Simulation of idle-times energy savings on a welding line

Pavel Burget, Přemysl Šůcha, Libor Bukata
Czech Technical University in Prague
Department of Control Engineering
{burgetpa,suchap,bukatlib}@fel.cvut.cz

Outline

- Introduction
- Welding line
- Basics of PROFIenergy
- Single-robot simulations
- Real-line measurements and savings potential
- Future enhancements

Department of Control Engineering

Scope

- Automatic control of engineering, physical, biological, medical, transport, economical and other systems in the broadest sense from theory, modelling, and design, through algorithms, software and hardware, networks and communication, automata, embedded systems and robotics, to practical applications, industrial implementations and their impact on society. Nanotechnology and thin films.

Mission

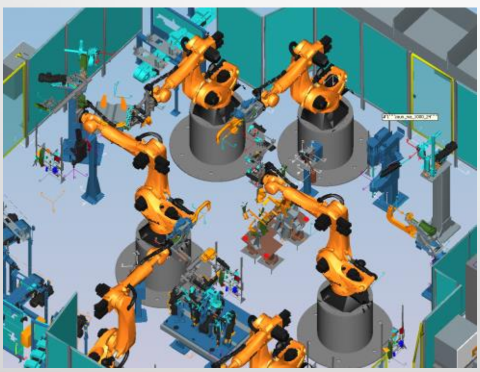
- Education of bachelors (Bc.), masters (Ing.) and doctors (Ph.D.) in Control Engineering
- Basic and applied research recognized worldwide
- Technology and science promotion in industry and society

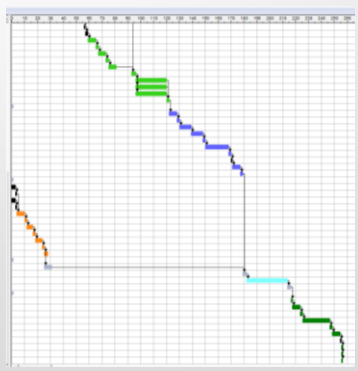
Industrial Automation Group

- Strong cooperation with Profibus & Profinet International
  - Certified Competency and Training Centres
  - Working groups on PROFINET Topology and PROFINET IRT Engineering
- Interesting projects
  - Ethernet-based communication systems – diagnostics, modelling
  - Advanced control of buildings – predictive control, system identification
  - Remote lab system – used in many courses at the department

Welding line

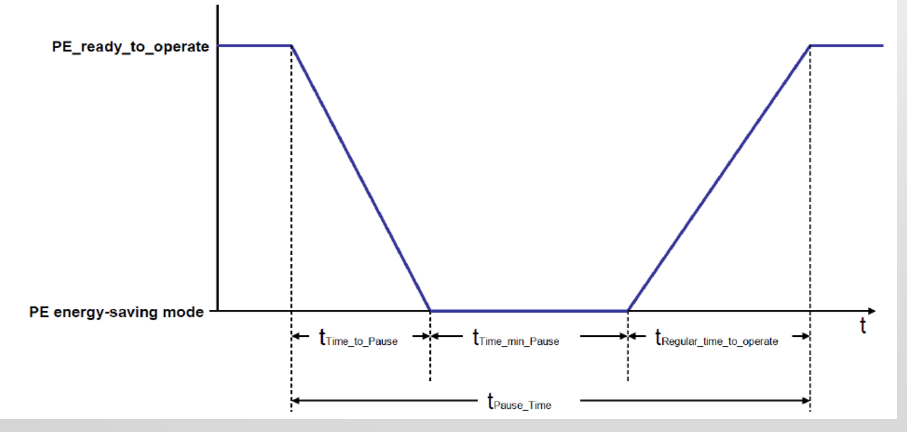
- Some facts
  - Mean production cycle time - 56 s
  - Time for the main part to pass through – 224 s
  - Operation from Sunday 6pm to Saturday 6am
  - Controlled with a Siemens Simatic PLC, uses PROFINET





