



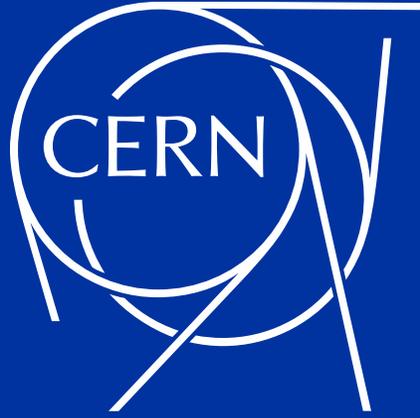
# CERN-ABB motorSENSE Project

Identifying Energy-Saving Potential through Smart Sensors, Digital Twins and Analytics

28.10.2025

A. Andersen | CERN | EN-CV-CES





# Why Energy Efficiency

# From Global Trends to CERN: The Need for Energy Efficiency



Electric motion drives global sustainability, automation, and mobility

- 45 % of the world's electricity is converted by electric motors
- Fewer than 25 % are controlled by speed drives
- Major potential for efficiency gains

*Global trend: demand for electric motion expected to double by 2040*

## Cooling & Ventilation: An Opportunity for Energy Savings at CERN

- CERN's total electricity use  $\approx$  1.3 TWh / year
- Cooling & Ventilation = 14 % of LHC consumption
- +2000 motors operated by EN-CV





**CERN-ABB  
motorSENSE Collaboration**

# motorSENSE: a CERN–ABB collaboration born from Big Science Sweden 2020



Duration: January 2022 to December 2023



## CERN team



**Ingo Rühl**  
EN-CV



**Anders Andersen**  
EN-CV-CES



**David Widegren**  
EN-IM



**Han Hubert Dols**  
IPT-KT



**Nauman Latif**  
EN-CV-CES



**Diogo Monteiro**  
EN-CV-CL



**Nikolina Bunijevac**  
EN-CV-CL



## ABB team



**Panagiotis Kakosimos**  
Principal Scientist  
Industrial digitalization



**Kristian Rönnerberg**  
Principal Scientist  
Thermal management



**Kari Saarinen**  
Principal Scientist  
Data analytics



**Simon Lundberg**  
Discovery Trainee  
ABB Sweden



**Dmitry Svechkarenko**  
Team manager,  
Powertrain & Digitalization



**Matti Laitinen**  
Business Research Manager,  
ABB Motion



**Ankush Gulati**  
Energy Efficiency Lead  
ABB Motion Services

# Collaboration Goals



## Goal 1

Creating a roadmap with the aim of achieving a 10-15% overall energy reduction in the cooling and ventilation infrastructure at CERN



## Goal 2

Create and validate a system digital twin of the cooling and ventilation infrastructure by enabling online diagnostics and maintenance



## Goal 3

Public dissemination of results to share the learnings, best practices to inspire industries and large-scale research facilities around the World to become more sustainable and reliable



# Approach and Methods

# It's all about the right approach to saving energy

## Choosing the right way to control flow and save energy



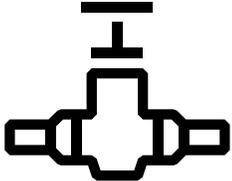
Speed control

How would you control your speed in this situation?

- 1 Take your foot off the accelerator and slow down?
- 2 Keep your foot hard on the accelerator and control your speed with the brakes?

What is the best approach? – is it obvious?

In cooling systems, controlling flow by throttling valves is like braking while keeping your foot on the accelerator



Flow control

Variable Speed Drives control flow by adjusting speed — saving energy instead of wasting it through throttling

For a 30% flow reduction:

- Throttling → only 11% power saving
- Variable Speed Drive → 55% power saving



Speed control

# Energy Appraisal

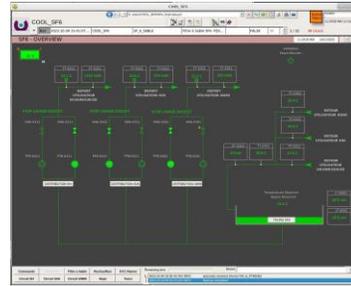
Finding the balance between efforts and accuracy needed

