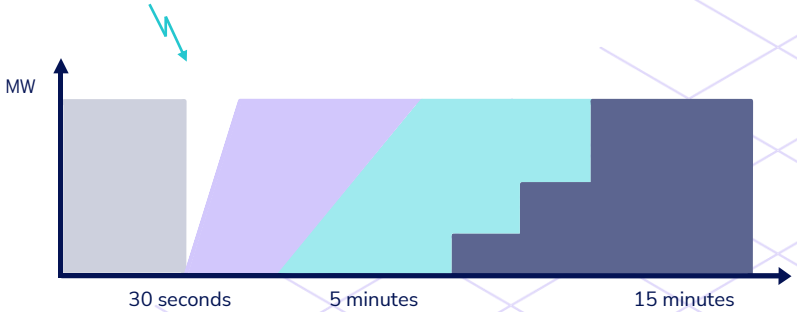


FCR

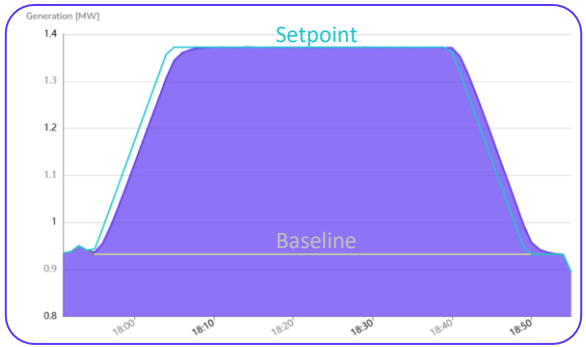
aFRR

mF RR

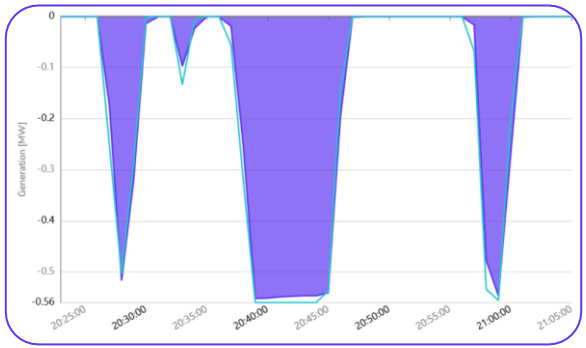




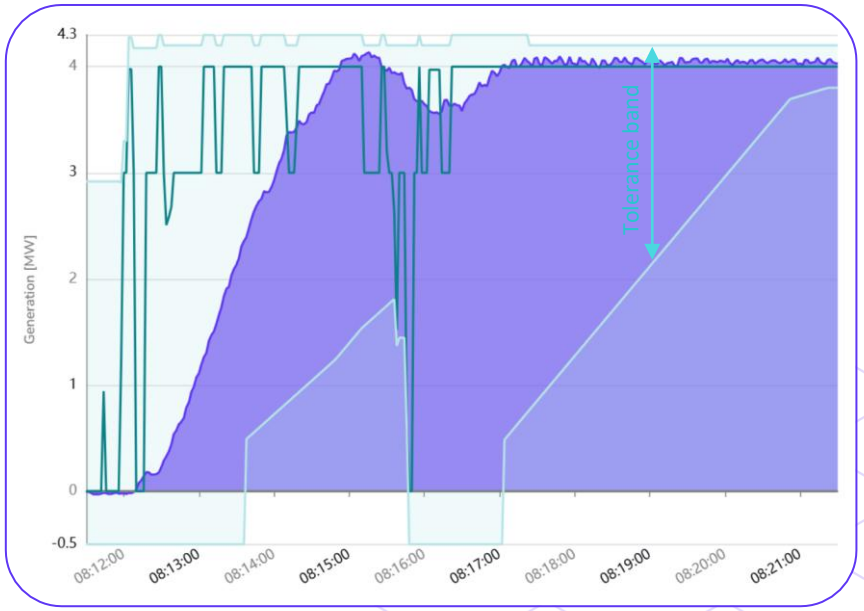
Flexibility Activation



mFRR+
(Hydro)



aFRR-
(P2H)



aFRR+ (Pool)

