Industrial Heat & Power / Project 6-25

(Aei®) - CO_2 impact with AI

12-10-2021 Rob Burghard

www.energq.com

Translation of the Law of conservation of energy into technology

ASSET DATA &
EXISTING KNOWLEDGE

+

ENERGY &
WEATHER DATA

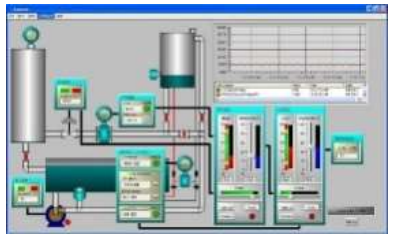
+

ARTIFICIAL ENERGY
INTELLIGENCE (Aei)

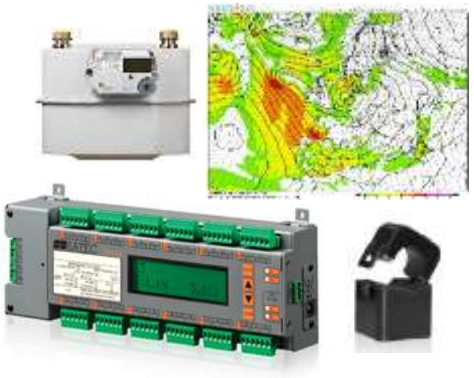
=

ENERGY SAVINGS
INCREASE MTTF
NEW KNOWLEDGE

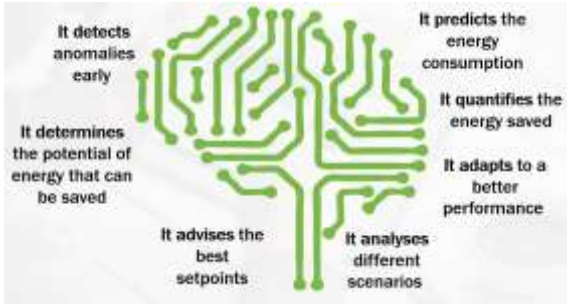
Asset performance



Additional sensors

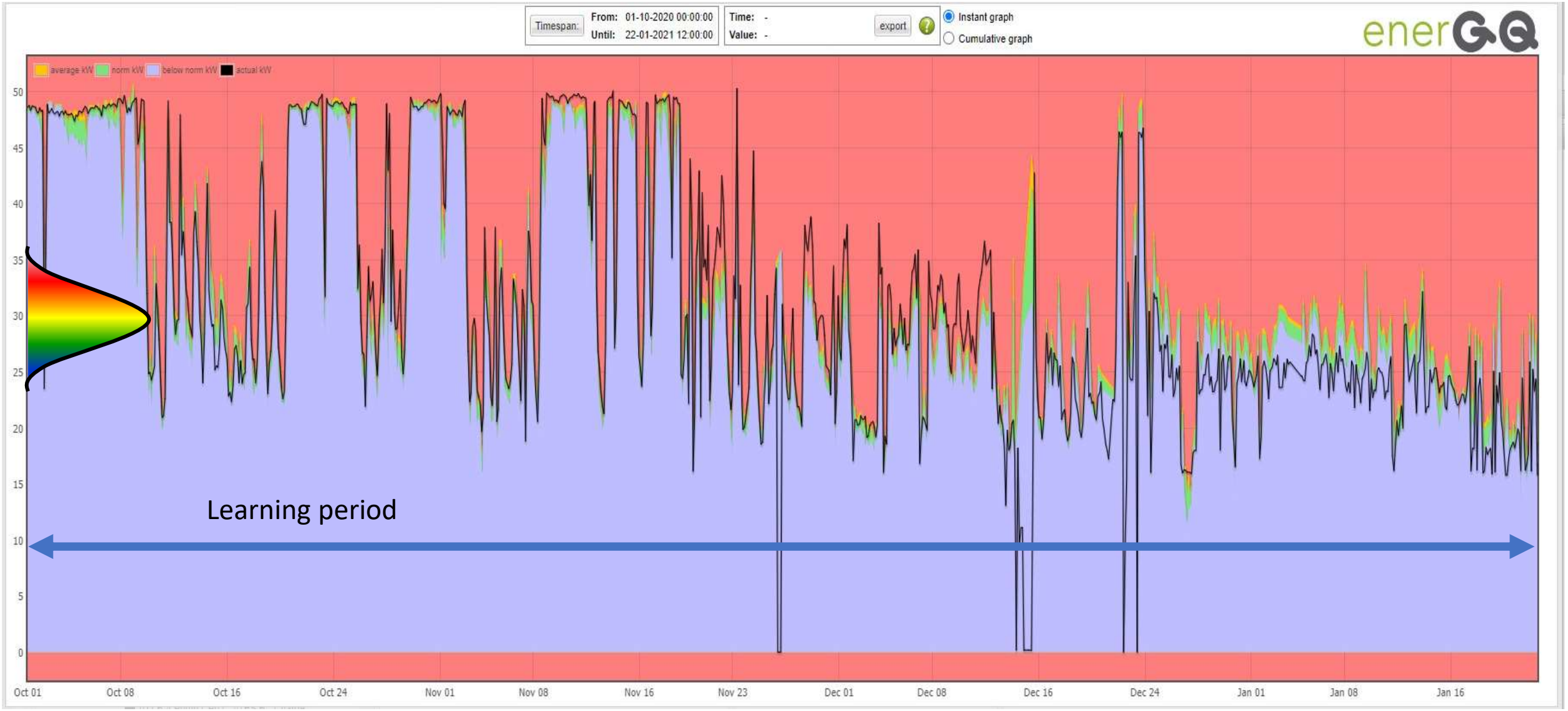


technology



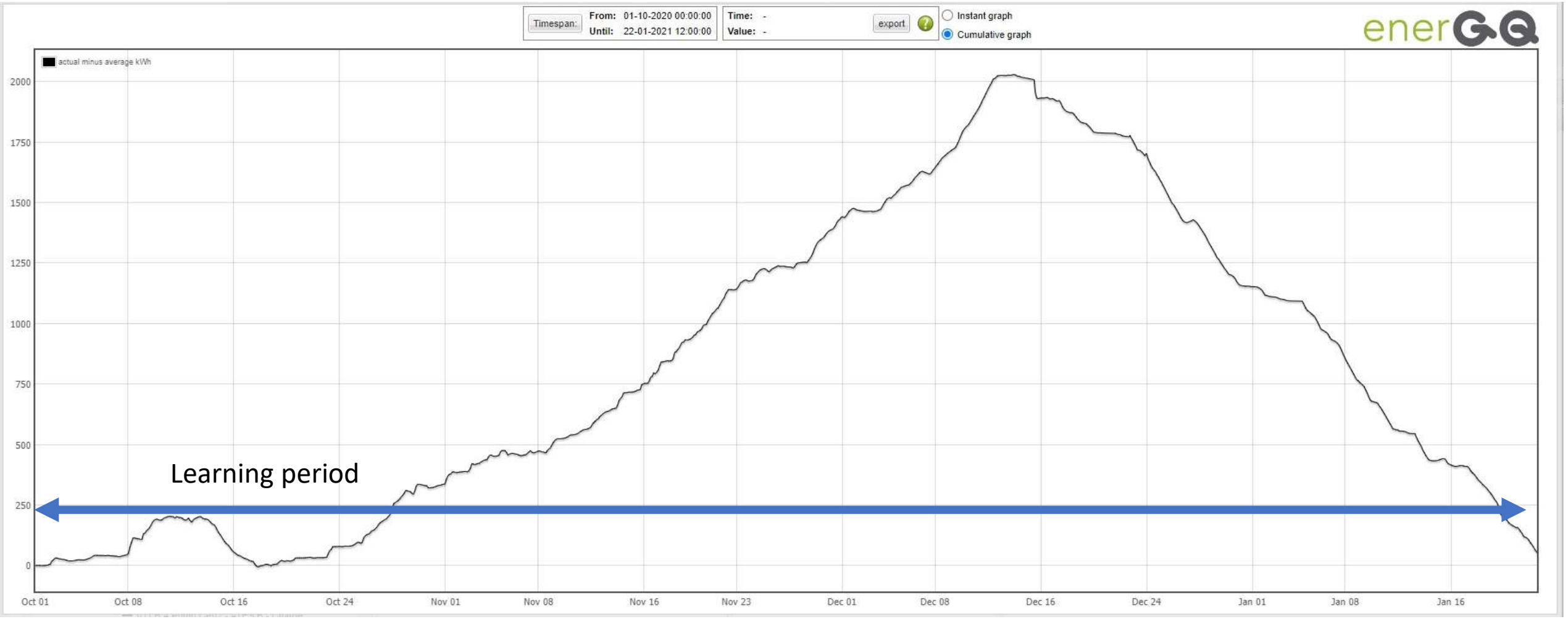
added values

