Improve your glass melting productivity and energy efficiency with *Expert System III*

by
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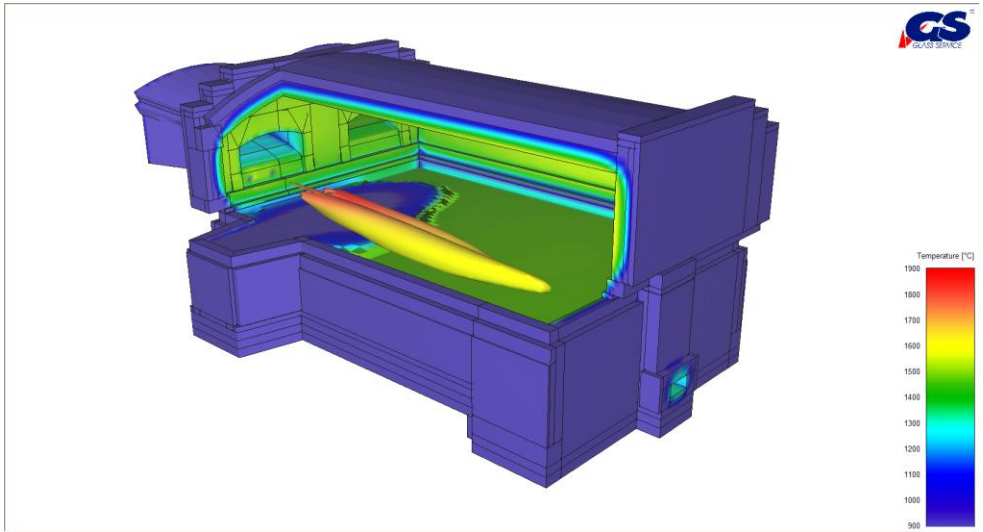
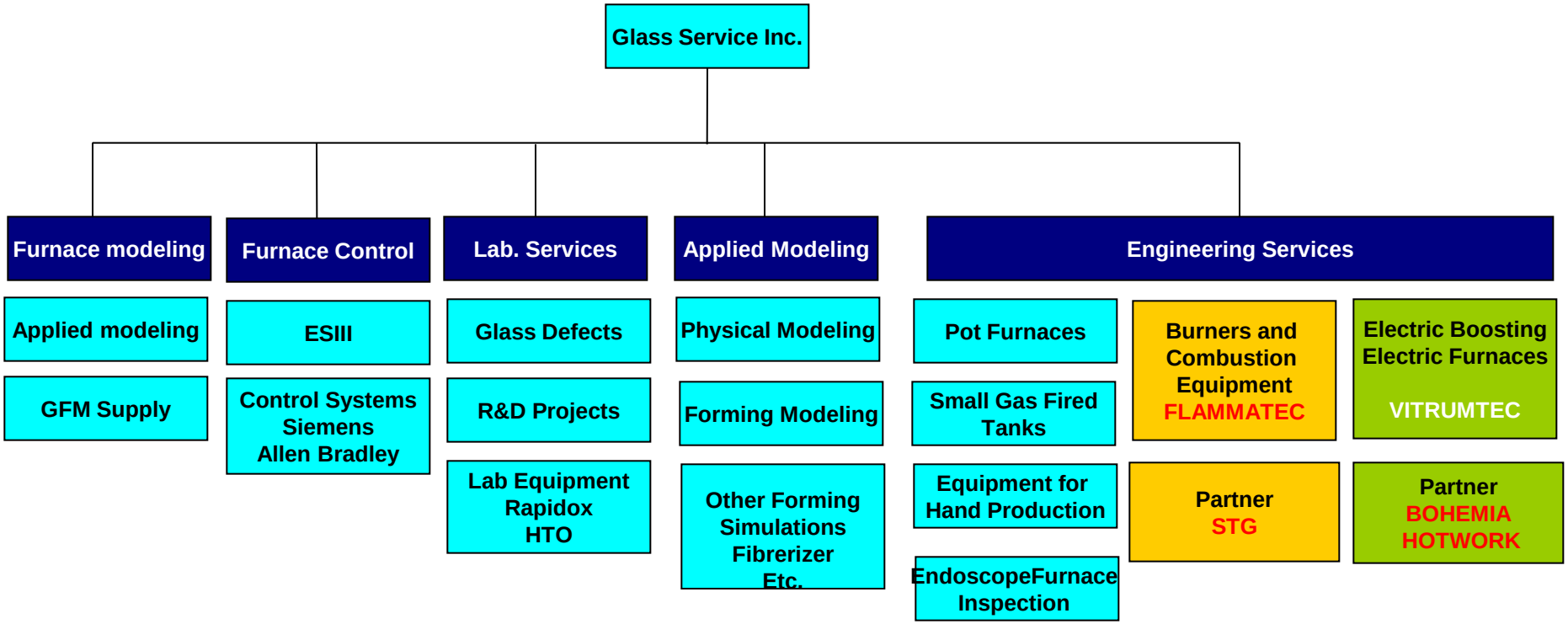


Glass Service (GS) Structure



Products Sold under GS brand

Products sold under FLAMMATEC Brand

Products sold under VITRUMTEC Brand

Burners were sold and installed by GS since 1992 JV FlammaTec established in 2007

Electric melting systems were sold by GS since 1992. New name VitrumTec is used since 2008

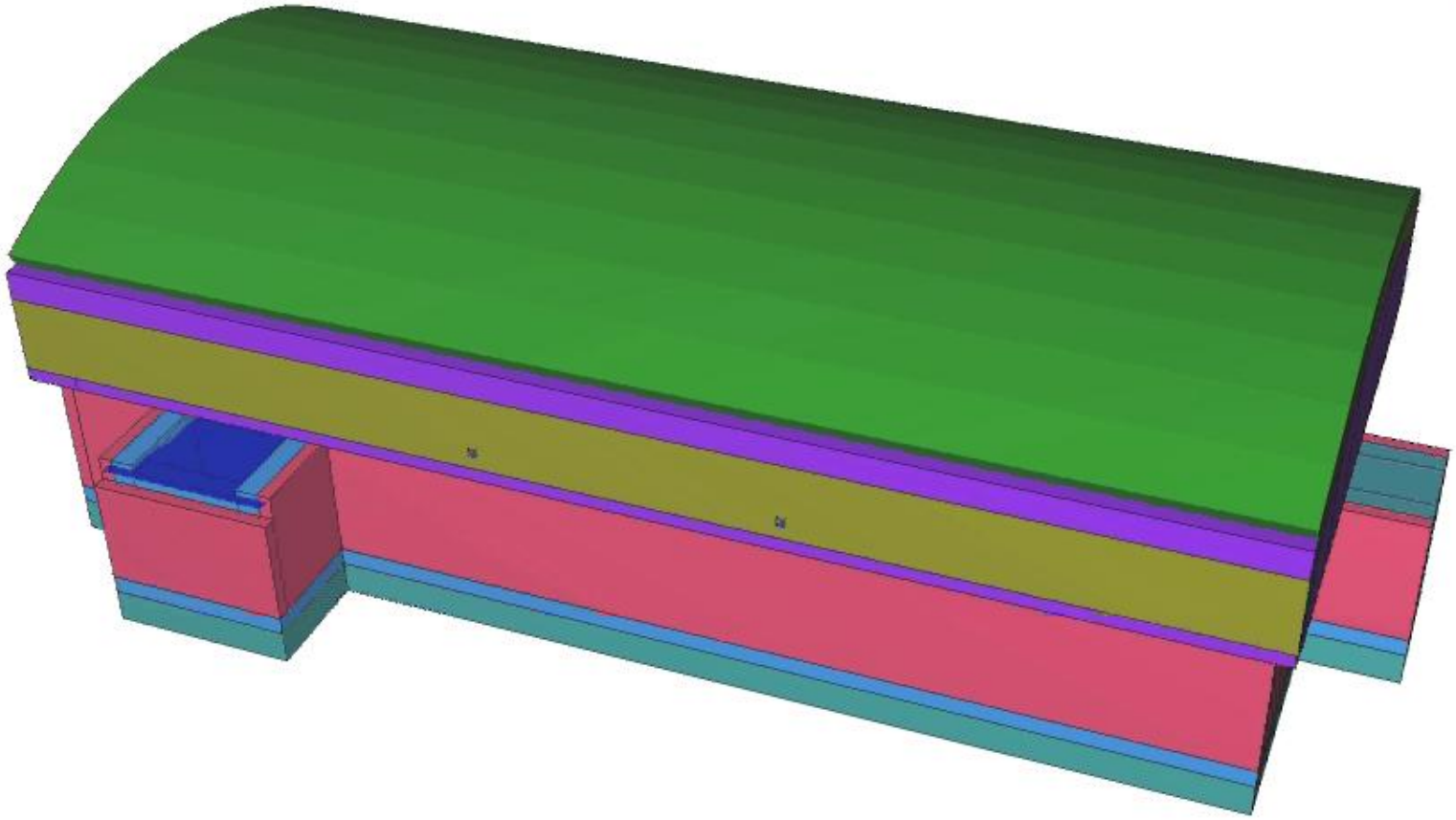
Glass Service (GS)
Glass production Optimization Tools

