



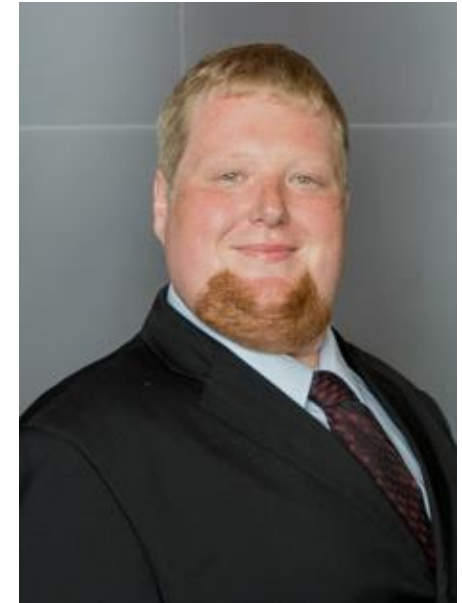
AALBORG UNIVERSITY  
DENMARK

7<sup>th</sup> International Conference on Smart Energy Systems  
21-22 September 2021  
#SESAAU2021



# Digital Energy Twin: Optimised Operation and Design of Industrial Energy Systems

by  
Gerald Birngruber



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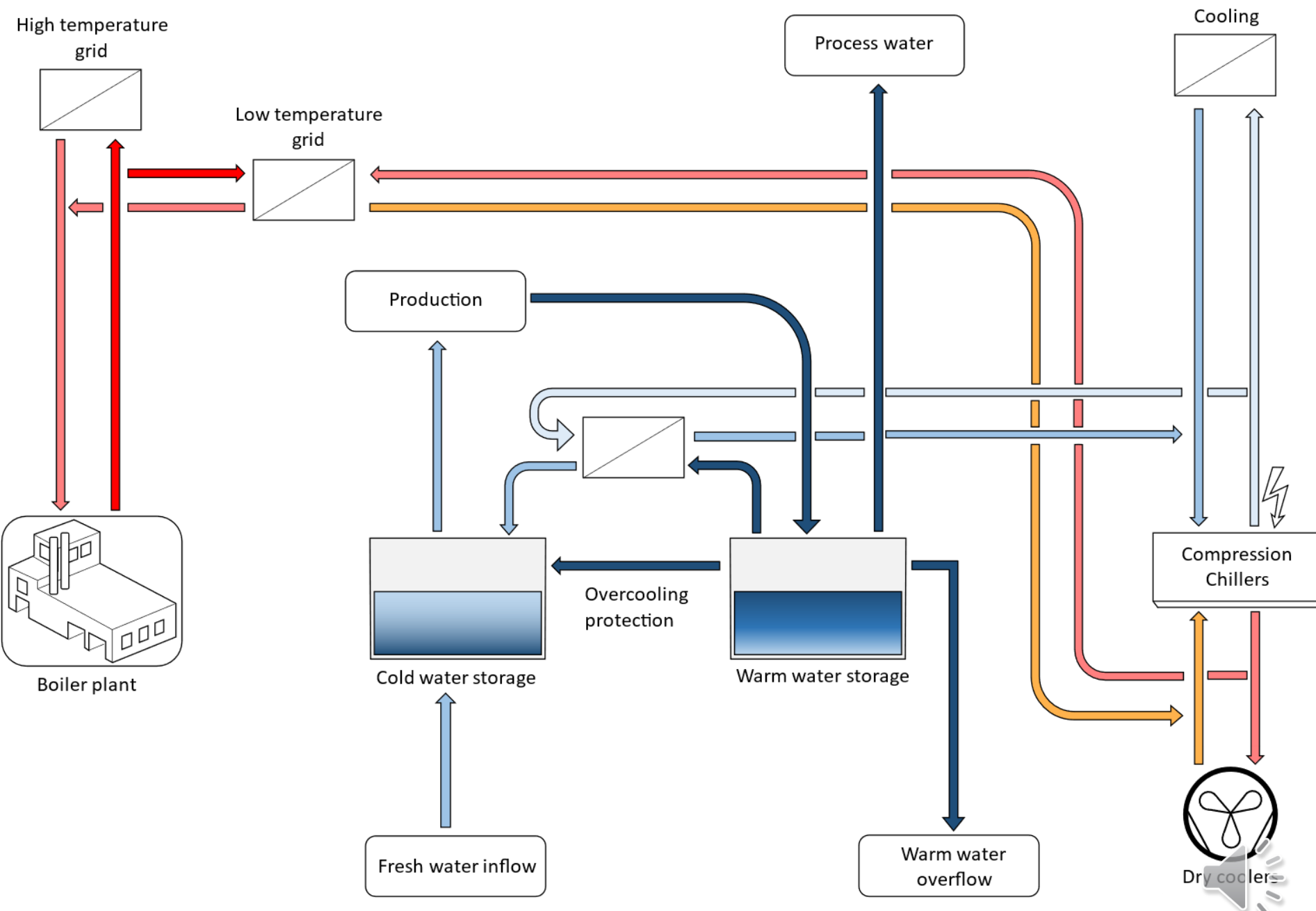
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# Introduction

- Creating a Digital Twin
  - Printed circuit boards plant
  - Focus on energy optimization
  - Therefore, Digital Energy Twin
- Modelling
  - Electroplating process
  - Drilling
  - Heated baths
  - Low/High temperature grid
  - Supply machines  
(Dry cooler, heat exchanger, compressors,...)