Effect of descaling closed circuit open cooling towers
Power consumption in kWh



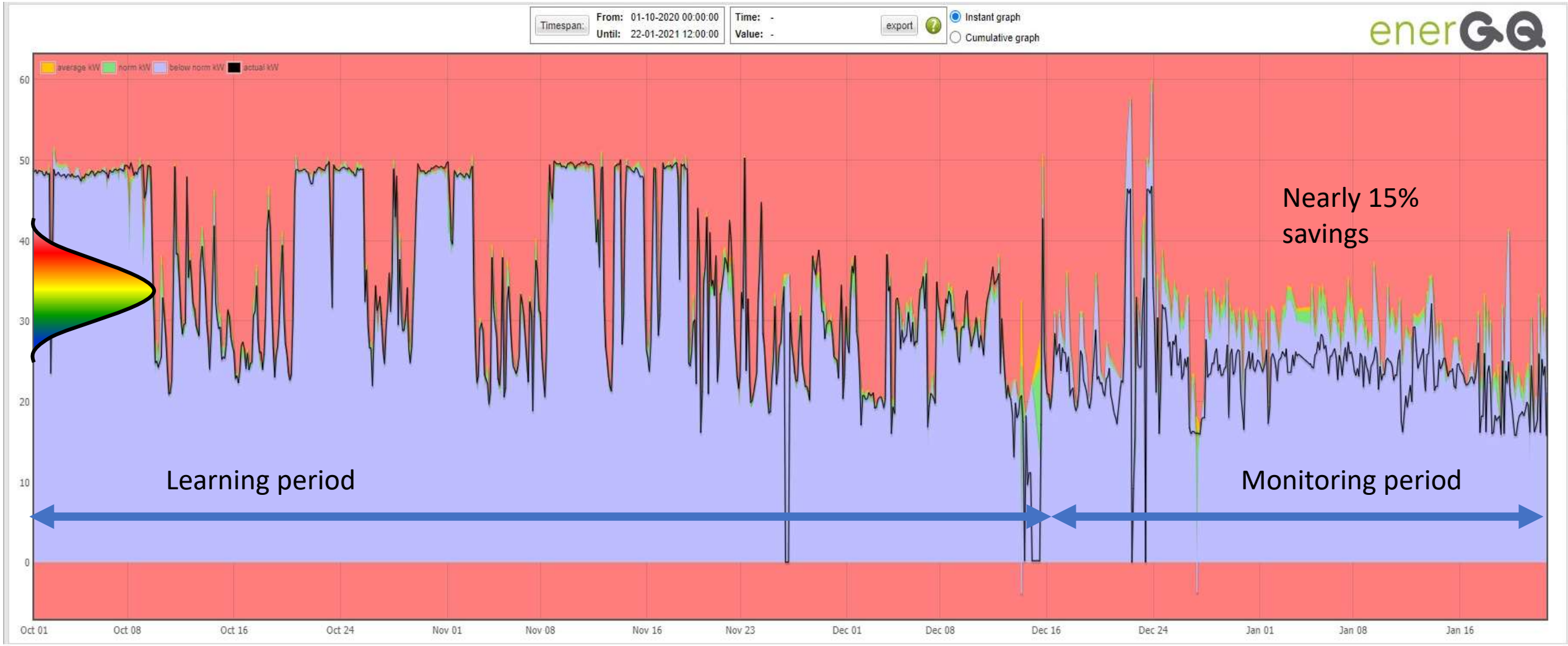
Learning period: October 1 – January 22

Effect of descaling closed circuit open cooling towers
CUSUM in kWh



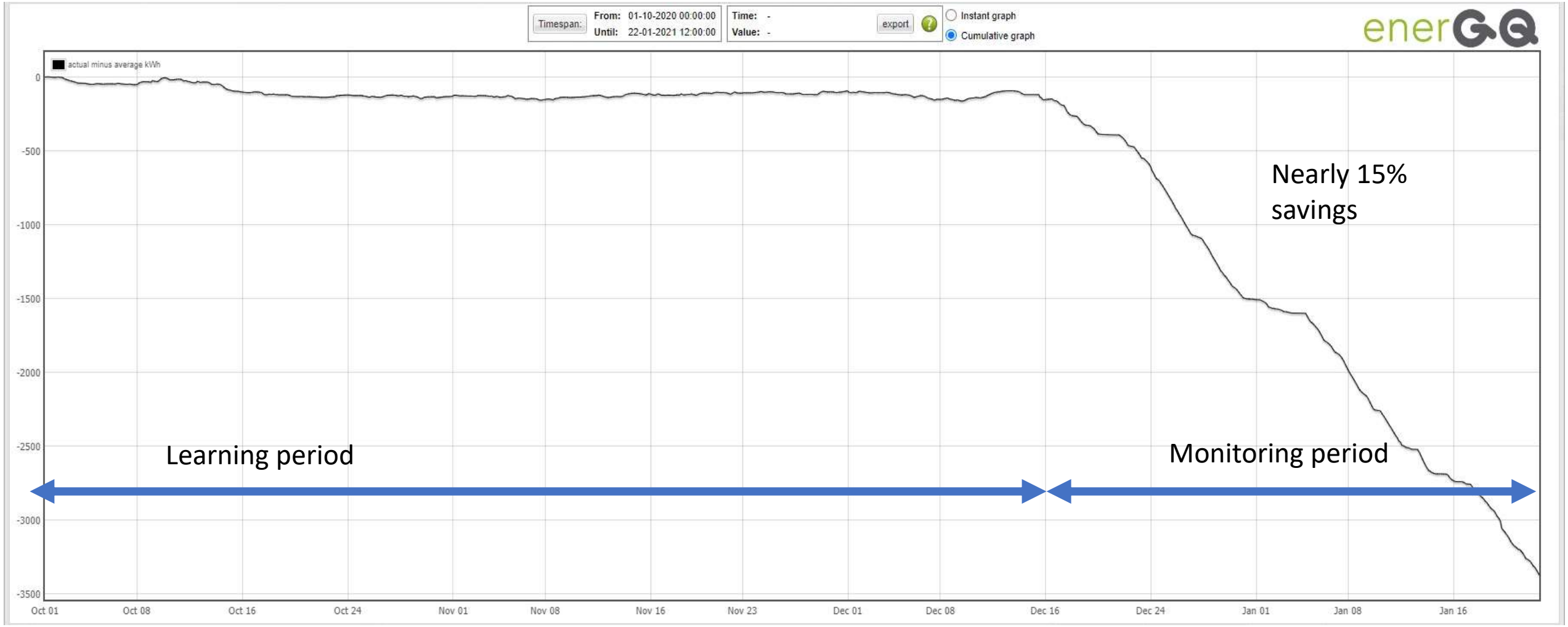
Learning period: October 1 – January 22

Effect of descaling closed circuit open cooling towers
Power consumption in kWh



Learning period: October 1 – December 16

Effect of descaling closed circuit open cooling towers
CUSUM in kWh

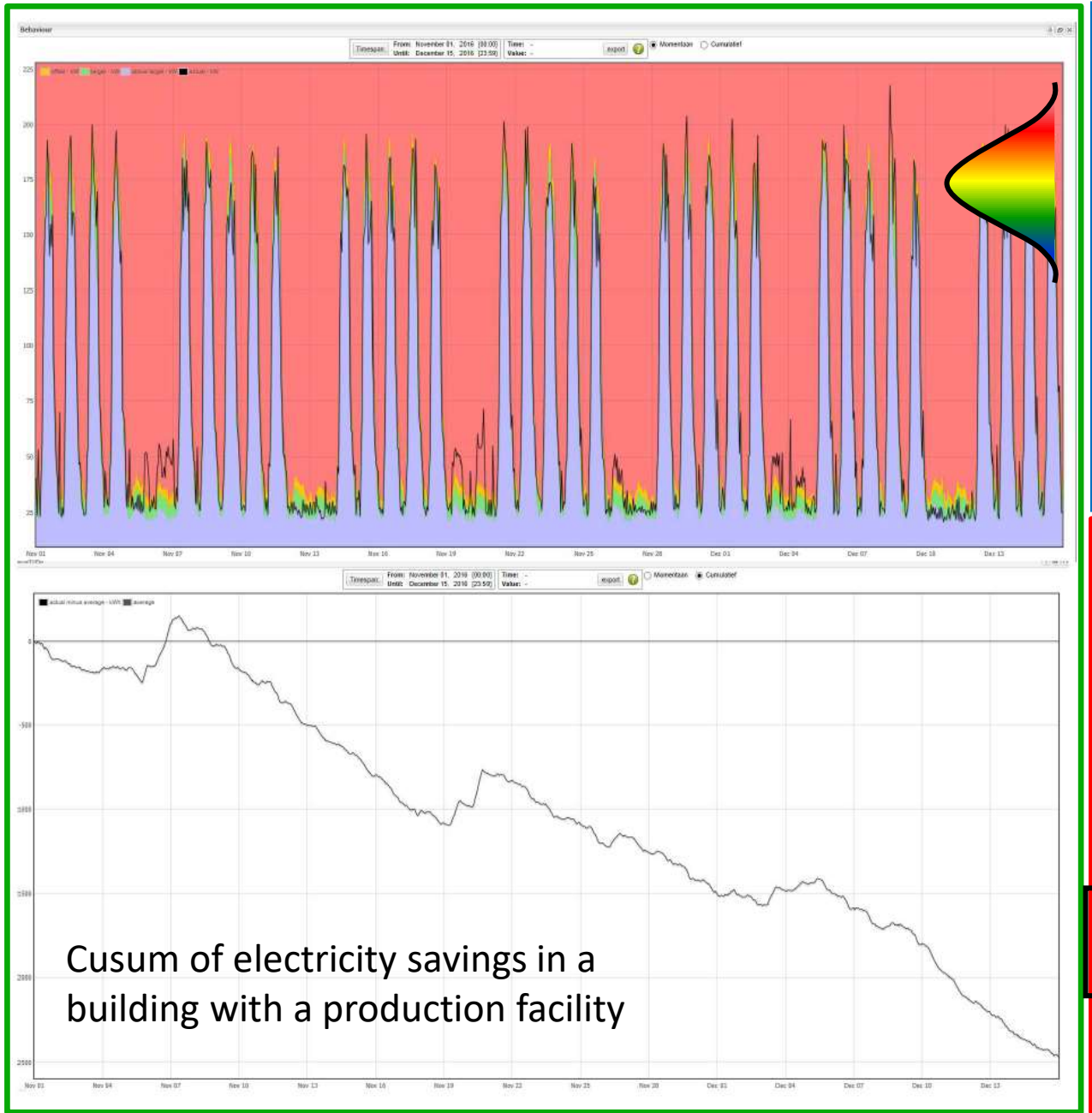


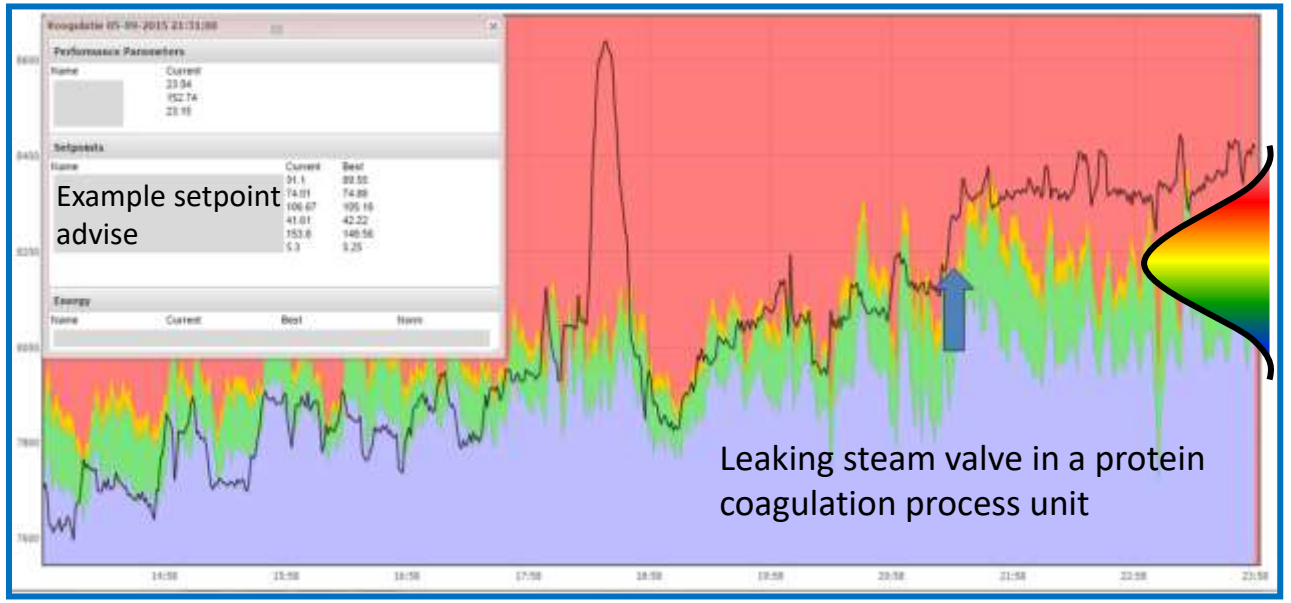
Learning period: October 1 – December 16