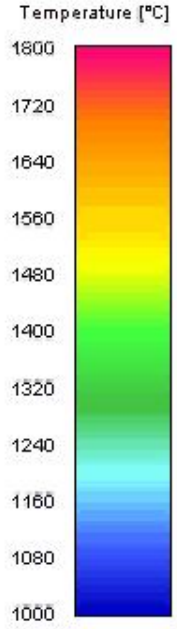
- Online optimization tools are for instance Model Based Predictive Control

  GS Expert System III (ESIII, MPC).
- Offline optimization tools are for instance mathematical models or also often referred to Computational Fluid Dynamic models

  GS Glass Furnace Model (GS GFM, CFD).
- In this presentation we would like to Focuss on Expert System III applications and show how they can help to stabilize melting performance, emissions and energy efficiency and than in reverse save energy with producing glass quality level that is sufficient and required by the customer.
- A combination of these tools can be used also

1 Example of GS GFM Furnace modeling
Oxy-gas container furnace





EXPERT SYSTEM III REFERENCES AND EXAMPLE RESULTS

FLOAT
36

FIBER COMPOSITE
16

CONTAINER
16

FIBER INSULATION
12

OTHERS
7

= **85** INSTALLATIONS AROUND THE WORLD

Combination of different technologies implement all know how into 1 controller

Why advanced process control for glass furnaces?

	MANUAL	PID	ADVANCED ES III™
Multi Input - Multi Output Control	LIMITED	NO	YES
Dead Time Operations	YES	NO	YES
Operator Utilization	FULL CAPACITY	MINIMUM	MINIMUM
Control Actions Reproducibility	NO	YES	YES
Process Behavior Prediction	LIMITED	NO	YES

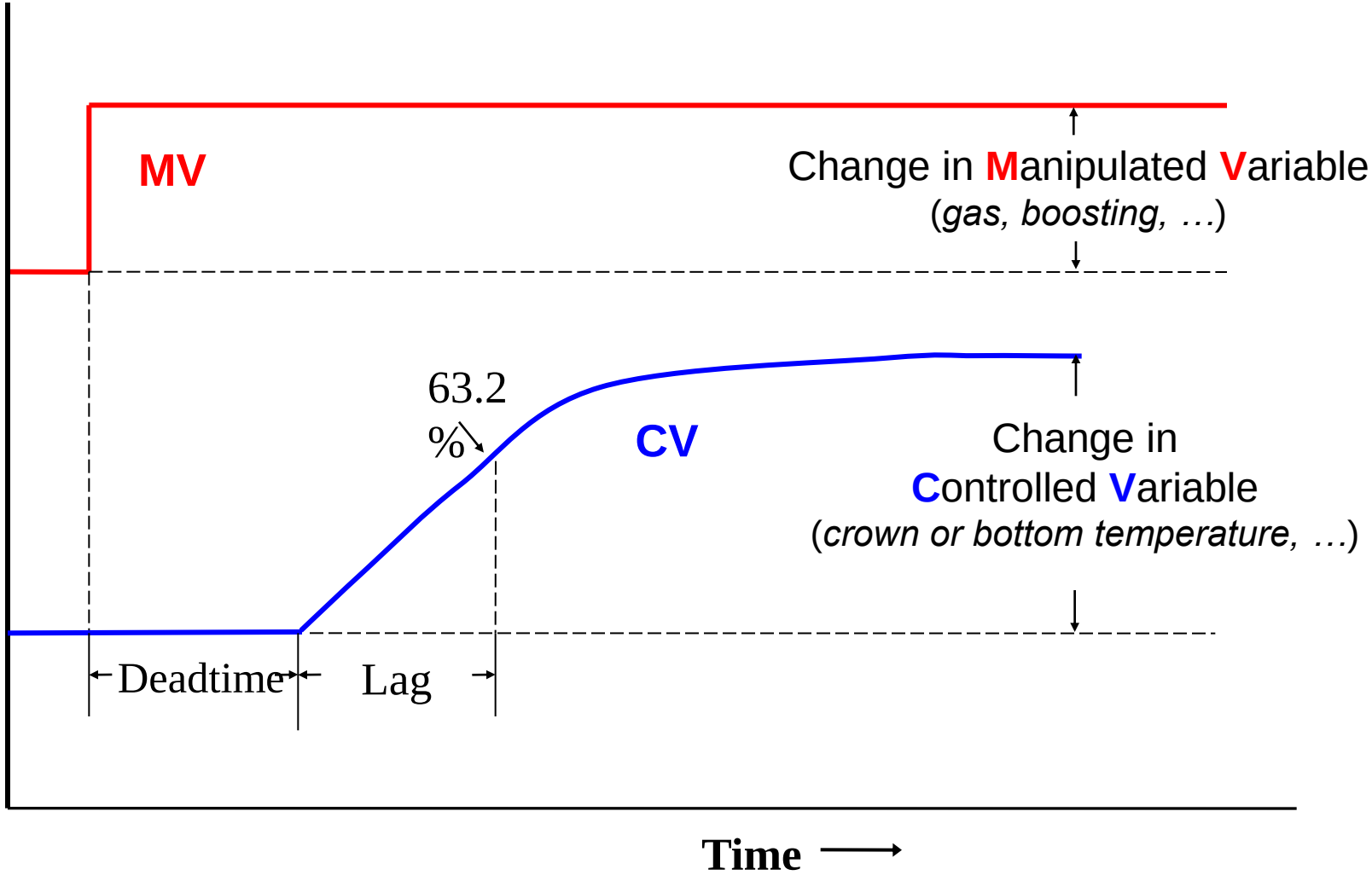
ESIII™ advanced controllers

- **M**odel-based **P**redictive **C**ontroller – **MPC** (mostly used)
- Fuzzy Logic Controller
- Rule Based Control
- Setpoint Logic Control

USE ONE OR ALL TOGETHER TO GET BEST RESULTS!