Your Asset placed on the right Market

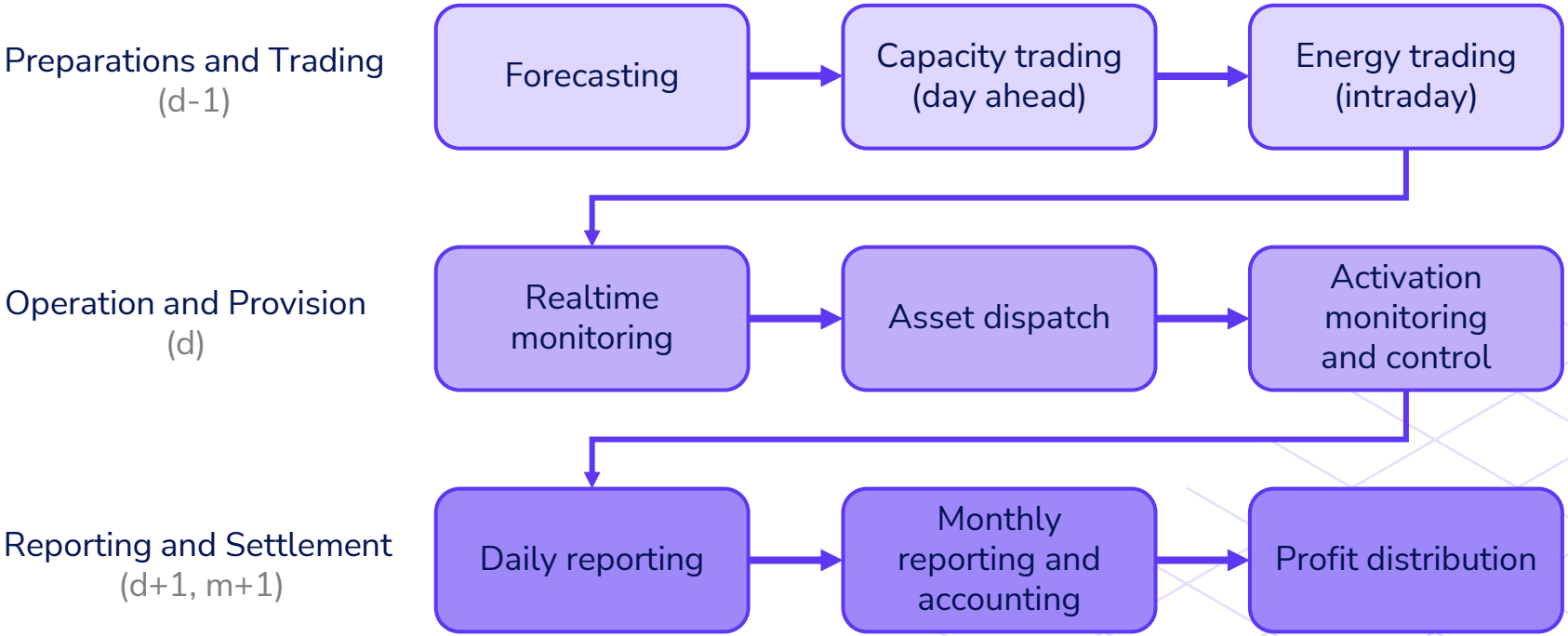
Example: Biomass CHP

- Medium reaction times (< 10 min)
- Good control behavior
- High availability, depending on heat load
- Technical limits typically depend on heat load
- Upward and downward controllability
- Markets: **mFRR+, mFRR-, (aFRR+, aFRR-),** (Intraday)

