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CEPAC Chemical Engineering PanAmerican Collaboration

Advanced Control System – Industrial Results and New Challenges

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PASI 2011 Process Modeling and Optimization for Energy and Sustainability

July 19-29, 2011, Angra dos Reis, RJ, Brazil

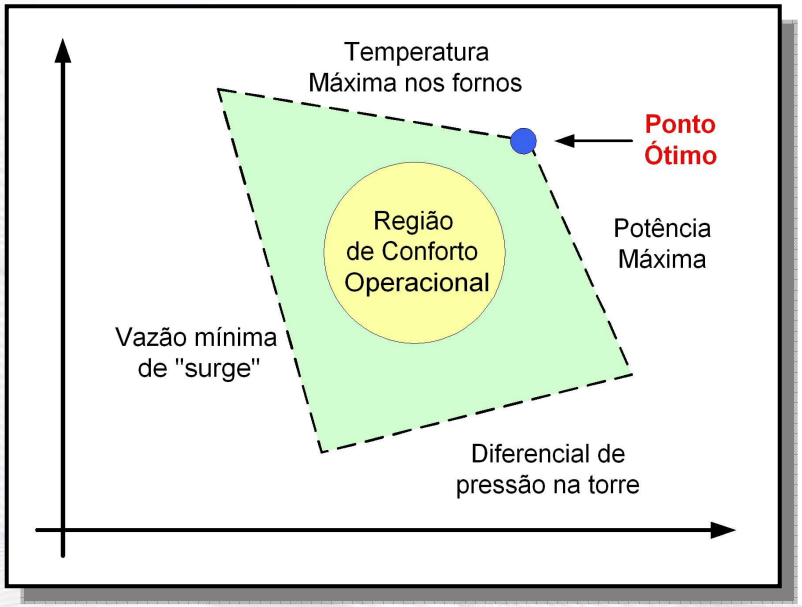
Summary
Advanced Control System

- Introduction
- Industrial Results
- Challenges
- Conclusions

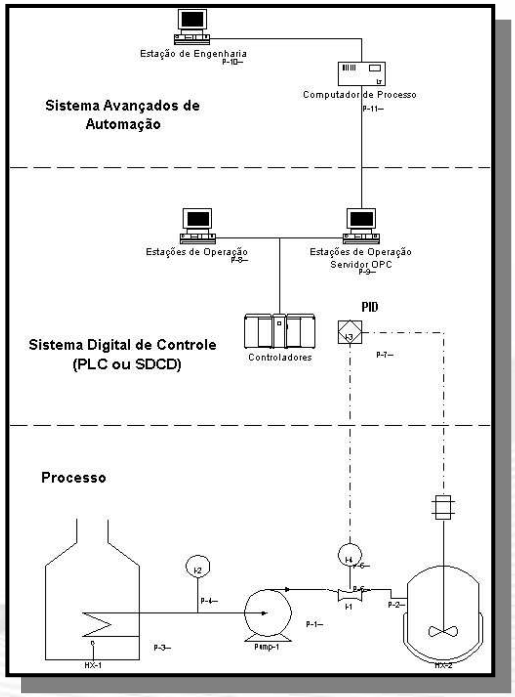
Advanced Control System

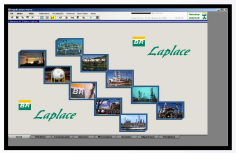
- Due to increasing demand for high performance units Advanced Control and Optimization Technologies will play an importante role in industrie in coming years.

Increase Profitability



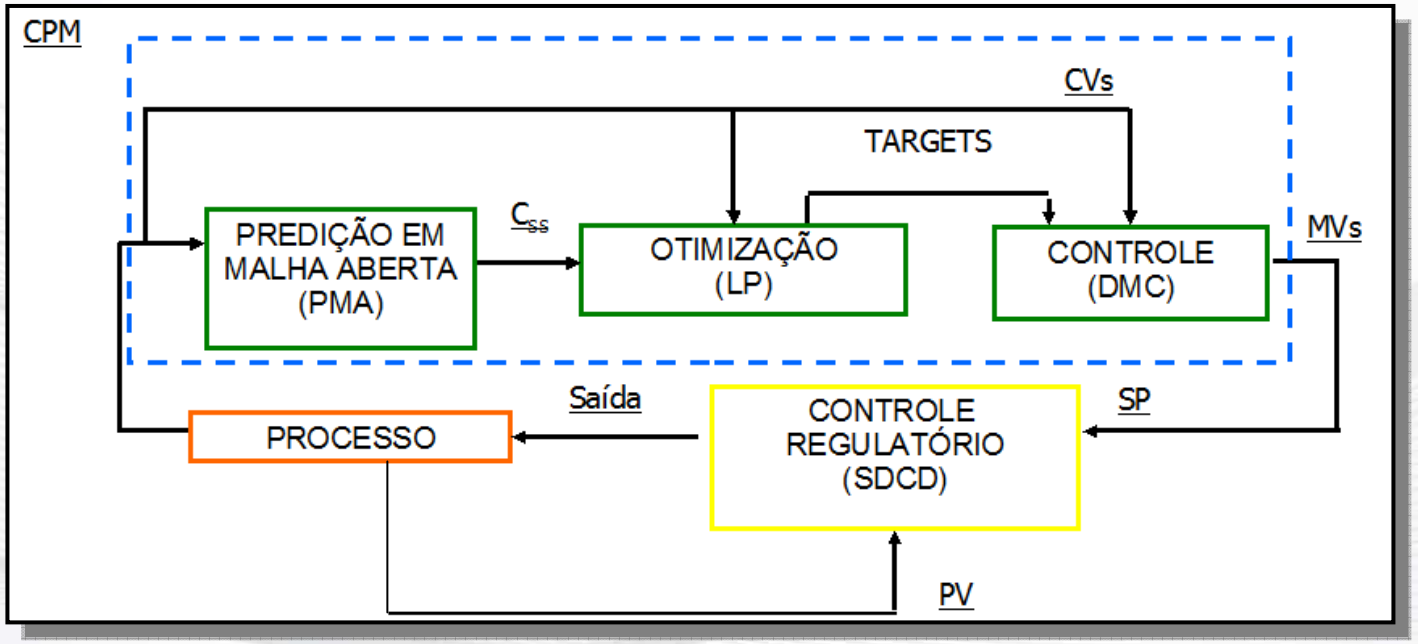
Operate safely on the constraints





Advanced Control Objectives

- ✓ **Maximize the production**
- ✓ **Ensure the specification of products,**
- ✓ **Minimize energy consumption,**
- ✓ **Minimizes the process variability which increases safety and minimizes the flare (prevent loss of products)**



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Methodology for Implementation of Advanced Control

- Functional Design (What are the goals of ACS?)
- Check the Instrumentation and Regulatory Control
- Pre-Tests and Inferences (virtual sensors)
- Plant Test and Identification of dynamic models
- Configuration and commissioning of the controller
- Tuning the Advanced Control
- Monitoring Advanced Control System performance
- Training of operators and Documentation

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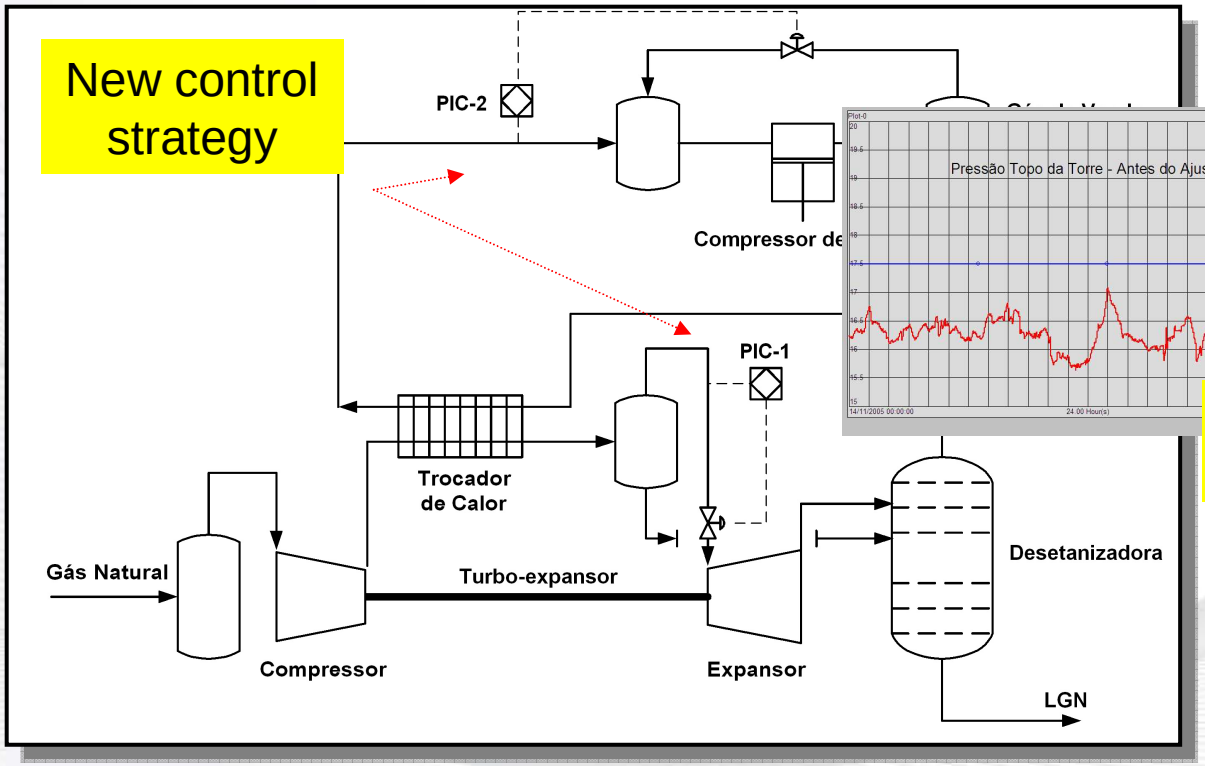
Advanced Control System
Industrial Results

