



AEE INTEC

# AEE – Institute for Sustainable Technologies

Member of



austrian  
cooperative  
research

# Department “Industrial Systems” Key Topics and Methods

## Modeling & Numerical Optimization

### Digitalisation for Decarbonisation

System Modeling & Simulation

Machine Learning & Artificial  
Intelligence Applications

Digital Energy Twin

Innovative Methods & Software  
Tools

## Process & System Optimization

### Energy & Resource Efficiency

Advanced Energy Assessment

Optimised Sector Coupling

Optimised System Integration,  
Design and Operation (Pinch,  
Exergy)

Nexus Industry-Water-Energy-Waste

## Technology & System Assessment

### Emerging Process and Supply Systems

Solar Heat for Industrial Processes  
(SHIP)

Renewable Energy Systems: Solar  
Energy, Waste to Energy, Biomass,  
Biogas, Heat Pumps, Excess Heat,  
Storage

Hybrid Supply Systems & Hybrid  
Energy Vectors

Technologies for Circular Economy

## Sustainable Energy Solutions

# IT-framework for Digital Energy Twin/Shadow applications

DI Dr. Wolfgang Weiß  
Department “Industrial Systems”

The research leading to these results has received funding from the Austrian Climate and Energy Fund Programme Energy Research (e!MISSION) under FFG project no. 873599.



# Content

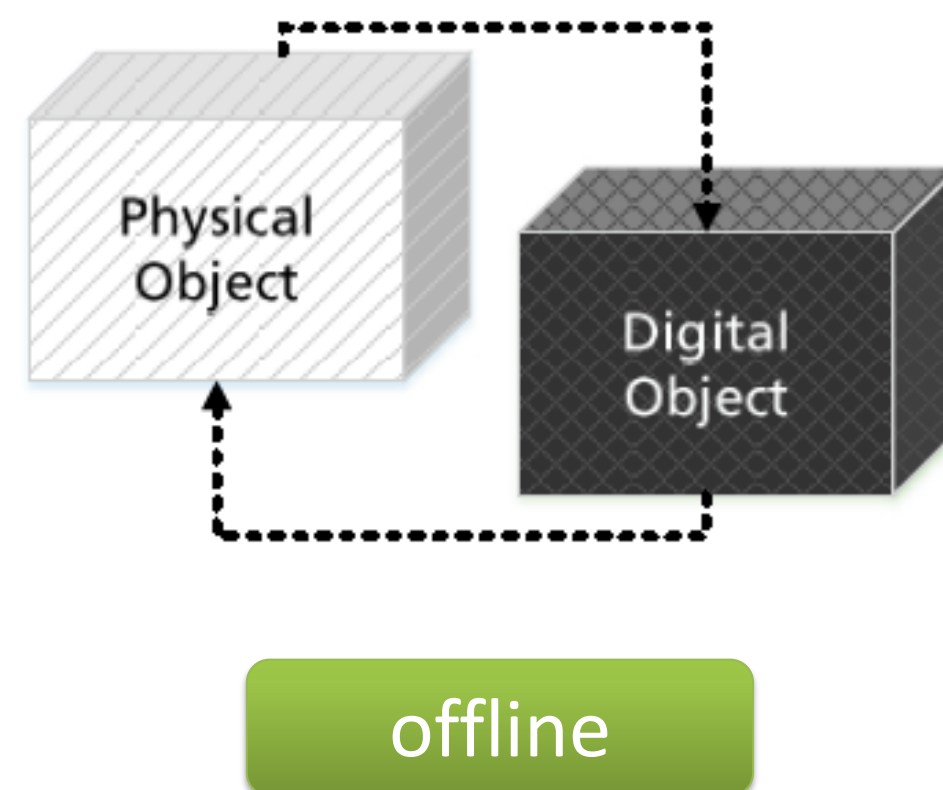
- Definition „Digital Twin“ and Goals
- Digital Energy Twin DET as a decision-making tool
- Digital Energy Twin DET for operational optimization
- DET implementation learnings
- Results and Outlook

# Digital Twin Definition:

## Differentiation by degree of data integration

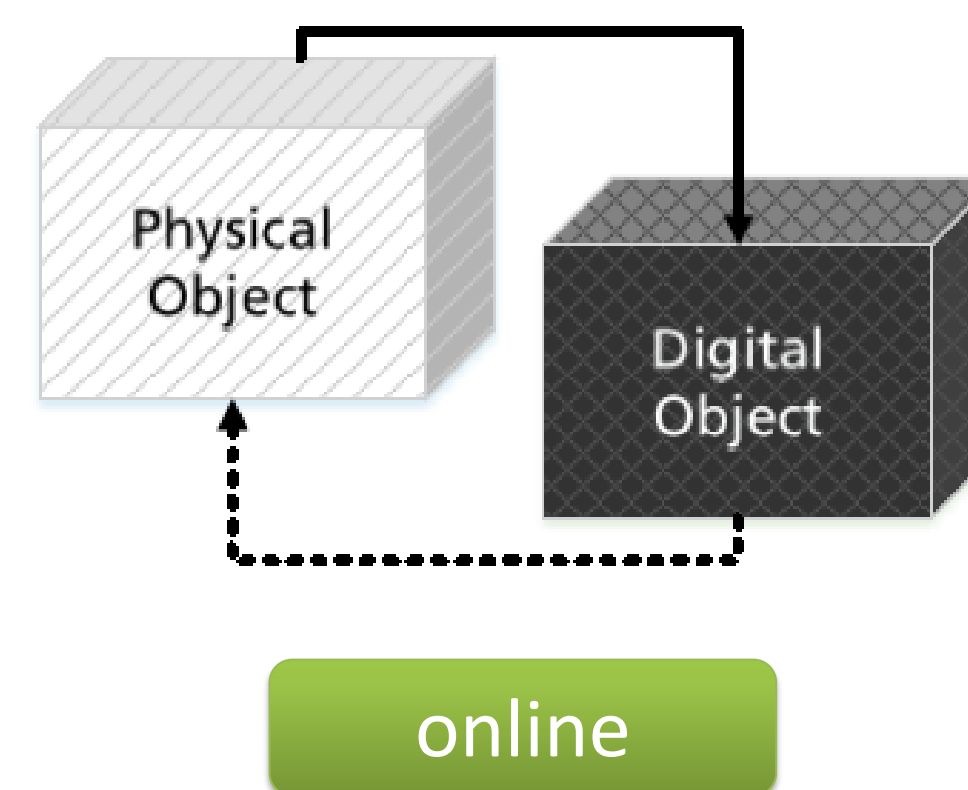
### Digital Model

Physical and virtual objects do not influence each other



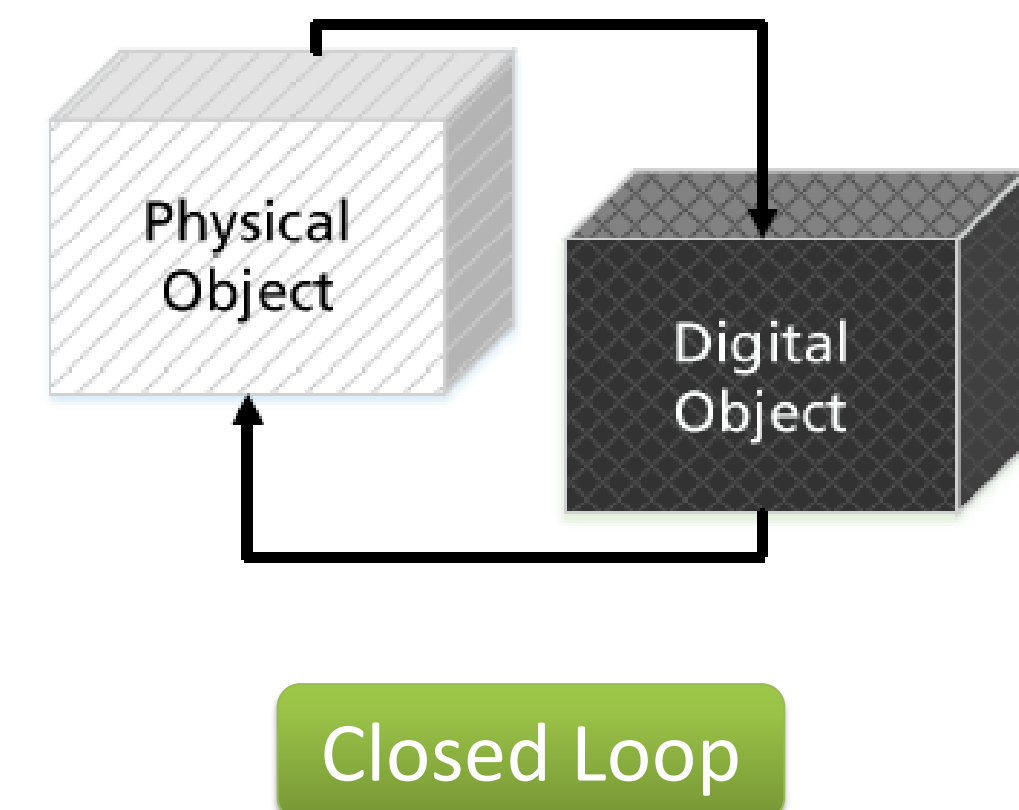
### Digital Shadow

Virtual object follows physical object



### Digital Twin

Physical and virtual objects influence each other



Quelle: Digital Twin manufacturing: A categorical literature review and classification, Kritzinger W. IFAC, 2018.

