Lucerne University of Applied Sciences and Arts

HOCHSCHULE LUZERN

**Technik & Architektur** 

# A Performance Predication Tool for ORC Applications based on Modelica

ASME ORC 2015

Adrian Rettig, Ulf Christian Müller

FH Zentralschweiz

#### Content

- Motivation
- Approach
- Application example
- Outlook





# Reality



## **Physically based Modeling**



- Anticipation of different scenarios
- Intervention easier at design/planning stage

### Modelica as Modeling Platform

- Mainly used libraries
  - ThermoCycle
  - CoolProp package for fluid property calculations
  - StateGraph2
- Aim: Database of validated plants and components





### **Application Example – Biogas CHP Klingnau**



# Klingnau – Overall Model



Folie 8, 2015-10-14

# Klingnau – Shutdown/Restart Criteria



Folie 9, 2015-10-14

#### Klingnau – Implementation of Control System



Folie 10, 2015-10-14

#### State Machine «Run Watcher» (1)

- Starting point: plant in operation
- Engine power > 45 %
- Ambient temperature < 30 °C



#### State Machine «Run Watcher» (2)

- Engine power < 45 %
- Ambient temperature < 30 °C
- Timer starts



#### State Machine «Run Watcher» (3)

- Engine Power < 45 %
- Elapsed time > time limit: change of state
- Activation of shutdown trigger and suspension of «Run Watcher»



# State Machine «Shutdown Procedure» (1)



# State Machine «Shutdown Procedure» (2)



# State Machine «Shutdown Procedure» (3)



# State Machine «Shutdown Procedure» (4)



#### Klingnau – Implementation of Control System



Folie 18, 2015-10-14

#### Simulation Results (1) – 30 Hours Run



Folie 19, 2015-10-14

#### Simulation Results (2) – 30 Hours Run B 45 40 2 L<sup>35</sup> J<sup>35</sup> L<sup>30</sup> Meas. cold in X Sim. cold in Meas. cold out • 20 Sim. cold out Tamb 15 160 B 140 <sup>120</sup> 0 4 100 • ٠ Meas. hot out Sim. hot out Meas. hot in Х 40 Sim. hot in 25 20 Power [kW] Meas. • Sim. Deviation produced electricity < 1 %15 10 20 25 5 30 Time [h]

#### Folie 20, 2015-10-14

# Simulation Results (3) – Generic 30 Days Run



# Conclusion

- ThermoCycle/CoolProp with robust and computationally efficient models
- Simple control strategy derived with automatic shutdowns and restarts
- Easy test and track online behavior of controller and its interaction with plant with State Machine (StateGraph2)
- Good agreement between measurement and simulation

