

Smart Industrial Concept!

Design- and Operational Optimization

Rene Hofmann
Scientific Coordinator SIC!



Worldwide changing energy system

Transformation of the energy supply in industrial systems



Challenges

- Diversification of energy production
- Load flexibilization/sanitization
- Volatility of renewable energy sources
- Consideration of the energy market

Energy-intensive industry – energy supply system

- **Optimal plant operation** → exploit full potential of industrial plants
- **Need for flexible designs** and predictive automation/control concepts

Digital Transformation of the Industrial Energy Supply

Cooperative Doctoral School: SIC!
[Smart Industrial Concept!]-

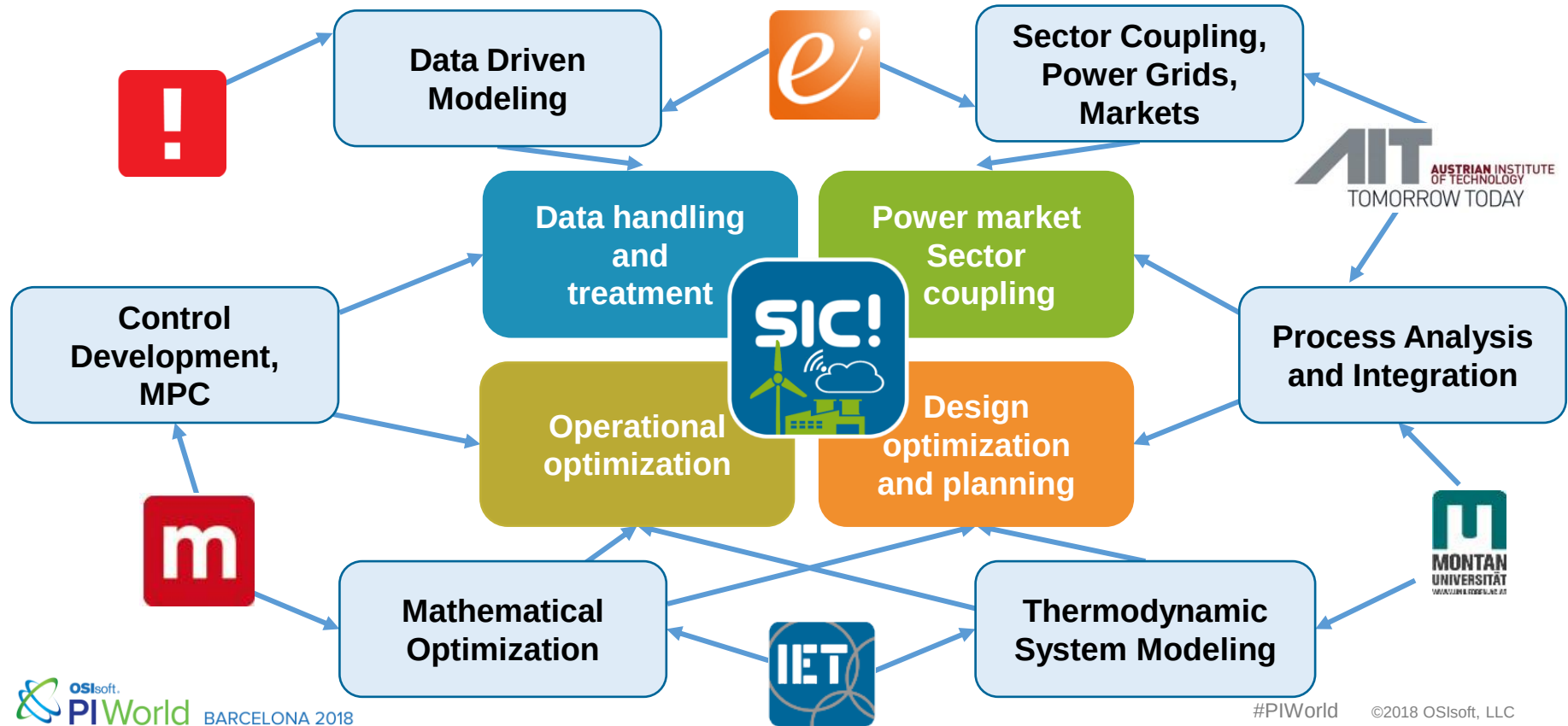
Holistic Approach with Digitalization of Industrial Processes and Applications for 2050 and beyond

SIC! in a Nutshell

- ✓ Added value through specific use of data
- ✓ Development of methods for energy-optimized operation of industrial plants
- ✓ Optimum system design for future environment
- ✓ Consideration of mutual interaction industry ↔ energy networks



Research Competences



SIC! [Smart Industrial Concept] <https://sic.tuwien.ac.at>

Data handling and
treatment

PhD#1



Design optimization and
planning

PhD#4



Power market sector
coupling

PhD#6



Operational optimization

PhD#3



PhD#2



PhD#8



PhD#7

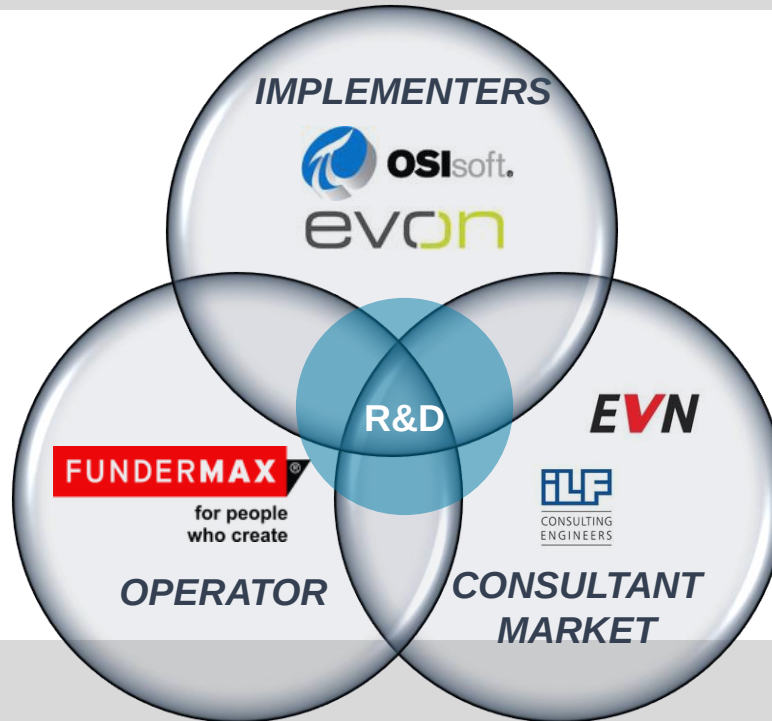


PhD#5



SIC! united and well balanced approach

Experienced industrial partners...