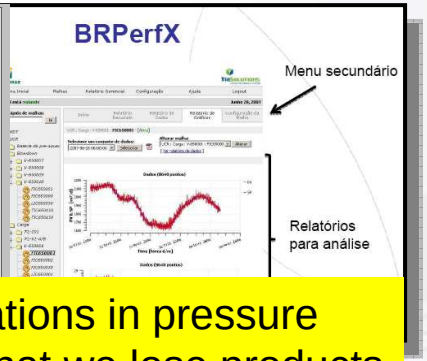
Gas Processing Plant

- Improved Regulatory Control

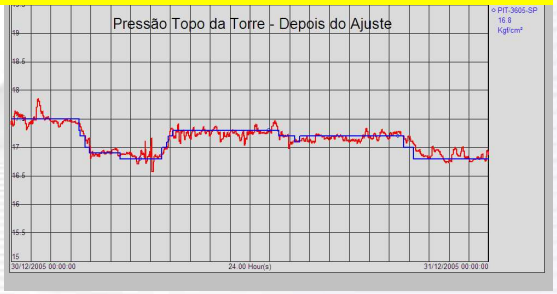
New control strategy



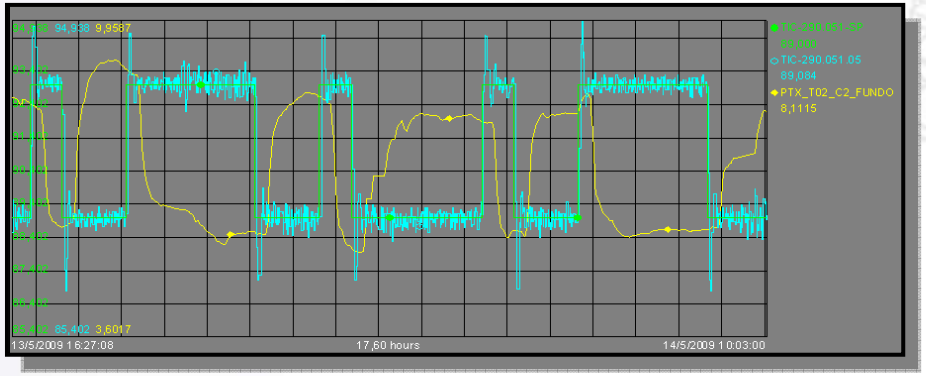
UFRGS



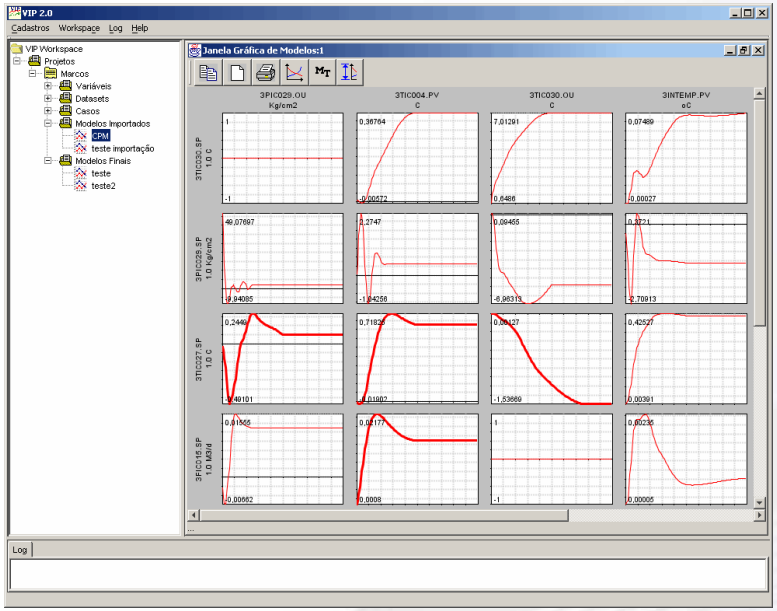
Variations in pressure means that we lose products



Implementation of Advanced Control



Identification Tests



Obtaining the dynamic models

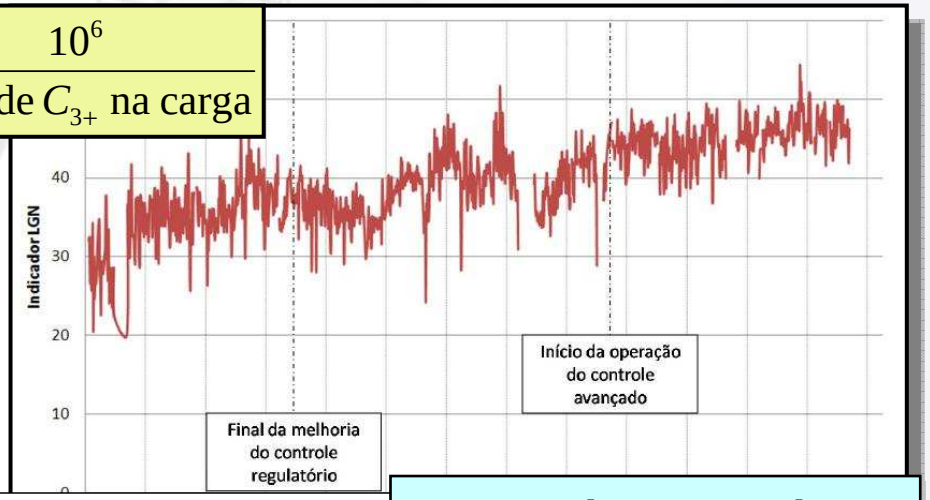
Disponível	TAG	Chave	Descrição	Unidade	Valor	Mínimo	Máximo	Objetivo	Custo Marginal
	Infere C3	Desligada	Infere teor de C3 no LGN	%	0.00	0.05	0.30	0.10	0.0
	Infere C2	Ligada	Infere teor de C2 no Gás	%	0.00	1.00	5.00	4.00	0.0
	PIC-3605	Ligada	Pressão da Torre	Kgf/cm²	16.4	16.5	17.5	17.0	0.0
	MV FFIC-3600	Ligada	Saída do controlador de refluxo	%	65.6	55.0	100.0	-	0.0
	MV LIC-3640	Desligada	Saída do controlador do vaso	%	55.4	10.0	90.0	-	0.0
	MV PIC-3422	Ligada	Saída do controlador do turbo	%	32.7	15.0	90.0	-	0.0
	PDIT-3602	Ligada	Diferencial de pressão na Torre	gf/cm²	0.14	0.01	0.28	-	0.0
	FIC-3422	Desligada	Anti-Surge Turbo	%	84.7	82.0	160.0	-	0.0