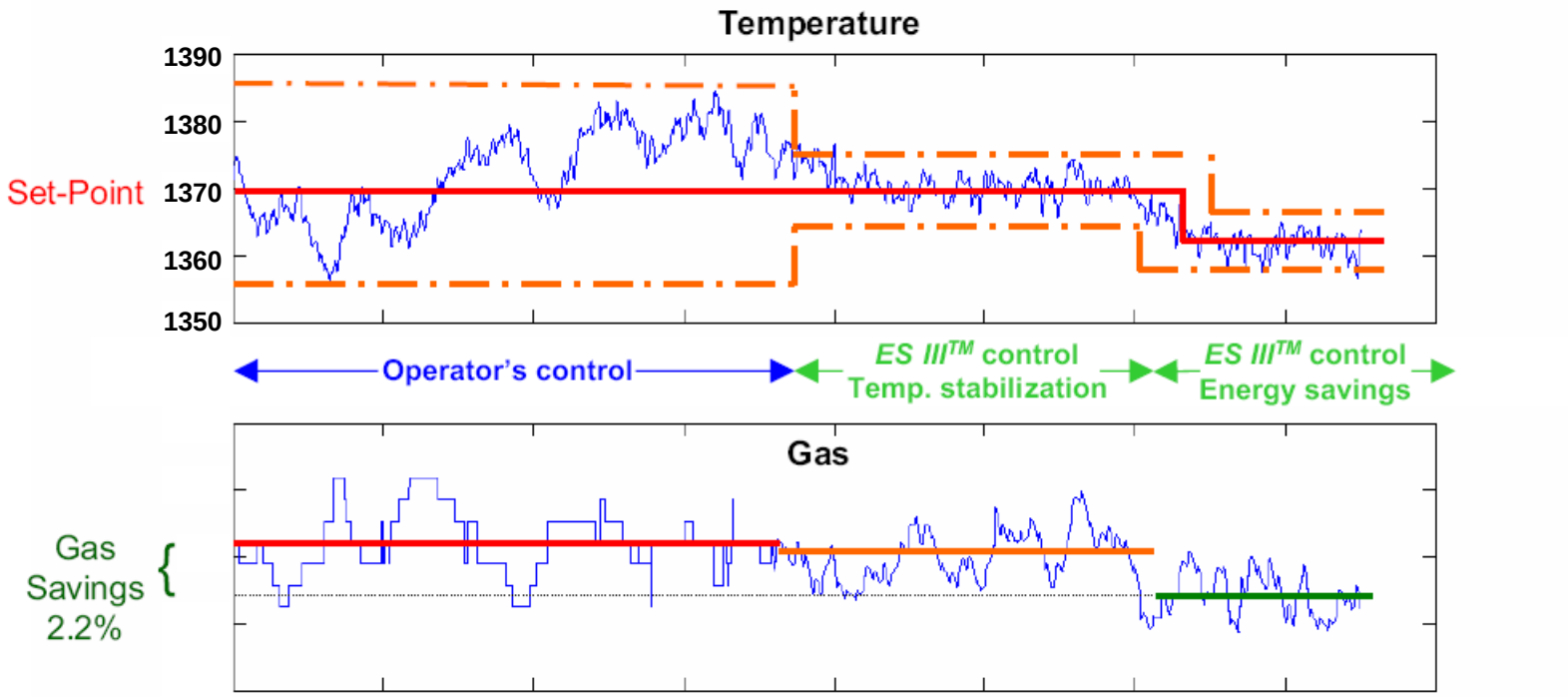
Example of a Model used for Model Based Predictive Control (MPC)

MPC Process Models



How ESIII can help to save energy

ESIII™ Melter Control – how to save energy? (option 1)



Glass temperature stabilization can be used to save energy by reduction of production temperature set-point

Operate furnace at lower temperature,
but keep above critical limit to prevent glass defects

Example with real data, courtesy of Gerresheimer group

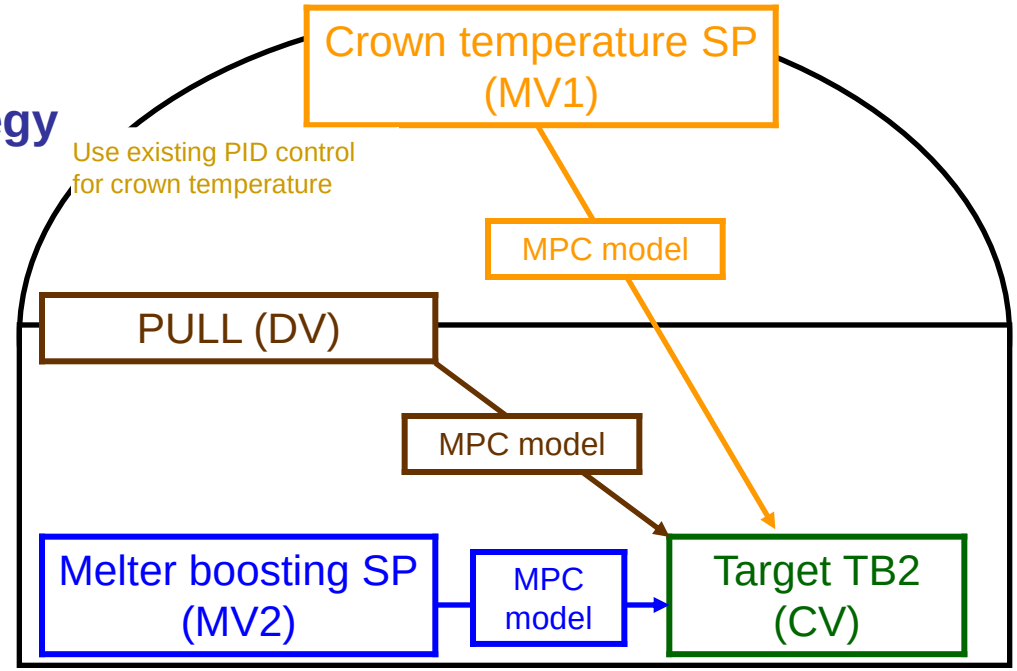
ESIII™ Melter Control at Gerresheimer Lohr GmbH

- Furnace #1 is an end port furnace producing high quality flint container glass for the pharmaceutical industry in the range 80 – 170 tpd, up to 5 job changes/day.
- The furnace is equipped with both melter and refiner electric boosting systems (refiner boosting only at low furnace pulls, only rarely).
- Furnace is operated at higher (glass) melter bottom temperature TB2 at high furnace pulls: setpoint TB2 depends on pull

