Science becomes

reality

LINZ CENTER OF MECHATRONICS

Modellbasierte Simulation und Optimierung eines mehrachsigen Antriebsstranges

Arnold Hießl

Agenda

1. Introduction
2. Measurements
3. Simulation & Optimization

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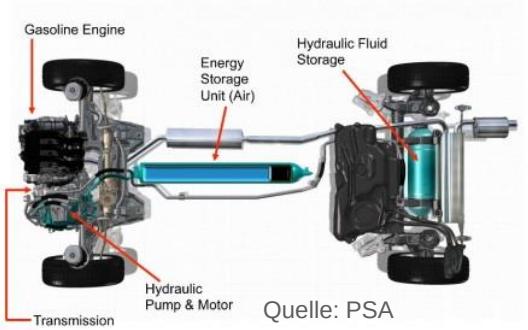
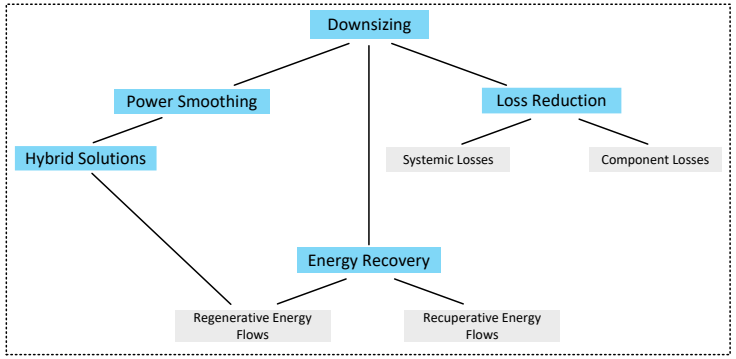
Introduction

- Hybrid Drives
  - At least two or more energy sources
  - Smoothing – Boosting – Recuperating
- Compact Excavator
  - 0.6 – 10 Tons
  - Dozer Blade
  - Boom Swing
- Downsizing

Quelle: Wikipedia – Wacker Neuson SE



Quelle: PSA



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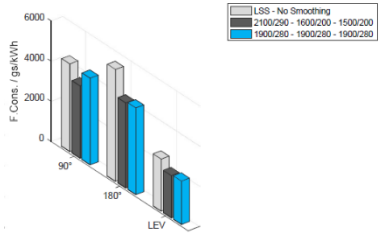
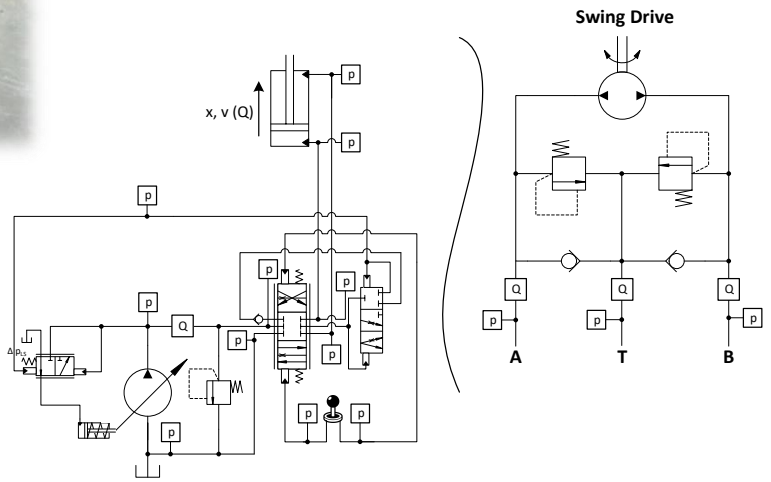
Measurements

- Power Digging
    - Fulfilment of a certain task as fast as possible
    - No Standstills
- Repro (reproducibility) Digging
    - Similar Cycles
    - Basis for statistical analysis
- Single Movements
    - Parameter identification