## Method A: Least amount of data



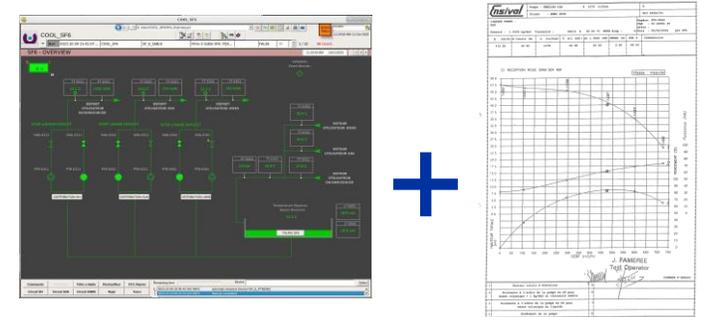
- Basic motor data
- Control method (VSD, DOL, ...)
- Load estimated or measured by ABB Smart Sensor

## Method B: Medium amount of data



- Flow data from CERN SCADA system

## Method C: Large amount of data



- SCADA flow data
- Pump curve data

Effort & Accuracy increase →

# Energy Savings Calculations

## Outcome Method A screening



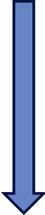

ABB Motion Services  
**Quick Scan Report - Energy Savings Potential with IE4 and IE5**

Customer	CERN
Plants	Esplanade des Particules 1, P.O. Box 1211, Geneva 23, Switzerland
Date of report	05.07.2023
# of Assets	788

**Assumption:**  
70% motor loading = 100% flow

The report presents **two separate scenarios**:

- **Motor only** replacement
- Upgrade to **Variable Speed Drive (VSD)**



≈ 60 % of motors operate without speed control  
 Most are IE1 or IE2 (low efficiency)

Excerpt from **Top 30 assets** with highest energy savings potential identified.

**Estimated Savings with appropriate Energy Savings Solutions**

#	Application	Annual Energy Cons. (kWh)	Annual Energy Cost (CHF)	Annual Energy Savings with ABB SynRM (VSD) (kWh)	Annual Energy Savings with ABB SynRM/ IE4 (VSD) (%)	Annual Energy Savings with IE4 (DOL) (%)
7	2229-C211A	1'339'642	217'022	770'033	57.5%	1.6%
5	2229-C210A	783'193	126'877	480'386	61.3%	3.5%
6	2229-C210B	738'481	119'634	452'847	61.3%	1.6%

**788 assets considered**

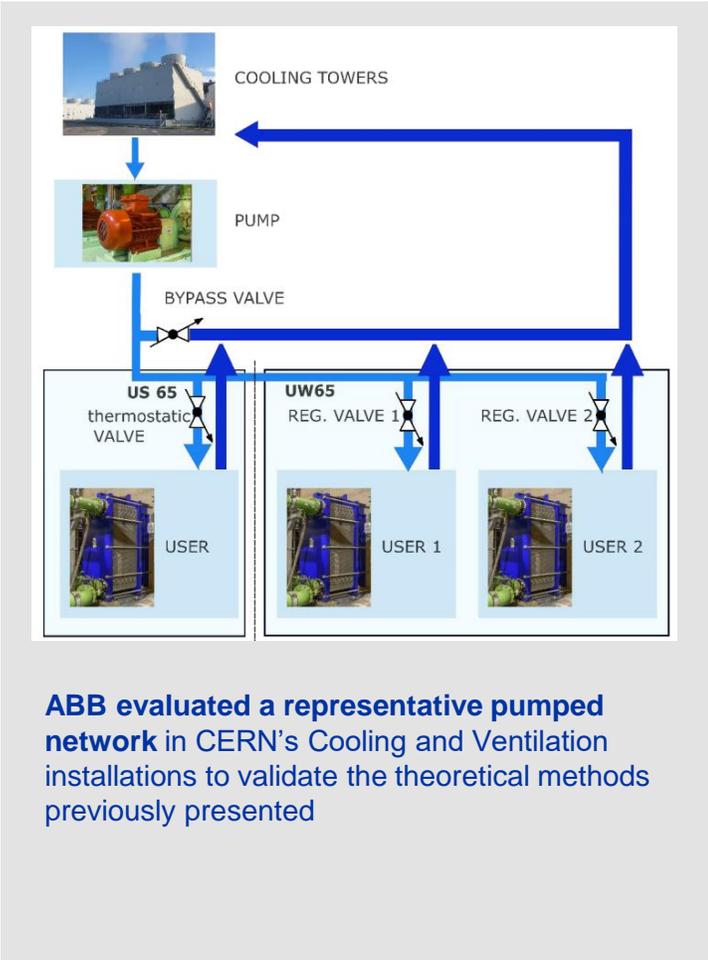
Top 30 assets → potential savings > 50 % (VSD) vs approx. 2 % (motor only)