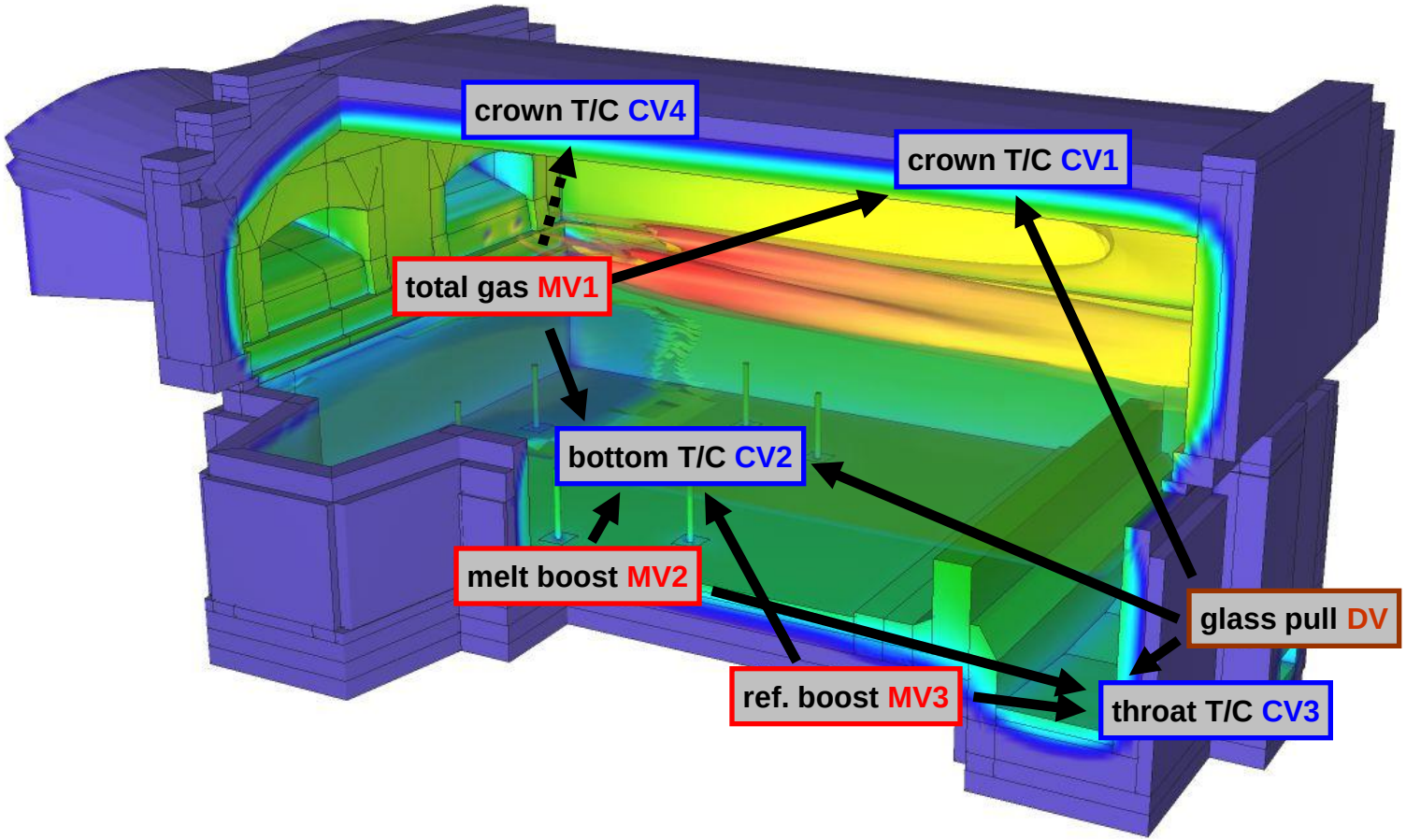
ESIII™ Melter Control Strategy

Disturbance **V**ariable (**DV**) model for pull informs MPC controller about effect of pull change on temperature TB2:

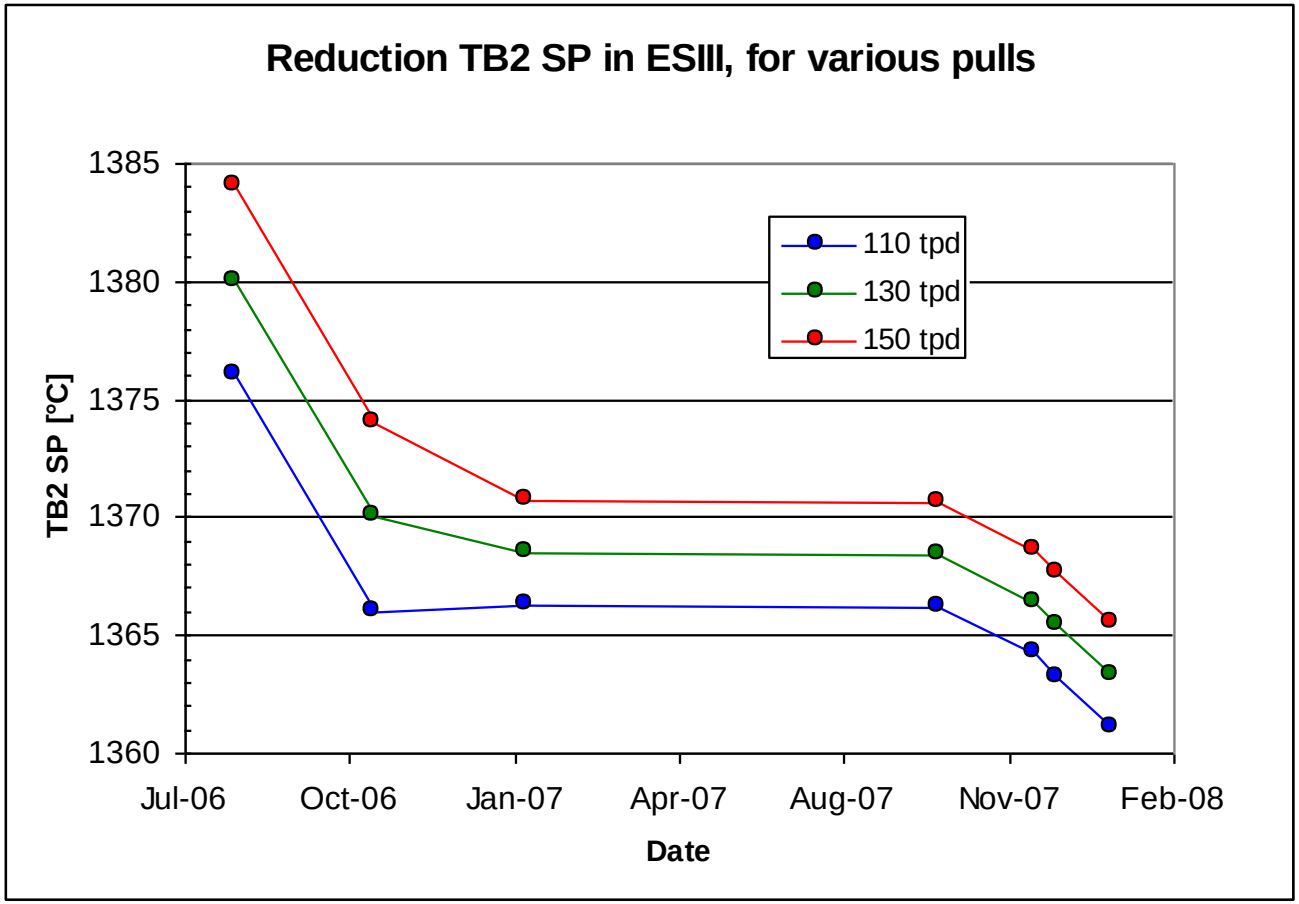
if pull ↑ then TB2 ↘
if pull ↓ then TB2 ↗



EXAMPLE: *ESIII*™ CONTROL OF END-FIRED FURNACE



Reduction of glass production temperature



Approximately 20 °C reduction in production temperature achieved

The reduction of TB2 setpoint in *ESIII*^{TM} is setup by production people, in step by step trials, but not by *ESIII*^{TM} itself!