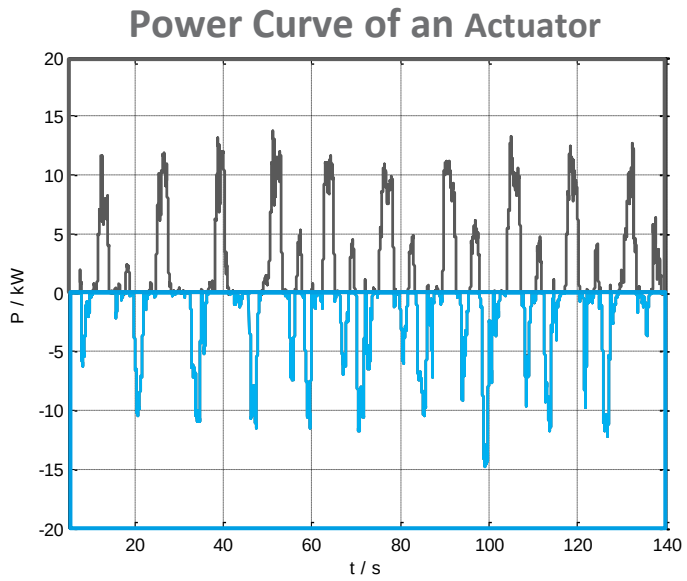
Measurements

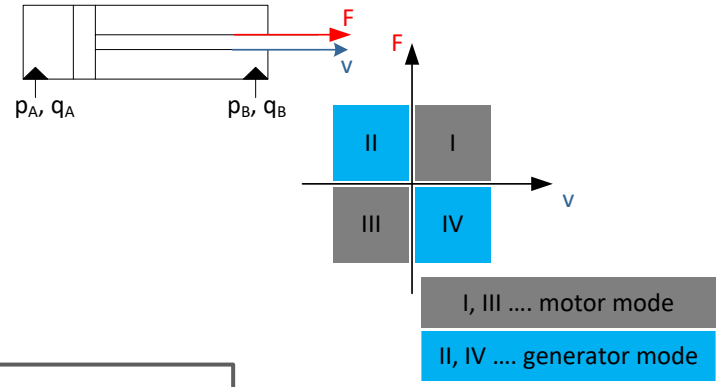
- Primary Aim of Measurements
  - Evaluation of Recovery Potentials
  - Consideration of Losses
  - Information about System Design
- Data Acquisition
  - Special designed signal boxes
  - Over 50 gauges
  - Mobile acquisition system (National Instruments)
  - Additional Video recording
- Data Analysis with MATLAB





Measurements Analysis





$$P_{pos} = \underbrace{p_A \cdot Q_A - p_B \cdot Q_B}_{P} \cdot \frac{1}{2} \cdot \left(1 + \text{sign}\ P\right)$$

$$P_{neg} = \underbrace{p_A \cdot Q_A - p_B \cdot Q_B}_{P} \cdot \frac{1}{2} \cdot \left(1 + \text{sign}\ -P\right)$$

Measurements Analysis

- Evaluation of the maximum recovery degree
  - Relative degree of recovery (RRD)

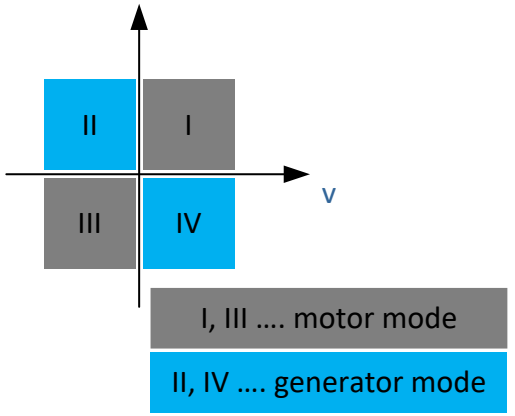
    Ratio between mean output and mean input energy