-----➔ Manual Data Flow  
 —————➔ Automatic Data Flow

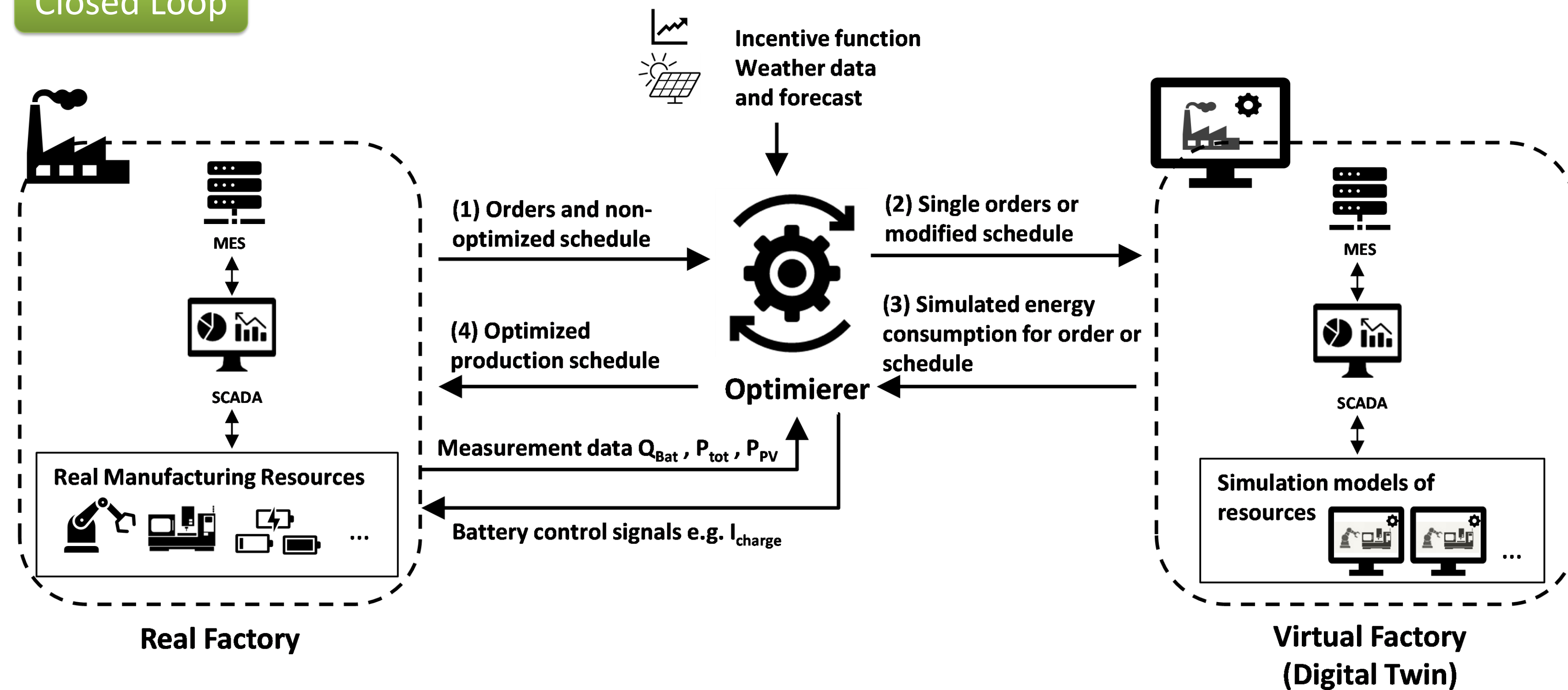
# Goals of the Digital Energy Twin

- Optimization of industrial energy systems
  - Decision-making tool for production planning
  - Operational optimization
  - Basis for design optimization
- Application in an industrially relevant environment
  - Modelling of complex supply systems
  - Standardization (FMU) and Simplification (MOR)
- Energy Manager 4.0 & E-Learning
  - Tool for scenario development of hybrid energy supply
  - Augmented and Virtual Reality (AR/VR)

# DET as a decision-making tool in production planning

- Usecase in the laboratory of the Vorarlberg University of Applied Sciences

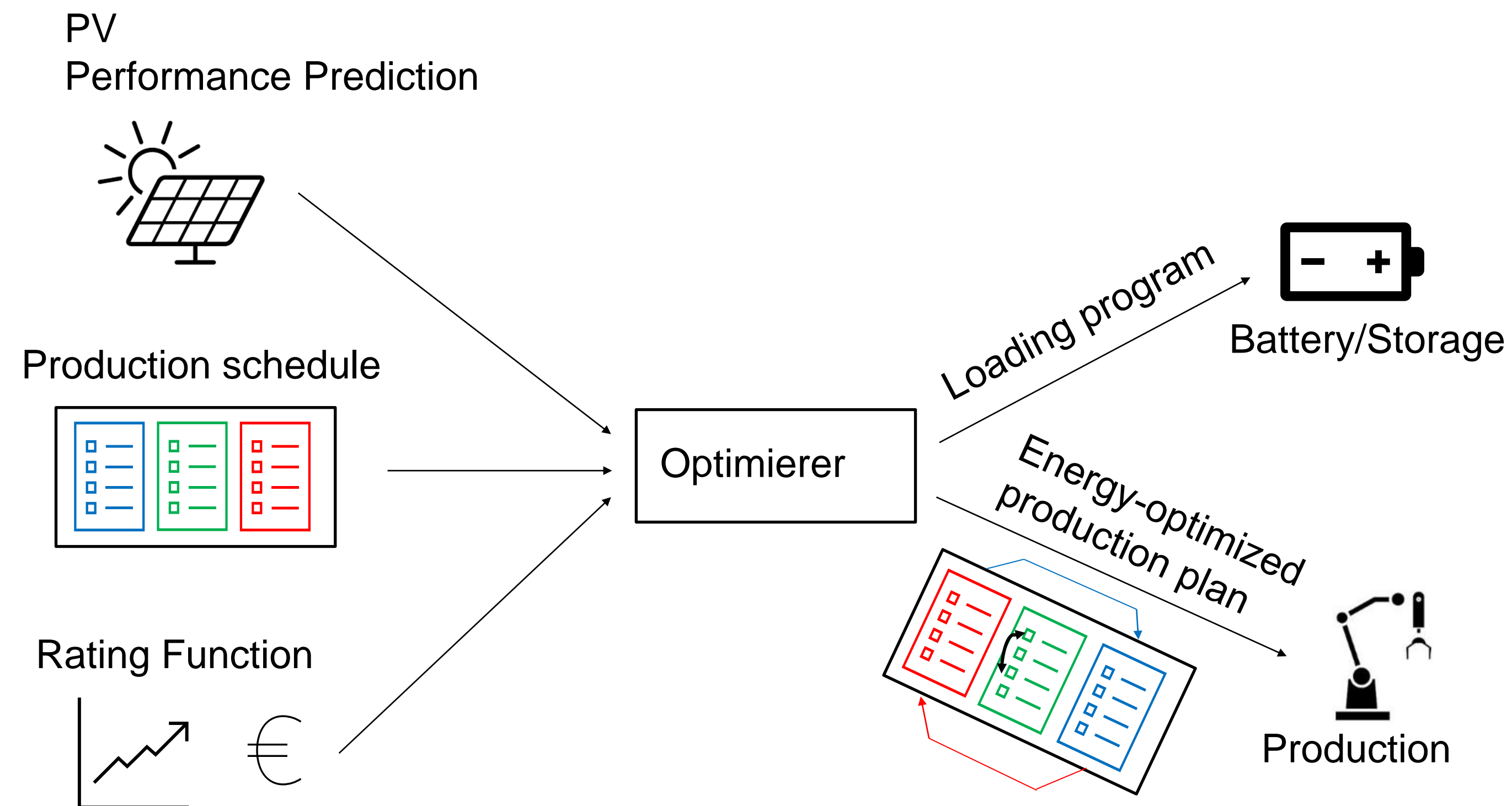
Closed Loop



Quelle: FH Vorarlberg: FZ Digital Factory & FZ Energy; Eberle Automatische Systeme