artificial energy intelligence

3 more examples

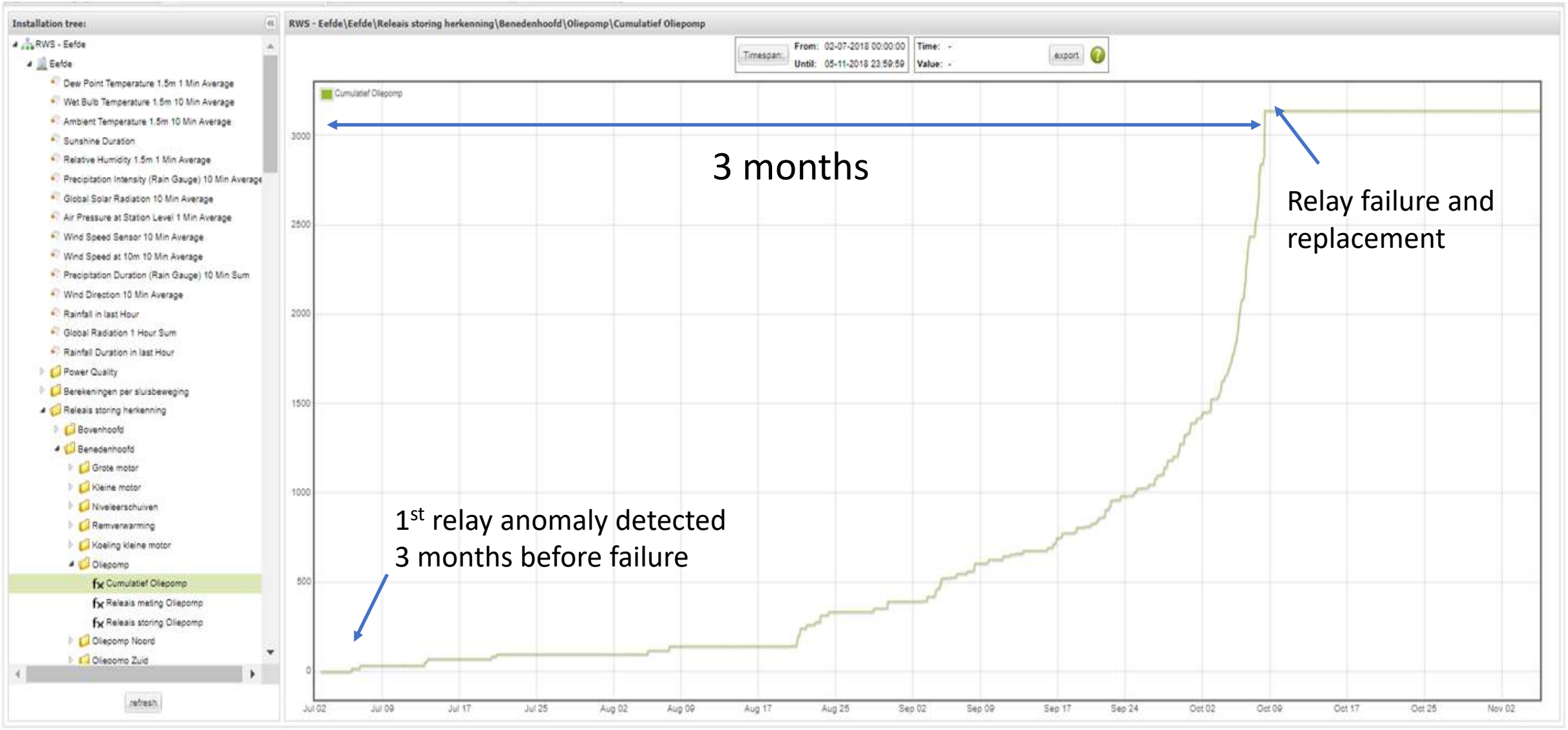
enerGQ™





artificial energy intelligence

Condition monitoring relay failure ‘Early Warning’



Potential scan for maximising value from energy

Operations & Maintenance

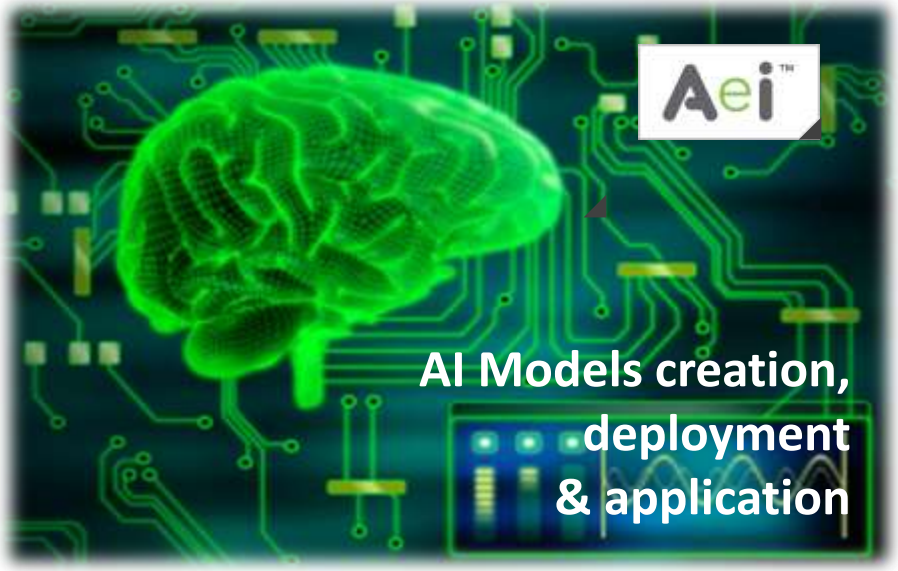
domain knowledge & historical events with loss of value

Weather

Energy + PQ

Data infrastructure

historical data and setpoints



real time data

Process Control System

Potential value gains + BC

Senior Management

artificial energy intelligence

Maximising value from energy

Operations & Maintenance

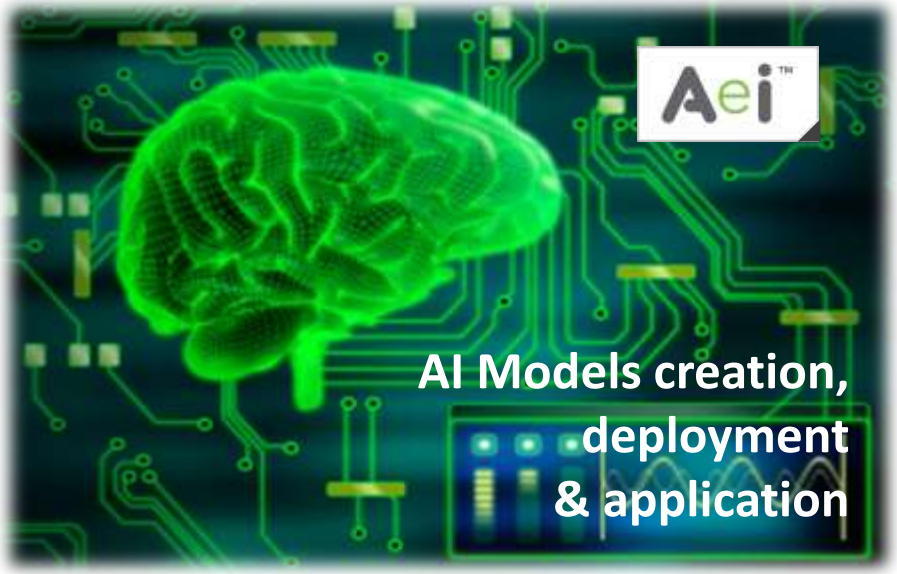
domain knowledge

Weather

Energy + PQ

Data infrastructure

near real time data and setpoints



real time data

optimized setpoints

early anomaly detection

Operations

Predictive Maintenance

Process Control System

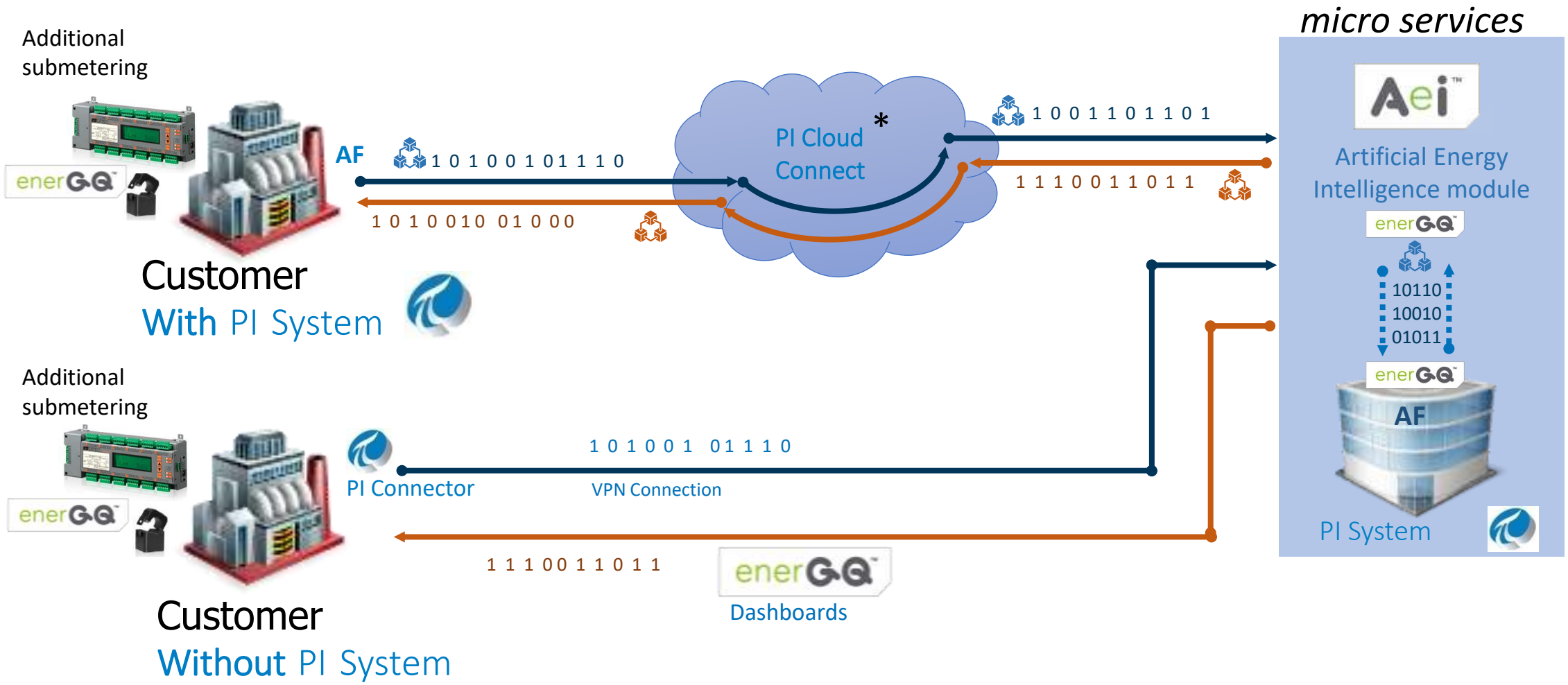
optimized setpoints

Results

CO2 ↓

€€€ ↑

Solution architecture for customers with and without PI systems



* on-premise installation with access by enerGQ is optional.