Operator interfaces in DCS

Economic Benefits of ACS

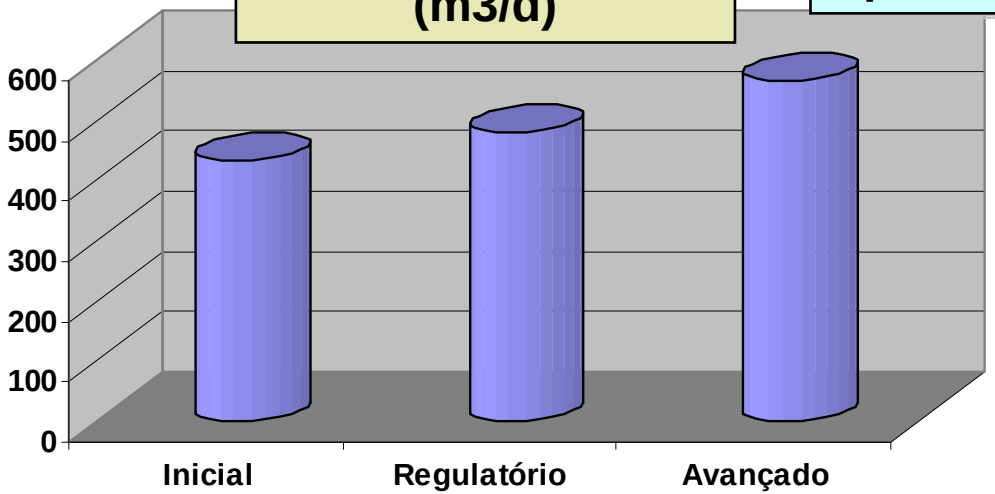
$$Indicador = \frac{\text{Vazão de LGN produzido}}{\text{Vazão de Carga}} \times \frac{10^6}{\text{Teor de } C_{3+} \text{ na carga}}$$

	Indicador de LGN	Produção LGN (m^3/d)
Inicial	34,3	431
Após melhoria regulatório	38	478
Após implantar CAV	45	566



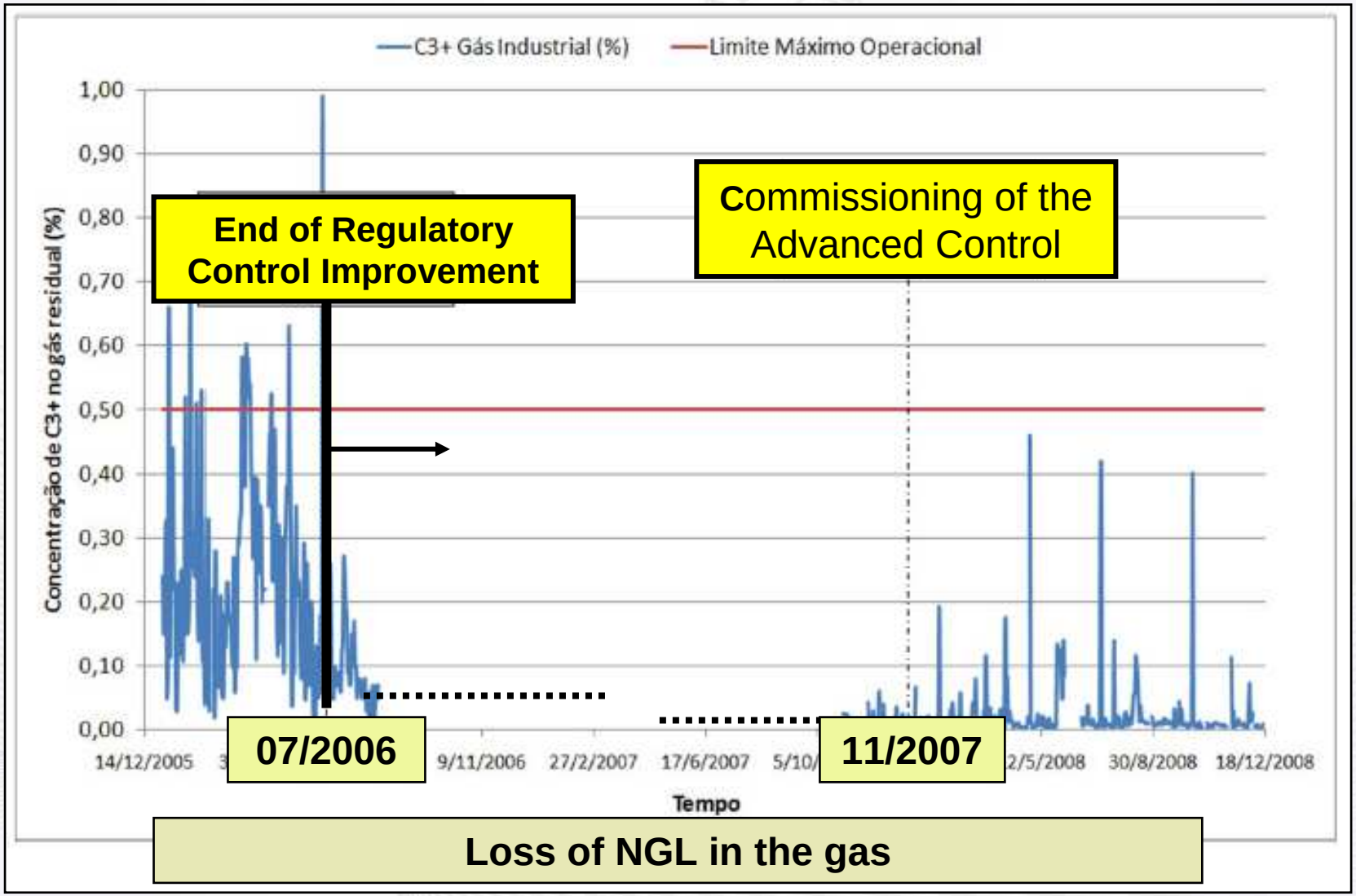
31% increase in production of NGL

NGL Production (m3/d)



Regulatory Control was responsible for 35% of the gain obtained

Losses Reduction



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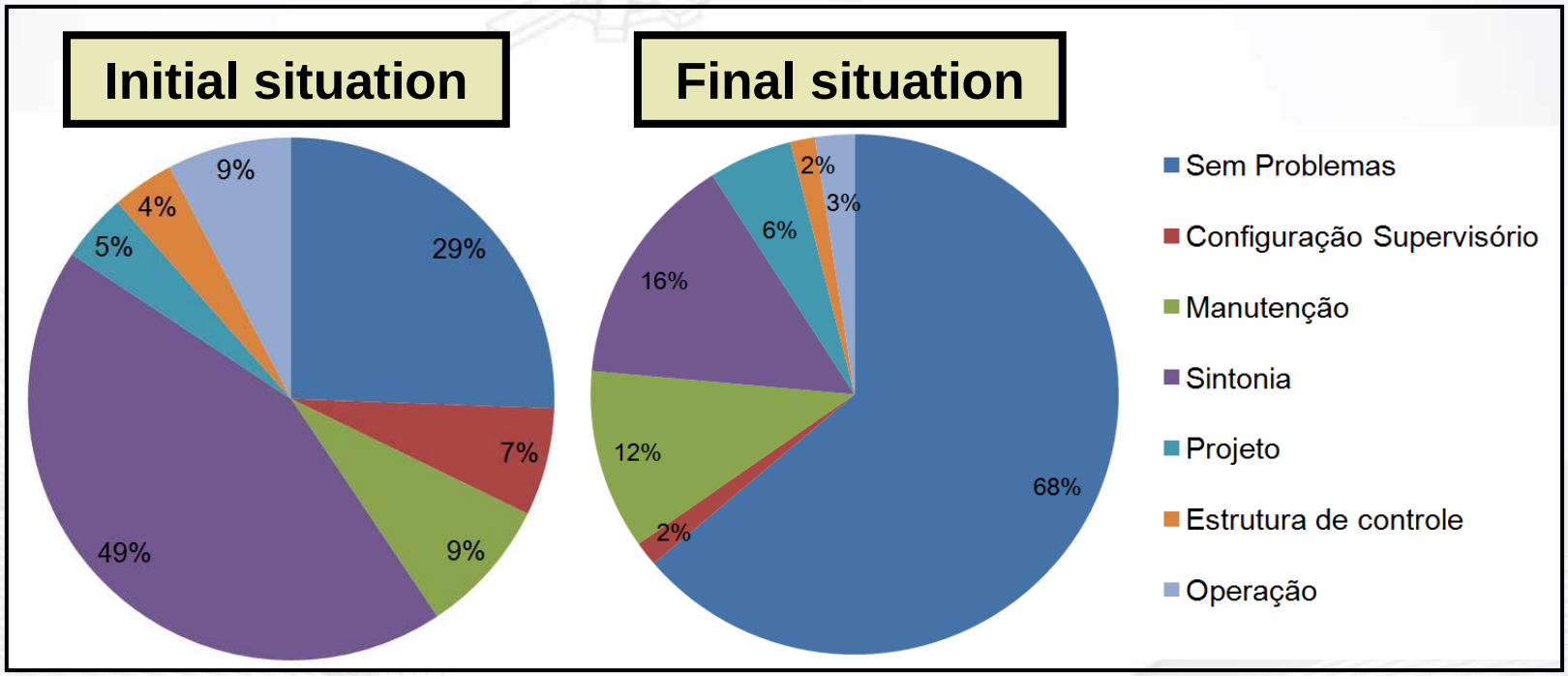
Other examples of the importance of advanced control systems for industry