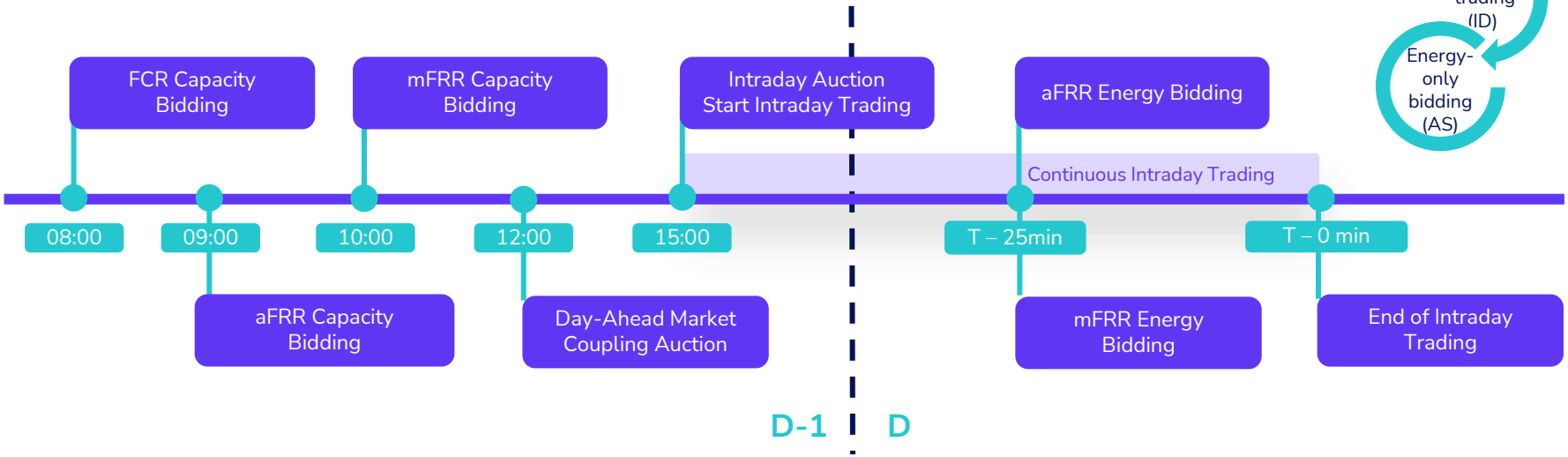
Example: Power-to-Heat

- Very fast reaction times (< 1 min)
- Very good control behavior
- Very high availability
- Static technical limits
- Limited usage in summer
- Markets: **aFRR-, mRR-, Intraday**

Flexibility Marketing Workflow



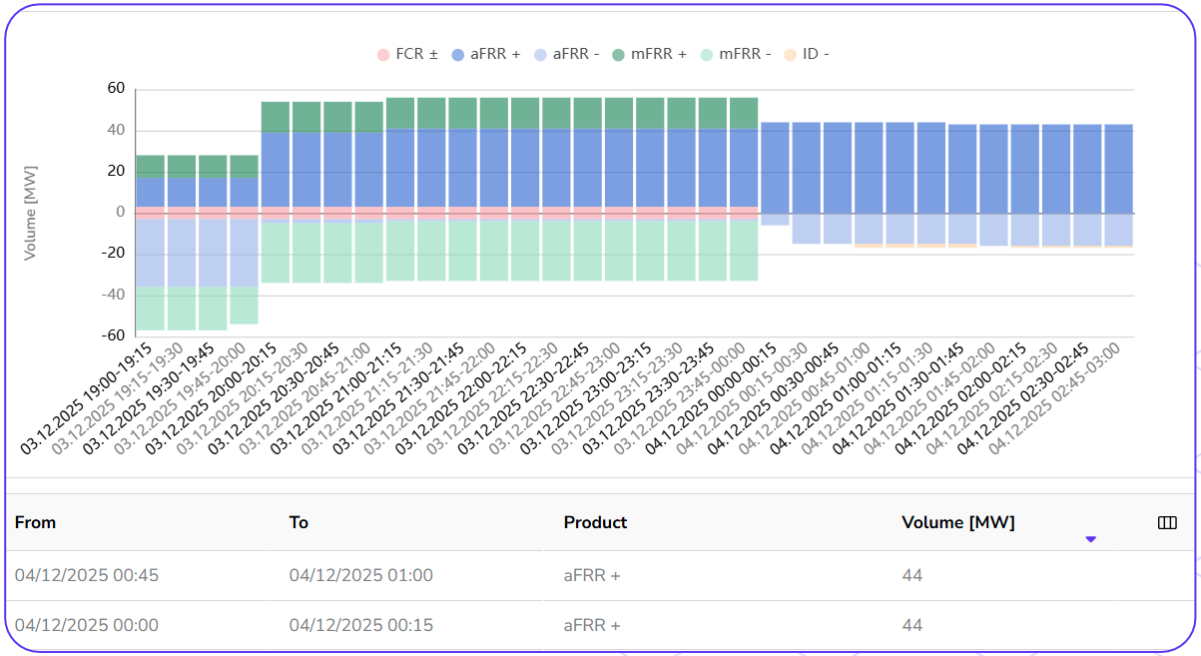
Multi-Marketing in a Nutshell



- Opportunity costs of subsequent markets need to be considered in seamless bidding strategies across the markets.
- Forecasts for market prices, activation probabilities, contribution margins and flexibilities.