TECHNISCHE
UNIVERSITÄT
WIEN



AUSTRIAN INSTITUTE
OF TECHNOLOGY
TOMORROW TODAY



...supported by scientific excellence

DEMO

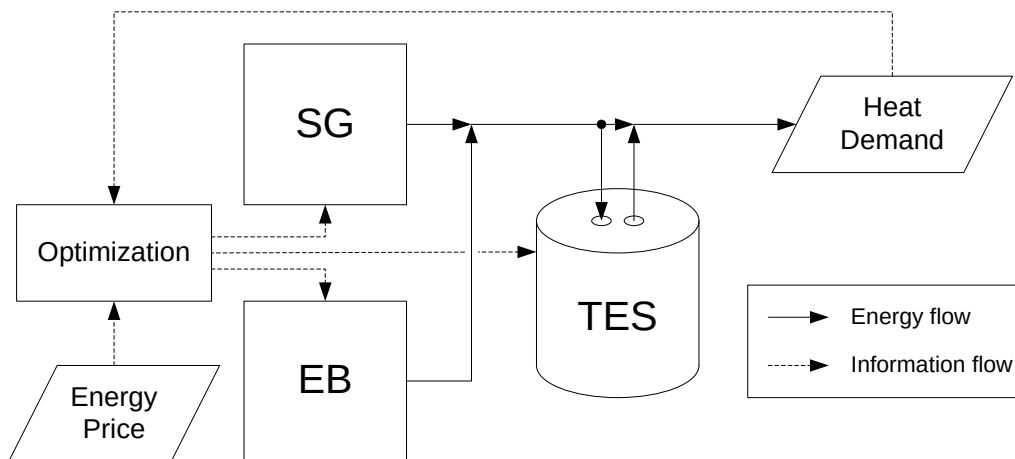
Industrial Flexibilization Concept – Storage Integration



Operational optimization

PhD#3: Operational optimization concepts with integration of storage systems for load flexibilization in the energy-intensive industry

PhD#5: Development of methods to optimally control the supply of energy-intensive industrial processes by integrating waste heat and using components to increase load flexibility