Energy savings

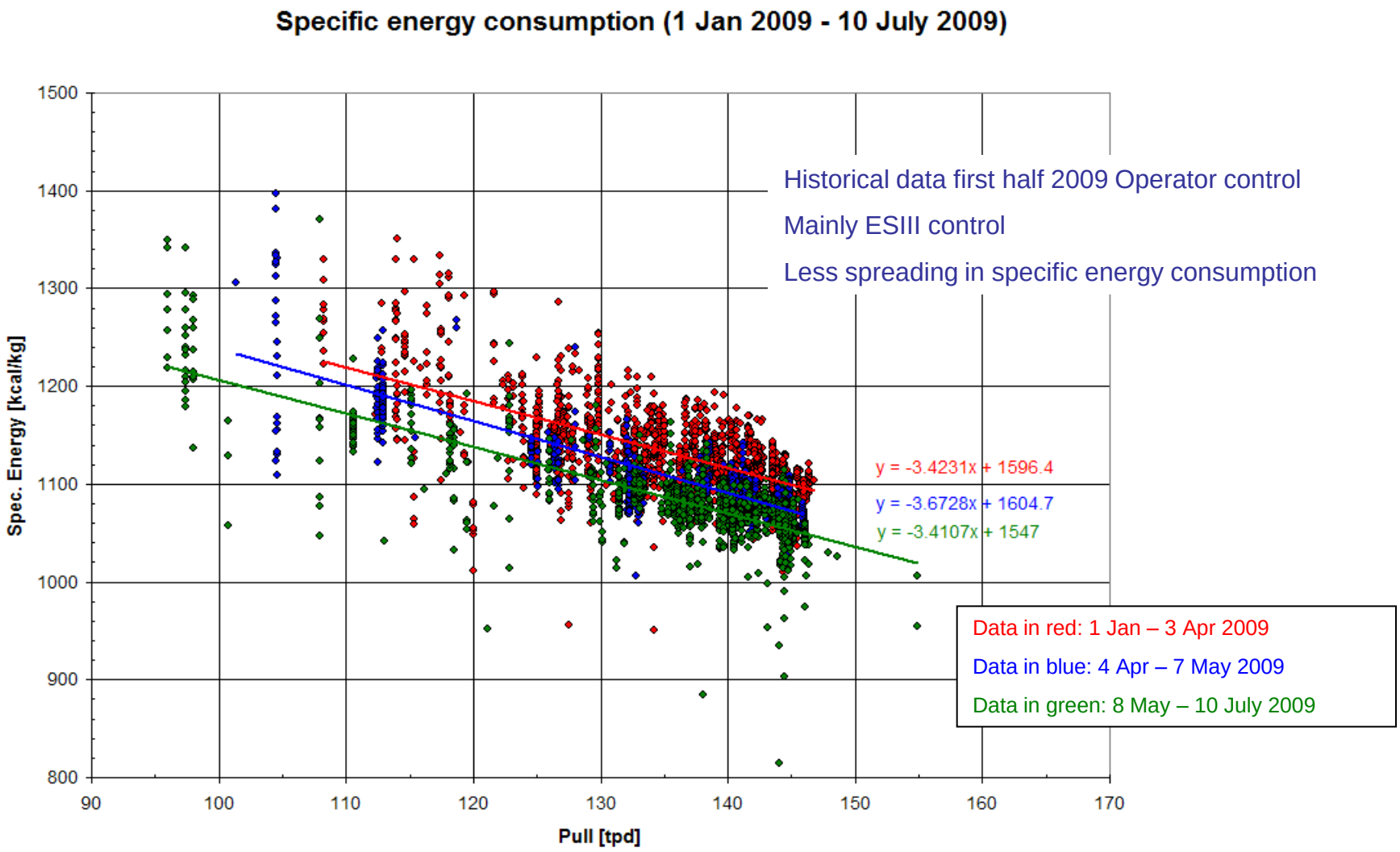
	120 tpd	140 tpd	160 tpd	comment
Total	-3.7%	-5.4%	-6.7%	Cost savings

Conclusion: at average furnace pull 130 tpd, the total savings are

-4.6%

(ROI < 1 year)

Summarized results of energy savings on other Gerrresheimer amber glass furnace in Essen



Average specific energy consumption at various pulls

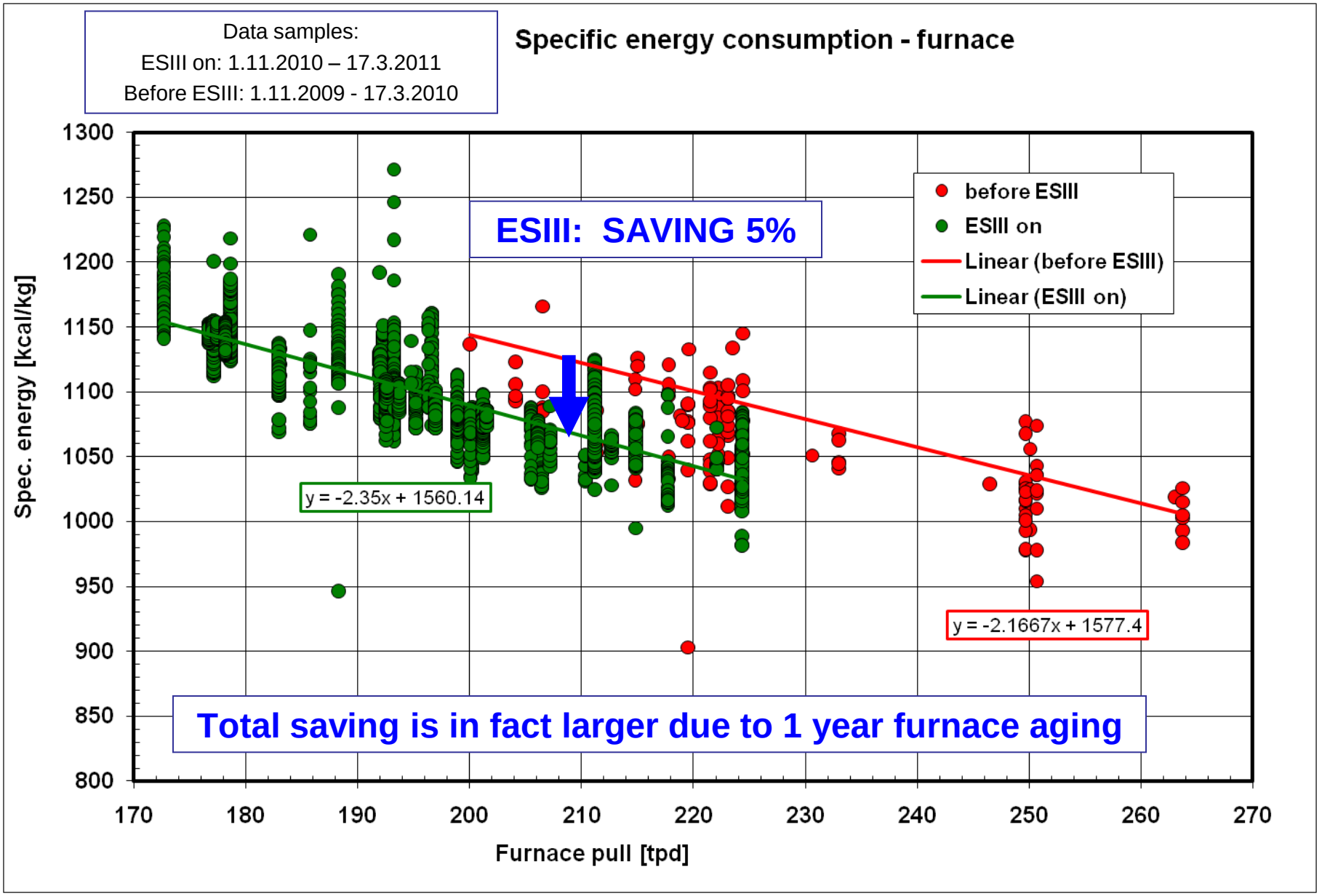
pull	01/01/2009 - 03/04/2009	04/04/2009 - 07/05/2009	08/05/2009- 10/07/2009		excl. furnace aging
[tpd]	[kcal/kg]	[kcal/kg]	[kcal/kg]		Total Saving
110	1220	1201	1172		-3.9%
120	1186	1164	1138		-4.0%
130	1151	1127	1104		-4.2%
140	1117	1091	1070		-4.3%
150	1083	1054	1035		-4.4%