$$RRD = \frac{\int_0^T P_{neg} dt}{\int_0^T P_{pos} dt}$$

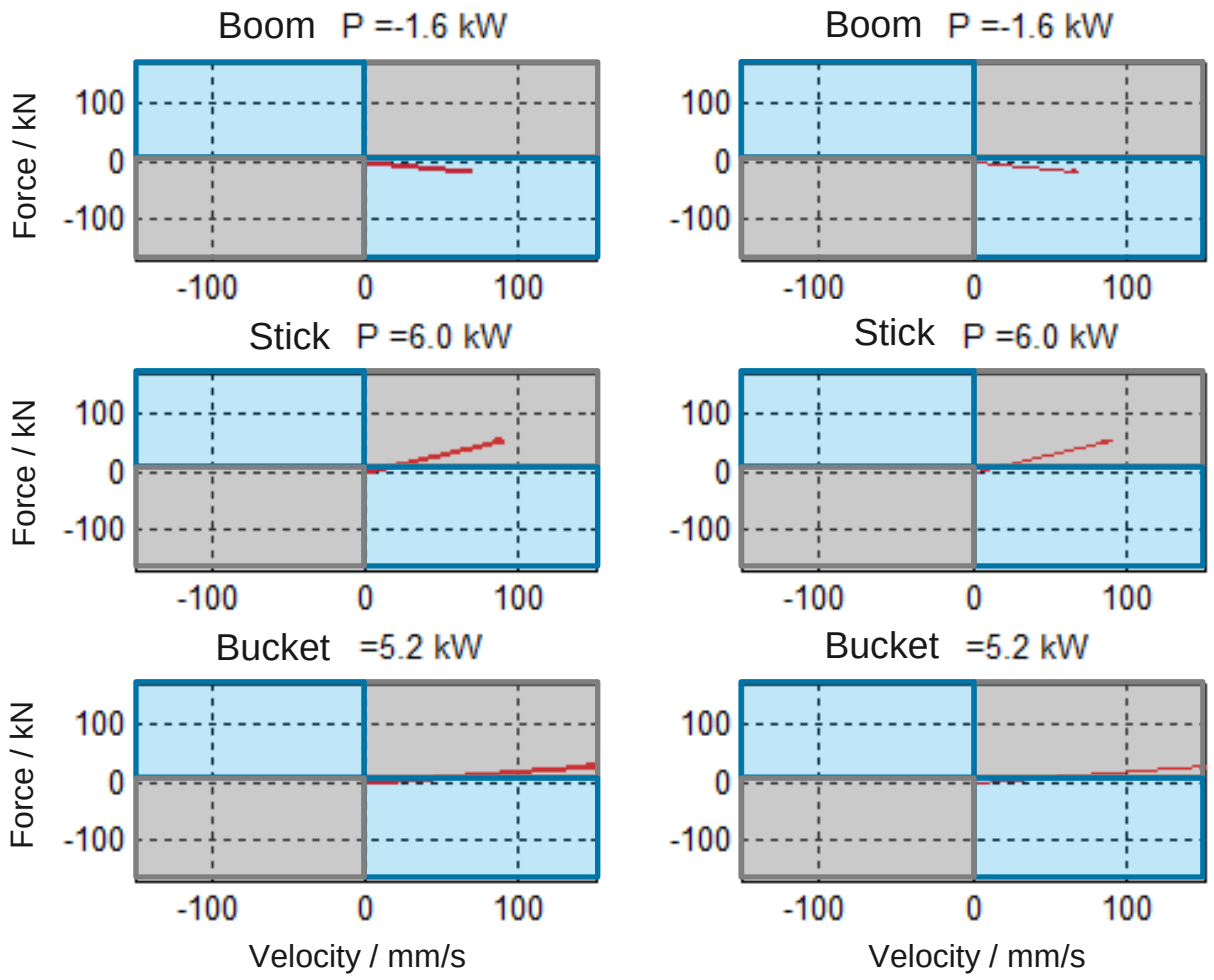
  - Absolute degree of recovery (ARD)

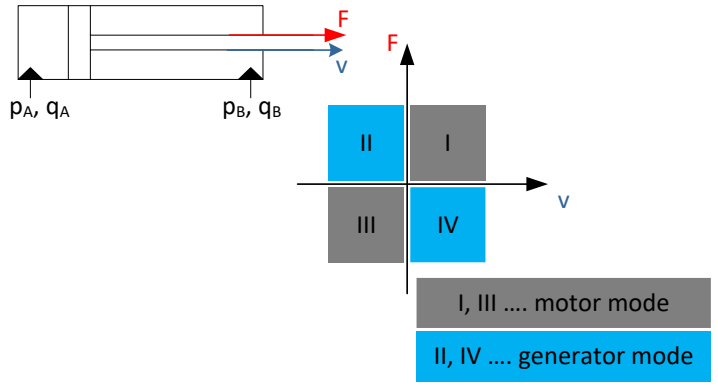
    Ratio between output energy and the hydraulic mean input (all pumps)