SG: Steam Generator

EB: Electrode Boiler

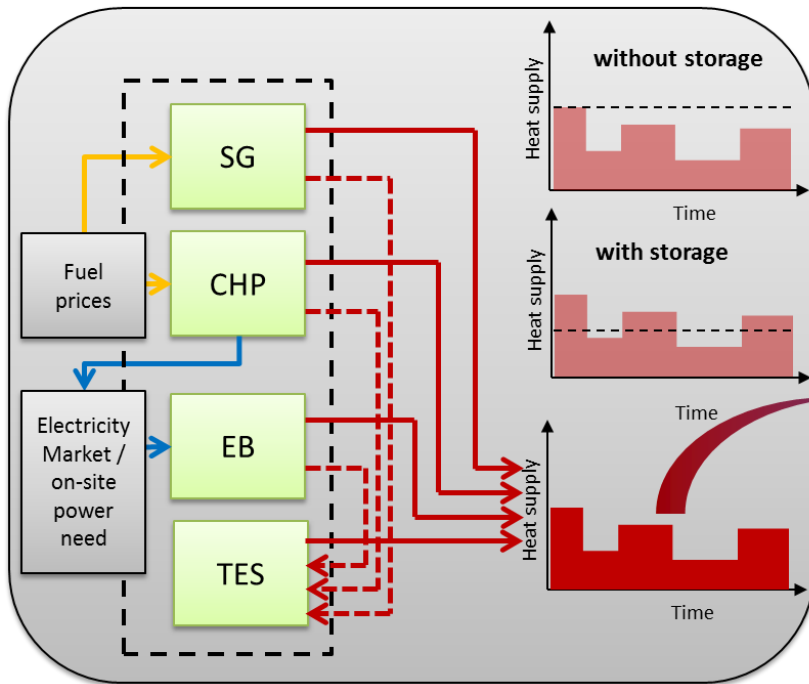
TES: Thermal Energy Storage



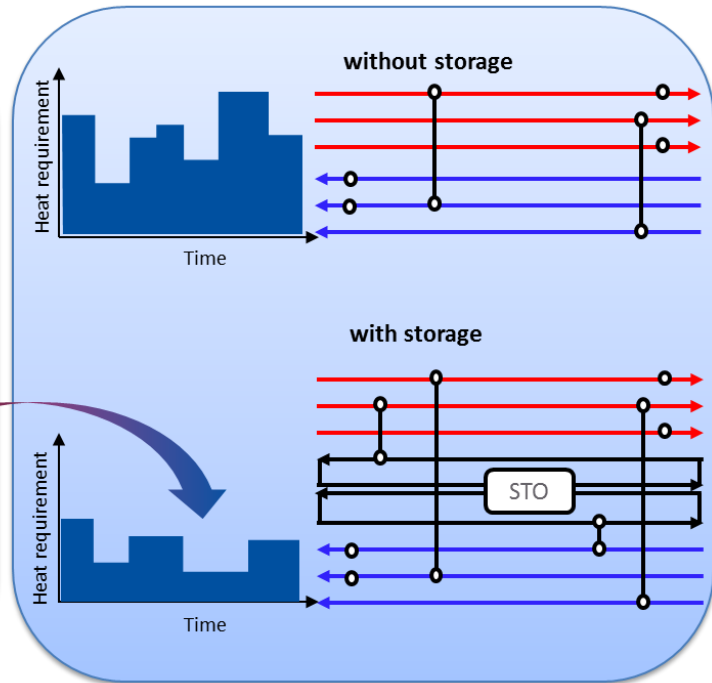
Operational
optimization

Intelligent Design/Operational Optimization

Energy Supply System



Industrial Process



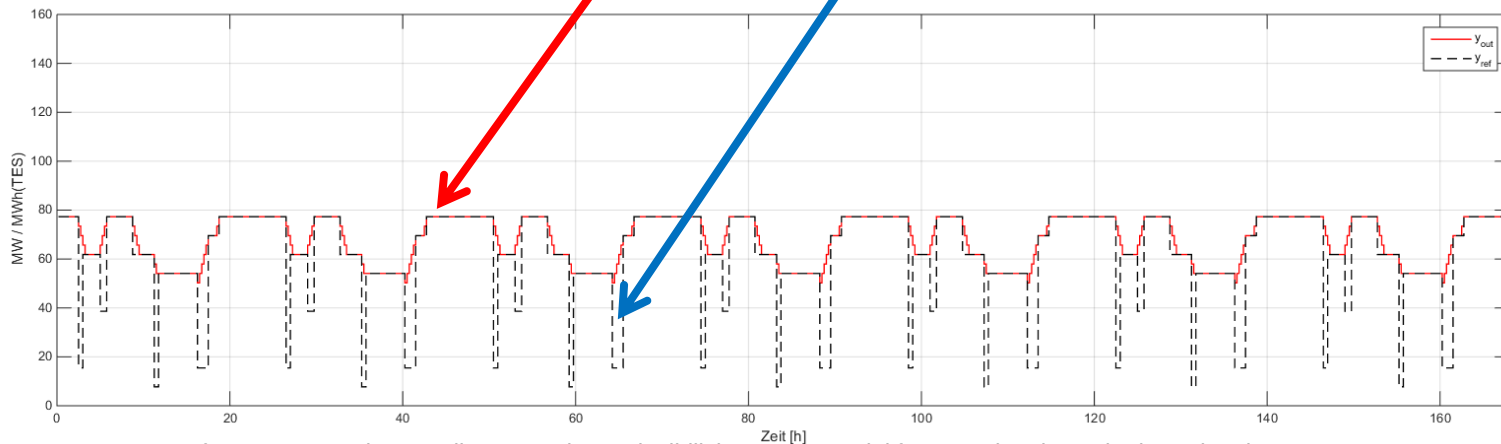


Operational
optimization

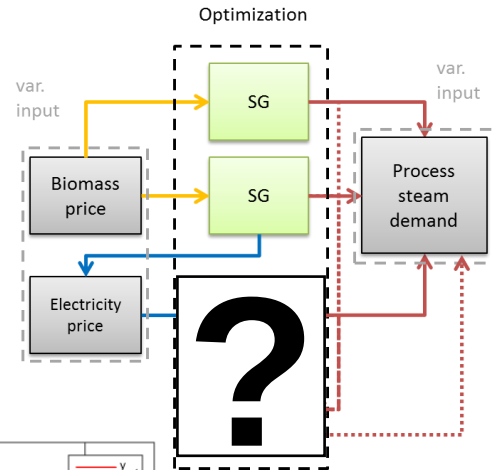
Simple Example

Supply $\neq$ Demand

Energy Supply Units



Source: R. Hofmann, S. Dusek, M. Koller, H. Walter: "Flexibilisierungspotenzial für Energieanlagen in der Industrie. Intelligentes Demand-Side-Management durch Integration von thermischen Speichern - Teil 1"; BWK, 68 (2016), 9; 6 – 11.