Improvements in regulatory control are fundamental

About 400 control loops analyzed

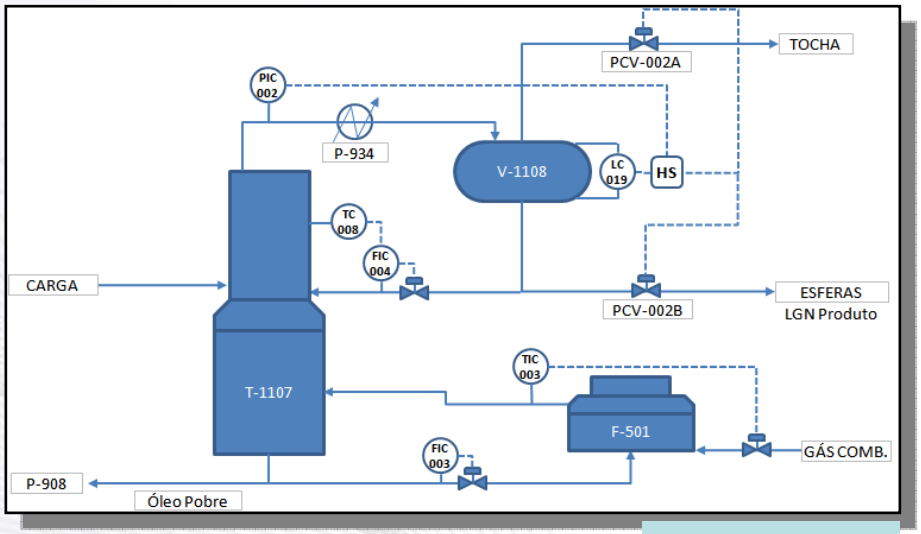


About 50% of the control loops had tuning problems

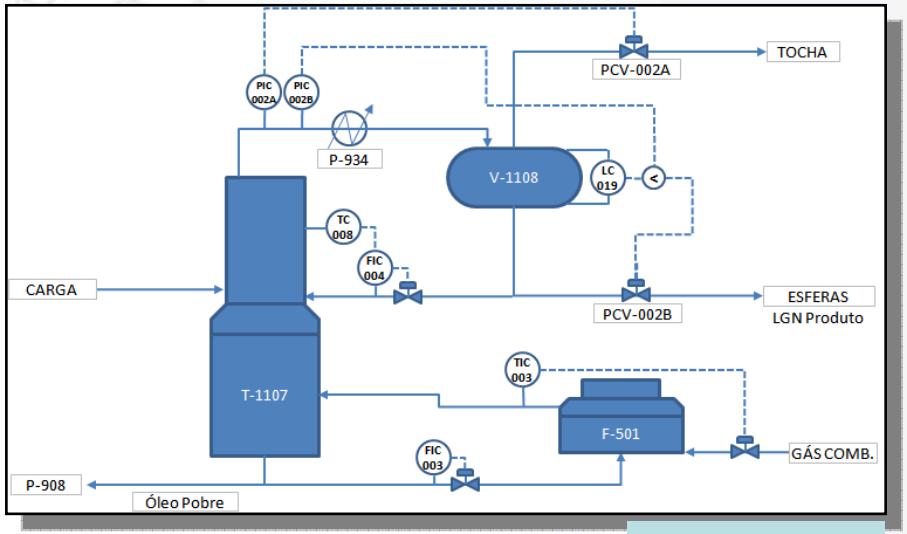
The number of control loops with a good performance rose from 29 to nearly 70%

New control strategy

- New control strategy minimizes the flare



Before



After

Reduced loss of products by 40% in the flare

Reduced emissions by about 230 tons/year of CO_2

Variability Reduction

Greater stability
Fundamental to the advanced control

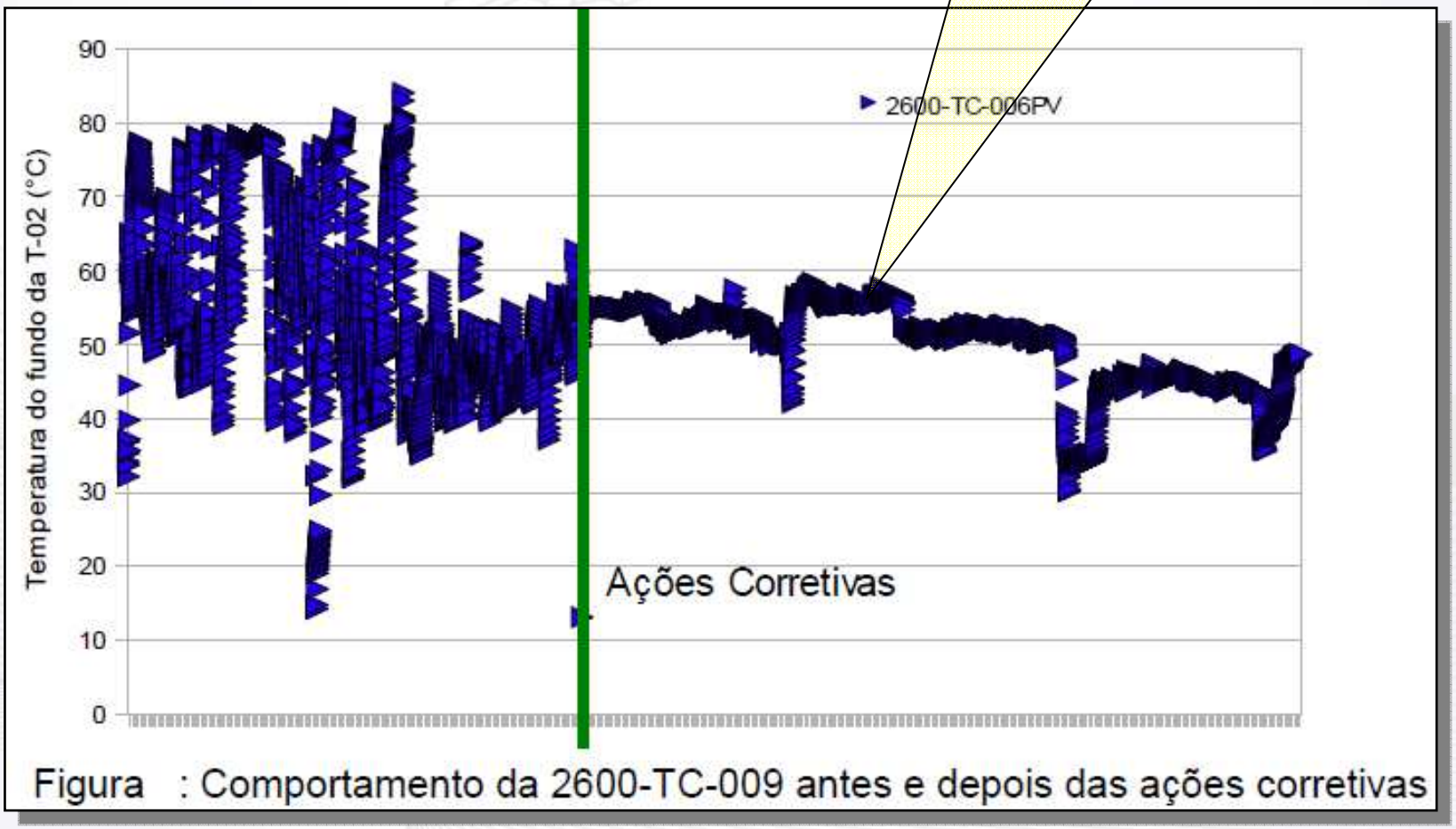
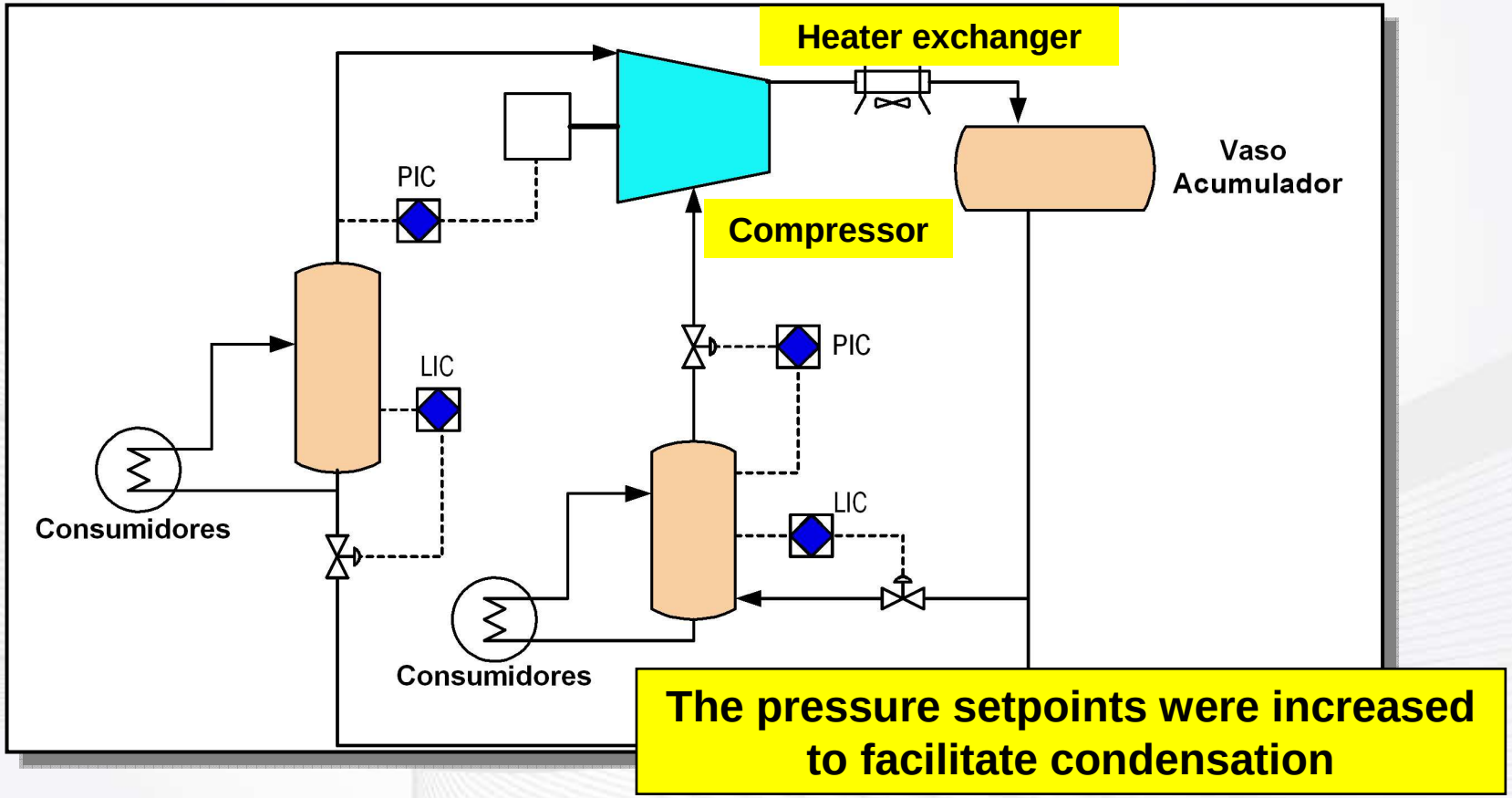