PROFIenergy

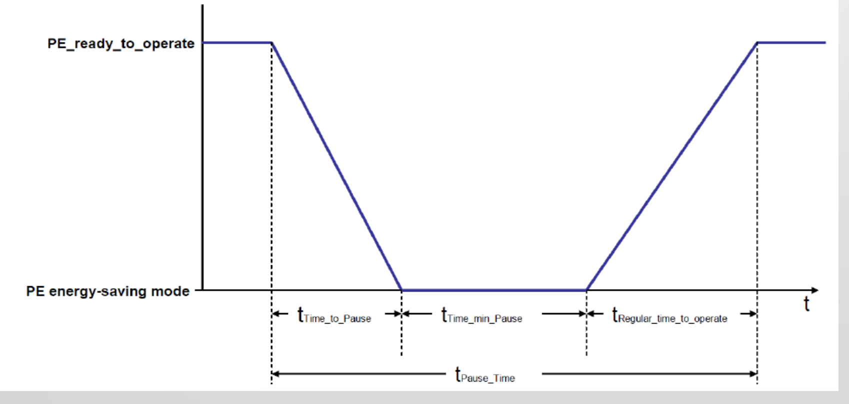
- Profile defined by Profibus&Profinet International
  - Allows for turning on and off different operating modes from the PLC
  - Measurement of energy consumption
  - Required by the automotive industry



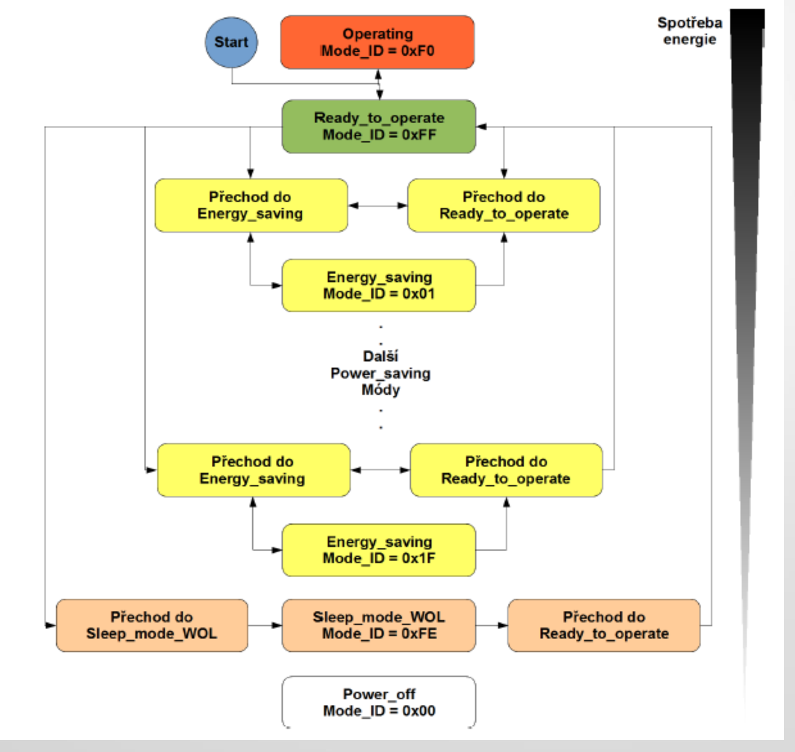
PROFIenergy

- Values of energy saving features for KR5arc

Parameter / mode	Drive_Bus_Off	Hibernate	Ready_to_Operate
T_{min_pause} [s]	25	110	x
T_{to_pause} [s]	5	50	x
T_{min_len} [s]	0	10	x
$T_{to\_operate}$ [s]	20	50	x
Energy [Wh]	150	30	220