$$ARD = \frac{\int_0^T P_{neg} dt}{\sum_{i=1}^{n} \int_0^T P_{pump-i} dt}$$



Measurements Analysis





Measurements Analysis

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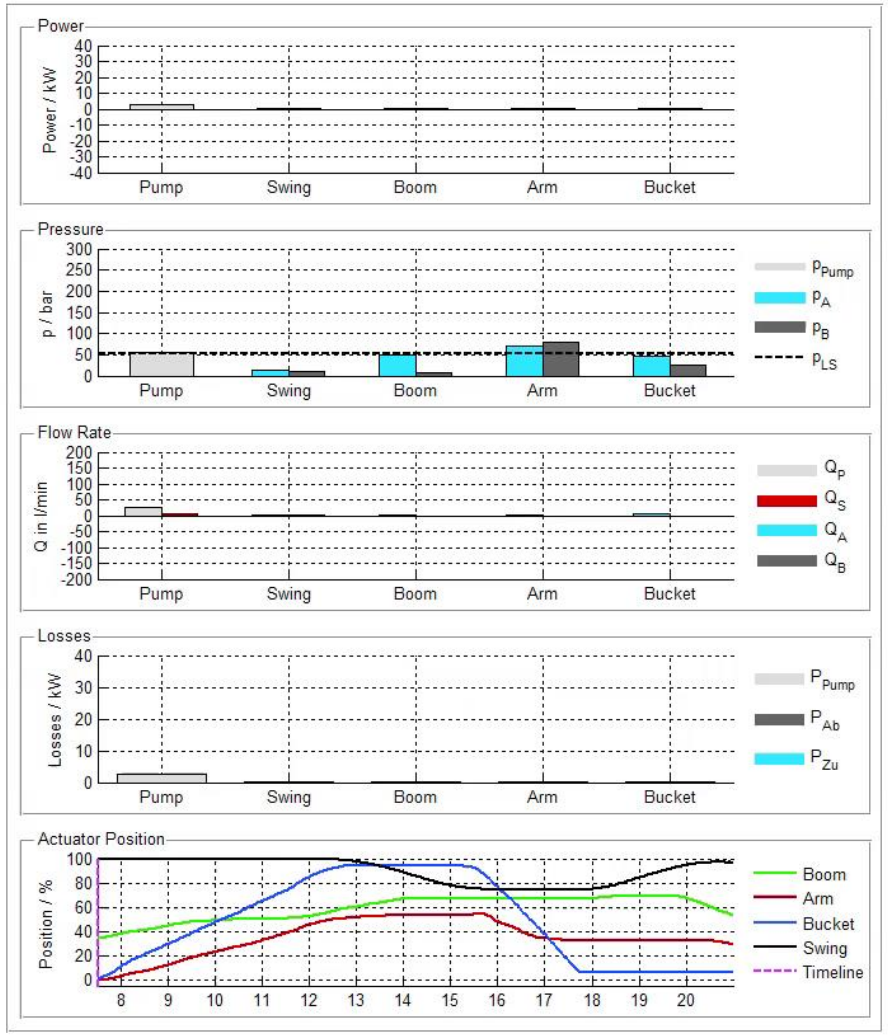
Repro Digging 90°



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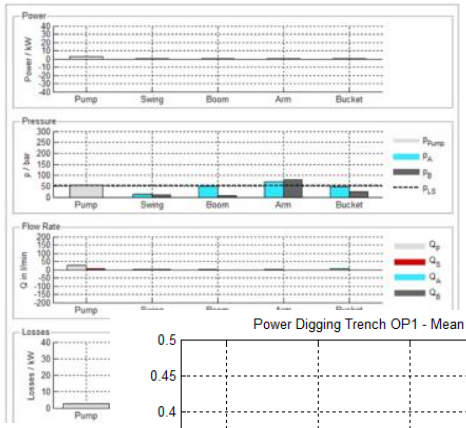
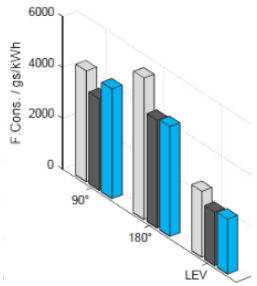
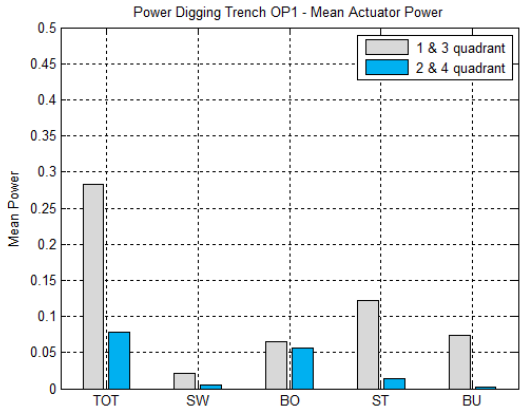
Measurements