# DET as a decision-making tool in production planning

- Optimization of:  
Loading program | Production schedule

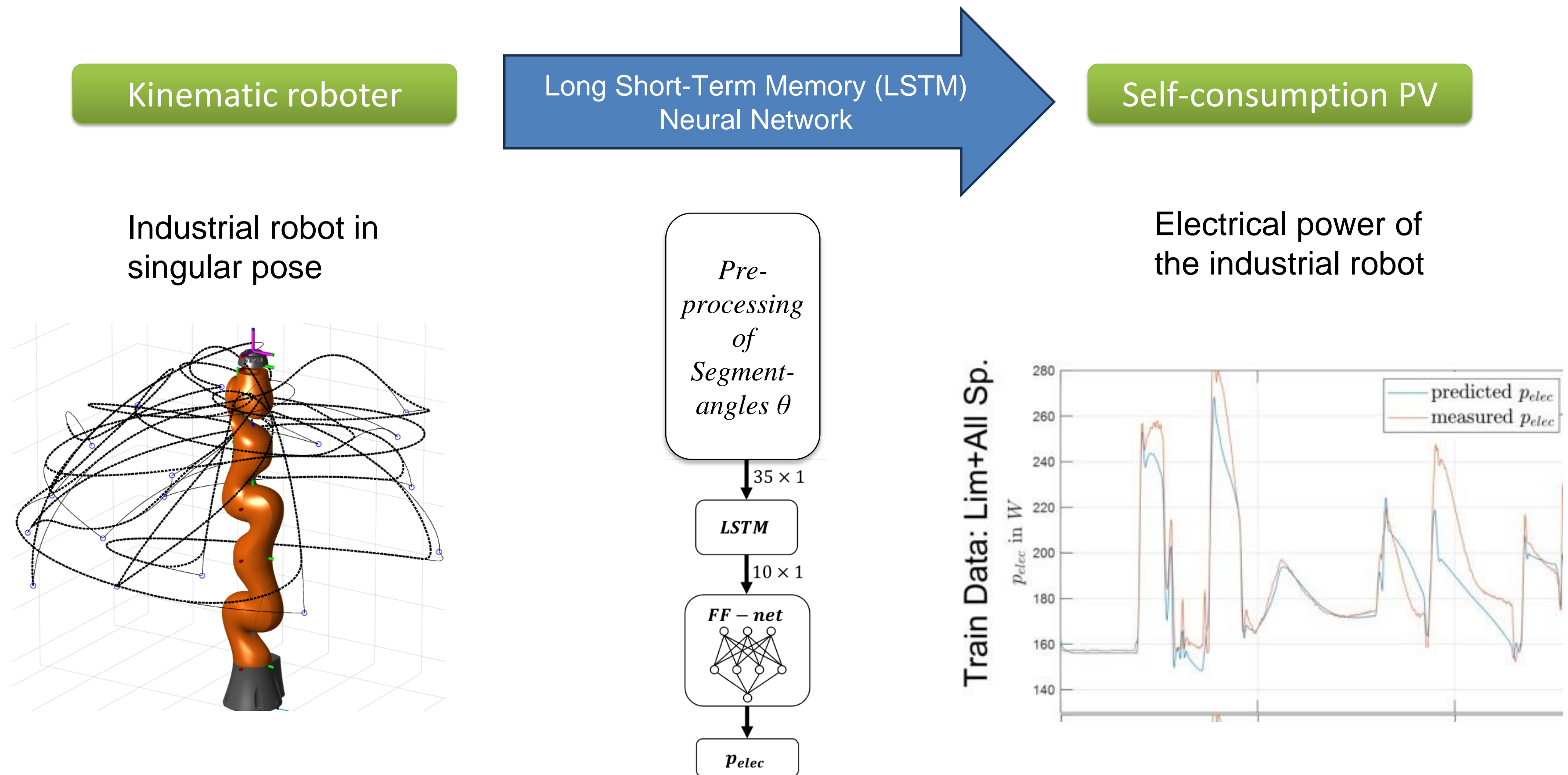


Quelle: FH Vorarlberg: FZ Digital Factory & FZ Energy; Eberle Automatische Systeme