Saving since last ESIII tuning (3 April)

Saving since thermowall boosting at minimum (7 May)

Example results of another recent container glass installation before vs after

Data samples:
ESIII on: 1.11.2010 – 17.3.2011
Before ESIII: 1.11.2009 - 17.3.2010



Customer conclusions for container glass

- Typical energy savings around 4% per year, since the use of the *ESIII*™
- The furnace has the lowest energy consumption since the startup, even with the cullet reduction from 1400 kg to 900 kg per batch charge (batch charge is 1150 kg, LOI 16,5%)
- Positive effect of waste gas, corrosion of furnace, less e-holder repairs
- Even with up to 5 job changes per day, the *ESIII*™ system is working well.

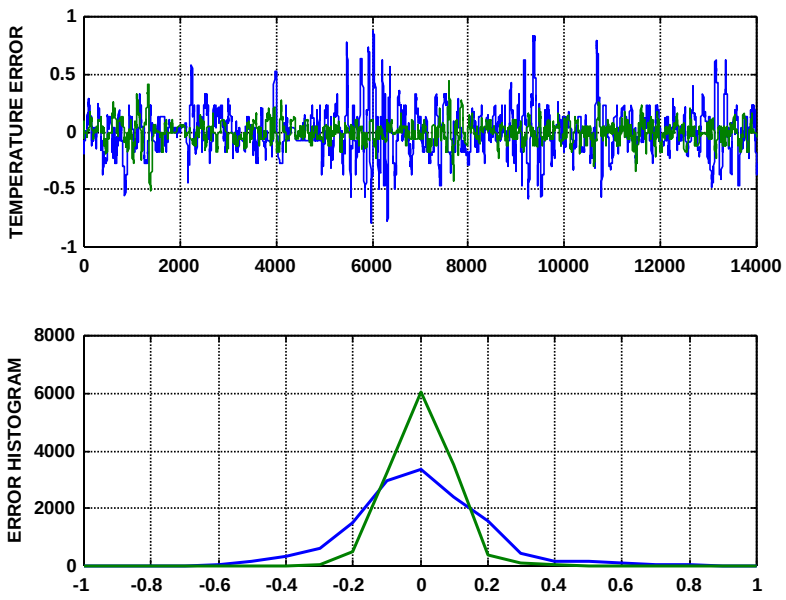
ESIII™ statistics

More than 85 installations on glass furnaces and forehearths worldwide

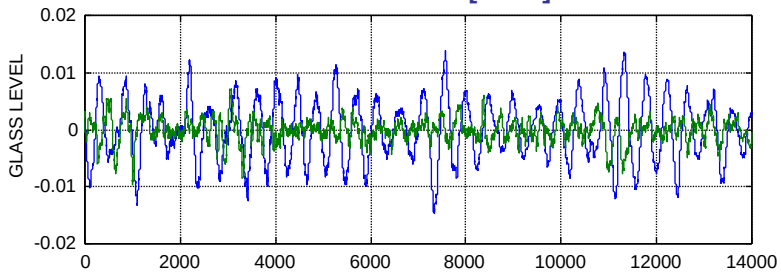
More than 15 years experience in advanced process control for glass industry

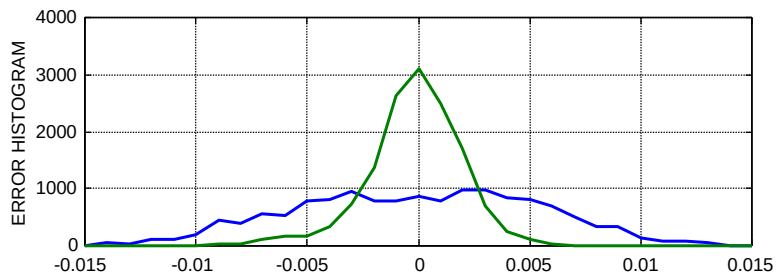
Some results from typical float glass application of ES III™ (before and after installation)

TRADITIONAL AND *ES III*™ CONTROL CANAL [°C]



TRADITIONAL AND *ES III*™ CONTROL GLASS LEVEL [INCH]



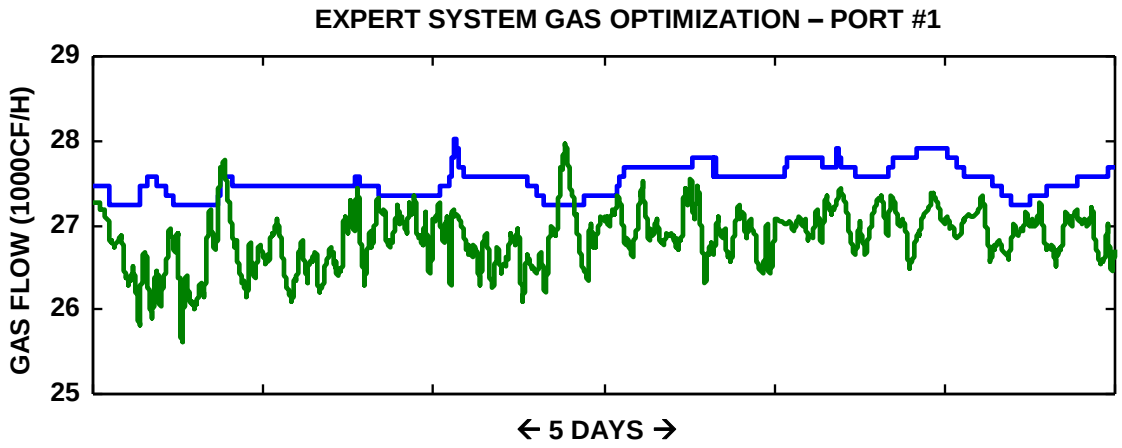


- HELPS TO MAINTAIN A SPREAD IN A TIN BATH
- TYPICALLY, ABOUT 7% OF RAW PULL RATE ARE EDGE LOSSES
- MORE STABLE SPREAD ALLOWS TO MAKE THESE LOSSES THINNER
- EXAMPLE:
  - IF AVERAGED EDGE IS ABOUT 70 MM AND WE CAN AFFORD 68MM, IT MEANS APPROX. 3% OF EDGE LOSSES LESS.
  - IF PULL RATE = 500 TPD THEN 0.03x 0.07 x 500 x 365 x 200 = 76,650 €

SAVINGS!