Thank you!

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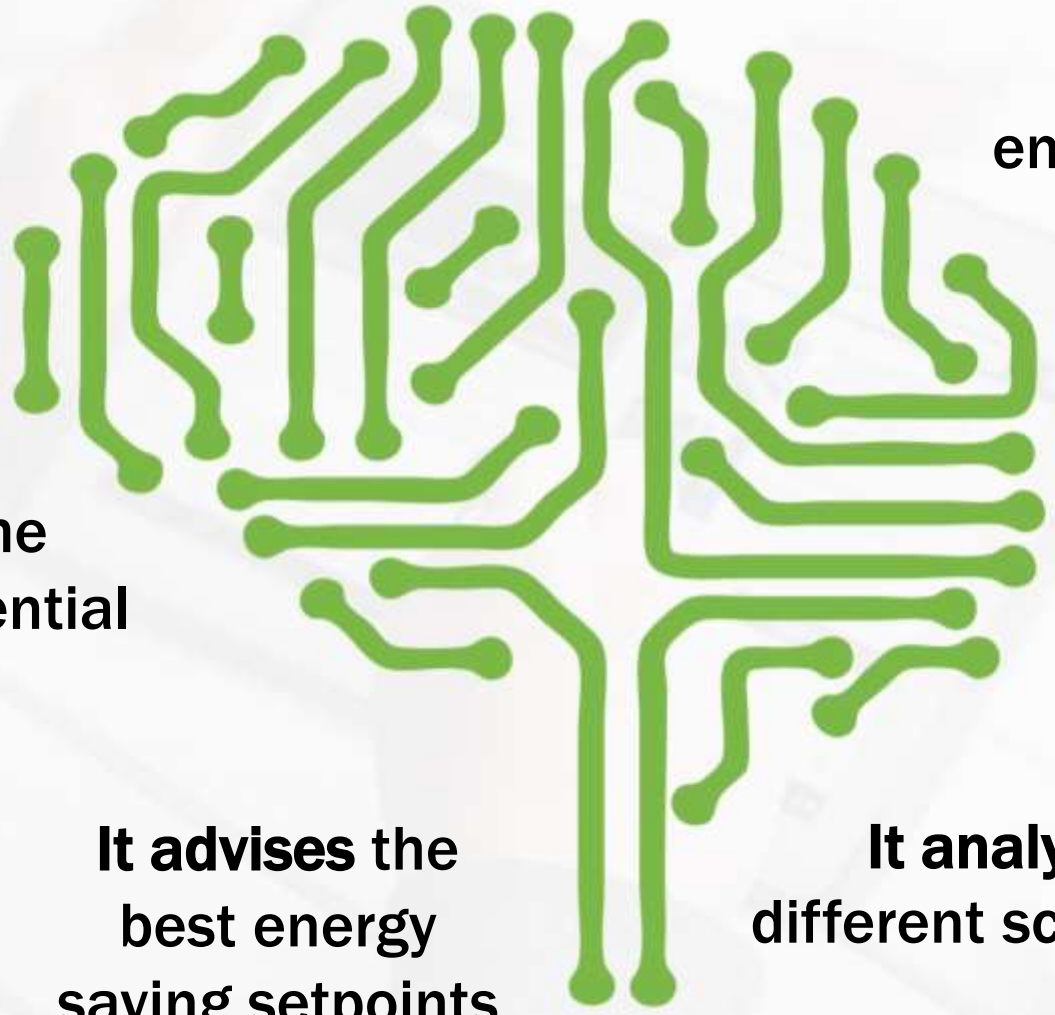
More added values of the Artificial Energy Intelligence Software that help to reduce the CO2 footprint

It detects anomalies early

It predicts the energy consumption



It quantifies the energy saved

It determines the energy saving potential

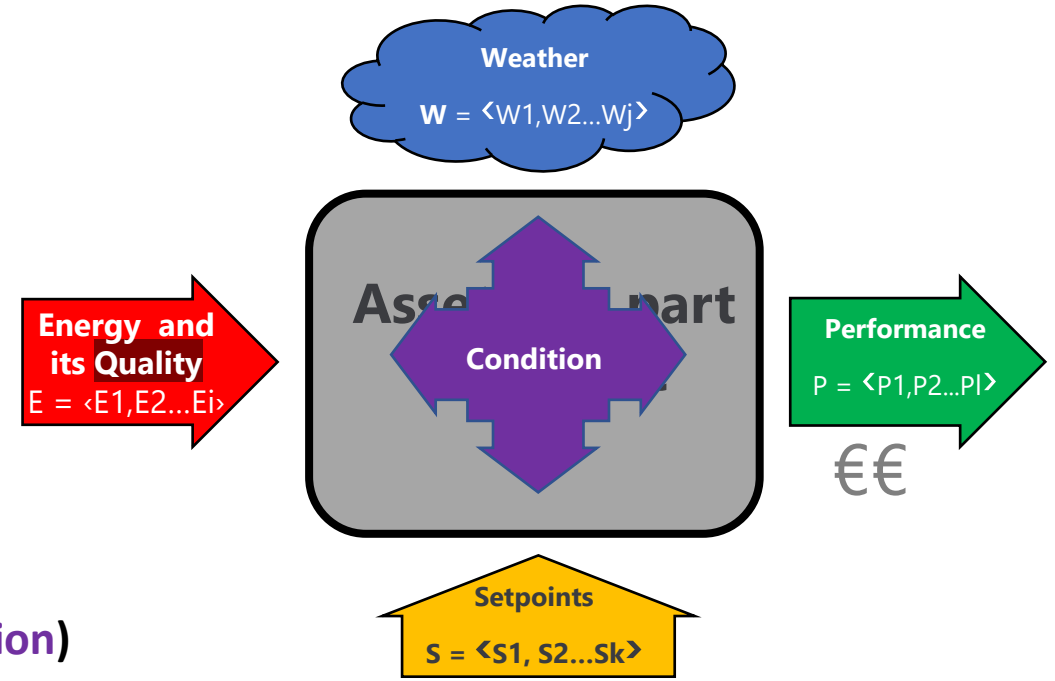
It adapts to a better performance

It advises the best energy saving setpoints

It analyses different scenarios

Law of energy conservation implies that every combination of parameters relates to an asset's specific *NORMAL* energy consumption

Weather (wind speed, wind direction, sun radiation, ambient temperature, wet bulb temperature, rainfall)



Quantity & Quality of the energy (power quality, gas quality etc.)

Performance (a quantified specific task, often a combination of water level, speed, pressure, weight, flows, temperatures etc.)

E, Q = f (P, W, S, asset condition)

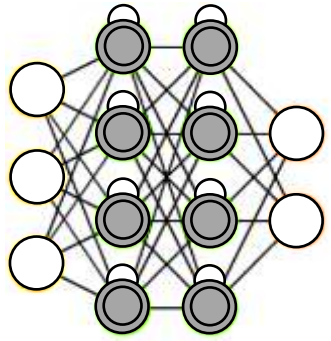
Settings (all degrees of freedom related to the operation of the asset (setpoints, controls settings, operational status of the asset)

artificial energy intelligence

Baselining & calculation of potential operational energy savings

(1)

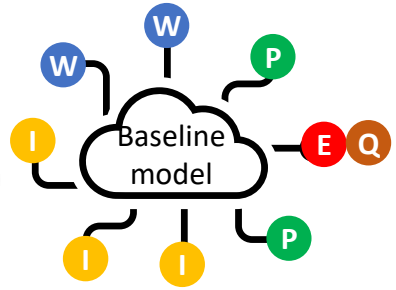
Input
Historical data of energy, process & weather
+ domain knowledge



Aei - LSTM

(2)

Output
Baseline models of normal energy use (quantity & quality)

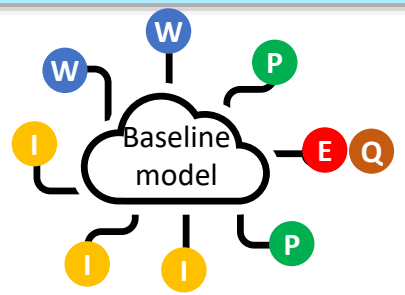


Monitoring asset status, and energy savings with Aei

(3)

near real time energy data

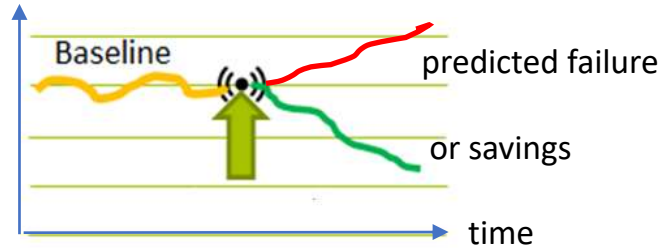
Input
near real time data of process & weather



(4)