# DET as a decision-making tool in production planning

## ■ Data-based modelling of processes

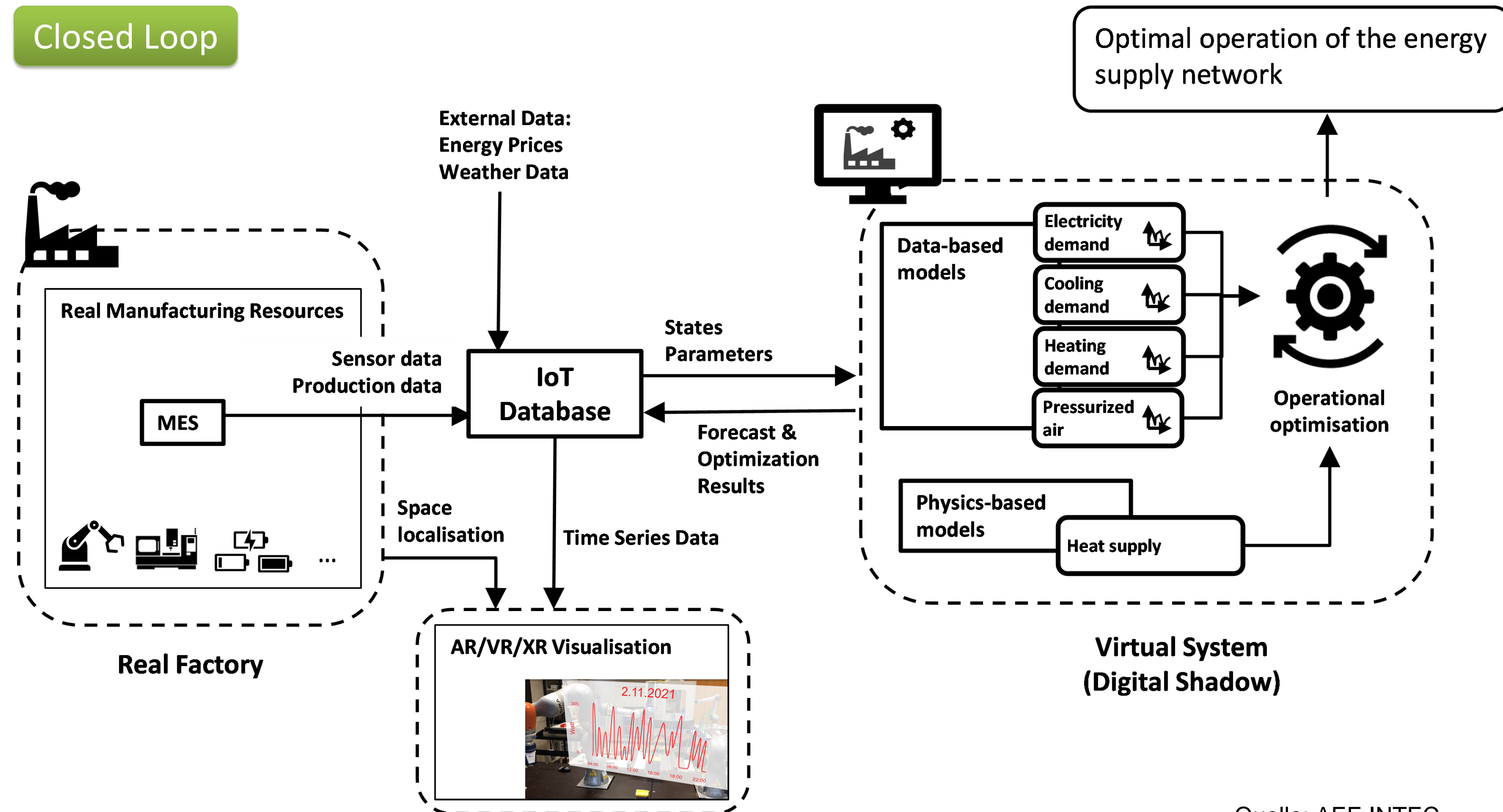


Quelle: FH Vorarlberg: FZ Digital Factory & FZ Energy

# DET for Operational Optimization

## ■ Use case of the energy supply AT&S

Closed Loop

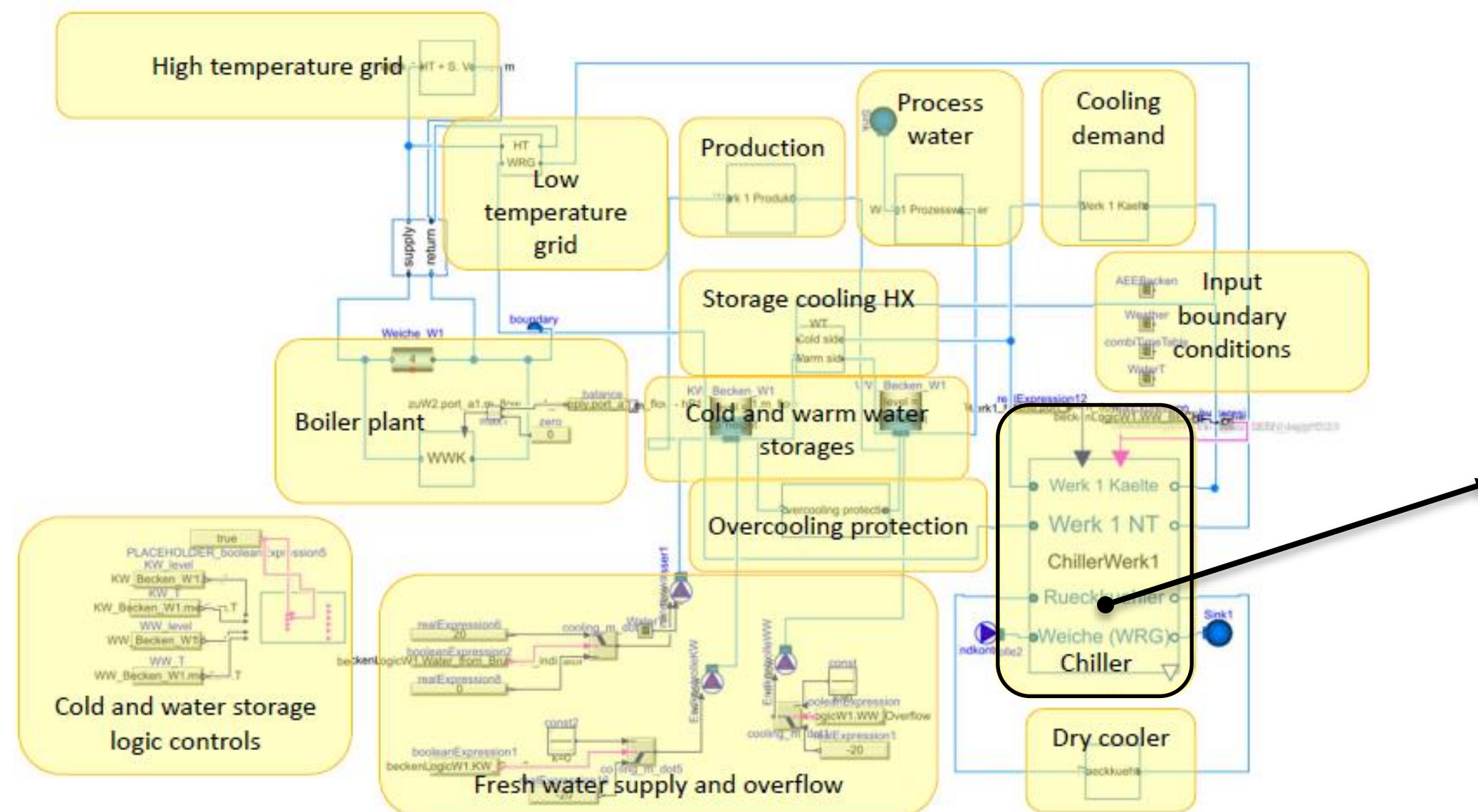


Quelle: AEE INTEC

# DET for Operational Optimization

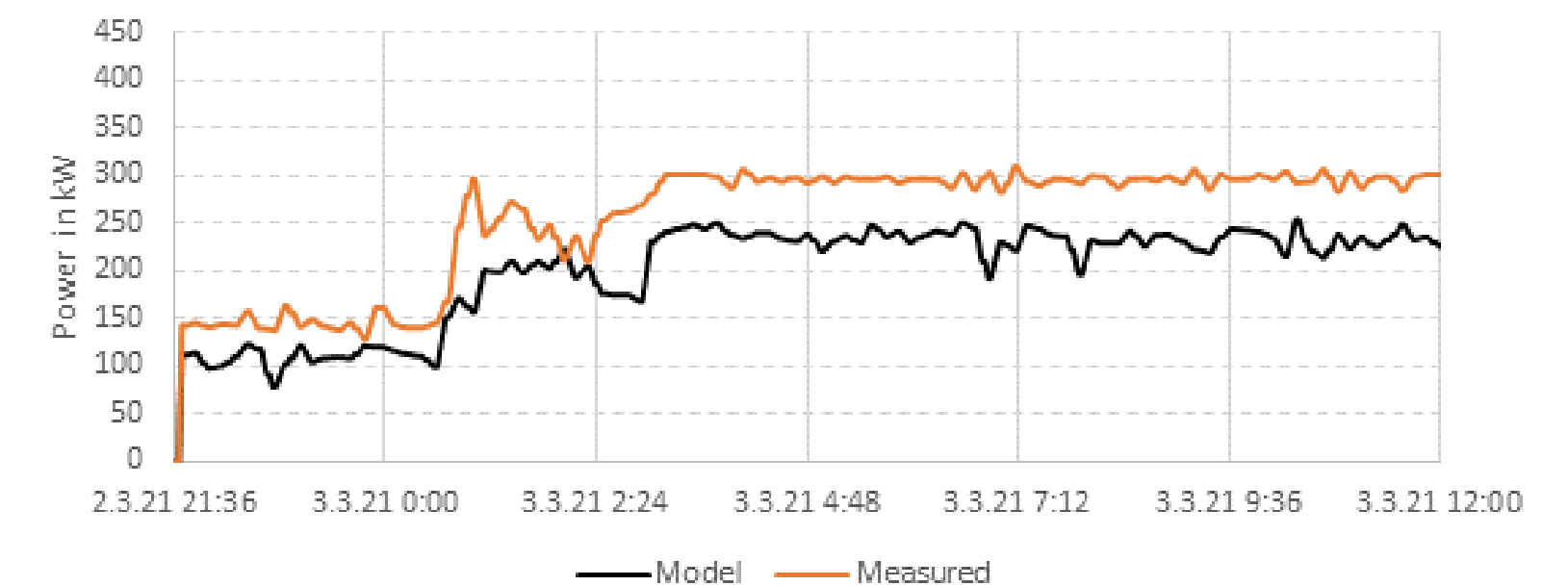
- Physically based model of heating and cooling supply at AT&S:

## Modeling by sub-systems



Heating and cooling supply units at AT&S

## Validation of the detailed model "Chiller"



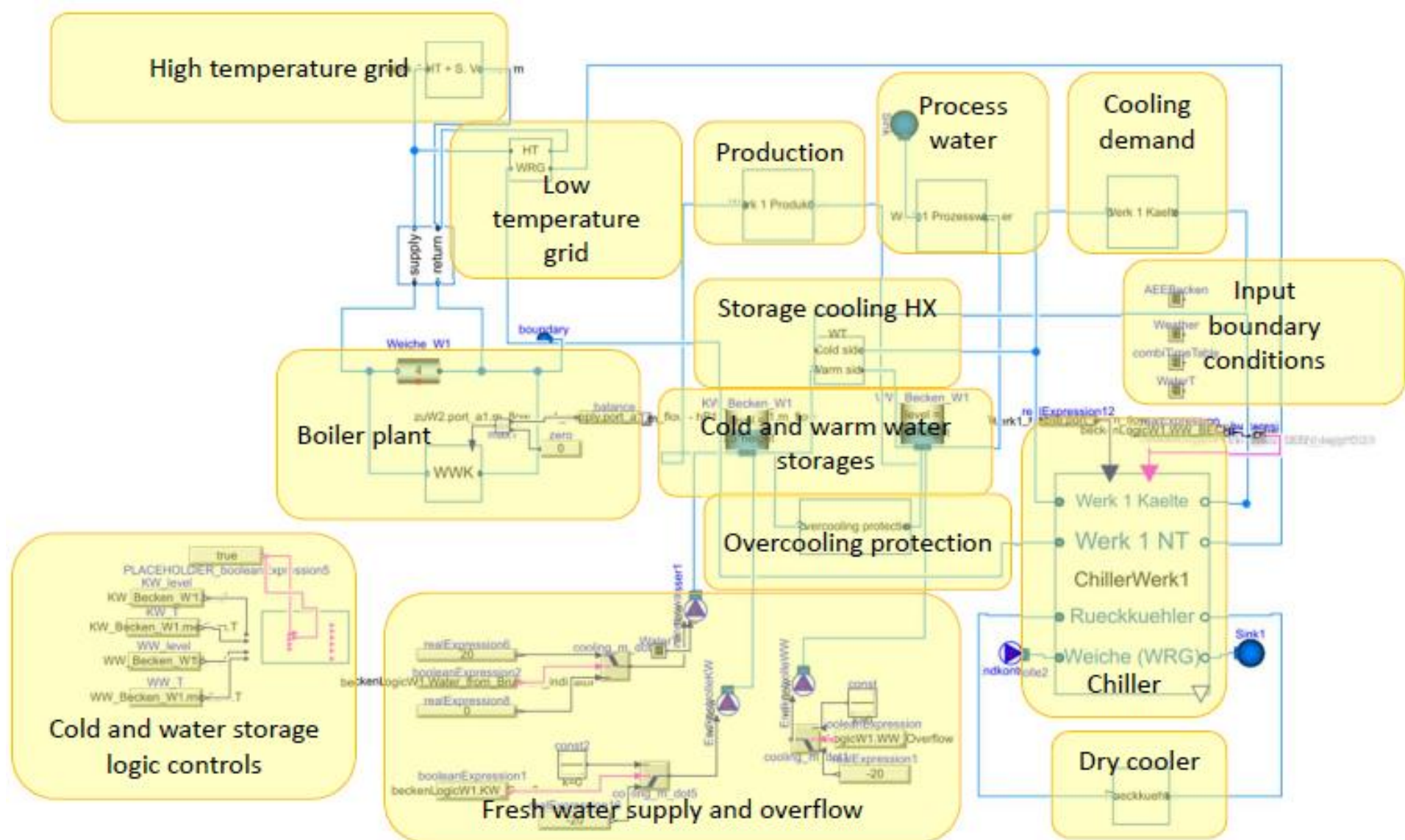
Comparison of simulation and measurement "Chiller"



