# Energy-SmartOps

Integrated Control and Operation of Process, Rotating Machinery and Electrical Equipment

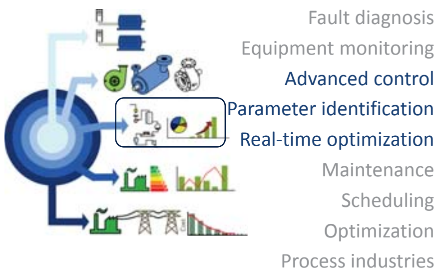
# Electrical Drives for Compressors – Work Package 4

ETH Zurich, ABB Corporate Research Poland, TU Cracow

## WP4 in Energy Smartops

**Aim:** Develop control techniques for electrical drives for compressors which minimize the power loss:

- Focus on a single machine, with the goal of delivering a desired torque for some process (e.g., taking inputs from WP2)
- Real-time implementation, which allows on-line computations
- Advanced power losses modelling, to account for more loss sources




**WP4** Optimization and energy saving

## EARLY STAGE RESEARCHERS IN WORK PACKAGE 4

**Giampaolo Torrisi** (ETH Zurich)

Loss modelling of electrical drives and MPC of compressors

**Bart Van Parys** (ETH Zurich)

Robust control of dynamical systems

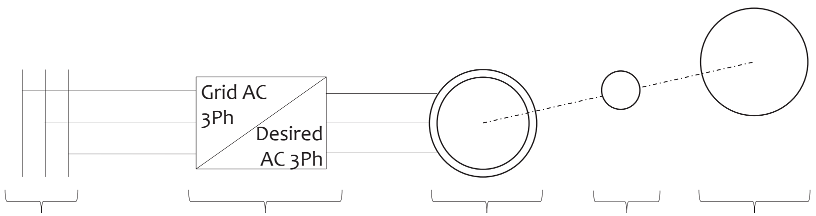
**Alejandro F. Gomez** (TU Cracow)

Compressor modeling for real-time applications

**Victor Jaramillo V.** (ABB PL)

Control of compressor and optimization of PM motors

## A generic framework for compression systems




### 3-phase grid

- Three-phase voltages at typical frequencies of 50-60Hz (EU-US),
- Variable speed control is not possible if the drive is directly connected to grid;

### 3-phase inverters

- 6-switch voltage source inverters to realize the desired voltage,
- Frequency and magnitude are important control parameters;

### Electrical Motor

- Among available technologies, we currently focus on induction motors,
- Field Oriented Control for high performance and efficiency;

### Mechanical Load

- Focus on industrial pumps and compressors moved by the electrical motor,
- Model suitable for real-time control is hard to derive;

## Optimization of electrical drives

- Development of accurate losses models and optimization schemes for electrical motors
- Design of robust control algorithm to take into account uncertaintes and performance bounds
- Preliminary experimental results suggest that our steady-state optimization approach:

i. Reduces power losses up to 20% on the tested 1HP induction motor

ii. Allows one to reduce thermal stress and/or increase the machine rating substantially

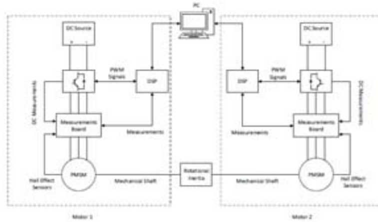
iii. Improves the efficiency at nominal conditions of 3%

## Control of compressors

- Derivation of a compressor model, suitable for embedded platforms
- Design of several controllers for compressors, suitable for embedded platforms, as PI control, backstepping control and Model Predictive Control
- Extension of the feasible operating regions to include potentially unstable points (due to surge phenomena), by opportunely controlling the recycle anti-surge valve
- Substantially improvements w.r.t. state of the art controls

## ETH case study

- An experimental test rig is employed to validate the theoretical results
- The test bench is made of two motors whose shafts are connected to each other
- Each of the motors is controlled by a DSP board, programmable in C. The data acquisition system allows us to take measurements of the input voltages and currents



| Type | Unit | Value |
|---|---|---|
| Number of pole pairs | - | 4 |
| Nominal voltage | V DC | 48 |
| Nominal speed | Rpm | 4000 |
| Nominal torque | N m | 0.36 |
| Nominal current | A | 4.5 |
| Nominal output power | W | 150 |
| No-load speed | Rpm | 6800 |
| Rotor moment of inertia | Kg m$^2$ | $19\ 10^{-6}$ |

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energy smartOps

Energy-SmartOps consortium investigates equipment and process monitoring, integrated automation and optimization for energy savings.

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