- Data Analysis was done with MATLAB
  - Data Preprocessing
  - Data Evaluation
  - Data Postprocessing
    - Figures
    - Videos







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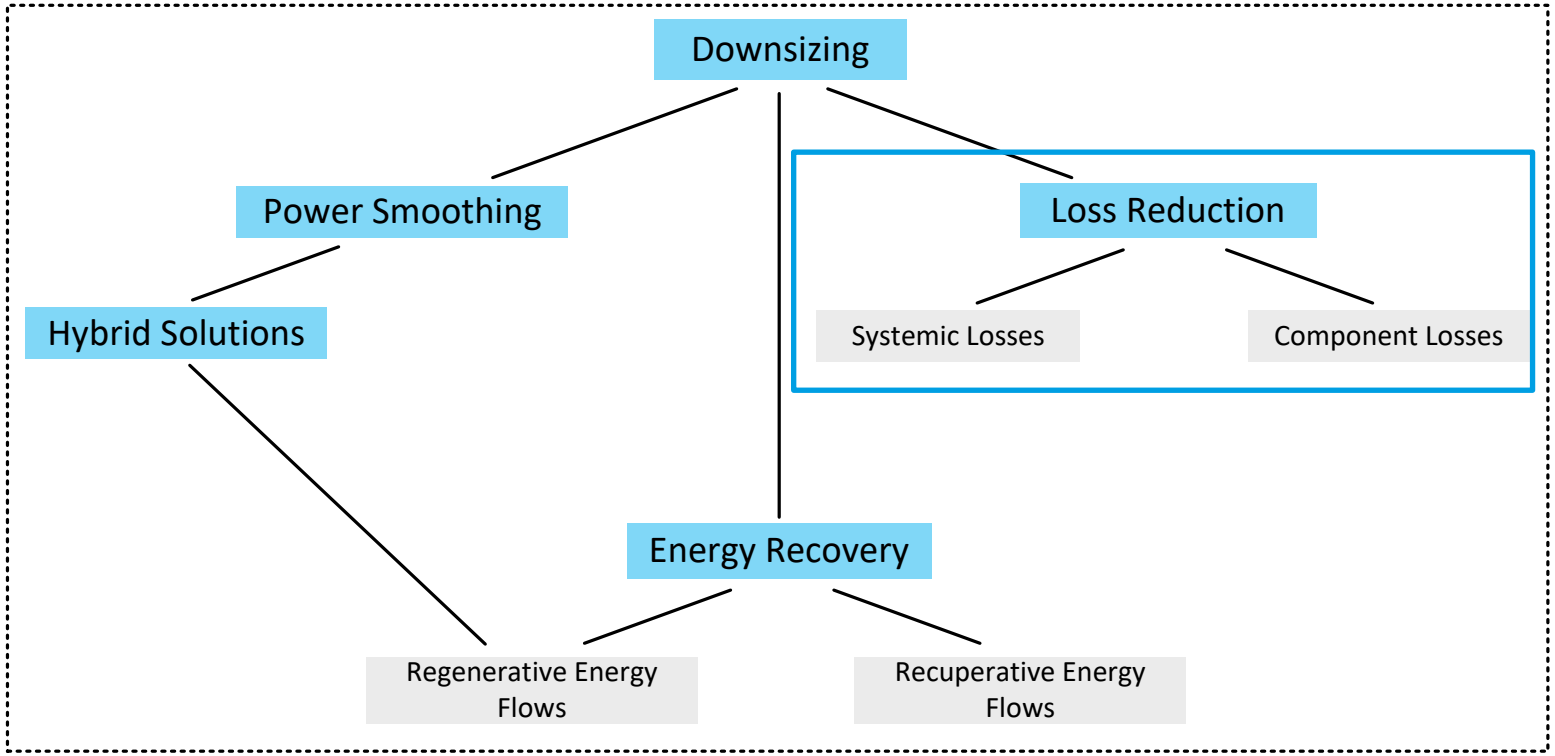
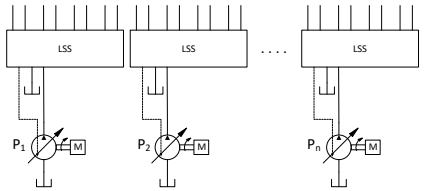
Simulation & Optimization