# DET for Operational Optimization

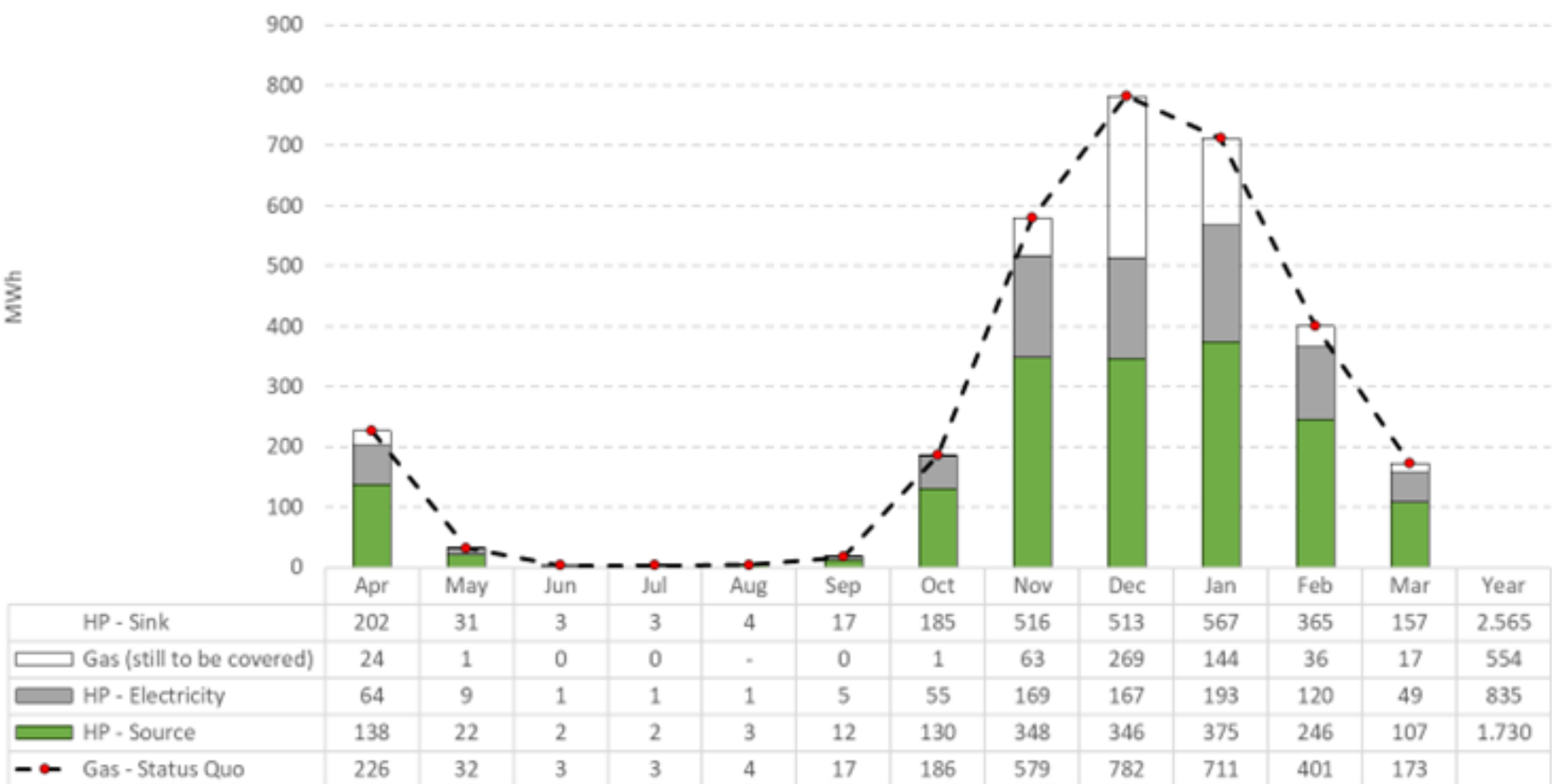
- Physically based model of heating and cooling supply at AT&S:

## Modeling by sub-systems



Heating and cooling supply units at AT&S

## Design optimization through simulation

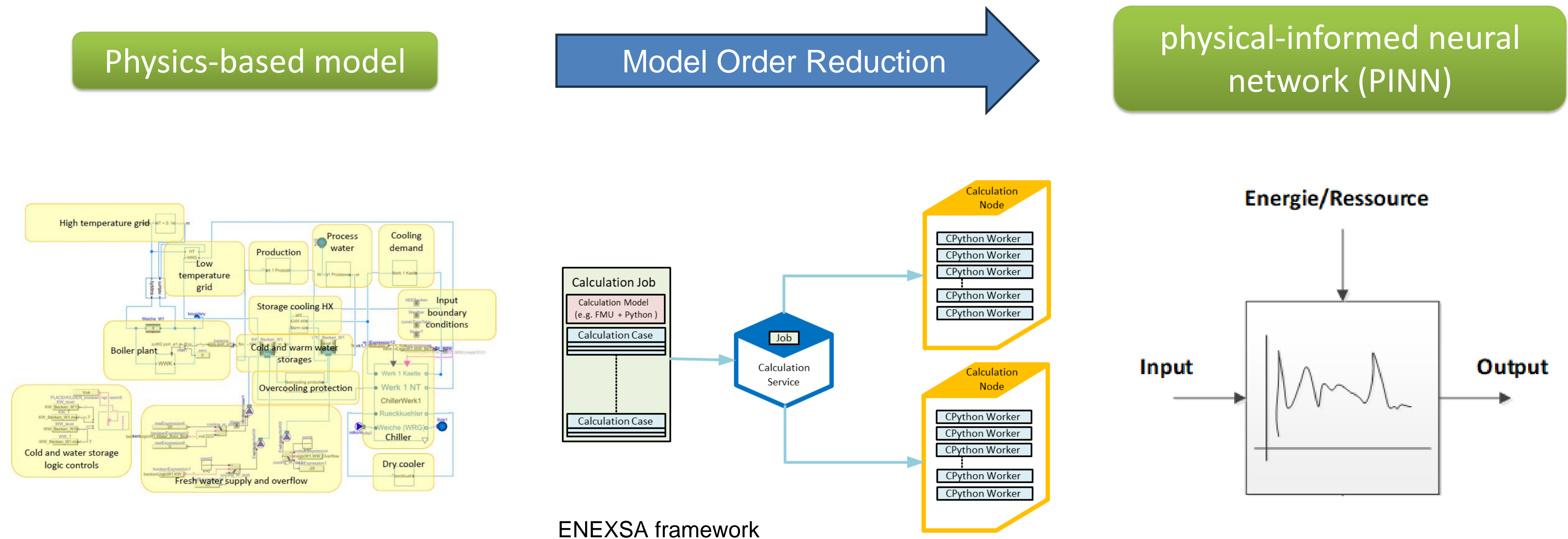


Use of water dumped out of the system as source for a heat pump



# DET for Operational Optimization

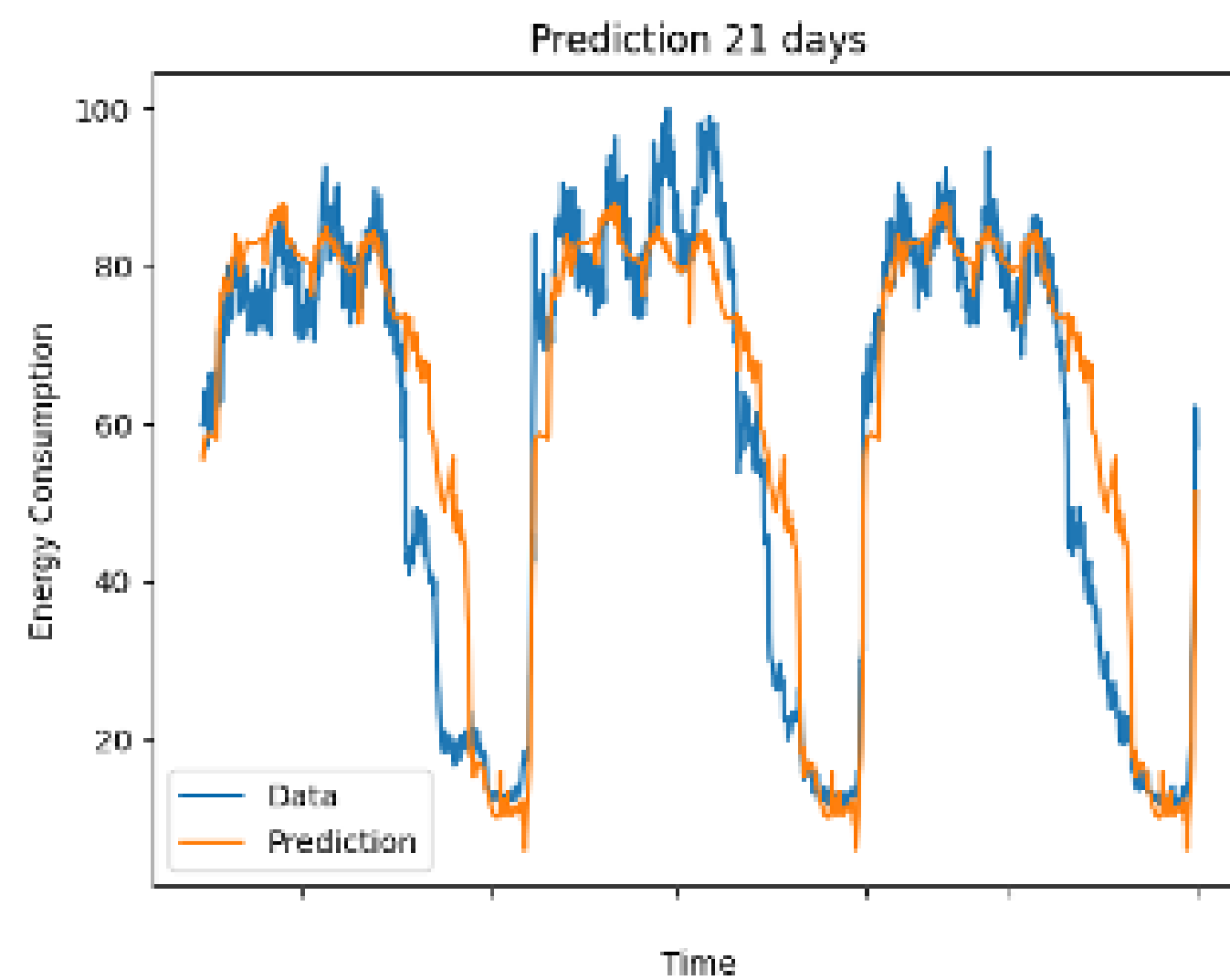
- **Accelerating computational time through Model Order Reduction (MOR)**
  - Transfer of physical relationships into a data model with reduced degrees of freedom