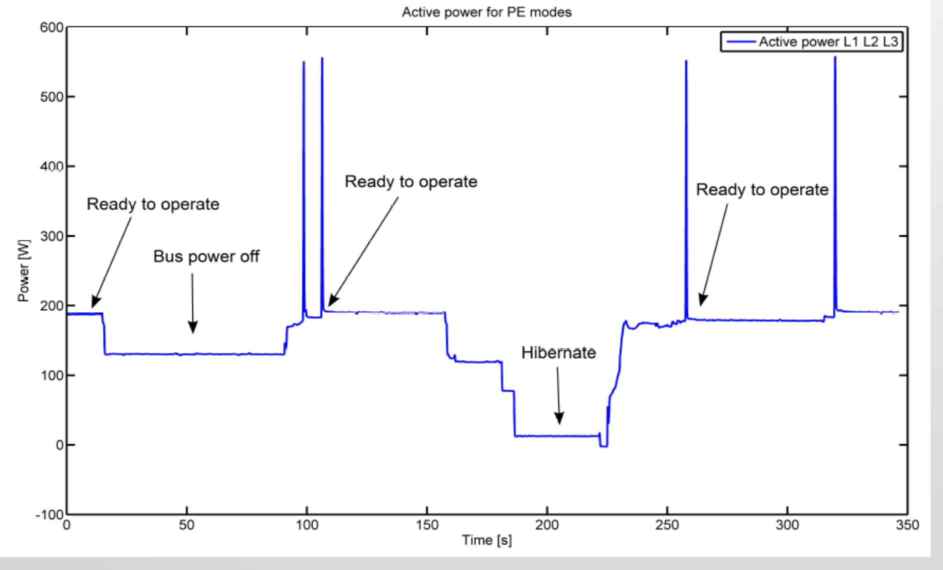


PROFIenergy



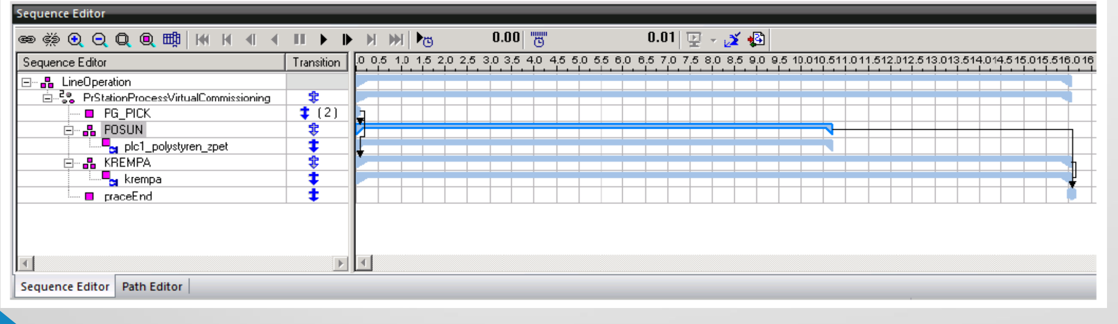
Experiments on the robot

- Connection over Profinet as PN IO Device
  - In BPO mode – it still acts as PN IO D and Controller for its own devices (e.g. gripper)



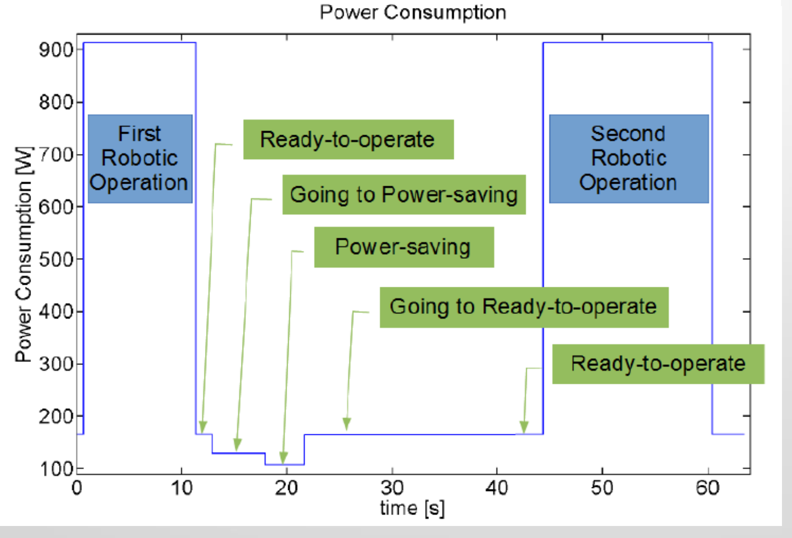
Robot simulations

- Tecnomatix Process Simulate
  - Implementation of the PE state machine
  - Two different trajectories separated with transitions to the power-saving modes
  - Virtual commissioning