**Going Further...**  
**Case for a Pumped Network**

# Detailed Study of a Pumped Network

## SF6 to UW65 network – ABB analysis

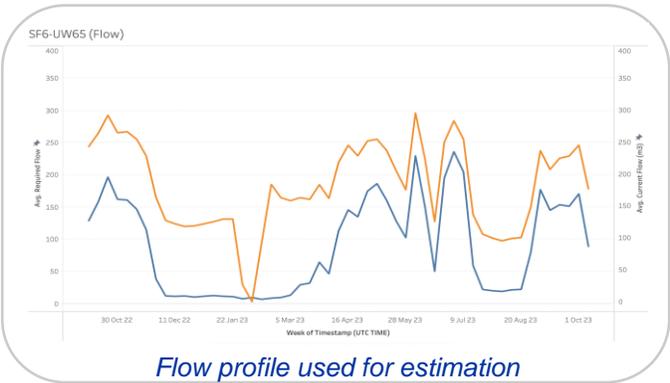


### Scope

- Detailed assessment of a representative pumped cooling network
- Network currently operating with **combined throttling and bypass regulation**
- Identification of required modifications for variable-flow operation
- Evaluation of energy savings through SynRM + VSD solution

### Key outcomes

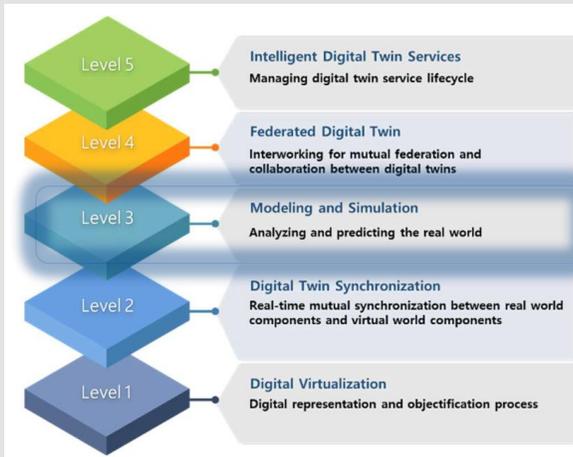
- Confirmed feasibility of variable-flow operation
- Estimated **64 % energy reduction** (~47 t CO<sub>2</sub> / year)
- **Return-on-investment under 3 years**



Study based on historical flow and operating data (2023)

# Digital Twin Study of the SF6–UW65 Network

## CERN Controls Analysis



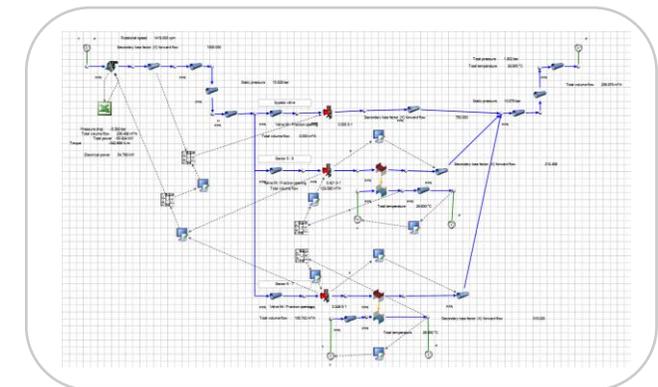
CERN developed and simulated a full digital twin of the same pumped network to validate and extend the ABB analysis using real operating data and advanced control strategies