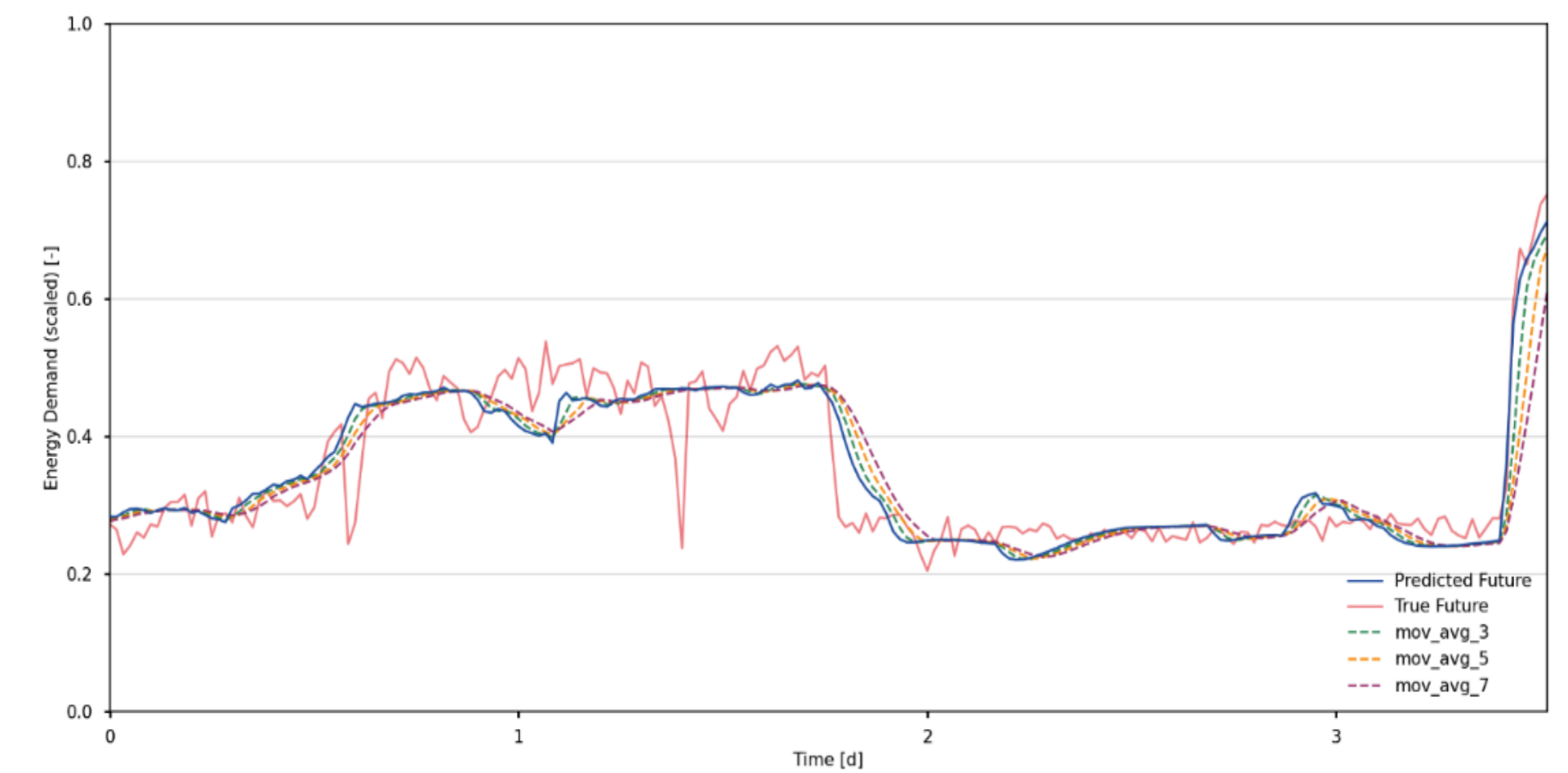
# DET for Operational Optimization

- Data driven modeling of overall energy demand

Top-level energy demand forecasting

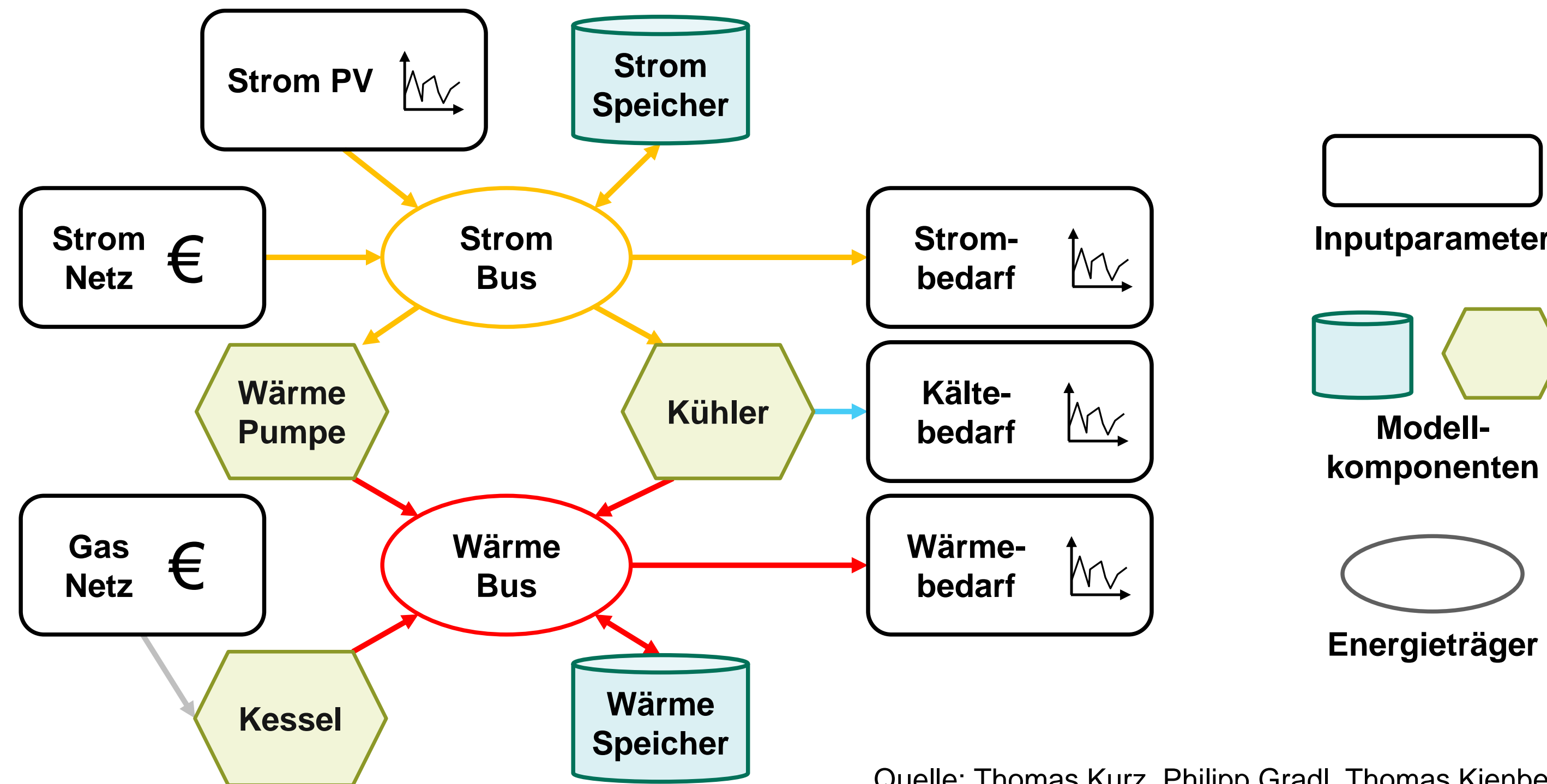


Forecasting on machine level



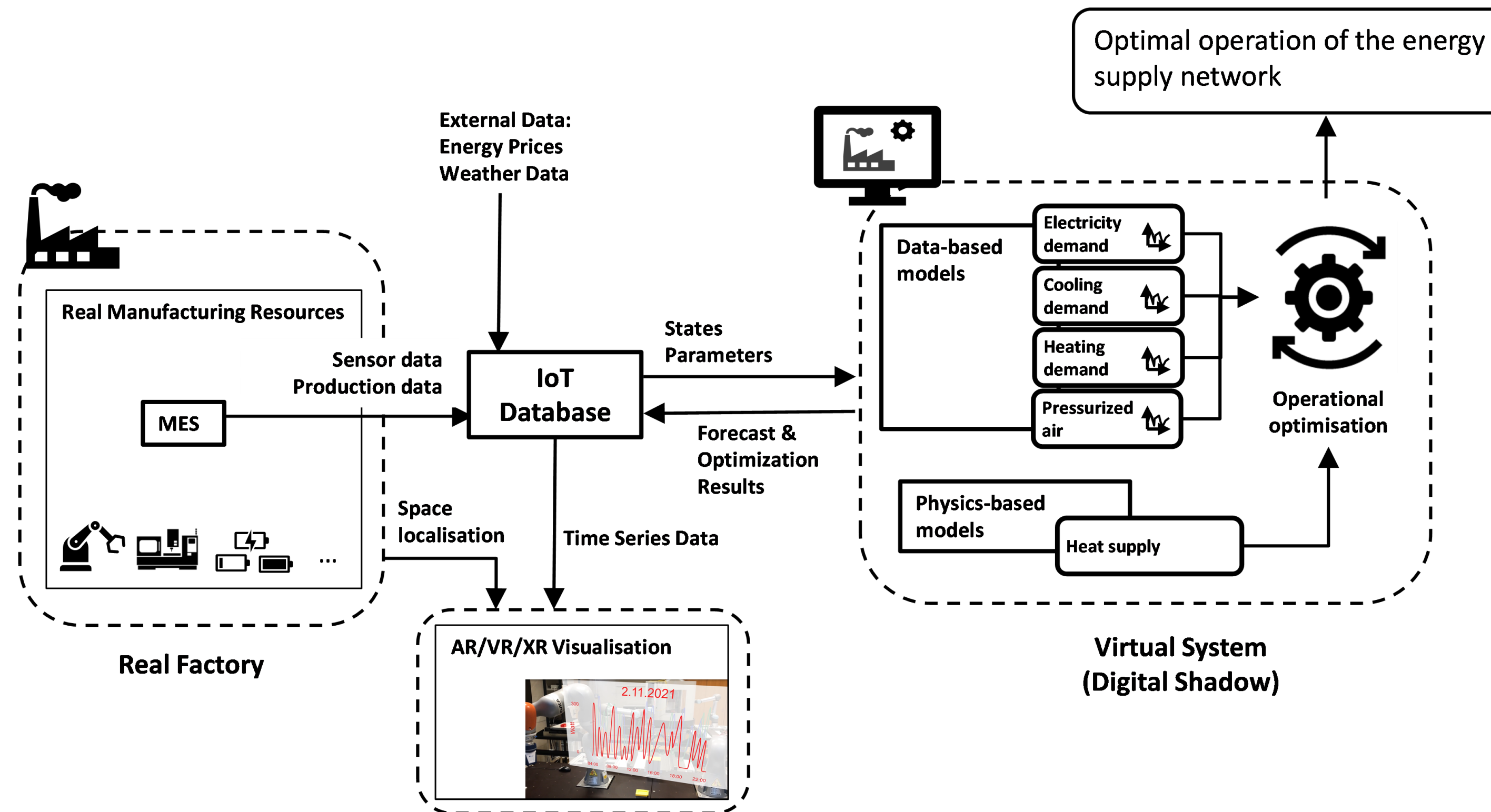
# DET for Operational Optimization

- **Operational Optimization Reference Model:**
  - Lowest costs to cover energy requirements



Quelle: Thomas Kurz, Philipp Gradl, Thomas Kienberger:  
*Linearisierung von komplexen industriellen Energiesystemen  
für die Betriebsoptimierung. IEWT2023.*

# DET implementation learnings



- The use of industrial standard is key
- Physics-based and data-driven modelling
- The availability and quality of the data is critic
- Highly integrated cloud data base
  - Data availability
  - Data understandability
  - Data access