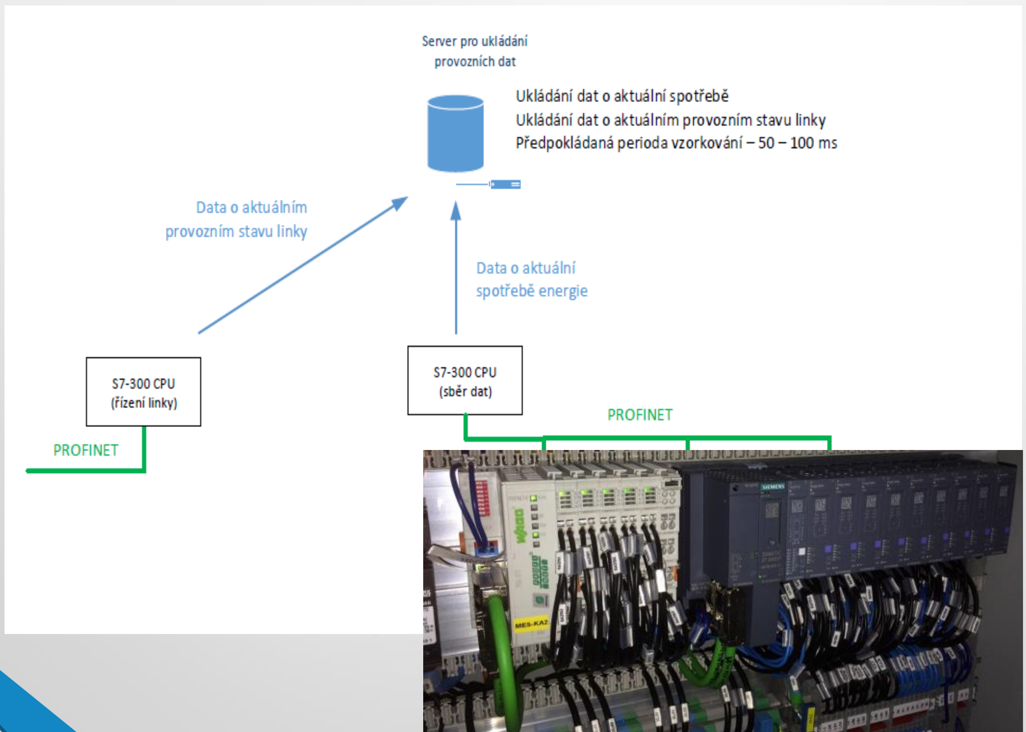


Energy consumption

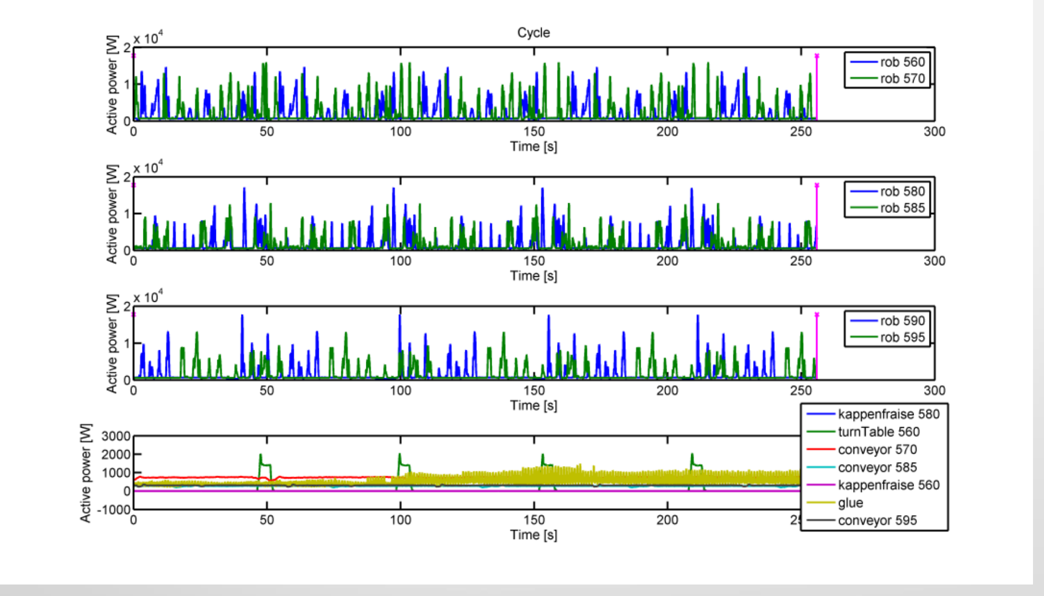
- Real robot – measured power
- Simulated robot – energy computed based on measured values