Full Automation and Control of seamless Multi-marketing

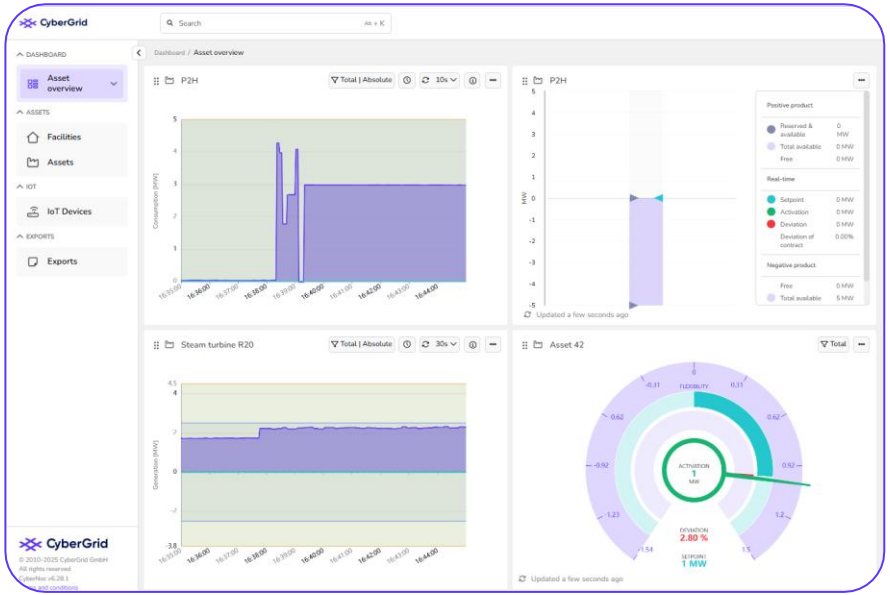
- Visualisation of value stacking for all multi-elastic-bids and markets in one view
- The whole 24/7 marketing is fully automated
- Possibility of manual interventions helps in the transition to full automation.

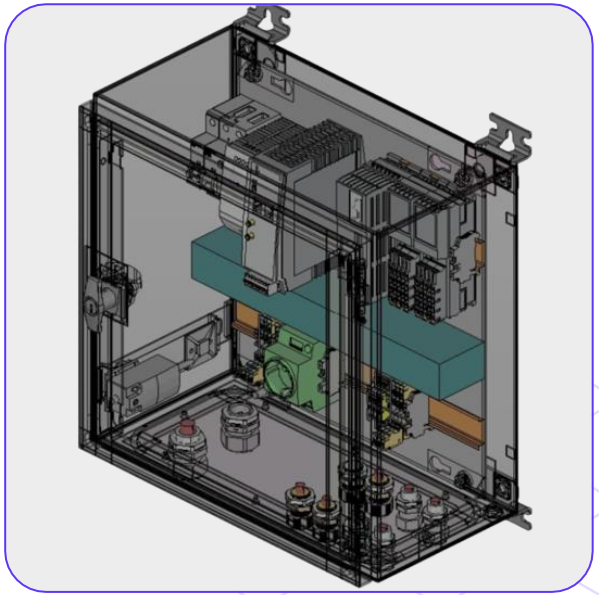


From	To	Product	Volume [MW]
04/12/2025 00:45	04/12/2025 01:00	aFRR +	44
04/12/2025 00:00	04/12/2025 00:15	aFRR +	44