ES III™ TEMPERATURE CONTROL

- **REAL INSTALLATION EVALUATION – CROSS FIRED REGENERATIVE FURNACE, 6 PORTS**



GAS (1000CF/H)	PORT #1	PORT #2	PORT #3	PORT #4	PORT #5	PORT #6	TOTAL GAS
OPERATOR	27.6	27.7	27.8	27.5	21.2	8.7	140.5
ES III™	27.0	27.0	27.1	26.7	20.6	8.3	136.7
SAVINGS	0.6	0.7	0.7	0.8	0.6	0.4	**3.8**

COST PER YEAR
$4,923,120
$4,789,968
$133,152

COST OF 1000CF OF NATURAL GAS: $4.00

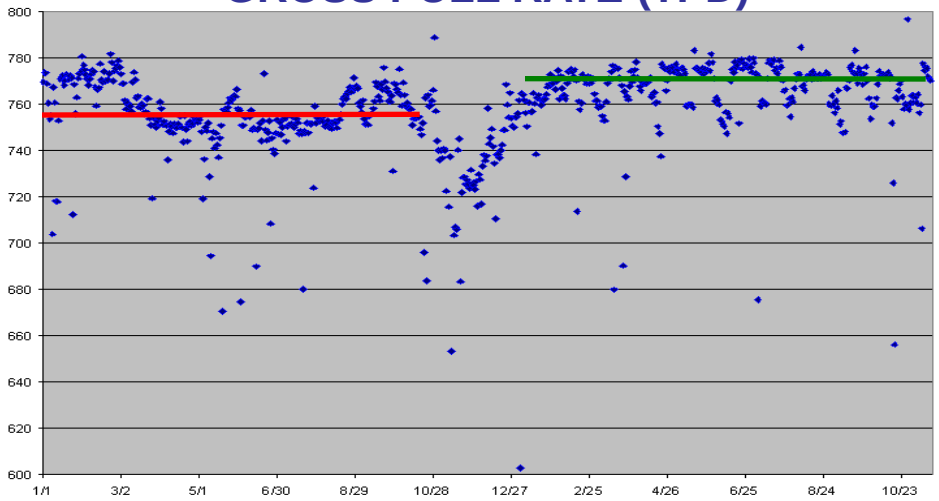
SAVING OF TOTAL GAS IN % **2.70**

SAVINGS!

ES III™ RAW PULL RATE INCREASING

- AFTER THE *ES III*™ SYSTEM IMPLEMENTATION THERE IS PULL RATE INCREASED MOSTLY.
- REAL INSTALLATION EVALUATION – CROSS FIRED REGENERATIVE FURNACE, 6 PORTS

GROSS PULL RATE (TPD)



	STANDARD	*ES III*™
RAW PULL RATE [TPD]	753.4	764.9
DAILY INCREASING [T]	11.5	
YEARLY INCREASING [T]	4197.5	
TURNOVER INCREASING (YEARLY INCREASING x PRICE FOR 1 TON OF GLASS)*	839,500 €	

EXTRA REVENUE FROM SALE!

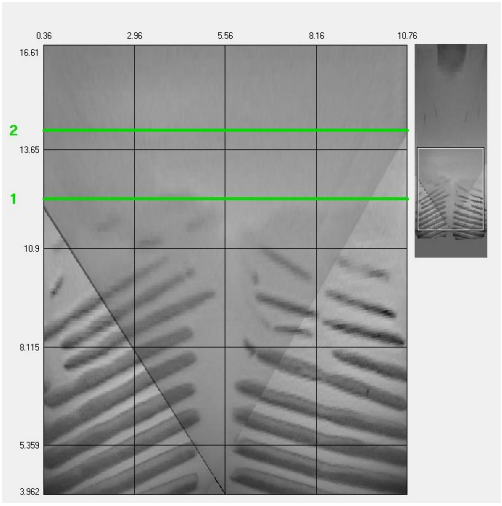
* SAME EFFICIENCY IS CONSIDERED. TYPICALLY, THE EFFICIENCY IS ALWAYS HIGHER SO THE BENEFITS ARE HIGHER TOO

ES III™ Camera extension – How does the sensor work ?

+

Correspondence between the real world and the images

Orthogonal projection



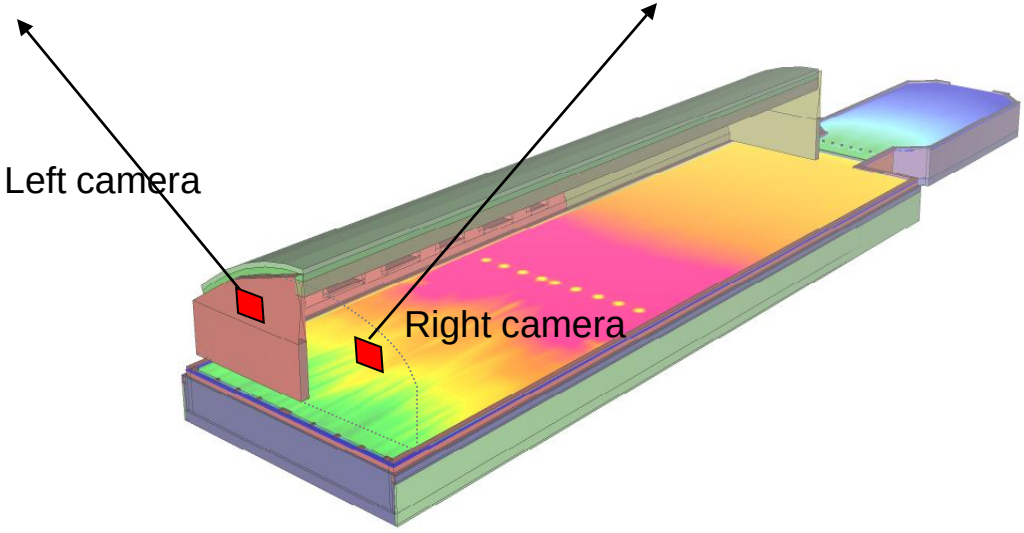
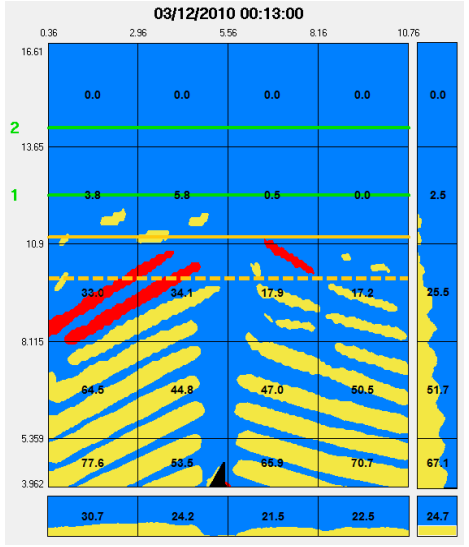