Operational
optimization

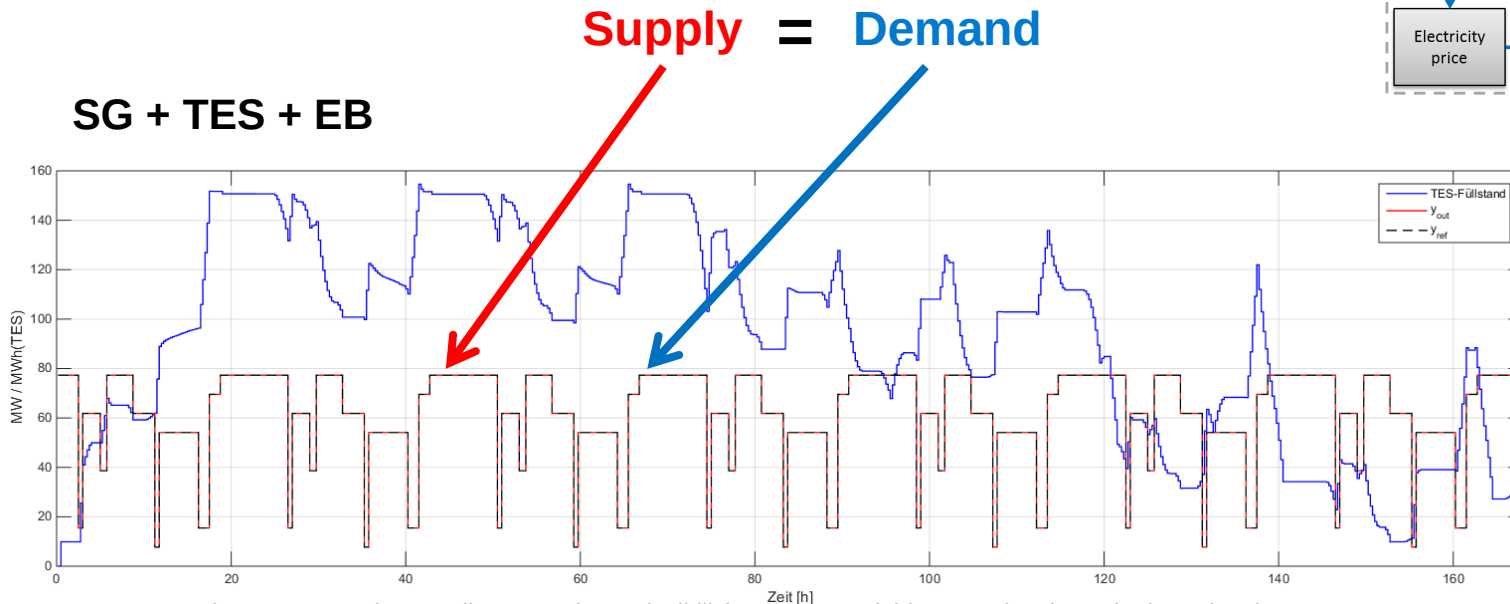
Results

SG: Steam Generator

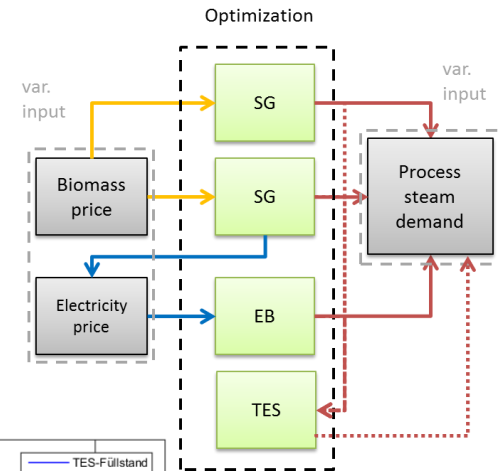
EB: Electrode Boiler

TES: Thermal Energy Storage

SG + TES + EB



Source: R. Hofmann, S. Dusek, M. Koller, H. Walter: "Flexibilisierungspotenzial für Energieanlagen in der Industrie. Intelligentes Demand-Side-Management durch Integration von thermischen Speichern - Teil 1"; BWK, 68 (2016), 9; 6 – 11.





Operational
optimization

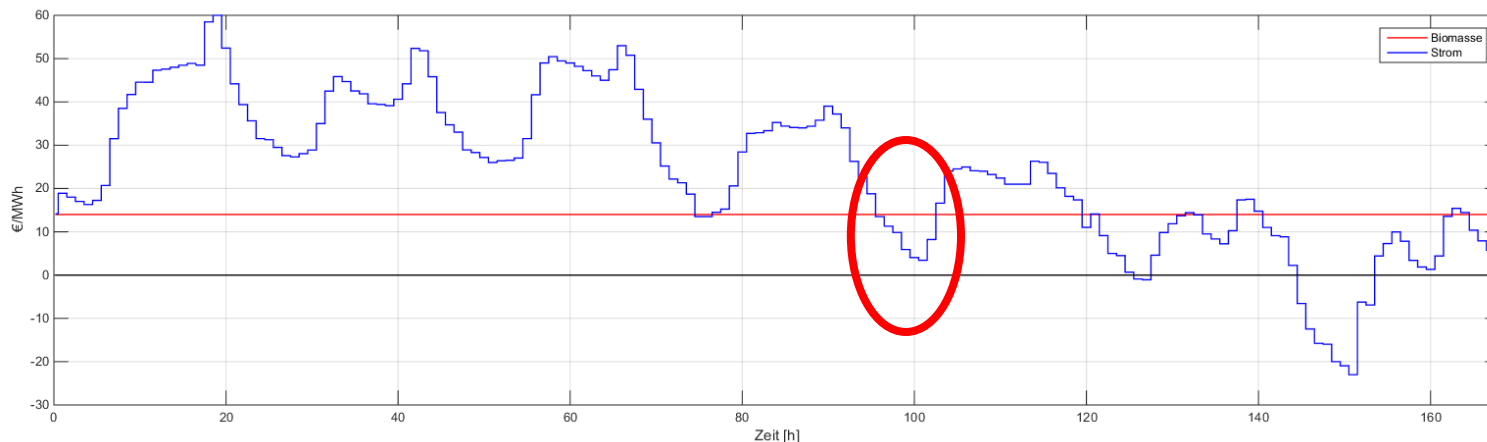
Results

SG: Steam Generator

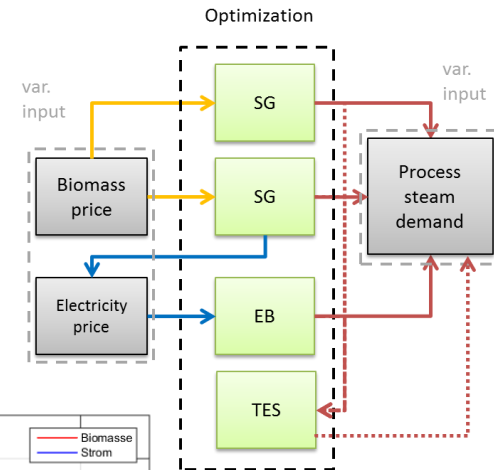
EB: Electrode Boiler

TES: Thermal Energy Storage

Energy Market-Prices



Source: R. Hofmann, S. Dusek, M. Koller, H. Walter: "Flexibilisierungspotenzial für Energieanlagen in der Industrie. Intelligentes Demand-Side-Management durch Integration von thermischen Speichern - Teil 1"; BWK, 68 (2016), 9; 6 – 11.