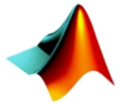
Simulation & Optimization

Component & Systemic Losses

- Multi Circuit Systems



- Matrix and vector manipulation



- Entire Excavator Model (Simscape Fluids & Multibody)
  - Mechanical Multi-Body System
  - Hydraulic Model
  - Digging Force Model

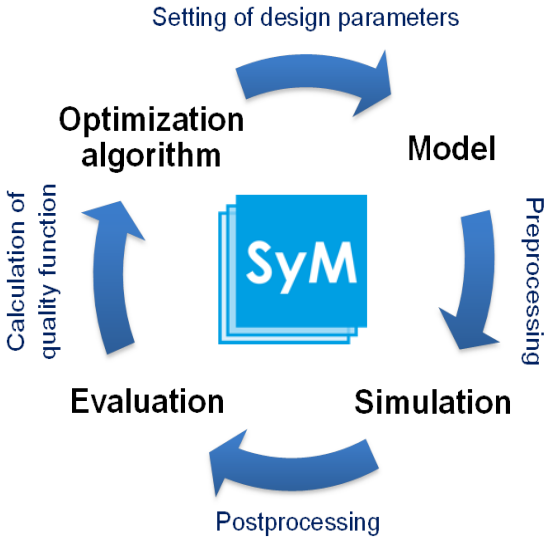
- Pressure Level Adaption
  - Actuator Size
  - Mechanical Geometry Change

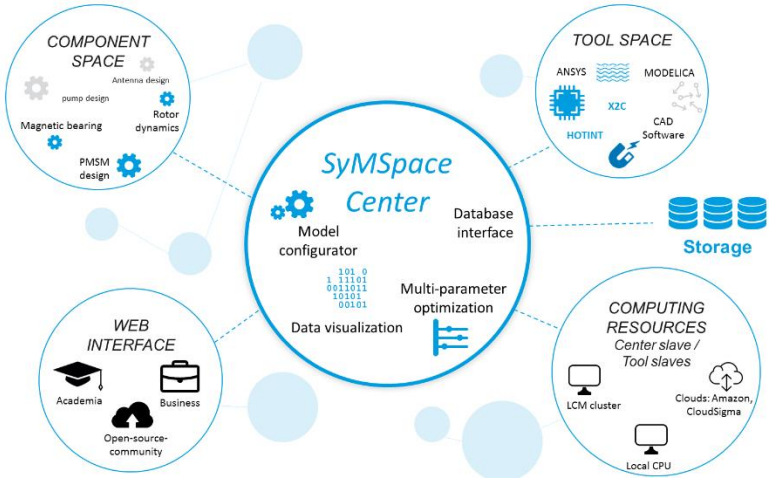
	BO A	BO B	ST A	ST B	BU A	BU B	SW A	SW B
1	1	1	1	1	1	1	1	1
2	1	1	1	1	1	1	2	2
3	1	1	1	1	2	2	1	1
4	1	1	1	1	2	2	2	2
5	1	1	2	2	1	1	1	1
6	1	1	2	2	1	1	2	2
7	1	1	2	2	2	2	1	1
8	1	1	2	2	2	2	2	2