### Scope

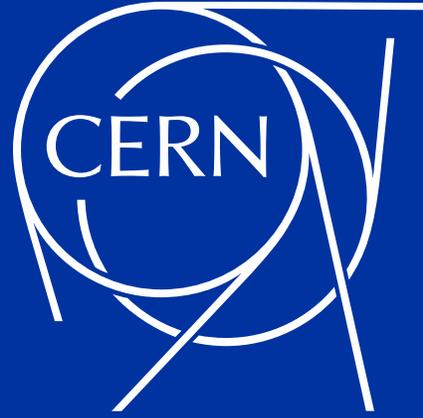
- Full hydraulic reproduction of the SF6–UW65 network in Flownex digital twin platform
- Dynamic simulation using historical operating data and real control parameters
- Evaluation of variable-flow operation with CERN's smart regulation

### Key outcomes

- Estimated 79 % energy saving, 2 years return-on-investment
- Validated feasibility of stable variable-flow operation across all load conditions
- Demonstrated the impact of advanced control and regulation strategies on network efficiency



Digital twin reproducing the full hydraulic network – validating and extending ABB's energy savings assessment.



# Results and Beyond

# motorSENSE Collaboration – Key Conclusions

## POTENTIAL SAVINGS

# 17.4%

across a fleet of  
800 motors based on  
method A appraisal

## POTENTIAL SAVINGS

# >50%

on networks suitable for  
variable-flow operation  
validated through detailed  
studies



# Beyond the motorSENSE Collaboration

**10 years**  
energy efficiency consolidation  
program

On CERN Cooling and Ventilation  
installations

Approved in May 2025

Implementation phase to extend efficiency  
improvements across CERN installations



**CERN's 2022 collaboration** with ABB inspired a similar energy-efficiency partnership at **GSI in 2025**



# Thank you for your attention

Questions?

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# ABB Ability Smart Sensor Specifications



SPECIFICATIONS	High performance sensor	Standard performance sensor
Lifetime	up to 15 years operation under standard conditions <sup>1)</sup>	up to 5 years operation under standard conditions <sup>1)</sup>
1) ABB indicates a maximum sensor lifetime which varies between sensor types and is based upon standard usage conditions. Standard conditions of operations are as follows: sensor measurement interval of 1 hour; raw data collection once per day; non-condensing environment; measured asset skin temperature: +15 °C to +50 °C		
<b>Vibration measurement</b>		
Acceleration, low frequency (x, y, z direction)		
Amplitude range	0.03 - 157 m/s <sup>2</sup> (16g)	
Frequency bandwidth	0.4 Hz – 3.3 kHz	
Acceleration, high frequency (z direction)		
Amplitude range	0.1 - 490 m/s <sup>2</sup> (50g)	N/A
Frequency bandwidth	2.4 Hz - 10 kHz	N/A
<b>Magnetic field measurement</b>		
Magnetic field (x, y, z direction)		
Amplitude range	1 - 1600 µT	
Frequency bandwidth	0.1 - 280 Hz	
<b>Ultrasonic sound measurement</b>		
Microphone		
Amplitude range	0.6 mN/m <sup>2</sup> - 20 N/m <sup>2</sup>	
Frequency bandwidth	100 Hz - 80 kHz	
<b>Temperature measurement (asset skin temperature)</b>		
Measurement range	-40 °C to +85 °C	
Resolution	0.1 °C	
Accuracy	+/-0.5 °C	
<b>Wireless communication</b>		
Communication standards	Bluetooth® 5.0, Bluetooth® Low Energy or WirelessHART (HART 7.4)	Bluetooth® 5.0, Bluetooth® Low Energy
Radio standard	IEEE 802.15.4	
Frequency	2.4 GHz, license free ISM band	
Range (nominal)	>200 m @ line of sight	