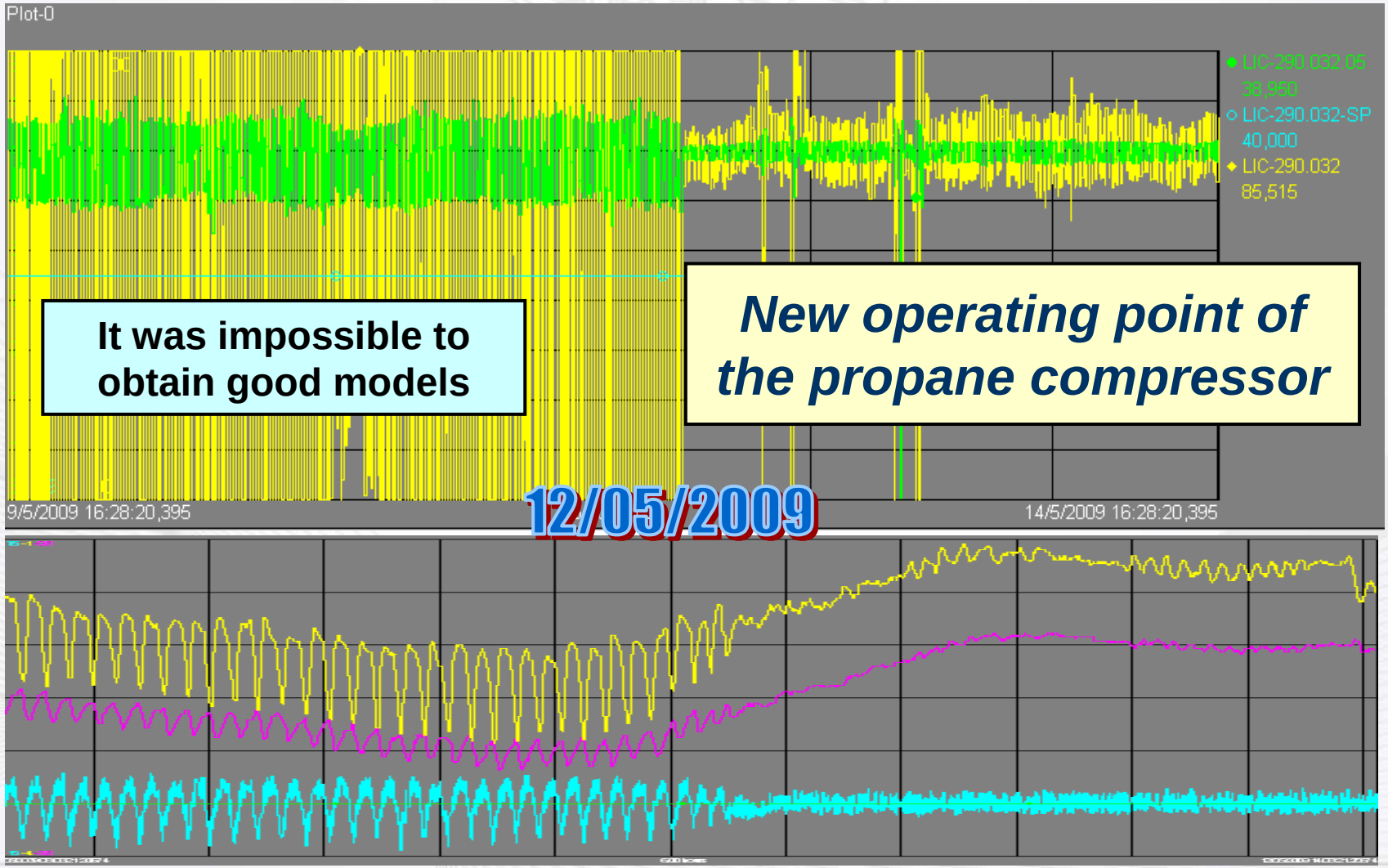
Figura : Comportamento da 2600-TC-009 antes e depois das ações corretivas

Instabilities in the propane refrigeration system

- Limitations due to low thermal exchange area were generating saturation in the suction pressure control