CyberNoc snapshot of capacity and intraday bids

Integration of Assets

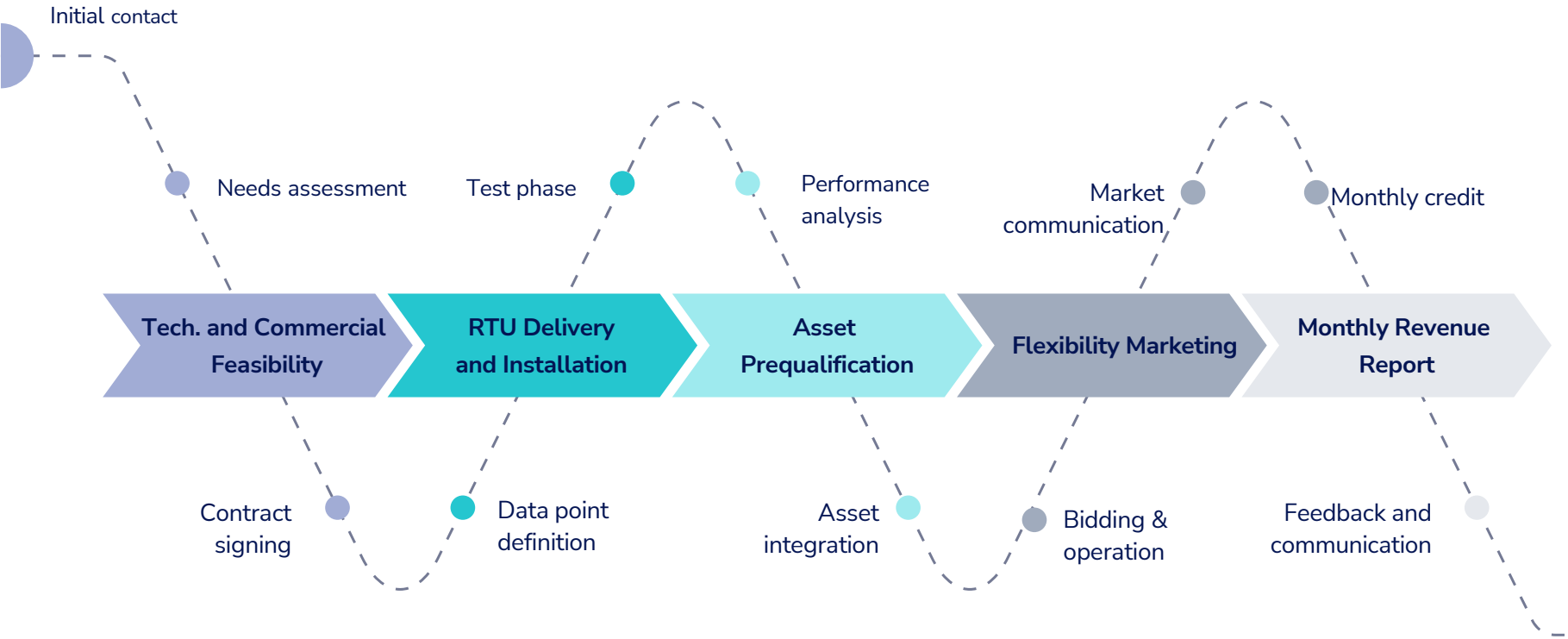




- Customer Portal for monitoring and data exchange
- Public APIs for automated data exchange

RTU for real-time control

Customer‘s Journey with an Aggregator



Thank you for yor kind Attention!

Get in touch

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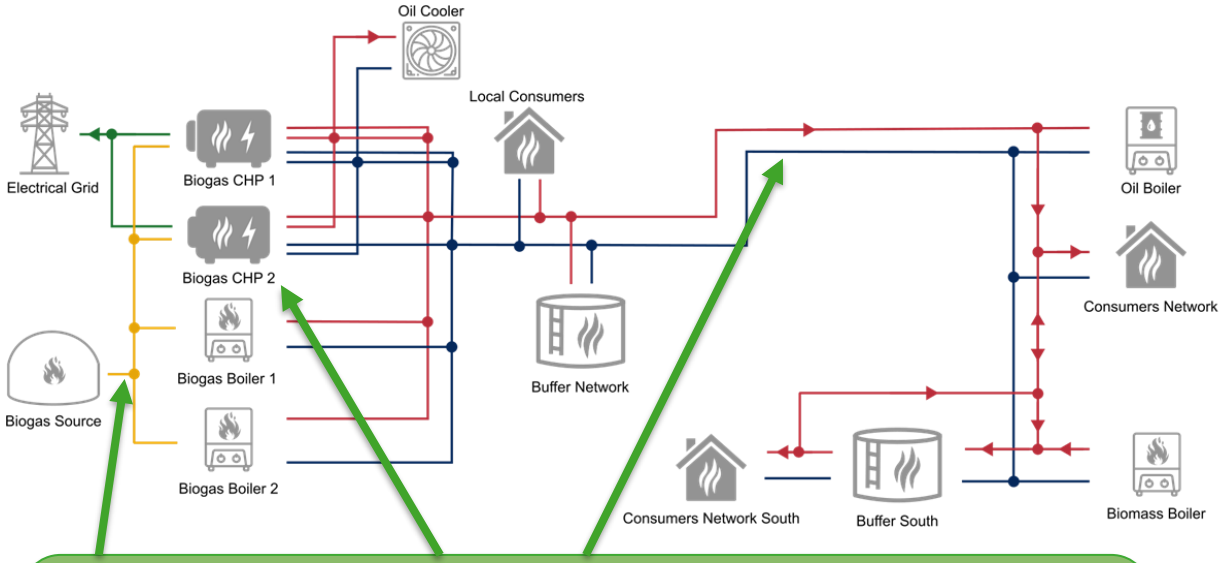
Questions / comments from the audience?