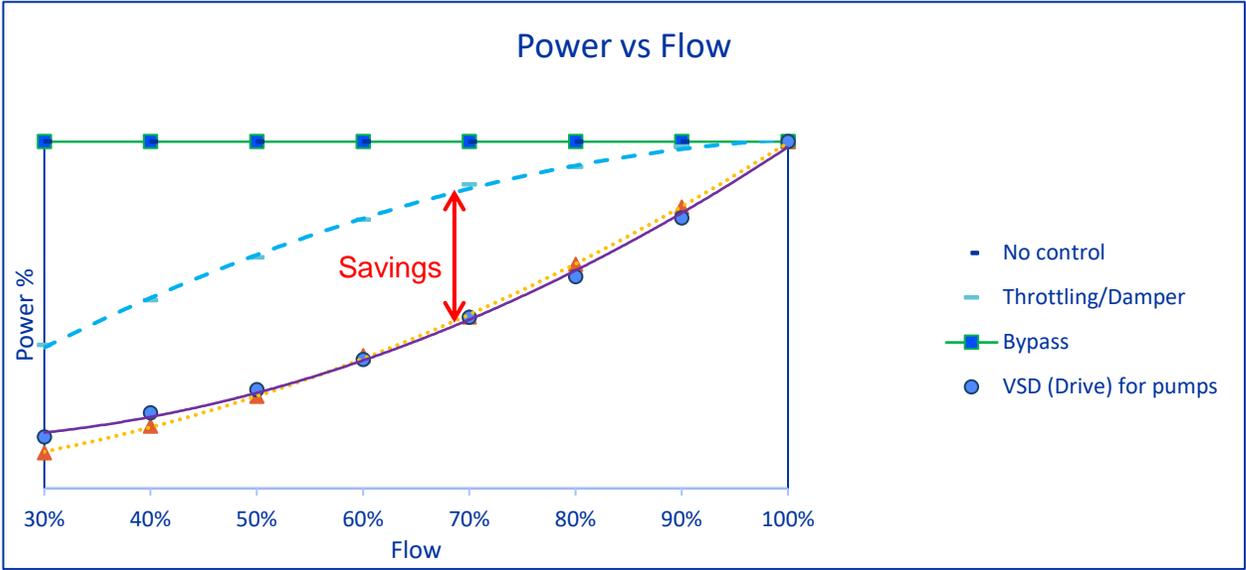
<b>Security</b>		
Encryption	128-bit AES encryption	
Authentication	IEC 62351 (role-based access control)	
<b>Power</b>		
Battery type	not replaceable	
<b>Environmental</b>		
Temperature	Operation: -40 °C to +85 °C Storage: : <30 °C	
IP class	IP66/67 (dust-tight and resistant to powerful water jetting and submersion)	
Chemical tolerance	See chemical tolerance sheet for PBT (Polybutylene terephthalate)	
<b>Certifications</b>		
Hazardous areas	Ex ia I Ma -40 °C ≤ Tamb ≤ +85 °C (Mining) Ex ia IIC T4 Ga -40 °C ≤ Tamb ≤ +85 °C (Gas) Ex ia IIIC T157 Da -40 °C ≤ Tamb ≤ +85 °C (Dust) CI I, Div 1, Gr A, B, C and D T4 CI II, Div 1, Gr E, F and G T4 CI III, Div 1	
Radio	EN 300 328 v.2.1.1, EN 301 330 v.2.1.1 FCC/IC	
<b>EMC</b>		
Immunity	EN/IEC 61000-6-2	
Emission	EN/IEC 61000-6-3	
<b>Physical</b>		
Dimensions (W x D x H)	82 mm x 69 mm x 45 mm	75 mm x 58 mm x 33 mm
Weight	185 g	130 g
Case material	Stainless steel/reinforced PBT	
Mounting	On equipment housing or frame. Please consult installation manuals.	

More information can be found in [ABB Ability™ Digital Powertrain - Condition monitoring of rotating equipment fitted with ABB Ability™ Smart Sensors \(EN\)](#)