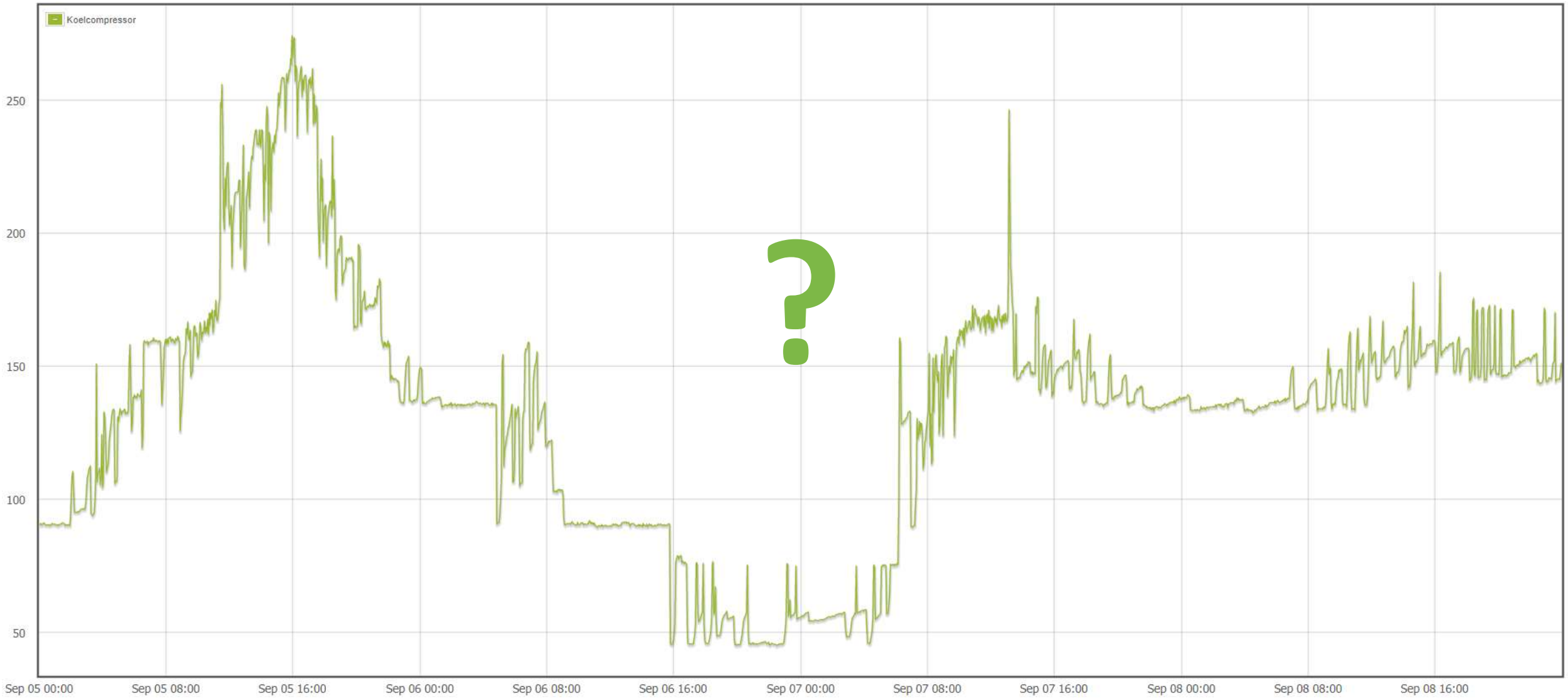
Output
alarms deviating energy use or deviating power quality

CUSUM's showing deviations

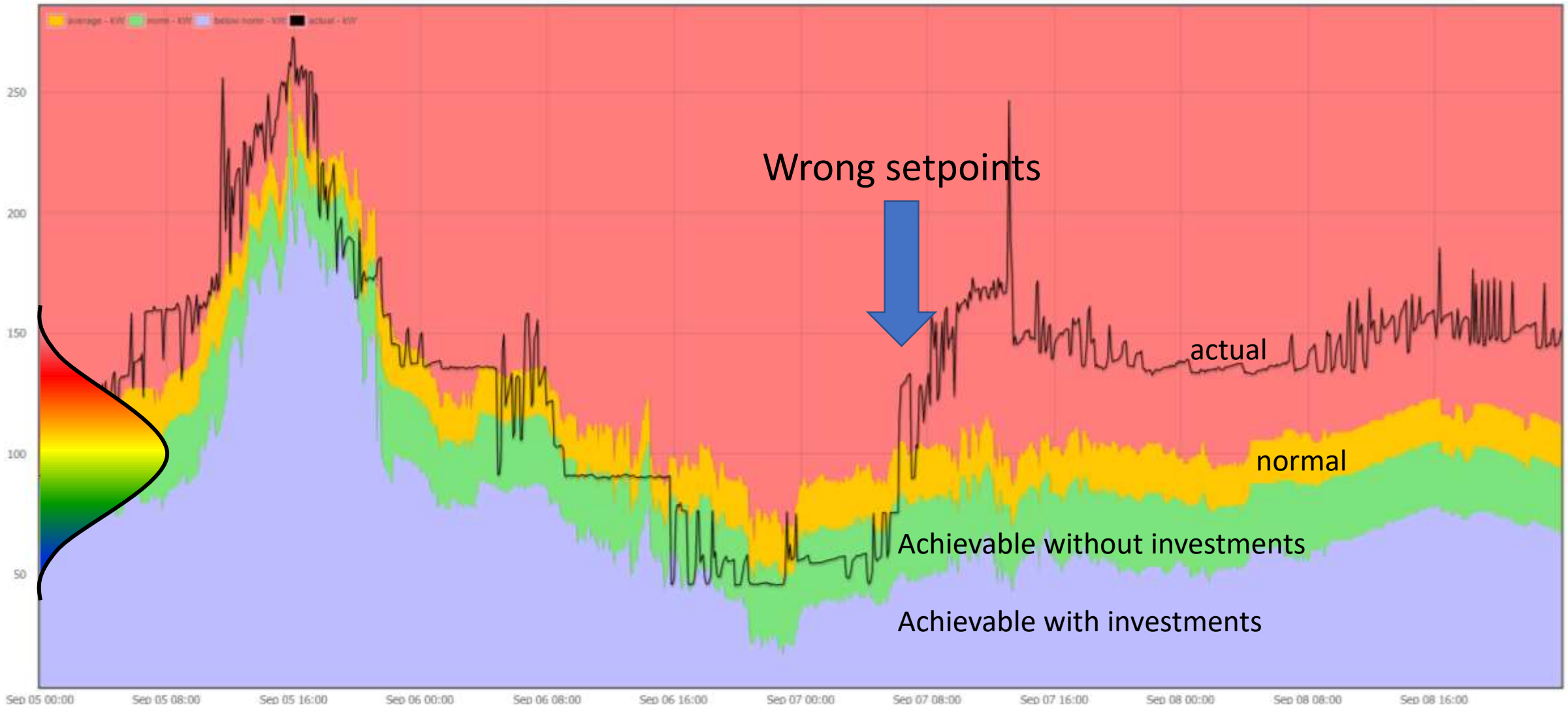


Detection of deviation of asset condition

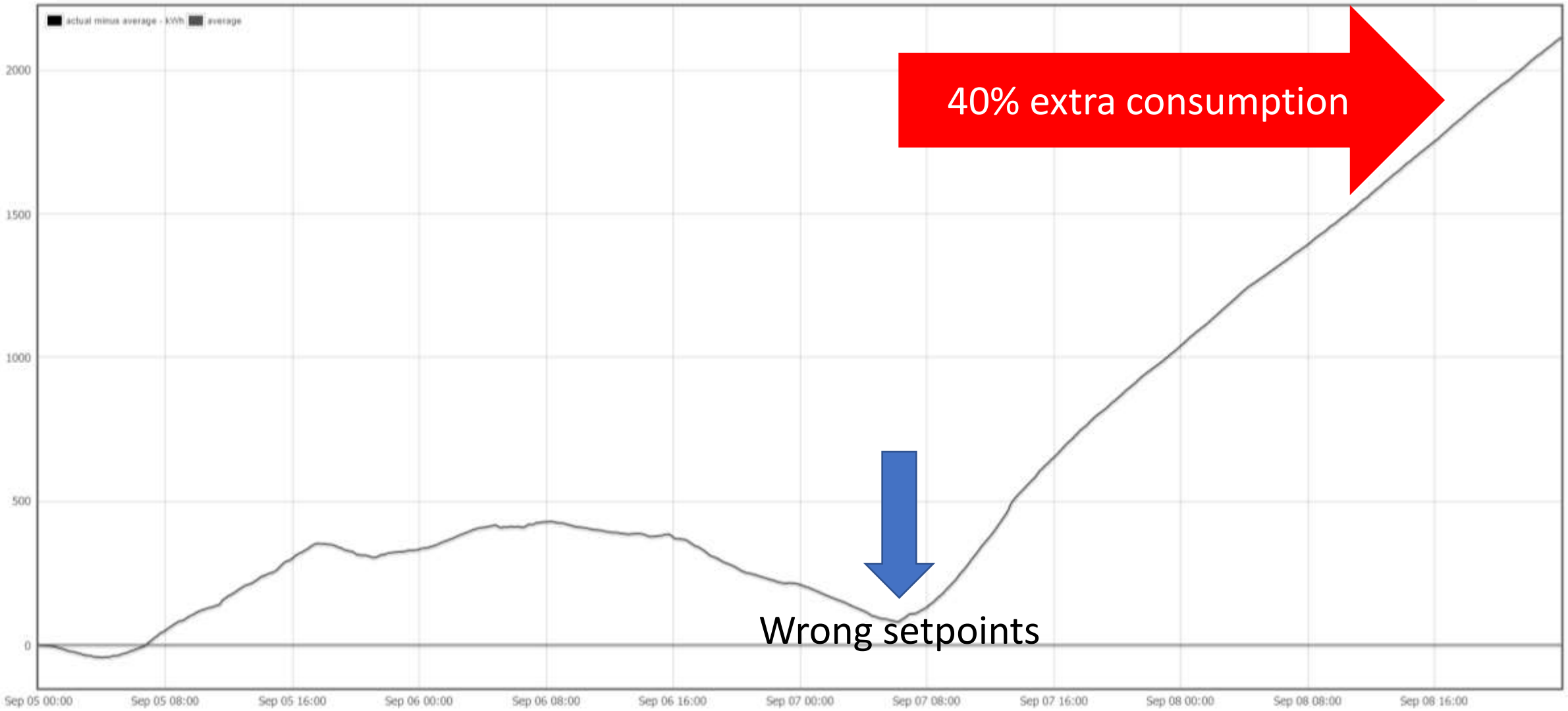
Cooling power consumption in kW without learned reference