Operational
optimization

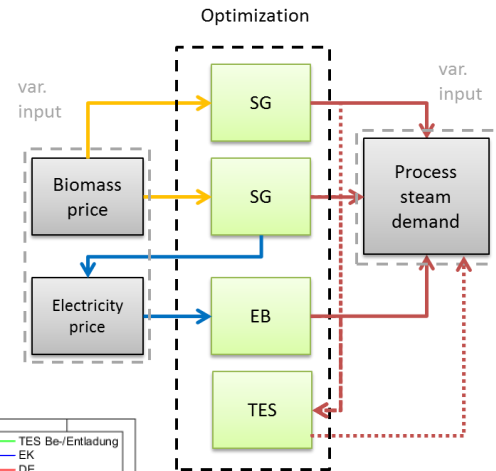
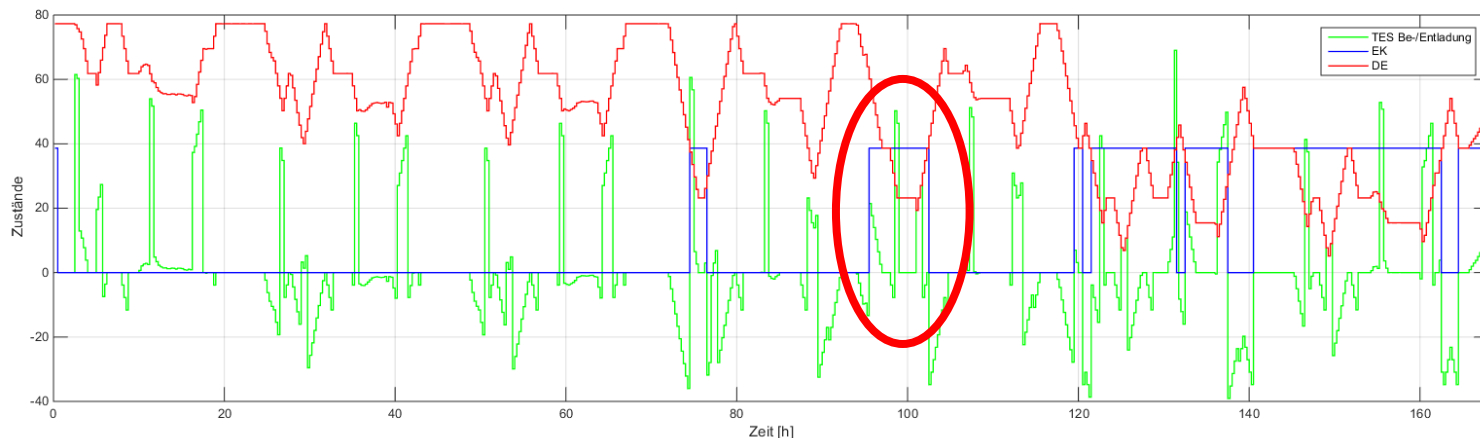
Results

SG: Steam Generator

EB: Electrode Boiler

TES: Thermal Energy Storage

States (SG + TES + EB)



Source: R. Hofmann, S. Dusek, M. Koller, H. Walter: "Flexibilisierungspotenzial für Energieanlagen in der Industrie. Intelligentes Demand-Side-Management durch Integration von thermischen Speichern - Teil 1"; BWK, 68 (2016), 9; 6 – 11.

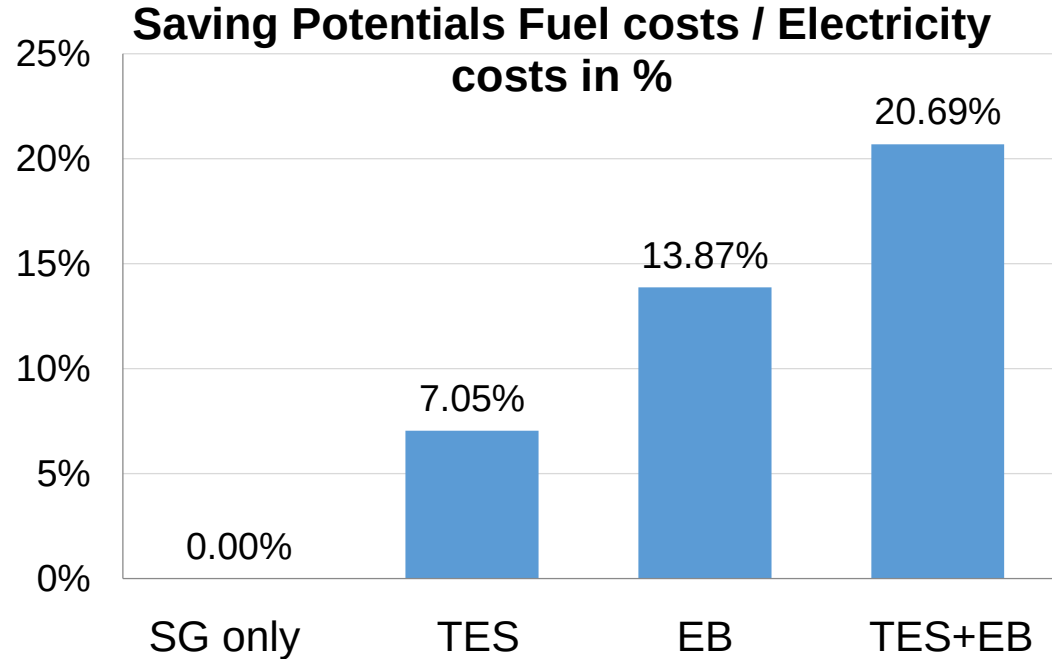


Operational
optimization

Potential depending on individual Process

Result of a test study:

- fictitious energy supply system
- historical electricity prices
- constant biomass price
- simulation time: 1 week



DEMO

PI System in context of SIC! - Runtime Model



Data
handling
and
treatment



Motivation...

PI system beneficial for research activities:

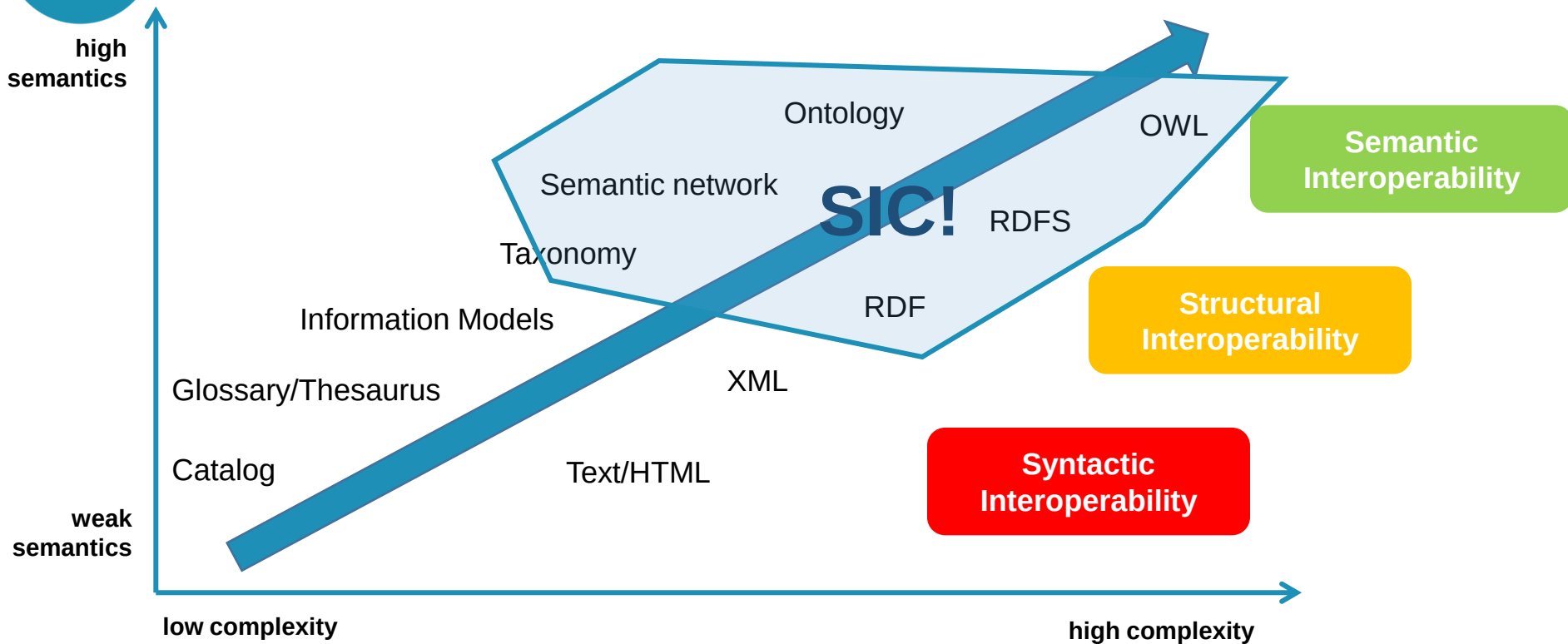
- ✓ single point of truth
- ✓ preparation of data for data scientists
- ✓ cross border enablement

“Unified data from different sources to provide data scientists the same view at the same time step...”



Data
handling
and
treatment

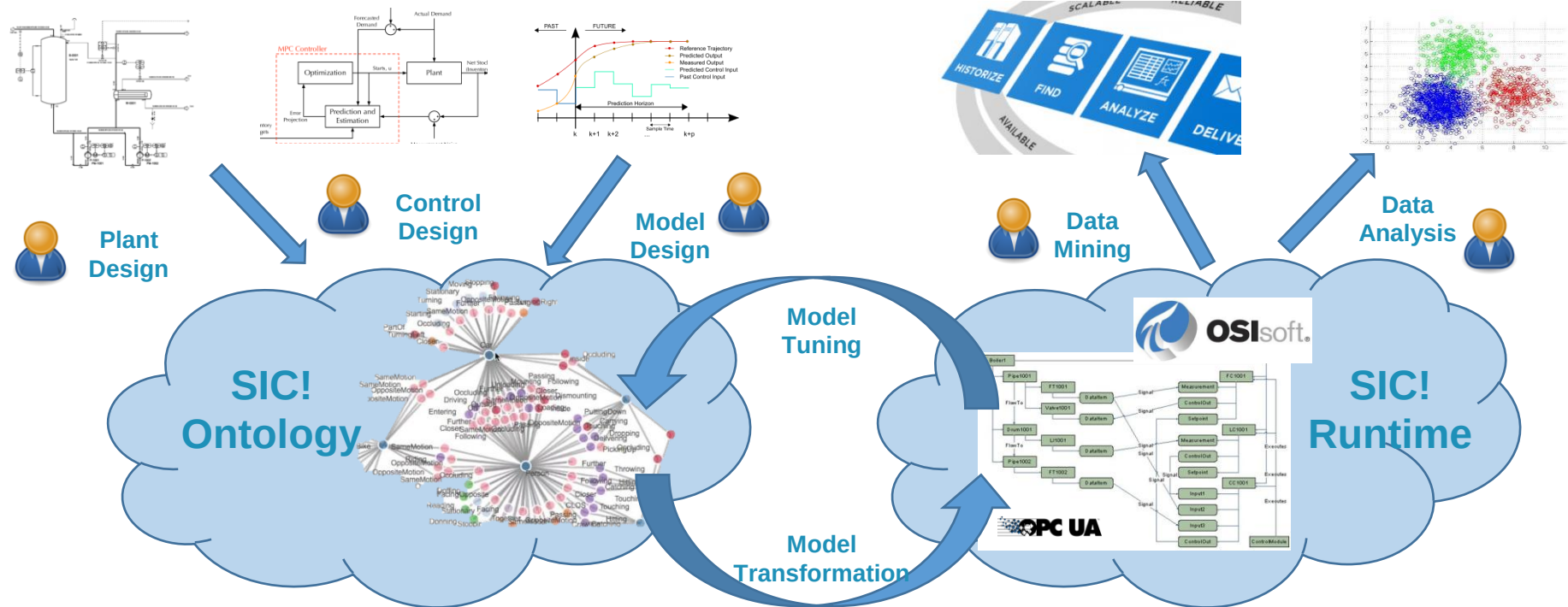
Knowledge Representation: Expressiveness





Data
handling
and
treatment

Knowledge Representation: Design/Runtime





Data
handling
and
treatment

SIC! Runtime System

Classic PI System

OSIsoft
Cloud Services

PDC/Edge

Sensors

An icon showing three wireless signal towers and a server rack, representing smart devices.

Millions of
Smart Devices

Assets

An icon showing a motor and a power source with a lightning bolt, representing multiple sensors.

Multiple
Sensors

Plant

An icon showing a factory building, representing multiple assets.

Multiple
Assets

Enterprise

An icon showing multiple factory buildings, representing multiple plants.

Multiple
Plants

Community

An icon showing a globe with multiple factory buildings, representing multiple enterprises.