# Monitored Parameters & Advantages

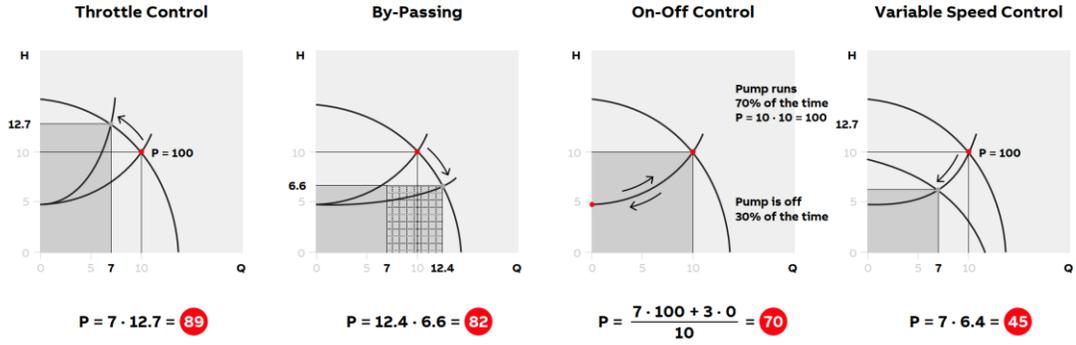
Monitored Motor Health Parameters	Monitored Motor Operating Parameters	Advantages
<ul style="list-style-type: none"> <li>• Overall condition</li> <li>• Overall vibration</li> <li>• Bearing condition</li> <li>• Skin temperature</li> <li>• Misalignment</li> </ul>	<ul style="list-style-type: none"> <li>• Vibration (radial, tangential, axial)</li> <li>• Velocity RMS</li> <li>• Acceleration RMS</li> <li>• Acceleration peak to peak</li> <li>• Speed (rpm)</li> <li>• Running time/Operating hours</li> <li>• Total number of starts</li> <li>• Supply frequency (Hz)</li> <li>• Output power (hp/kW)</li> <li>• Regreasing count-down</li> <li>• Magnetic Field</li> <li>• Acoustic signals</li> </ul>	<ul style="list-style-type: none"> <li>• Early detection of potential problems minimises unplanned downtime</li> <li>• Condition-based maintenance lowers costs</li> <li>• Process optimisations reduce operating and energy costs</li> <li>• Remote condition monitoring increases personnel safety</li> <li>• Operating in explosive atmospheres</li> <li>• Easily retrofitted to ABB or third-party equipment</li> </ul>

# How Variable Speed Drives Cut Pump Energy Use



## Different control methods for water pumps

Needed power for reduced flow (70%)

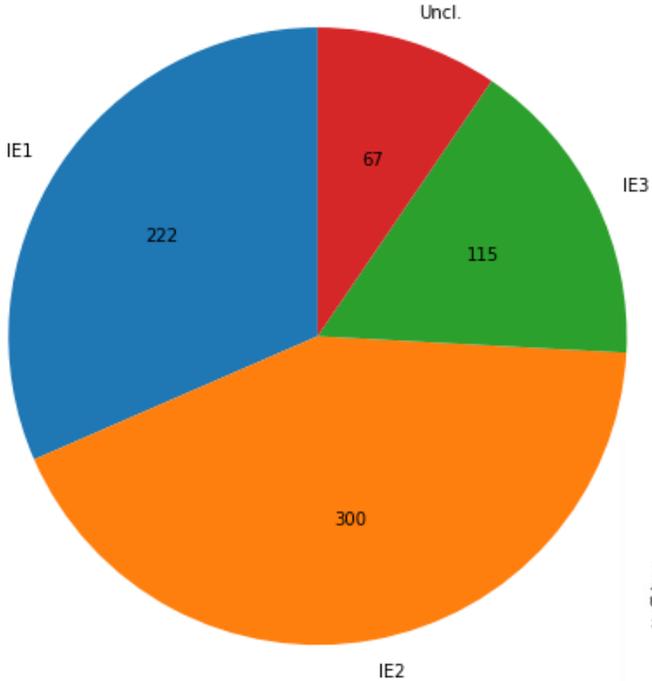


VSDs adjust speed instead of throttling, avoiding energy loss at partial flow

# Motor Population and Efficiency Baseline

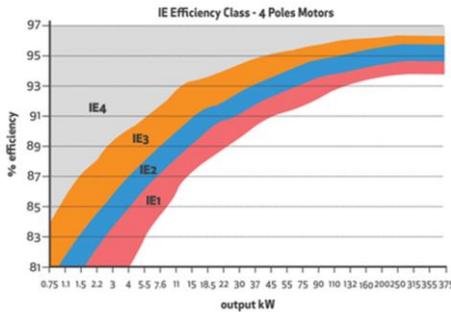
Data extracted from ABB motor audit – basis for energy savings calculations

Motor efficiency class distribution



Most motors are IE1 or IE2

Efficiency ranges for motors



Motor control method breakdown

Starting method	Number of motors
2-speed motor	25
Direct-on-line (DOL)	323
Soft starter	47
Star-Delta	33
Variable Speed Drive (VSD)	275

≈ 60 % of motors operate **without speed control** (DOL, Soft starter, Star-Delta, or 2-speed,)

# CERN Smart Regulation

White paper:

<https://inspirehep.net/files/8adf5f2ffa67dd786649f45b274b8125>