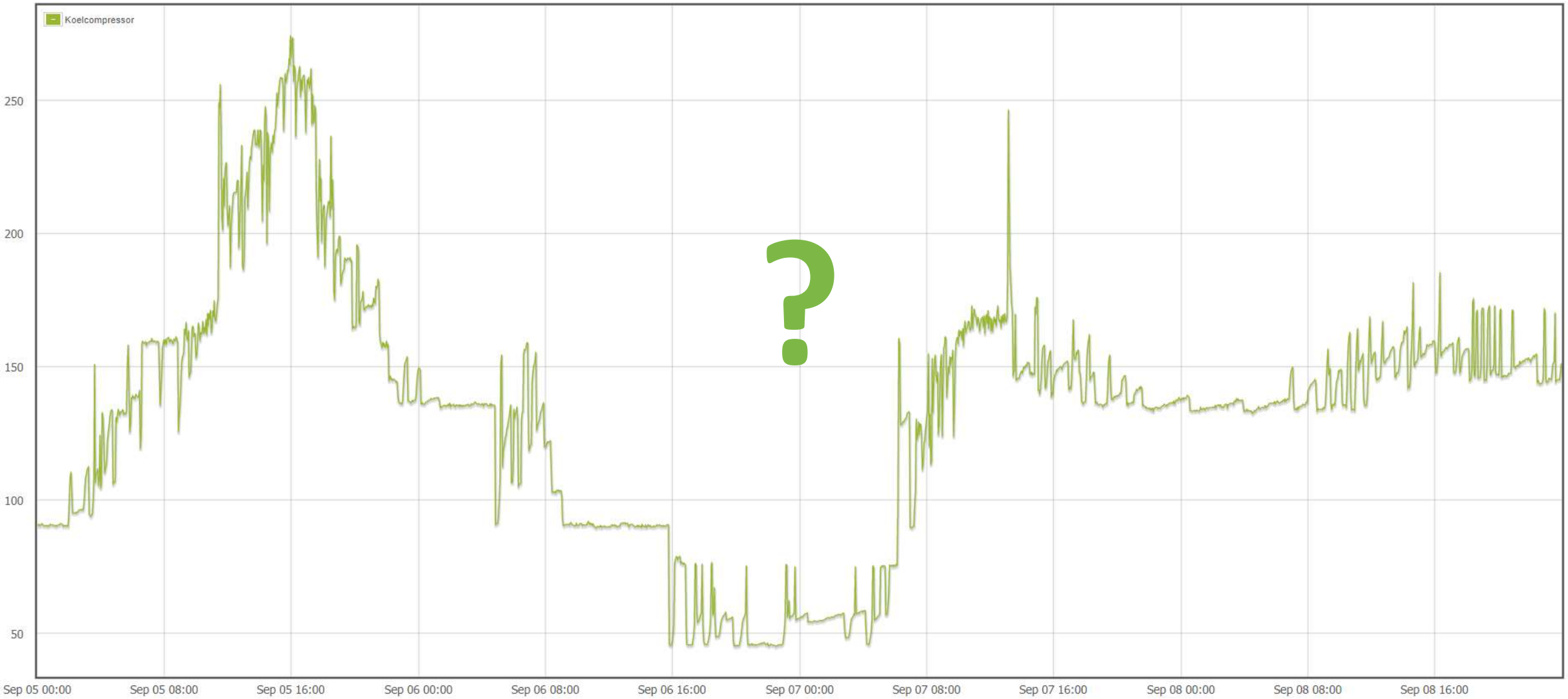
Cooling Plain power consumption in kW with learned reference



CUSUM in kWh (of power consumption *minus* learned reference)



Cooling power consumption in kW without learned reference




Aei®
artificial
energy
intelligence
enerGQ™
1. What is Aei?
2. How does it impact CO2 footprints?
3. How can it be applied?
4. More examples (if time permits)
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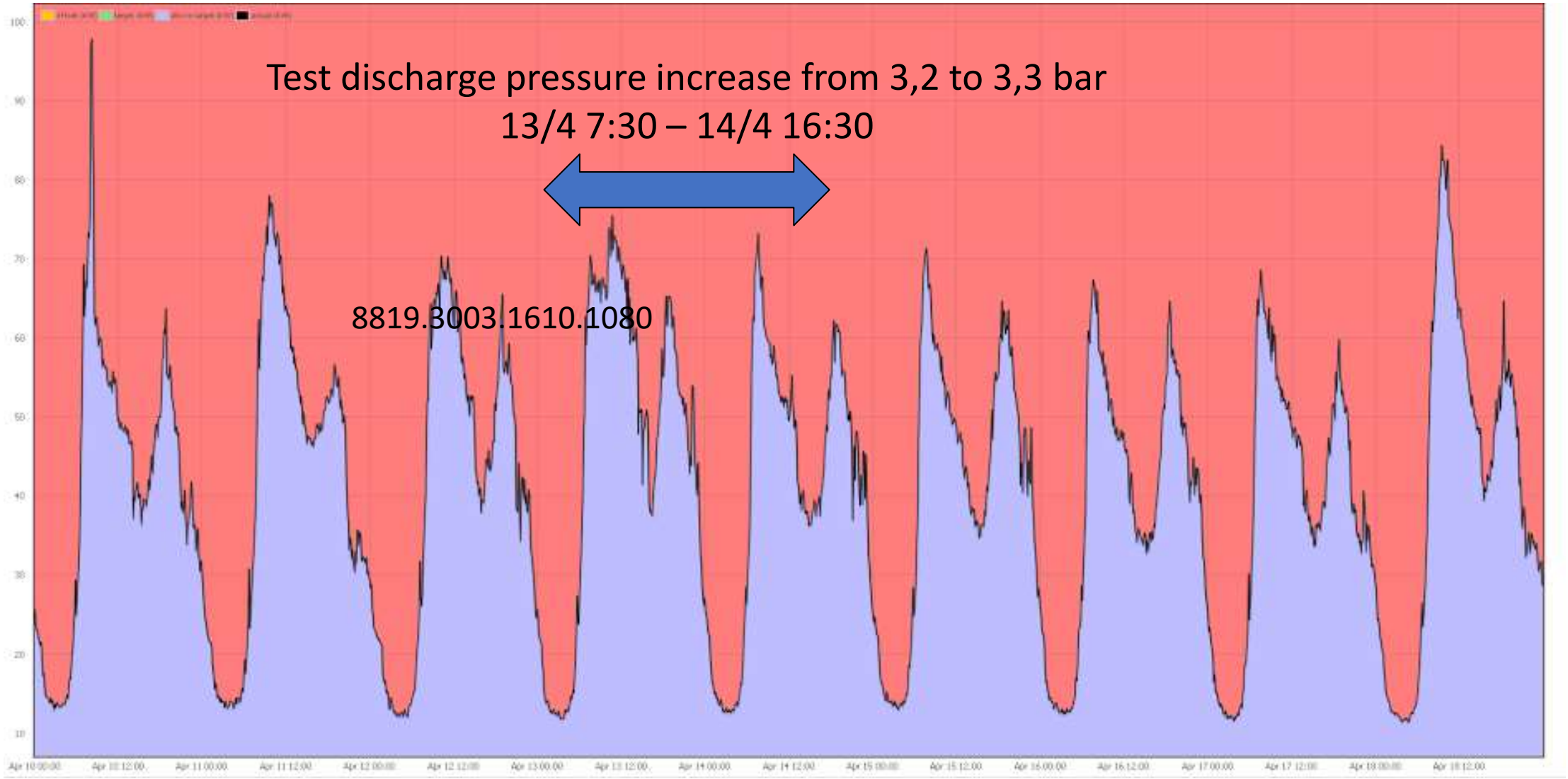
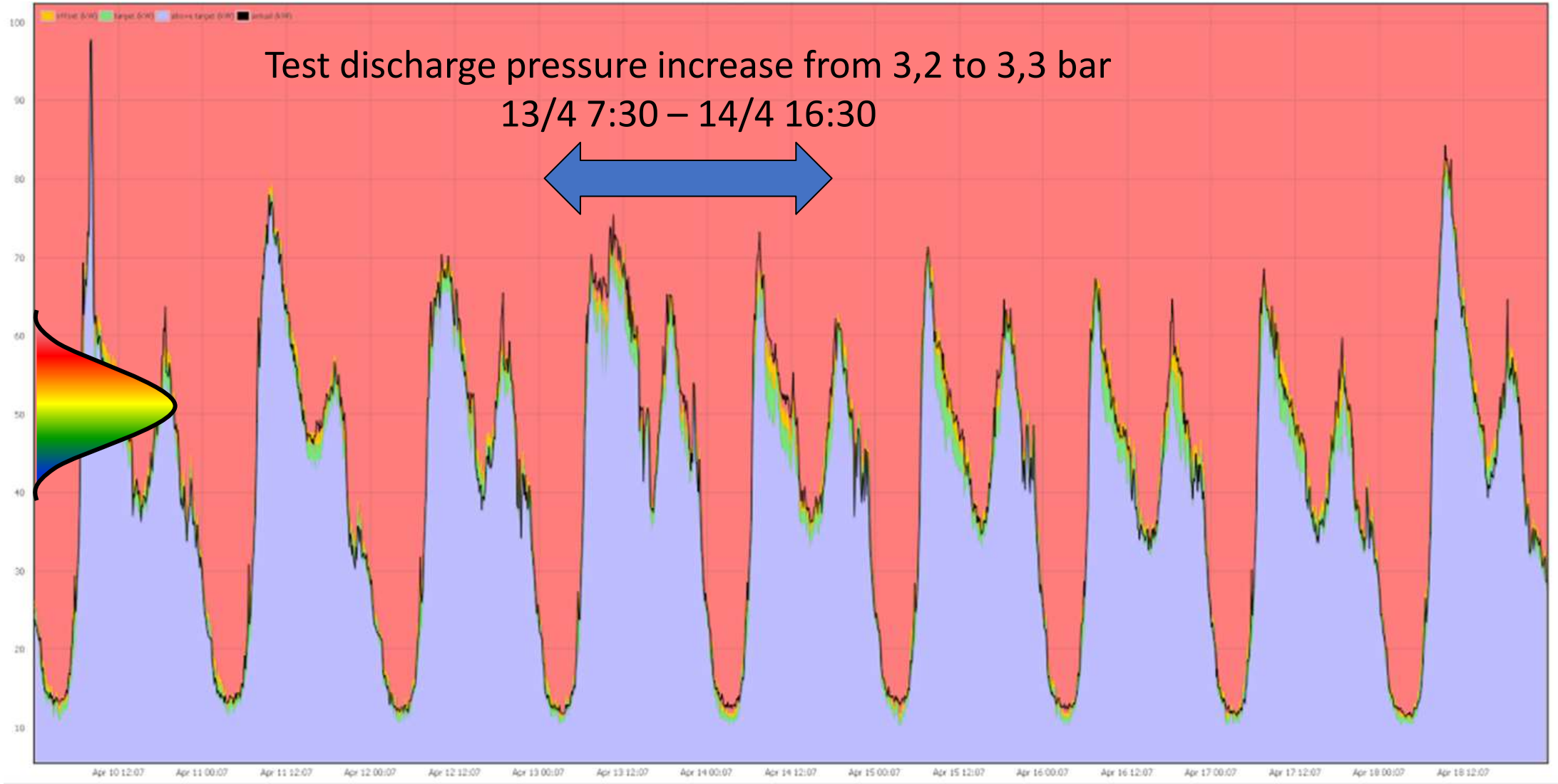
artificial energy intelligence