- Greater stability has allowed the identification tests

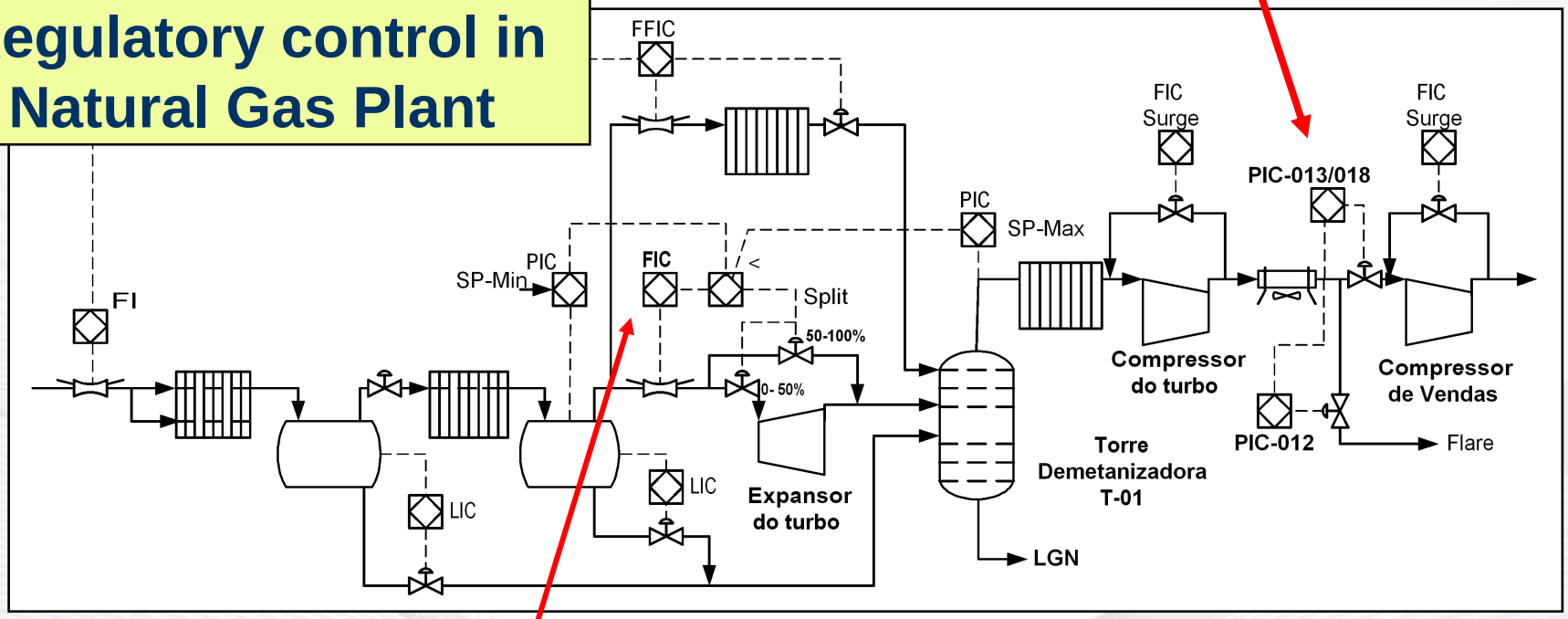


Control strategy problems

Many trips due to high pressure in the column

It was difficult to choose a setpoint

Regulatory control in a Natural Gas Plant



PID Control always operated in manual mode

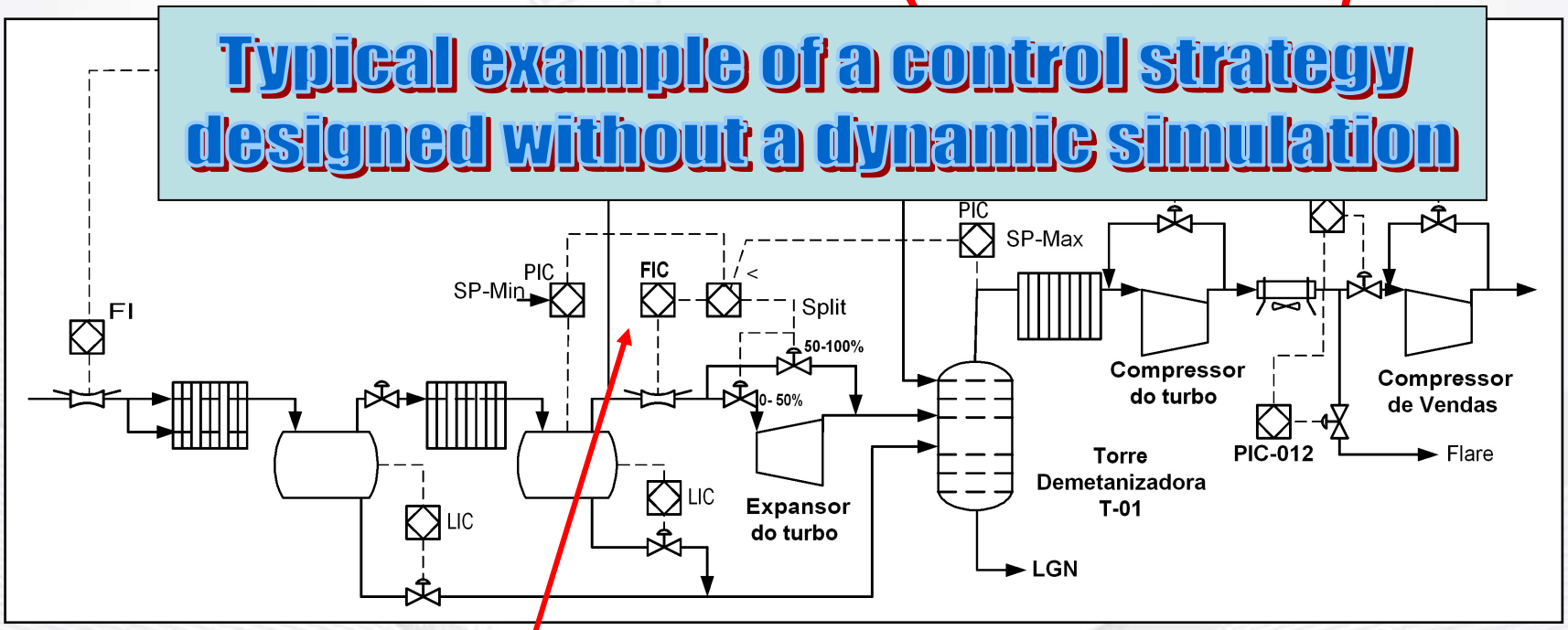
After a turbo-compressor's shutdown, the PID acts incorrectly