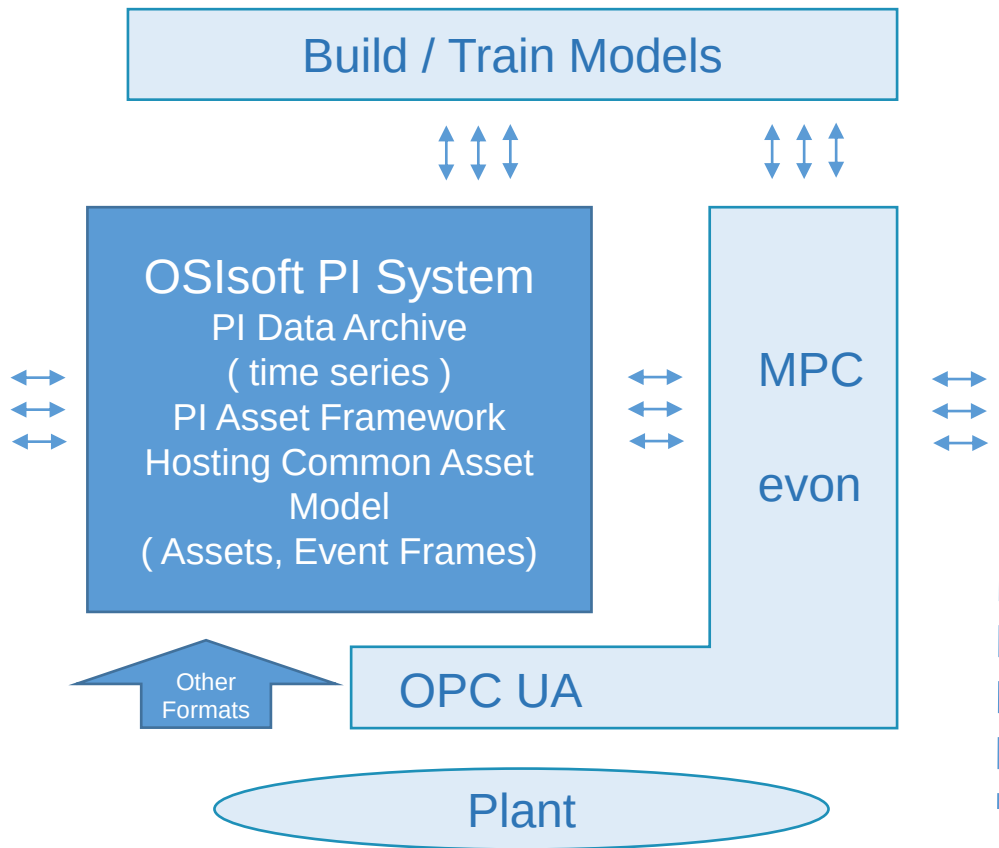
Multiple
Enterprises



Data
handling
and
treatment



User

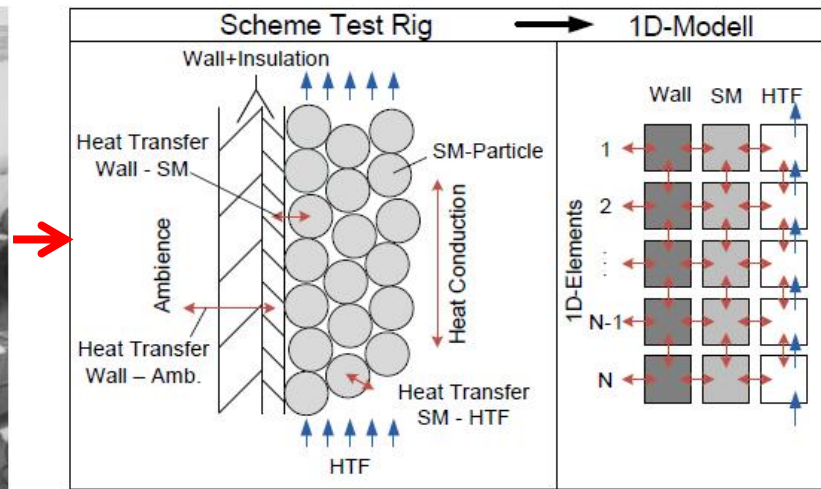
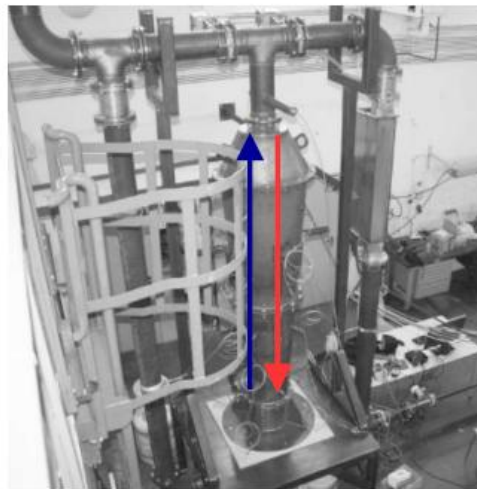


User



Data
handling
and
treatment

Thermal Energy Storage Model



1D Model

+

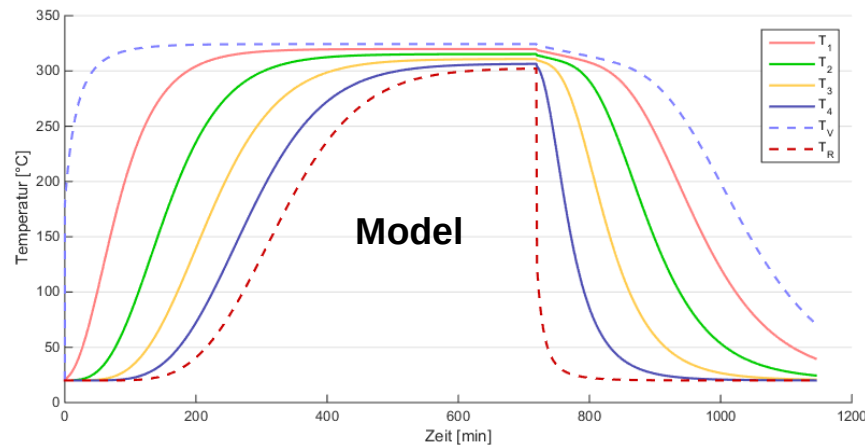
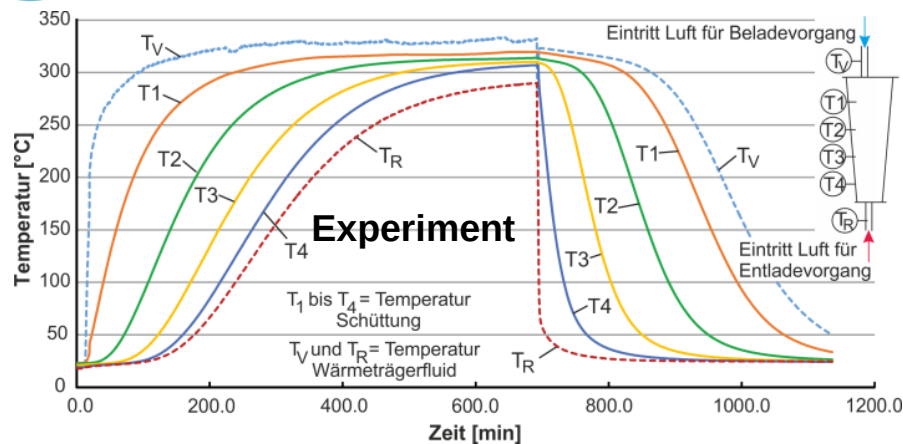
Model validation with real Lab measurement data