Welding line measurements

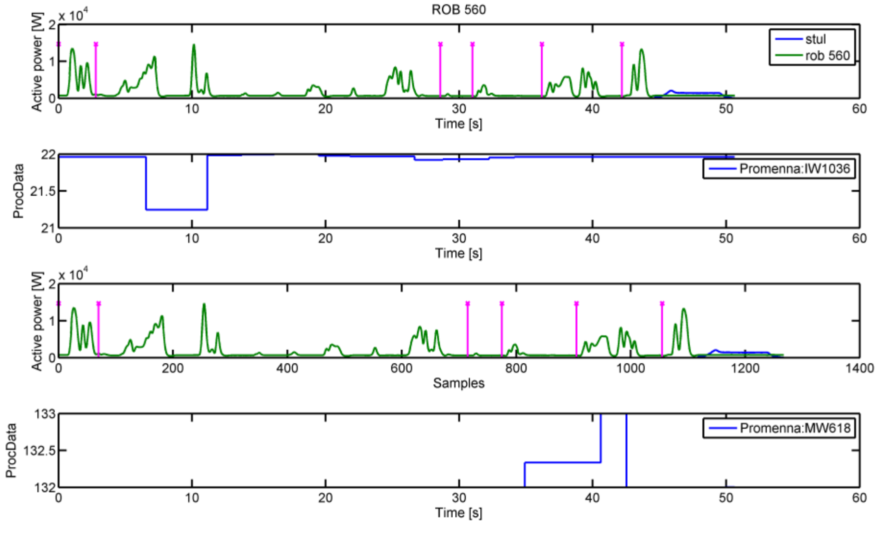


Welding line measurements



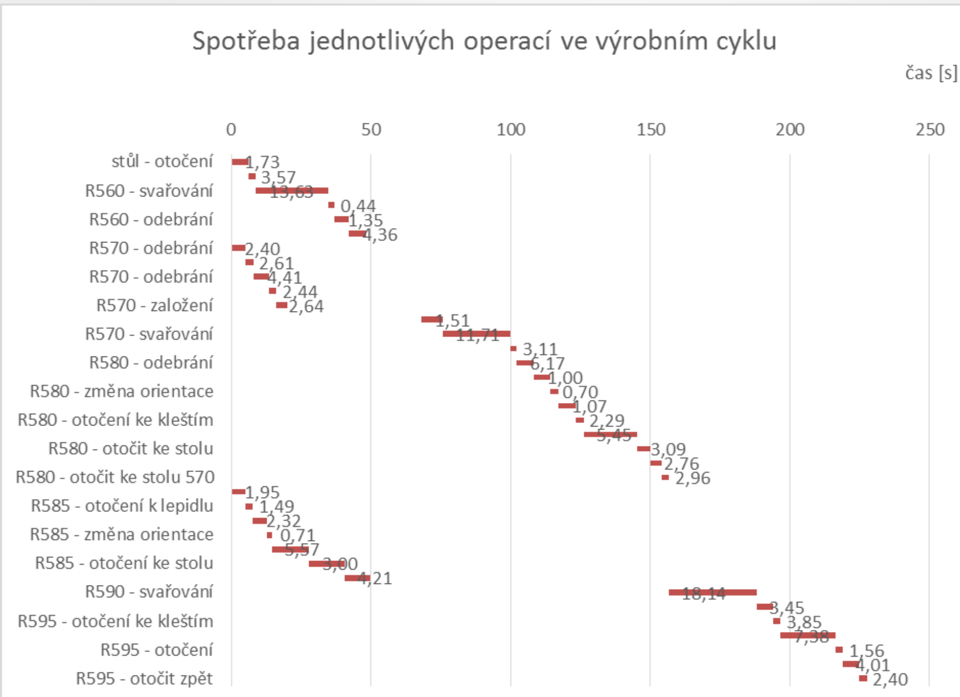
Interval corresponding to one-part path.