Regulatory control in a Natural Gas Plant

Suction pressure under control

Discharge pressure under control

Typical example of a control strategy designed without a dynamic simulation

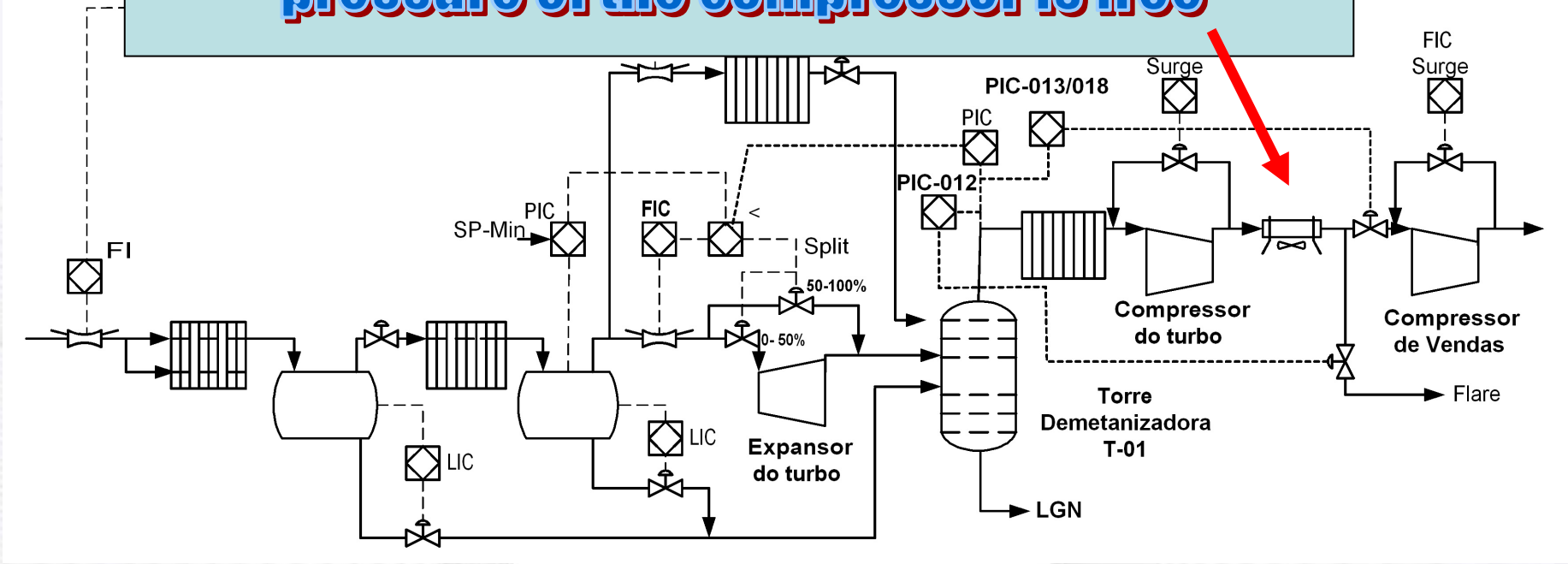


Expander and compressor flow under control

There are no degrees of freedom for the compressor

New Regulatory control for this Natural Gas Plant

There is a degree of freedom, the discharge pressure of the compressor is free



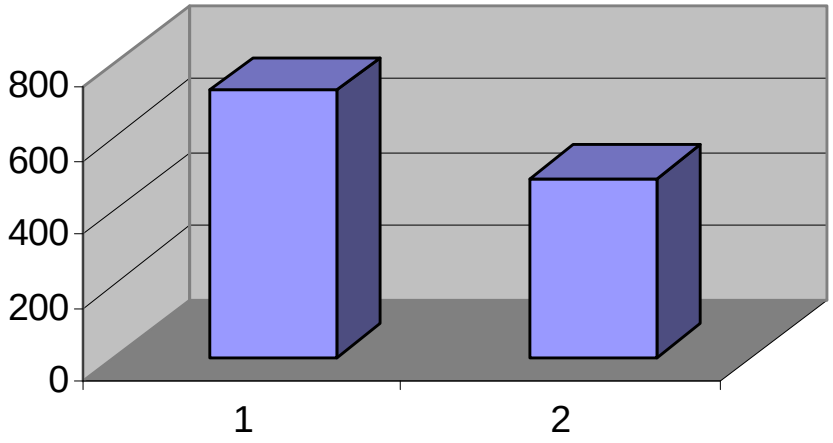
Now, the setpoints don't change if the turbo-compressor is operating or not

New Regulatory control for this Natural Gas Plant

PID now operates in automatic mode

Reduction

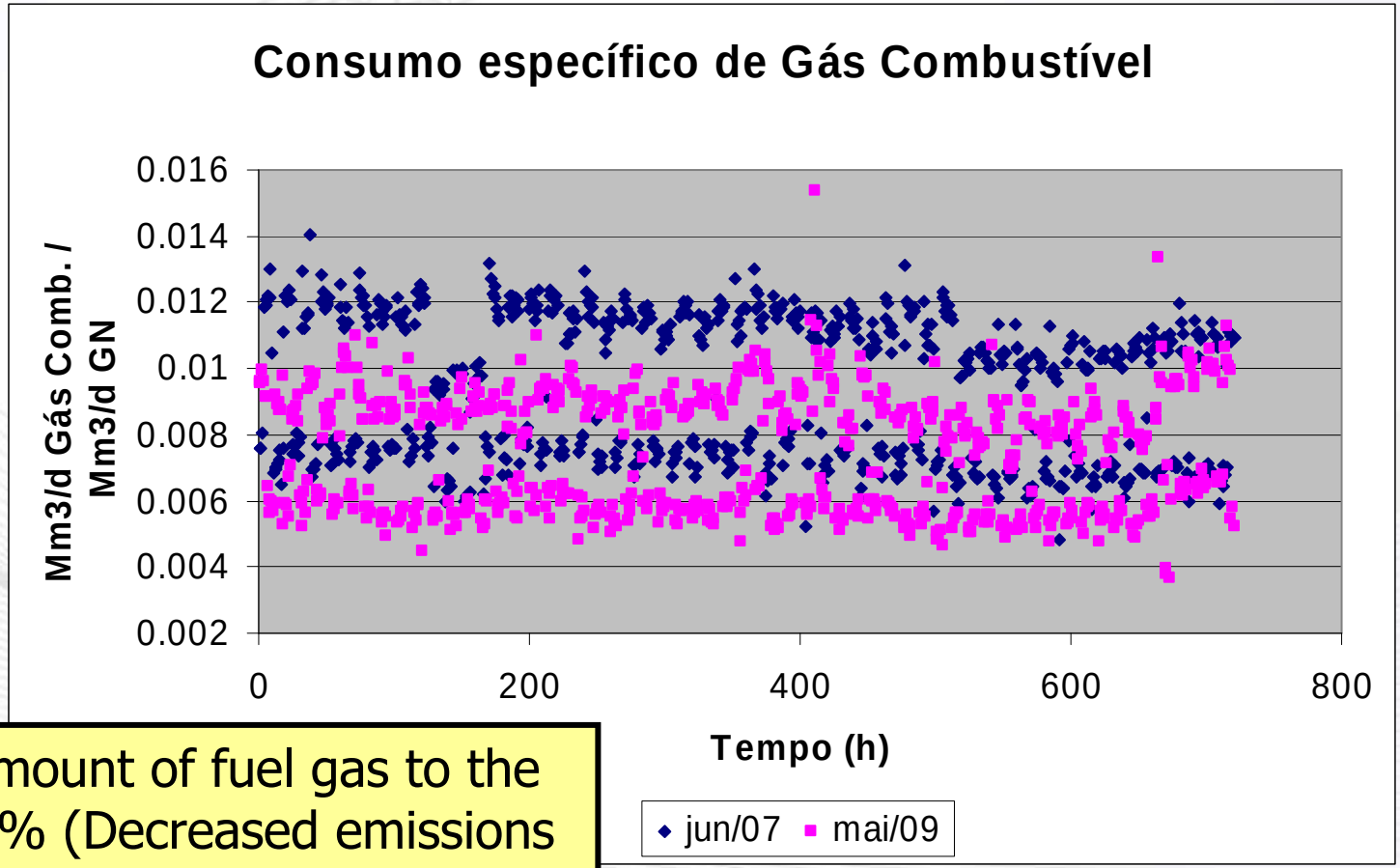
Shutdown Time



Reduction of 33% in the undesirable shutdown

Increases in energy efficiency

- There are two levels of energy consumption at this unit depending if we are or not regenerating

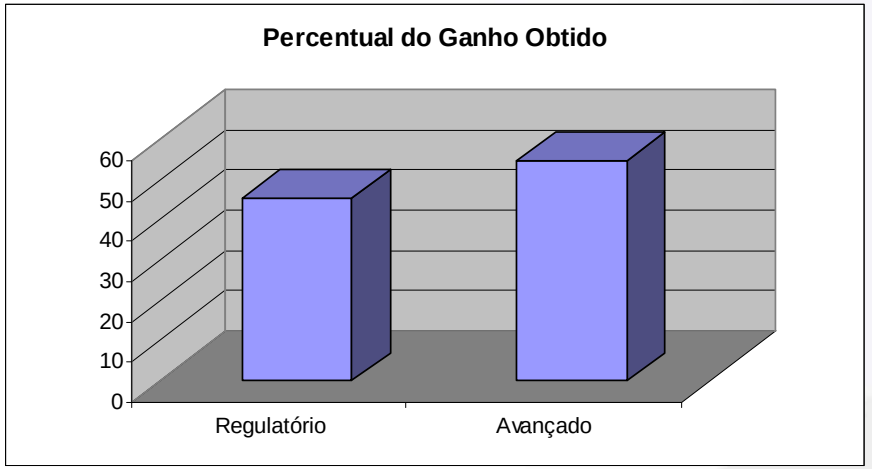


Reduced the amount of fuel gas to the furnaces by 18% (Decreased emissions by about 1600 tons/year of CO_2)

Economic Benefits

Profitability Gains

- Increase of 1.59 m^3/h in the production of LPG (Liquefied petroleum gas) due to improvement of regulatory control
  - US$ 1.806.913,50 por ano
- Increase of 1.7 m^3/h in the production of LPG (Liquefied petroleum gas) due to the advanced control system
  - US$ 2,163,015.47 por ano



Regulatory Control was responsible for 45% of the gain obtained

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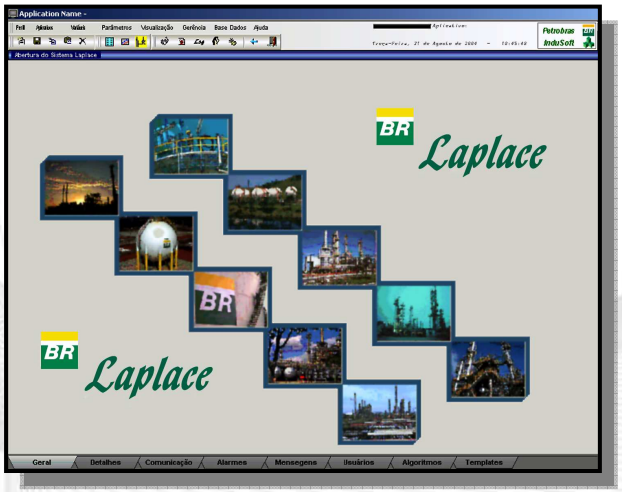
Advanced Control System Challenges

Regulatory Control

- Regulatory control is essential for the success of advanced control systems and it is responsible for important gains.
- Why we don't see many industrial projects using dynamic simulation and other methodologies for design a good control strategy?
- Why do we still have many control loops with a bad PID tuning? Many tools don’t deal with MIMO approach for design and tuning decentralized PID controllers.