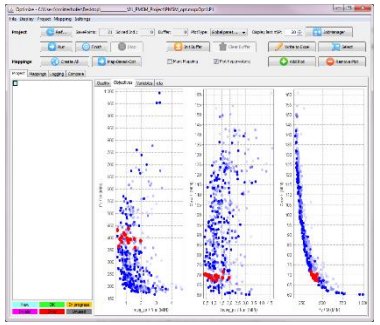
Simulation & Optimization

SyMSpace

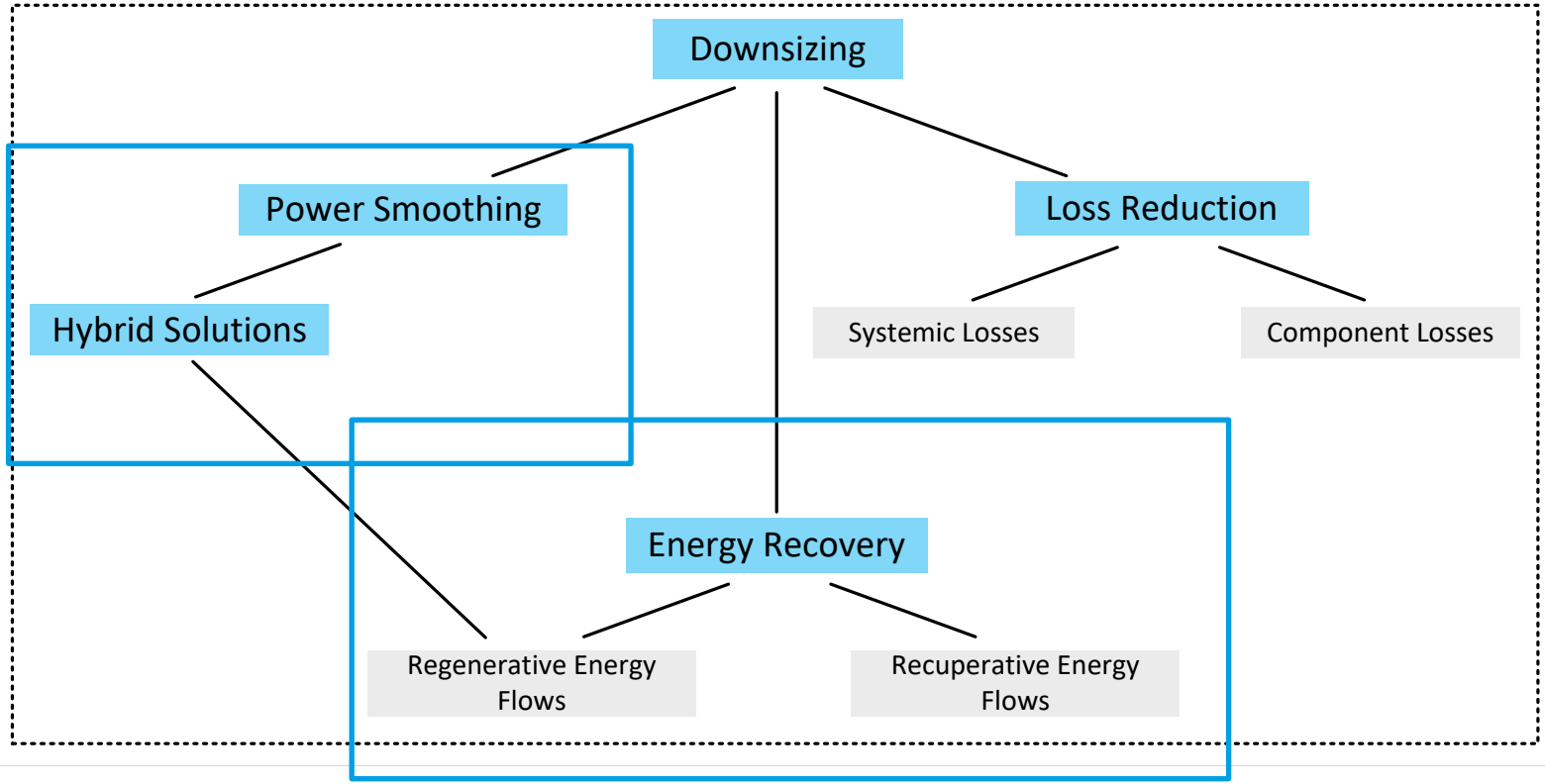
- Evolutionary Optimization Algorithm
  - Multi Domain Tool
  - Multi Criteria Optimization