Welding line measurements



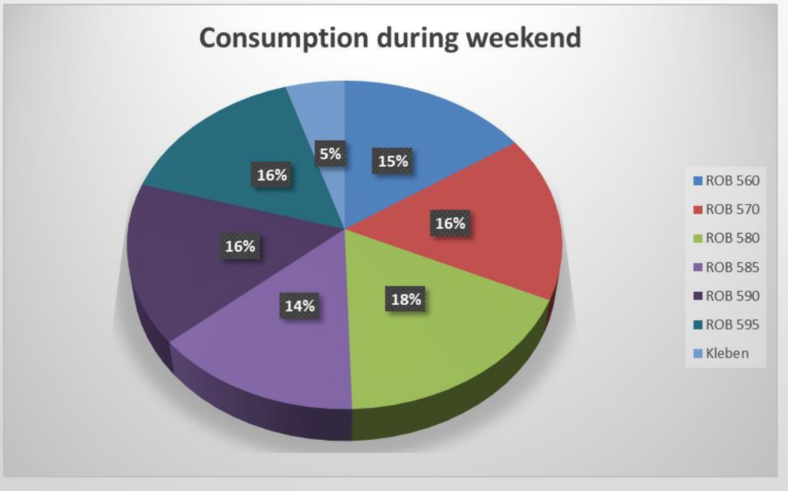
Interval corresponding to one production cycle.

Welding line measurements



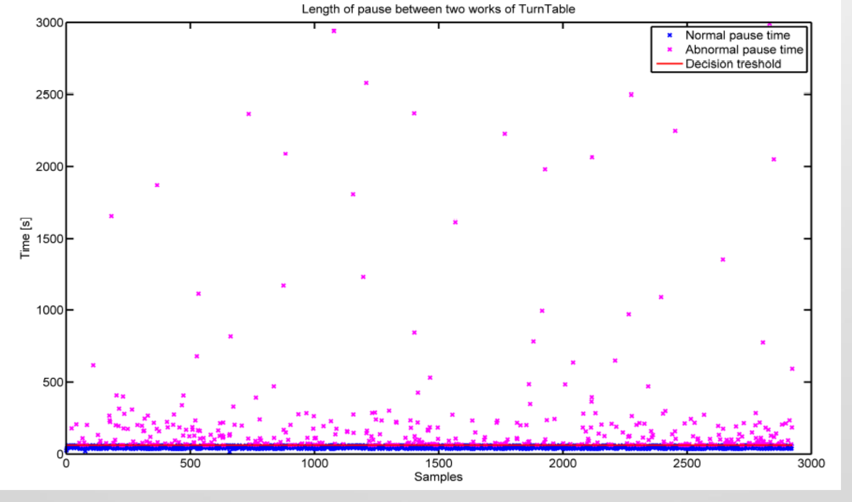
Energy consumption

- Weekend consumption
  - 60 kWh
  - if hibernated, then only 5 kWh (estimated)