Practical example: district heating grid with distributed producers, storages and consumers



Flexibility provision requires targeted design

→ Investments: larger gas storage, 3rd Biogas CHP & high heat transport capacity between storages

Which possibilities should get pursued?

- What service / market?
- What is necessary for it?
- What must be installed?
- What needs to be changed in the current control system?
- Which interfaces are provided

A) Rule-based supervisory control

- No forecasts
- Scheduling of production units and transport between storages based on temperature levels

B) On-site optimizer available

- Considering forecasts
- Continuously optimizing (scheduling) all controllable assets
- Able to optimally consider time-varying tariffs and other decisions regarding different electricity markets

Interoperability

- **Provision of flexibility to electricity sector requires high degree of automation**
  - Interfaces need to be set up and implemented
    - Implementation of APIs
    - Definition of data points
    - …
  - Local controls need to be adjusted

- **How could we approach a higher degree of interoperability?**
  - Standard interfaces for the communication of different control levels
  - Linking subsidies / incentives to the provision of certain interfaces
  - …

Which other main barriers do you currently see for the flexibility provision to the electricity sector by decentral multi-energy systems?

Final statement of the presenters

Which key measures, technologies, solutions … are crucial to maximize flexibility provision to the electricity sector via decentral systems?

Please vote!

OR

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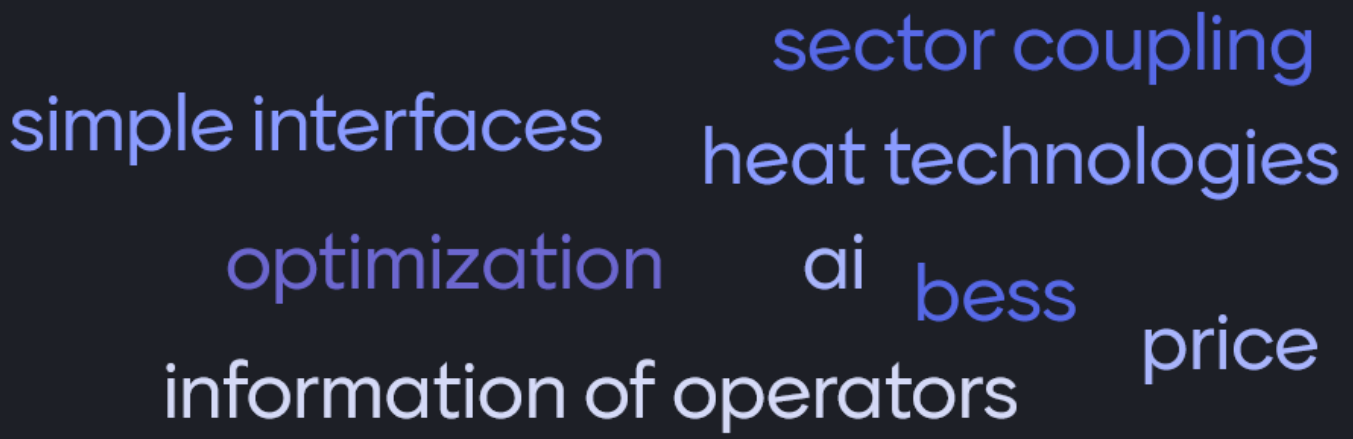
Mentimeter

What key measures, technologies, solutions, ... are crucial to maximize flexibility provision to the electricity sector through decentralized systems?



Parallel Session 13
Automated Control Systems for Flexibility Provision for the Heating and Electricity Sectors*

CEBC 2026, 22.01.2026

Chair: Markus Gölles, BEST, AUT

* Sessions organized by IEA Bioenergy
Task 44 Flexible Bioenergy and System Integration