Oasen searching for energy saving opportunity's and monitoring of assets

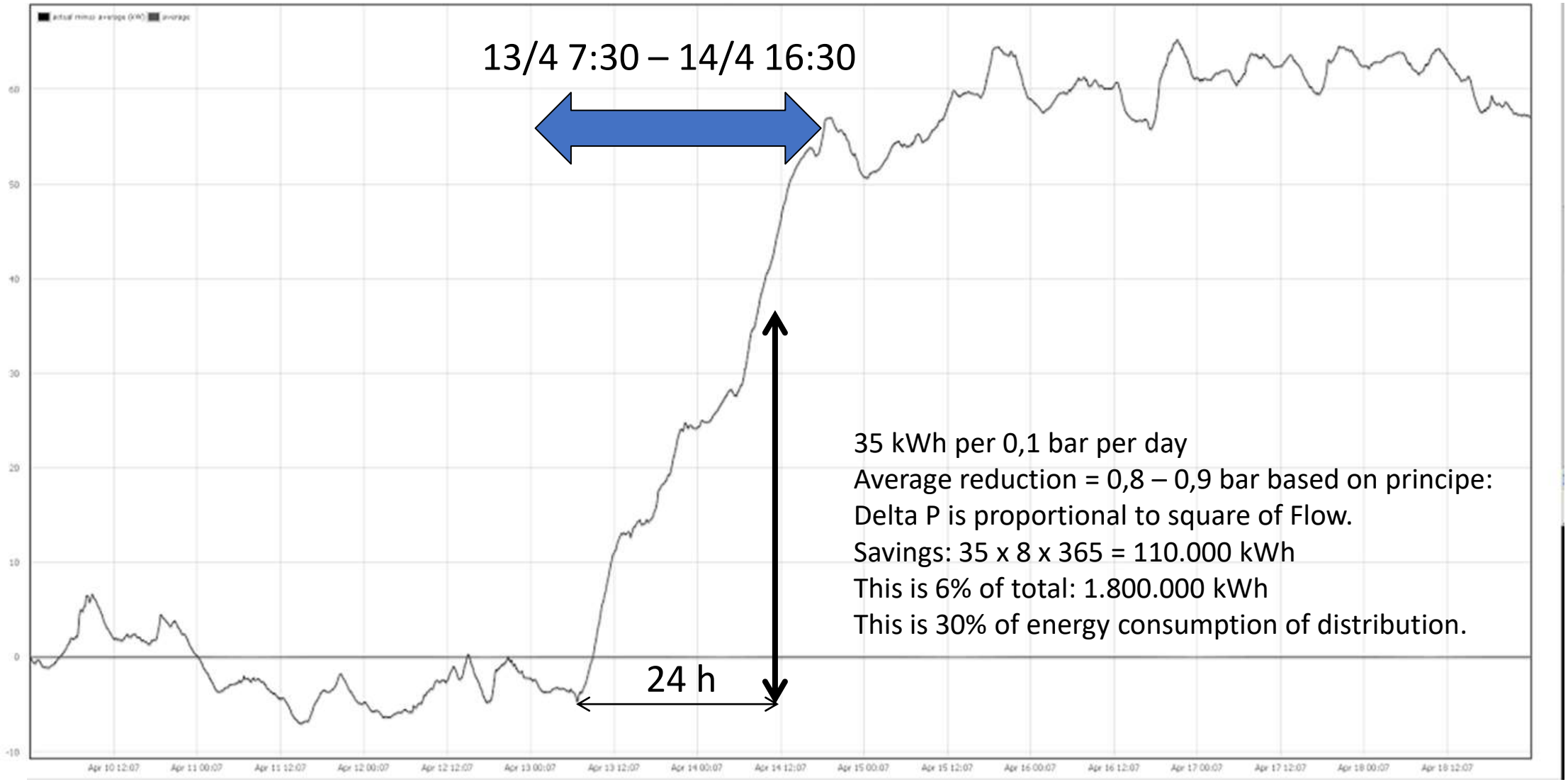


artificial energy intelligence

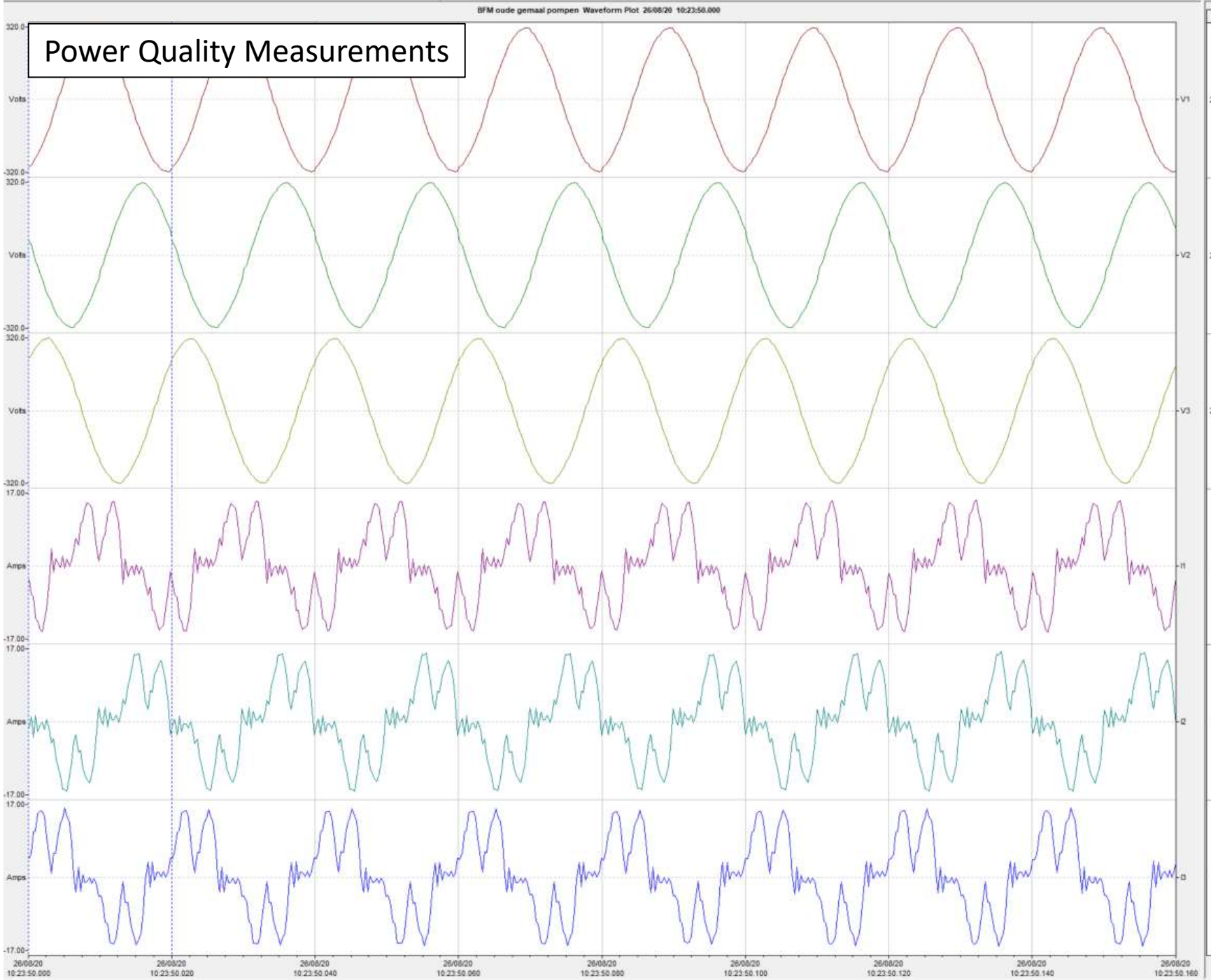
Oasen searching for energy saving opportunity's and monitoring of assets



Oasen Searching for energy saving opportunit's and monitoring of assets



Power Quality Measurements



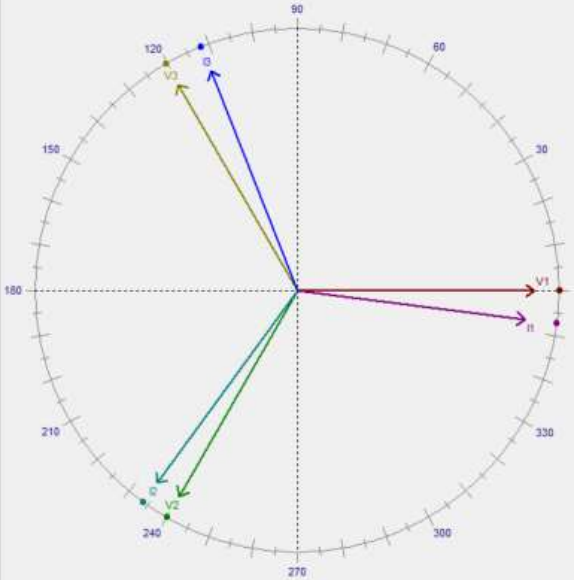
	RMS	MinPeak	MaxPeak	Angle
V1	220.5 V	-315.2 V	315.2 V	0.0°
V2	221.1 V	-317.0 V	317.9 V	-120.0°
V3	221.5 V	-317.3 V	318.2 V	120.1°
I1	8.64 A	-15.23 A	15.15 A	-7.3°
I2	8.77 A	-16.29 A	15.95 A	-126.1°
I3	8.92 A	-15.83 A	16.13 A	111.5°

26/08/20 10:23:50.000

Recorded 26/08/20 10:23:50.160
Started 26/08/20 10:23:50.000
Triggered 26/08/20 10:23:50.000
Recording time: 0.160 s
Sampling rate: 64 samples/cycle
Frequency: 50.01 Hz