Source: M. Koller, R. Hofmann, Mixed Integer Linear Programming Formulation for Sensible Thermal Energy Storages, Proceedings of the 28th ESCAPE, Graz 2018.



Data
handling
and
treatment

Comparison Experiment - Simulation



- ✓ Validation of the 1D model of the fixed bed regenerator
- ✓ Highly dynamic operation
- ✓ Temperature spread



Data
handling
and
treatment

Next Steps...

Implementation of OSIsoft

- ✓ PI System
- ✓ PI Data Archive (time series)
- ✓ PI Asset Framework

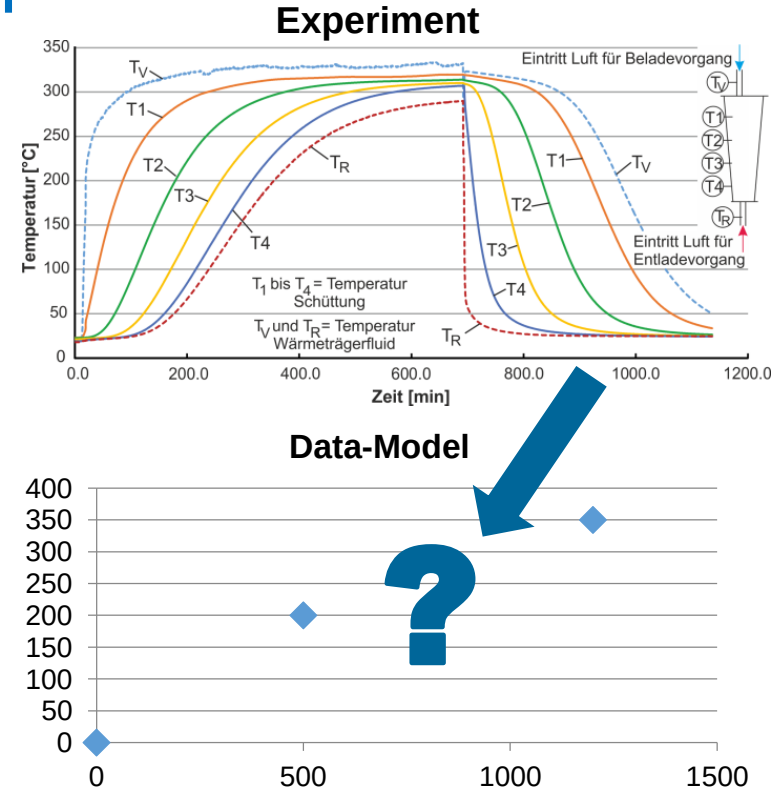
to the fixed bed regenerator at the
TU Wien lab.

Connection via evon – XAMControl[®]
automation system



Model Comparison

- ✓ Physical vs. data driven
- ✓ Analysis of model formulation (for exact description of storage behavior)
- ✓ Neuronal network techniques
- ✓ Full understanding of the highly dynamic operation



Acknowledgements

- ✓ To the numerous contributors of this presentation W. Kastner, PhD-candidates: S. Panuschka, A. Beck, M. Koller, C. Seykora, B. Pesendorfer.
- ✓ To AIT-TU Wien partnership with the joint professorship of *Industrial Energy Systems*
- ✓ To all partners and supporters of the Cooperative Doctoral School SIC!
- ✓ To OSI partnership and setup suggestions (Frank Batke)

This Presentation is based on Publications

- Keynote-Lecture: Beck, A. and Hofmann. R: “*Extensions for Multi-Period MINLP Superstructure Formulation for Integration of Thermal Energy Storages in Industrial Processes*”, in Proceedings of the 28th European Symposium on Computer Aided Process Engineering, June 10th to 13th, 2018, Graz, Austria. © 2018 Elsevier B.V. <http://dx.doi.org/10.1016/B978-0-444-64235-6.50234-5>, pp 1335-1340.
- Koller, M. and Hofmann. R: “*Mixed Integer Linear Programming Formulation for Sensible Thermal Energy Storages*”, in Proceedings of the 28th European Symposium on Computer Aided Process Engineering, June 10th to 13th, 2018, Graz, Austria. © 2018 Elsevier B.V. <http://dx.doi.org/10.1016/B978-0-444-64235-6.50163-7>, pp 925-930.
- R. Hofmann, S. Dusek, M. Koller, H. Walter: "Flexibilisierungspotenzial für Energieanlagen in der Industrie. Intelligentes Demand-Side-Management durch Integration von thermischen Speichern - Teil 1"; BWK, 68 (2016), 9; 6 – 11.
- F. Mayrhuber, H. Walter, M. Hameter, 2017. Experimental and numerical investigation on a fixed bed regenerator. 10th International Conf. on Sustainable Energy and Environmental Protection.

SIC! [Smart Industrial Concept]



Univ.Prof. Dr. René Hofmann

Scientific Coordinator SIC!

TU Wien – Institute of Energy Systems and Thermodynamics

AIT Austrian Institute of Technology

Rene.Hofmann@tuwien.ac.at

Rene.Hofmann@ait.ac.at



Questions?

Please wait for
the **microphone**

State your
name & company



Please rate this session in the mobile app!