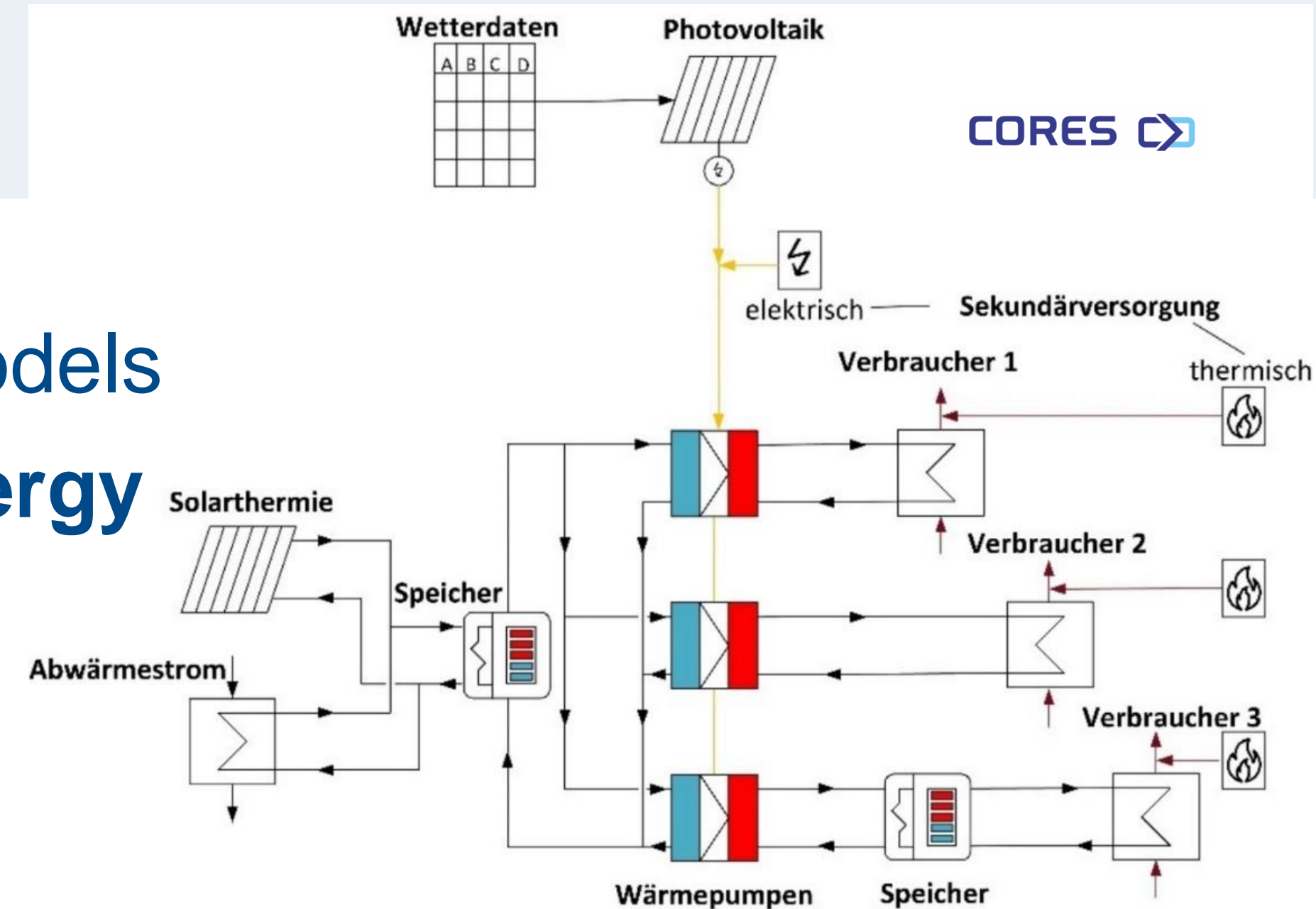
Quelle: AEE INTEC



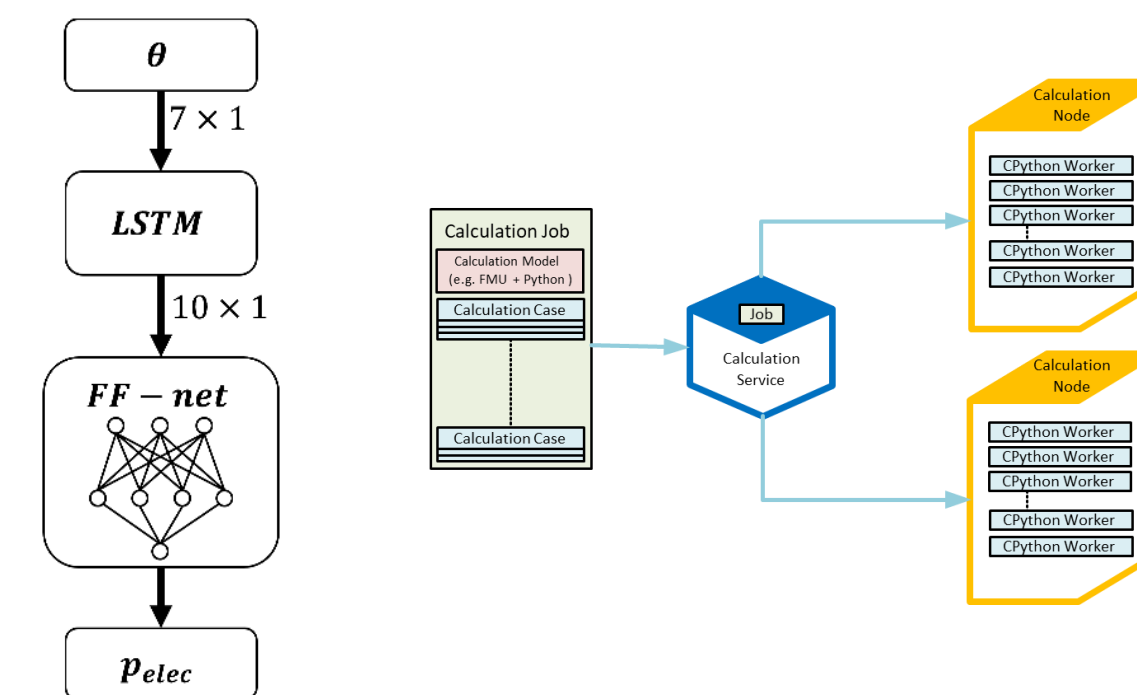
# Results

- Usecase Laboratory FH Vorarlberg
  - Reduction of energy costs by approx. ~10% in the laboratory setup
  - Consideration of a battery charge control AND an optimized production sequence
- Usecase AT&S
  - 25% reduction in fresh water demand through integration of free cooling
  - 20% reduction in gas consumption by using waste heat by means of a heat pump
- Concepts for the online simulation and optimization of energy supply systems were implemented

1. Flexible Simulation Models  
Design of Hybrid Energy Supplies
2. Integration of fast computational methods  
Optimization of industrial energy supply systems



Quelle: CORES - Integration kombinierter, erneuerbarer Energiesysteme in die Industrie







**AEE INTEC**

**IDEA TO ACTION**

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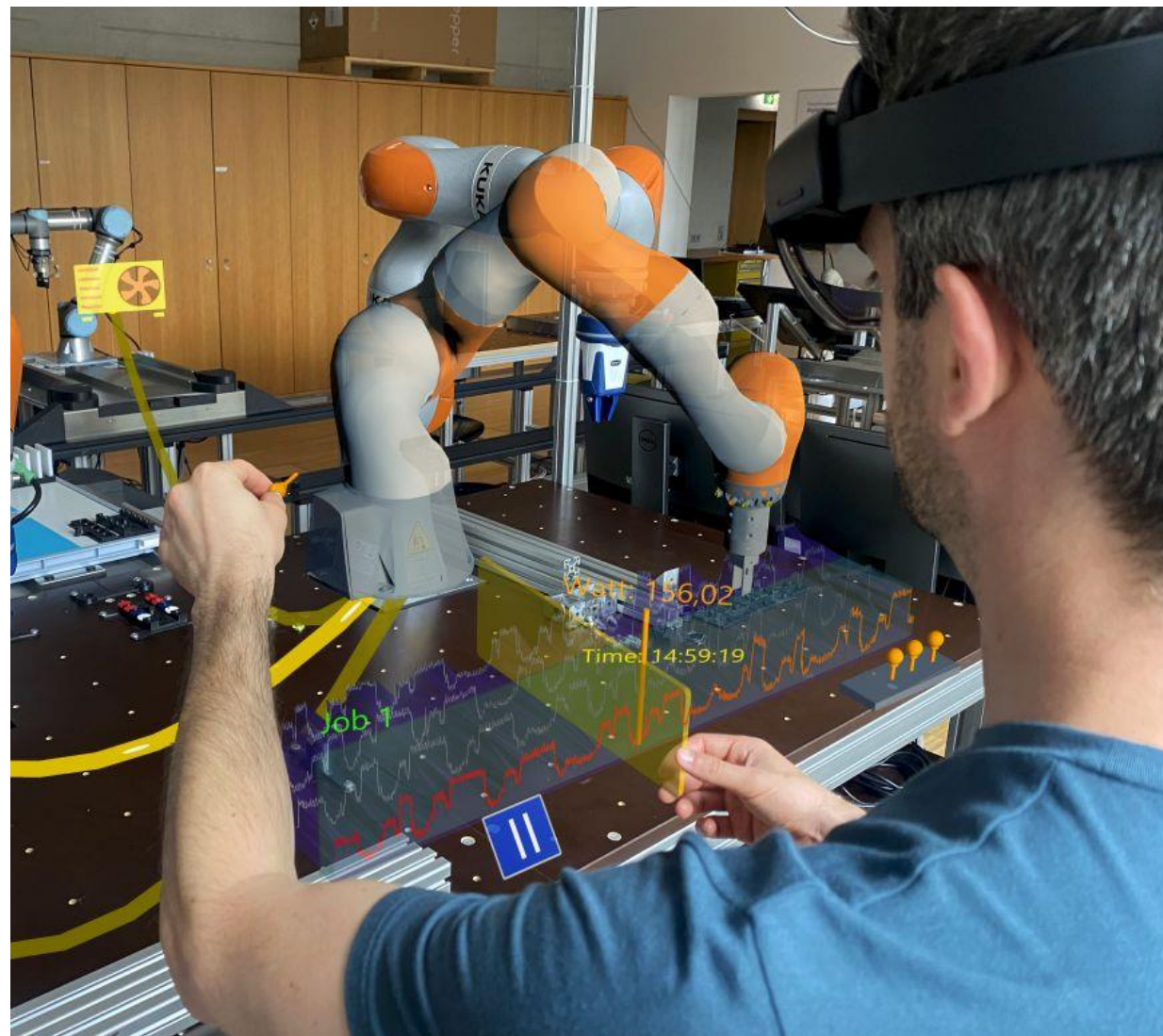




# Visualization using VR and AR

- **Visualization of (live) data at the point of origin**
  - High immersion through VR/AR/XR
  - Intuitive operation and information provision

Augmented Reality



Source: FH Vorarlberg

Virtual Reality



Source: AT&S