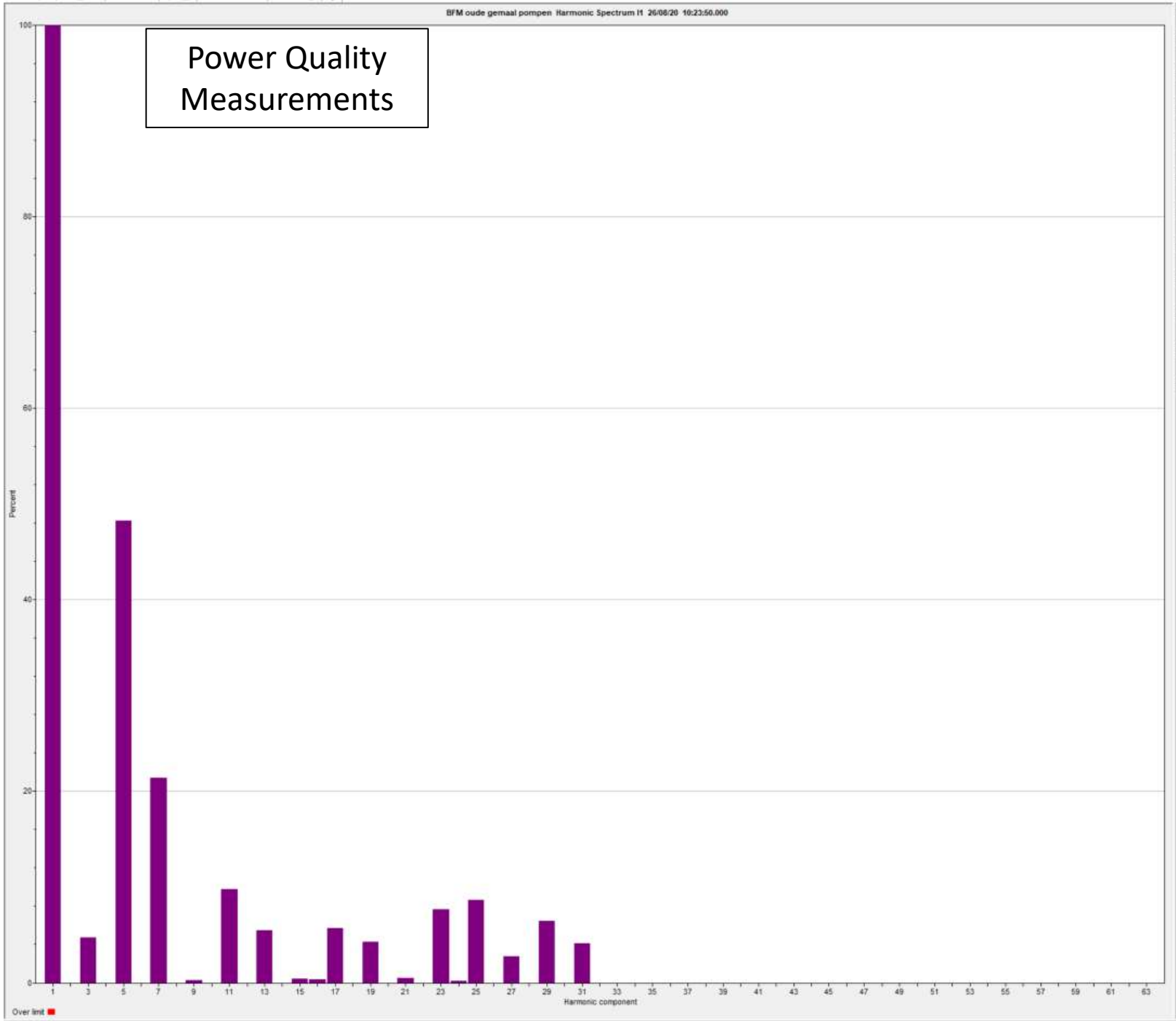
SYMMETRICAL COMPONENTS
V Positive sequence: 221.0 V
V Negative sequence: 0.3 V
V Zero sequence: 0.3 V
V Negative sequence unbalance: 0.1%
V Zero sequence unbalance: 0.1%
I Positive sequence: 7.68 A
I Negative sequence: 0.18 A
I Zero sequence: 0.02 A
I Negative sequence unbalance: 2.3%
I Zero sequence unbalance: 0.2%

Cooling fan at pumping station IJmuiden



26/08/20 10:24:12

Power Quality Measurements



Harmonics					
	HD%	A		HD%	A
H02	0	0	H03	4.77	0.36
H04	0	0	H05	48.28	3.62
H06	0	0	H07	21.43	1.61
H08	0	0	H09	0.35	0.03
H10	0	0	H11	9.84	0.74
H12	0	0	H13	5.58	0.42
H14	0	0	H15	0.52	0.04
H16	0.43	0.03	H17	5.80	0.43
H18	0	0	H19	4.35	0.33
H20	0	0	H21	0.59	0.04
H22	0	0	H23	7.73	0.58
H24	0.23	0.02	H25	8.74	0.65
H26	0	0	H27	2.83	0.21
H28	0	0	H29	6.56	0.49
H30	0	0	H31	4.15	0.31
H32	0	0	H33	0	0
H34	0	0	H35	0	0
H36	0	0	H37	0	0
H38	0	0	H39	0	0
H40	0	0	H41	0	0
H42	0	0	H43	0	0
H44	0	0	H45	0	0
H46	0	0	H47	0	0
H48	0	0	H49	0	0
H50	0	0	H51	0	0
H52	0	0	H53	0	0
H54	0	0	H55	0	0
H56	0	0	H57	0	0
H58	0	0	H59	0	0
H60	0	0	H61	0	0
H62	0	0	H63	0	0

Current I1

RMS: 8.61 A
H01 RMS: 7.49 A

TOTAL HARMONICS

THD: 56.6%
Odd harmonics: 56.6%
Even harmonics: 0.6%
Interharmonics: 0.5%
K-Factor: 19.9

Crest factor: 1.77
Form factor: 1.25

Frequency: 50.01 Hz

Cooling fan at pumping station IJmuiden

26/08/20 10:24:26

Power Quality Measurements

BFM oude gemaal pompen Harmonic Spectrum 26/08/20 10:23:50.000

	Phase L1 V1 THD: 1.5% I1 THD: 56.6%					Phase L2 V2 THD: 1.8% I2 THD: 51.5%					Phase L3 V3 THD: 1.6% I3 THD: 56.7%				
	V1%	I1%	P1%	Q1%	Angle	V2%	I2%	P2%	Q2%	Angle	V3%	I3%	P3%	Q3%	Angle
H01	100.0	100.0	100.0	100.0	7.42°	100.0	100.0	100.0	100.0	6.09°	100.0	100.0	100.0	100.0	8.49°
H02	0	0	0	0	0°	0	0	0	0	0°	0	0	0	0	0°
H03	0	4.8	0	0	132.62°	0.3	6.2	0	-0.2	-59.26°	0	1.7	0	0	116.19°
H04	0	0	0	0	0°	0	0	0	0	0°	0	0.3	0	0	0°
H05	0.8	48.3	0	-3.2	-90.83°	0.8	43.1	0	-3.1	-94.02°	0.8	48.5	-0.2	-2.5	-112.99°
H06	0	0	0	0	0°	0	0	0	0	0°	0	0	0	0	0°
H07	0.6	21.4	-0.1	-0.8	-126.37°	0.7	20.9	0	-1.2	-114.35°	0.7	22.2	0	-1.0	-105.67°
H08	0	0	0	0	0°	0	0	0	0	0°	0	0	0	0	0°
H09	0	0.3	0	0	0°	0.2	1.2	0	0	-91.26°	0	1.1	0	0	0°
H10	0	0	0	0	0°	0	0	0	0	0°	0	0	0	0	0°
H11	0.4	9.8	0	-0.2	-132.35°	0.3	8.2	0	-0.3	-96.63°	0	9.3	0	-0.1	-135.24°
H12	0	0	0	0	0°	0	0	0	0	0°	0	0	0	0	0°
H13	0.3	5.6	0	-0.1	-145.55°	0.3	5.2	0	-0.1	-118.29°	0.3	5.7	0	0	-147.44°
H14	0	0	0	0	0°	0	0	0	0	0°	0	0	0	0	0°
H15	0	0.5	0	0	0°	0.2	1.0	0	0	-151.72°	0	0.7	0	0	0°
H16	0	0.4	0	0	0°	0	0.5	0	0	0°	0	0.5	0	0	0°
H17	0	5.8	0	0	-164.79°	0.4	5.1	0	-0.2	-122.21°	0	5.8	0	0	0°
H18	0	0	0	0	0°	0	0	0	0	0°	0	0	0	0	0°
H19	0	4.4	0	-0.1	-84.29°	0.3	4.2	0	-0.1	-101.51°	0.3	4.5	0	-0.1	-99.22°
H20	0	0	0	0	0°	0	0	0	0	0°	0	0	0	0	0°
H21	0	0.6	0	0	0°	0.3	1.4	0	0	152.93°	0	1.1	0	0	0°
H22	0	0	0	0	0°	0	0	0	0	0°	0	0	0	0	0°
H23	0.4	7.7	0	-0.2	-130.42°	0.7	7.1	0	-0.3	-143.62°	0.7	7.7	0	-0.3	-110.76°
H24	0	0.2	0	0	0°	0	0	0	0	0°	0	0	0	0	0°
H25	0.6	8.7	0	-0.3	-123.79°	0.7	9.3	0	-0.6	-121.91°	0.7	7.4	0	-0.3	-119.87°
H26	0	0	0	0	0°	0	0	0	0	0°	0	0	0	0	0°
H27	0	2.8	0	0	0°	0.4	1.6	0	0	-39.55°	0	1.2	0	0	0°
H28	0	0	0	0	0°	0	0.2	0	0	0°	0	0.3	0	0	0°
H29	0.4	6.6	0	-0.1	-140.55°	0.5	4.4	0	-0.2	-104.71°	0.4	8.0	0	-0.2	-104.07°
H30	0	0	0	0	0°	0	0	0	0	0°	0	0	0	0	0°
H31	0.2	4.1	0	-0.1	-100.56°	0.2	3.1	0	-0.1	-84.35°	0.3	3.7	0	0	-105.64°
H32	0	0	0	0	0°	0	0	0	0	0°	0	0	0	0	0°
H33	0	0	0	0	0°	0	0	0	0	0°	0	0	0	0	0°
H34	0	0	0	0	0°	0	0	0	0	0°	0	0	0	0	0°
H35	0	0	0	0	0°	0	0	0	0	0°	0	0	0	0	0°
H36	0	0	0	0	0°	0	0	0	0	0°	0	0	0	0	0°
H37	0	0	0	0	0°	0	0	0	0	0°	0	0	0	0	0°
H38	0	0	0	0	0°	0	0	0	0	0°	0	0	0	0	0°
H39	0	0	0	0	0°	0	0	0	0	0°	0	0	0	0	0°
H40	0	0	0	0	0°	0	0	0	0	0°	0	0	0	0	0°
H41	0	0	0	0	0°	0	0	0	0	0°	0	0	0	0	0°
H42	0	0	0	0	0°	0	0	0	0	0°	0	0	0	0	0°
H43	0	0	0	0	0°	0	0	0	0	0°	0	0	0	0	0°

Voltage V1
RMS value: 220.3 V
THD: 1.5%
Interharmonics: 0.1%

Current I1
RMS value: 8.61 A
THD: 56.6%
Interharmonics: 0.5%

Voltage V2
RMS value: 221.3 V
THD: 1.8%
Interharmonics: 0.1%

Current I2
RMS value: 8.75 A
THD: 51.5%
Interharmonics: 0.5%

Voltage V3
RMS value: 221.6 V
THD: 1.6%
Interharmonics: 0.1%

Current I3
RMS value: 8.91 A
THD: 56.7%
Interharmonics: 0.4%

Kast RKV 1 pomp 1 ventilator 2 Hoogtoeren

Introduction to the concept of the Cumulative Sum of the deviation (CUSUM), a simple example

- **Principle:** is simple, sum up the deviation compared to a norm (an estimated average) over time.
- **Challenge:** How to determine the norm?
- **Answer:** By looking at power consumption at specific combinations of contributing factors, which influence the consumption, potentially with a delay.