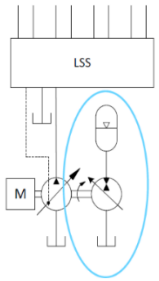
Simulation & Optimization

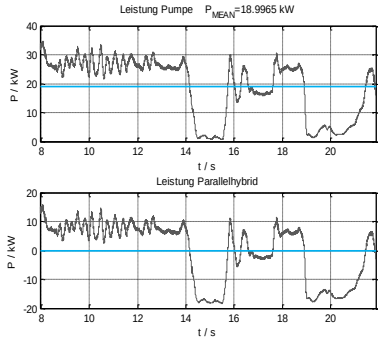


Simulation & Optimization

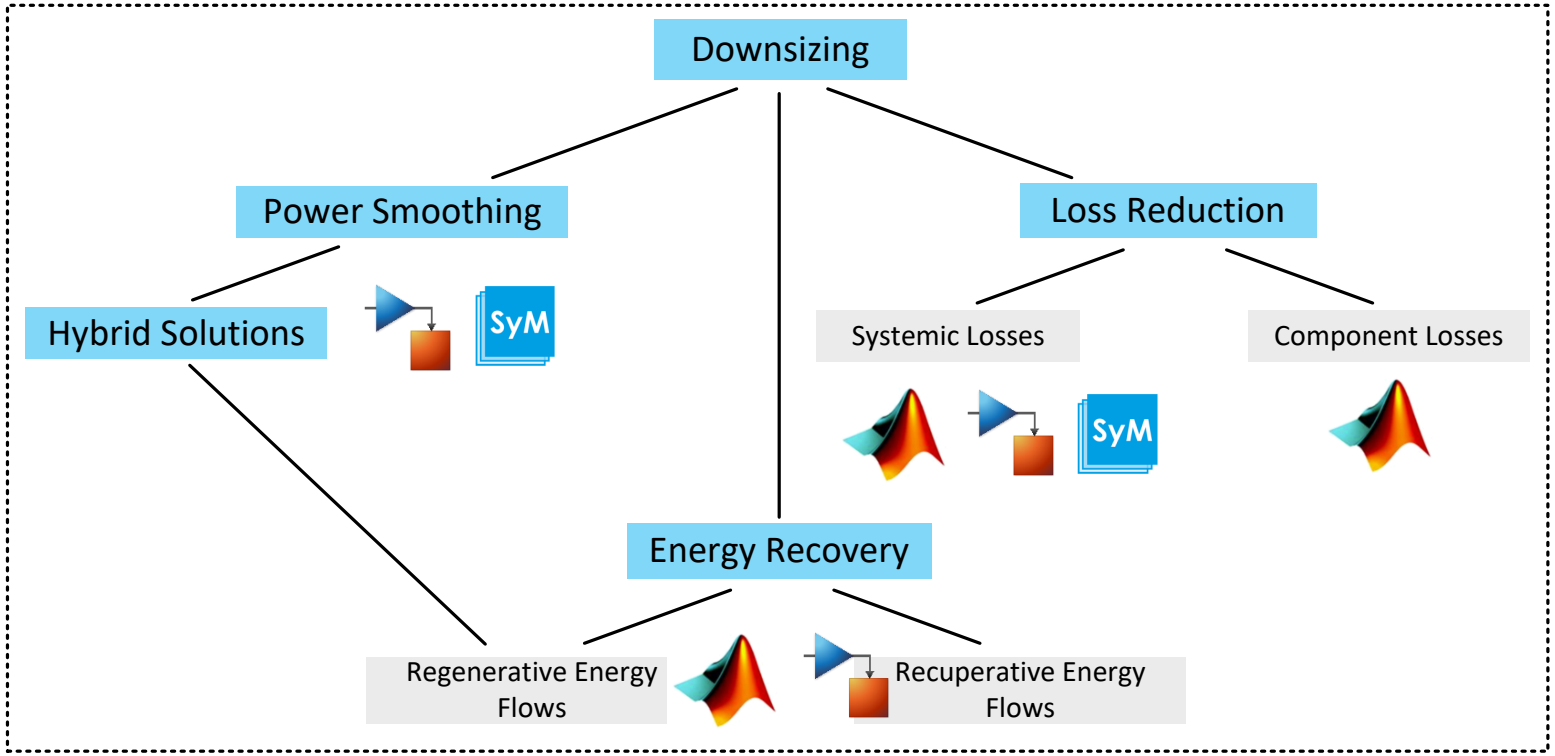
Hybrid Solutions & Energy Recovery Systems

- Classic Parallel Hydraulic Hybrid System
  - Design & Optimization
  - Energy Recovery System





Conclusion


Downsizing
Power Smoothing
Loss Reduction
Hybrid Solutions
SyM
Systemic Losses
Component Losses
SyM
Energy Recovery
Regenerative Energy Flows
Recuperative Energy Flows

Bleiben wir in

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