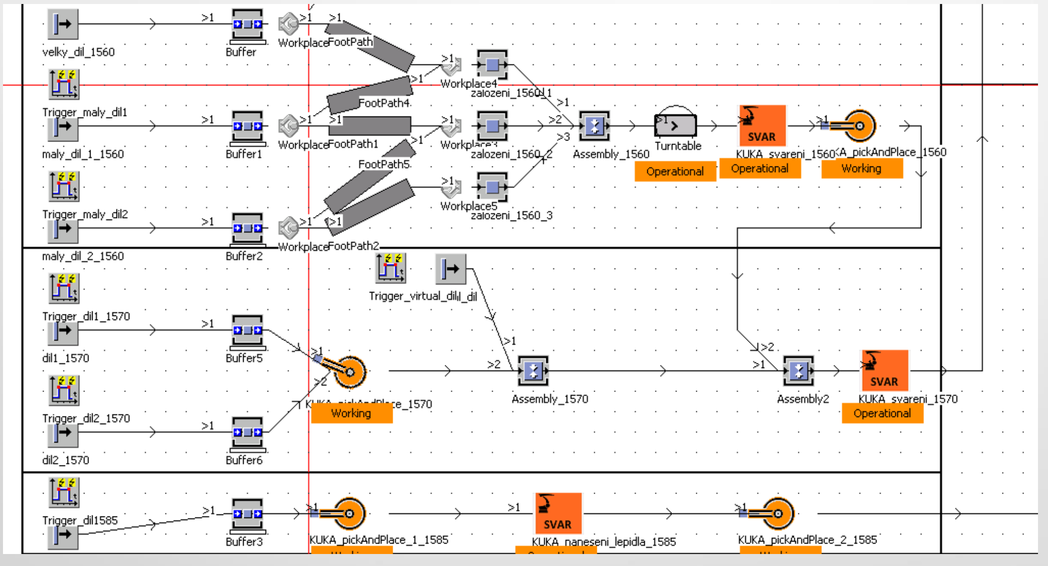


Energy consumption

- Working week
  - 1.1 MWh
- Pauses
  - Estimated savings: based on pause length and chosen energy mode

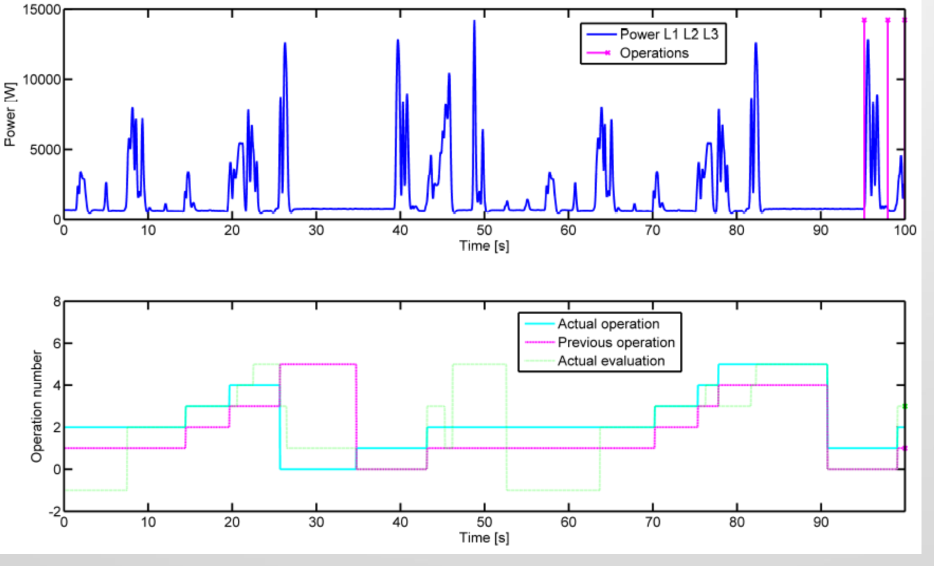


Model in Plant Simulation



Future work

- Detection and classification of operations
  - Decision making: to fall asleep or not to fall asleep
  - Relations of other devices: servo guns, glue, etc.



Future work

- Simulation of the line in Process Simulate
  - Analysis of the energy consumption and virtual commissioning with the power-saving modes
- Modelling of the energy consumption of the robot itself
  - Based on robot kinematics and dynamics, electrical parameters, etc.