# Introduction

## Tools

- Modelica: Buildings library [2]
  - Supply machines
  - Low/High temperature grid
- Python: Machine learning / Parametrized functions
  - Electroplating process
  - Heated baths



# Problem

How do these models work together?



# Possible solutions

- C – wrapper to call Python program
- Server – Client
- Functional Mock-up Unit (FMU)
  
- Work in progress: Evaluation



# UniFMU

- Developed in cooperation between Aarhus University and TU Graz [3]
- Functional Mock-up Interface (FMI) Version 2
- Generic C-binary
  - Handles communication between FMI-API and simulation code
  - Decouple simulation from FMI standard
- Supports Python, Java, Matlab and C#
  - Can be adapted to further languages



# UniFMU

- Docker support
  - Independent from system
  - Dependency handling
- Experimental GUI
- Shipped through pip
- Source code and documentation can be found here:  
<https://github.com/INTO-CPS-Association/unifmu>



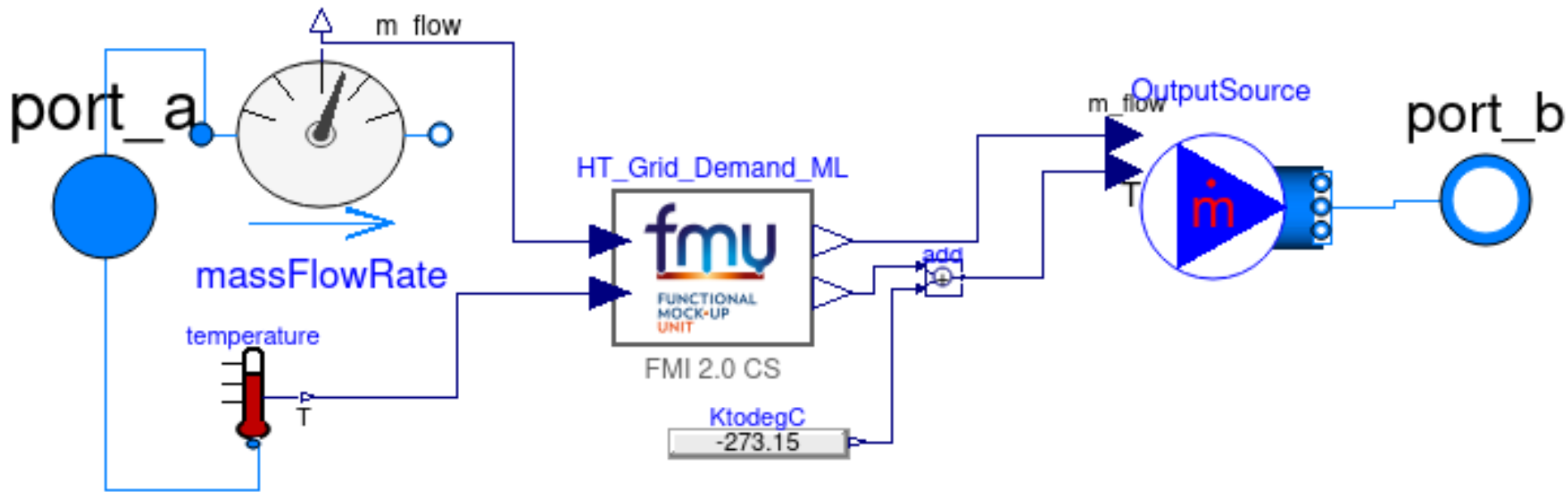


# Advantages/Disadvantages

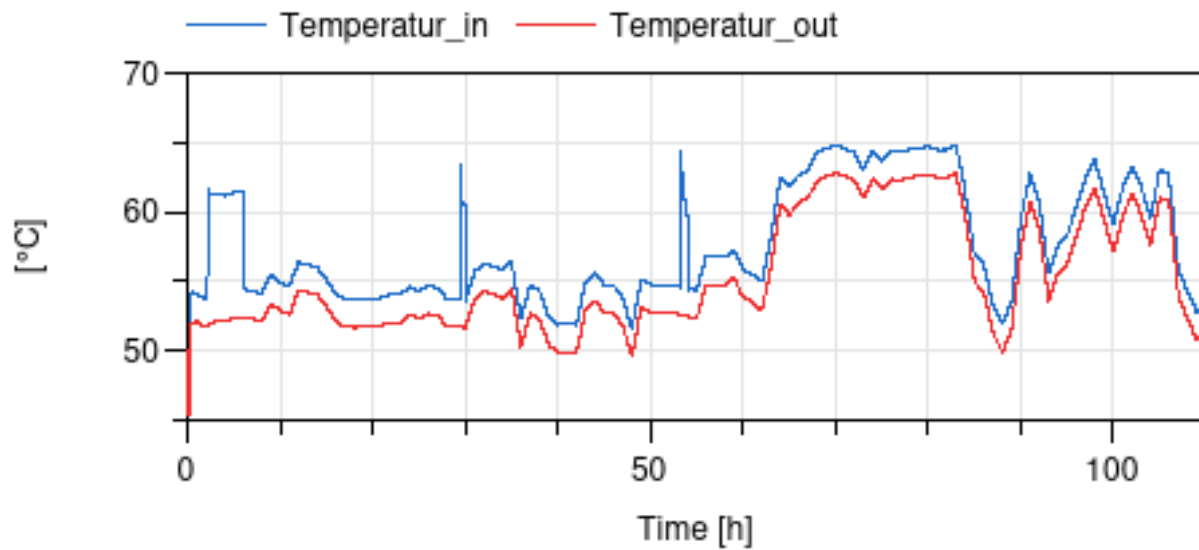
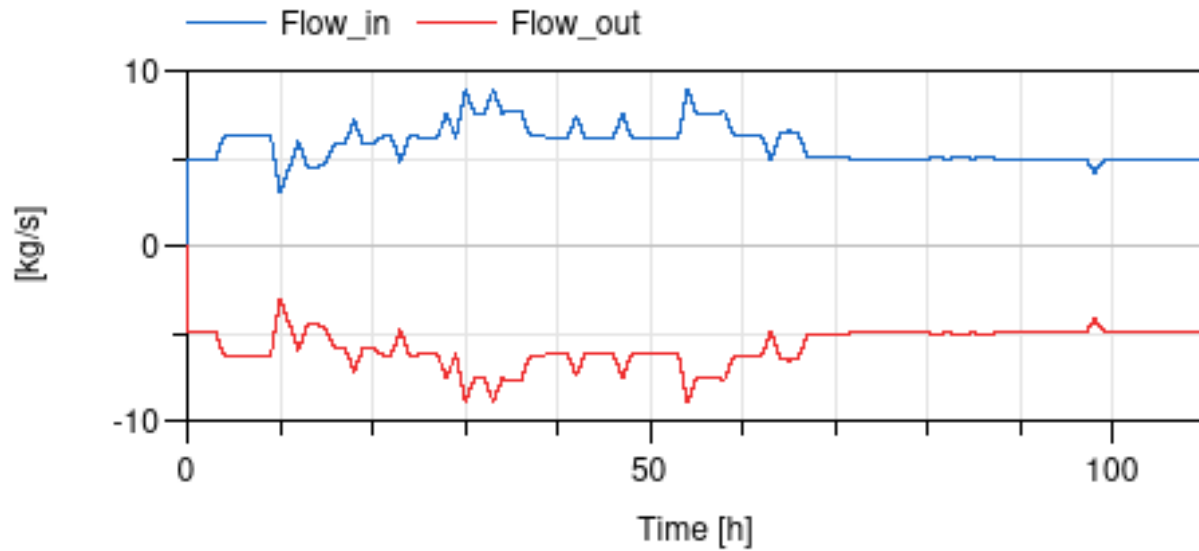
- + Create models in (nearly) any language
- + Replace compute intensive modules
- + Simulate machines where only sensor data is available
- + Opensource
- Compute overhead at initialization and simulation
- Only basic data types



# Results



# Results





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# Thank you for your attention

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# Sources

- [1] Carles Ribas Tugores, Gerald Birngruber, Jürgen Fluch, Angelika Swatek, and Gerald Schweiger. Decarbonization of industrial energy systems: A case study of printed circuit board manufacturing In 7th International Modelica Conference, 2021
- [2] Michael Wetter, Wangda Zuo, Thierry S Noudui, and Xiufeng Pang. Modelica buildings library. Journal of Building Performance Simulation, 7(4):253–270, 2014
- [3] Christian M. Legaard, Daniella Tola, Thomas Schranz, Hugo Daniel Macedo, and Peter Gorm Larsen. A universal mechanism for implementing functional mock-up units. In 11th International Conference on Simulation and Modeling Methodologies, Technologies and Applications, SIMULTECH 2021, page to appear, Virtual Event, 2021

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