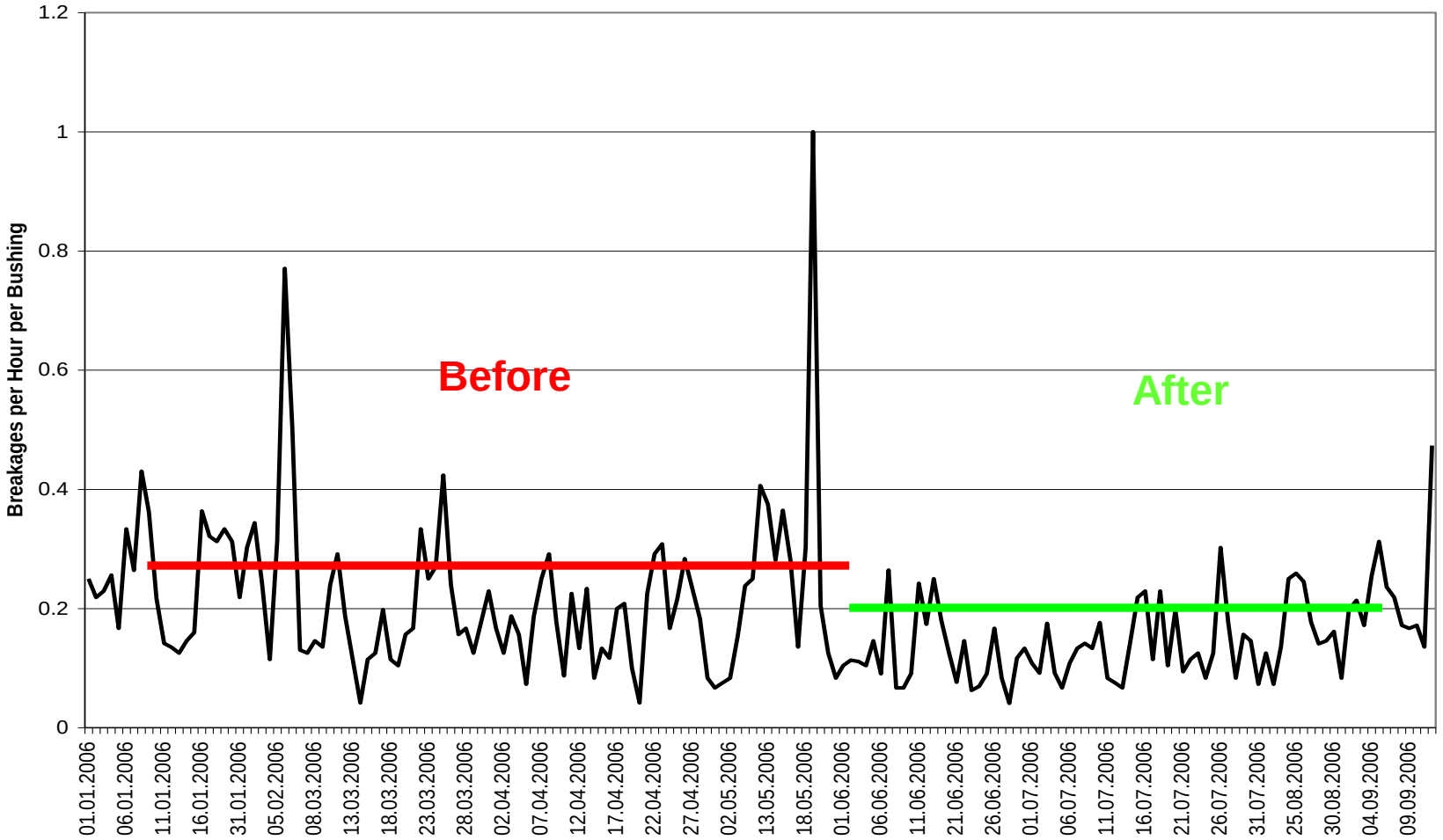
Image processing



Measured data				
Bach line position	Batch densities ([%], [sq. m])	Critical batch isle position	Check lines characteristics	Buildup measure

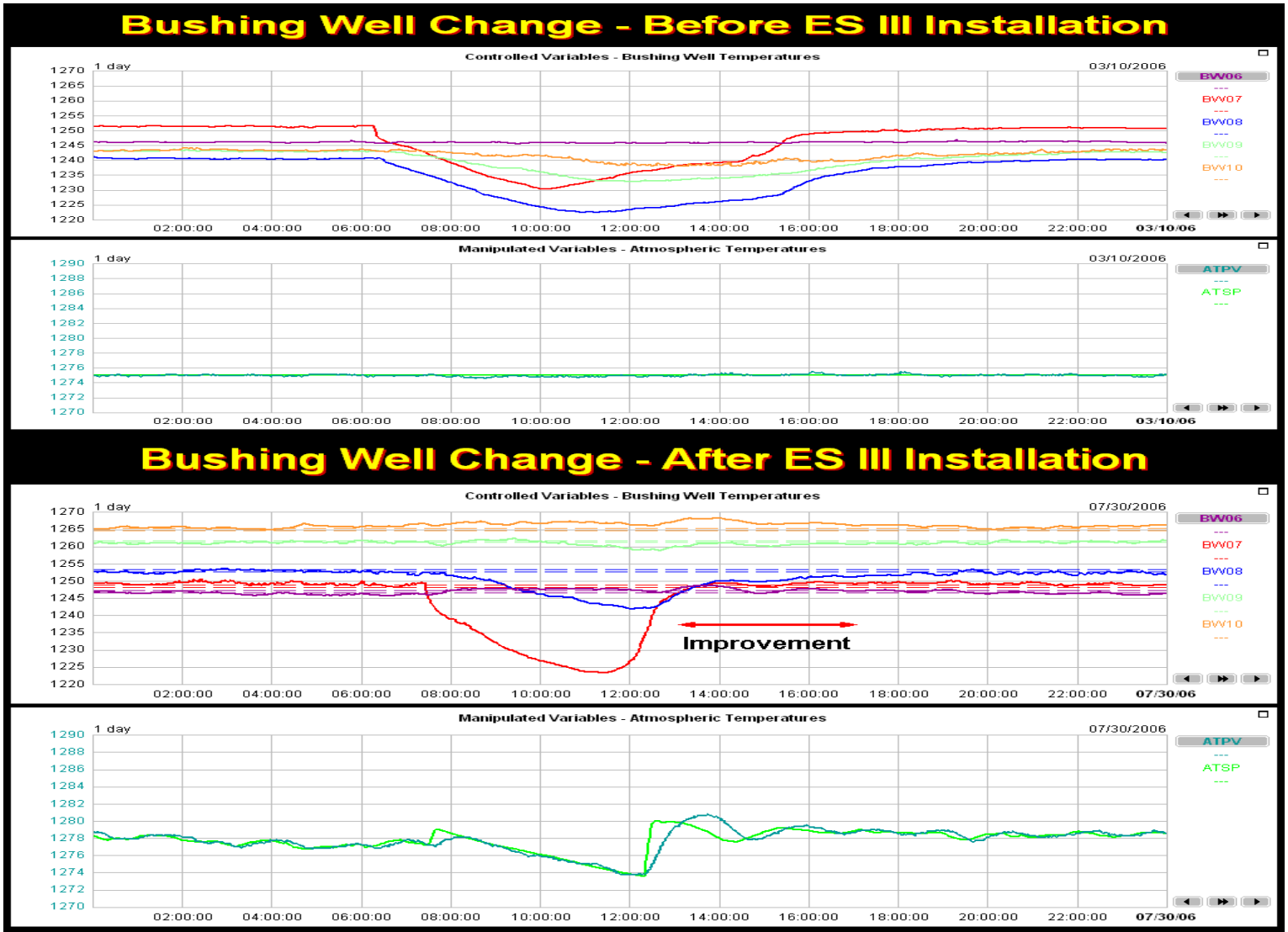
ESIII Fiber Forehearth Control

Breakage analysis – 20% Improvement



ESIII Fiber Forehearth Control

Bushing Service Logic



ES III™ BENEFITS

- **Expert System** ES III™ Major Benefits:
- Consistency 24 hours/d. Almost no operator intervention (reduced disturbance)
- More stable glass production
- Energy optimization
- Reduced time for product change
- Improved quality by reducing melt defects
- Improved yield by better forming conditions
- Effect on emissions
- Increased safety and furnace lifetime (fault detection, stable temp. profile)

Conclusions

- Offline (GS GFM CFD) and online (ESIII MPC) models can help to improve melting performance & save energy. But both are **tools** still need input and usage from experienced people either from customer side, a 3rd party involved or Glass Service side to achieve the required savings

- Thank you for your attention