Advanced Control in Oil&Gas Industries

- New technologies to accelerate the deployment and maintenance of advanced control systems are required.
- There is a significant gap between the recent MPC technologies development in the academy and those systems effectively used on industrial plants.



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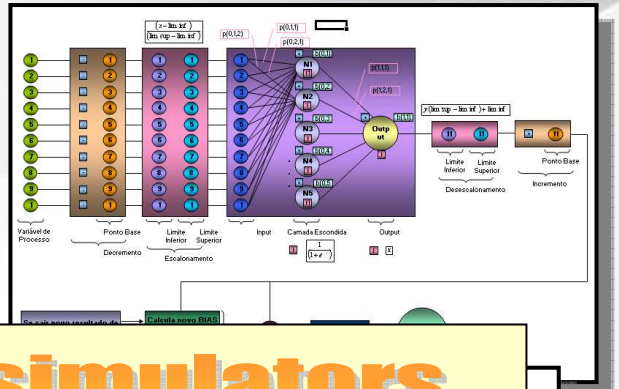
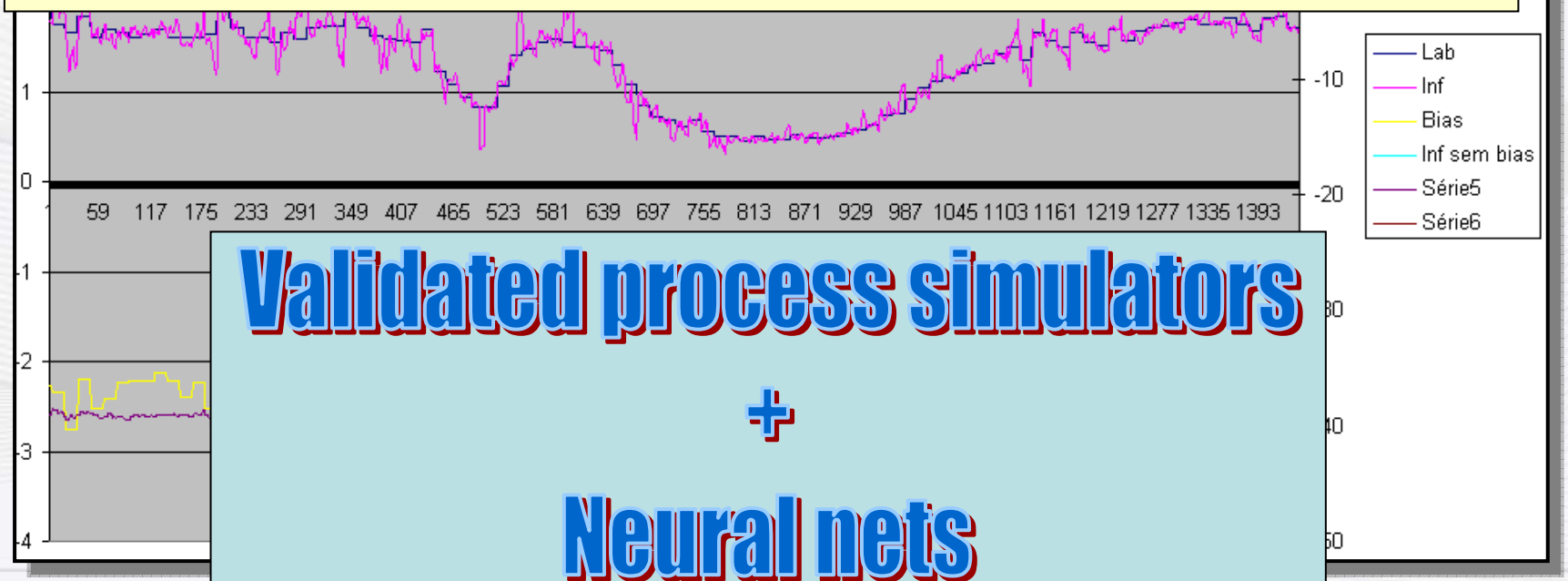
Virtual sensor - Critical Point



Use of rigorous dynamic simulators, or statistical methods for better inferences using less laboratory analysis data.



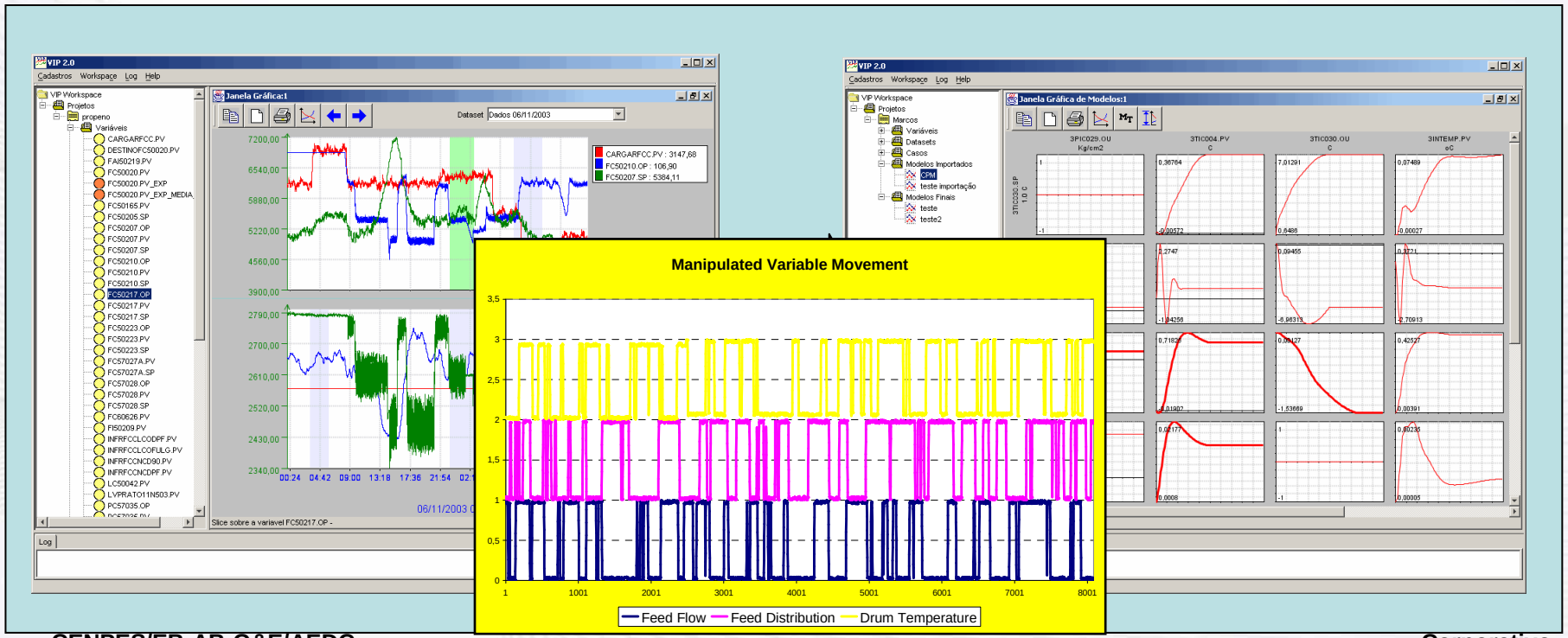
Validated process simulators

+

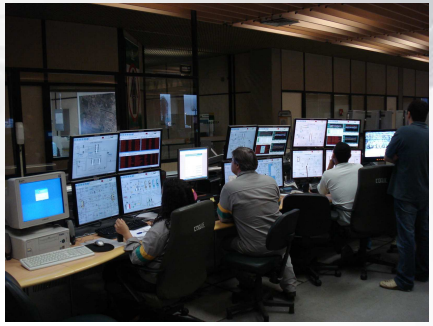
Neural nets

Dynamic model Identification

- Process identification of complex processes is still a hard task, where a significant part of the effort on MPC implementation is spent.
- Researches and developments for the identification methods are still necessary, and they can bring great economical earnings.



MPC Tuning

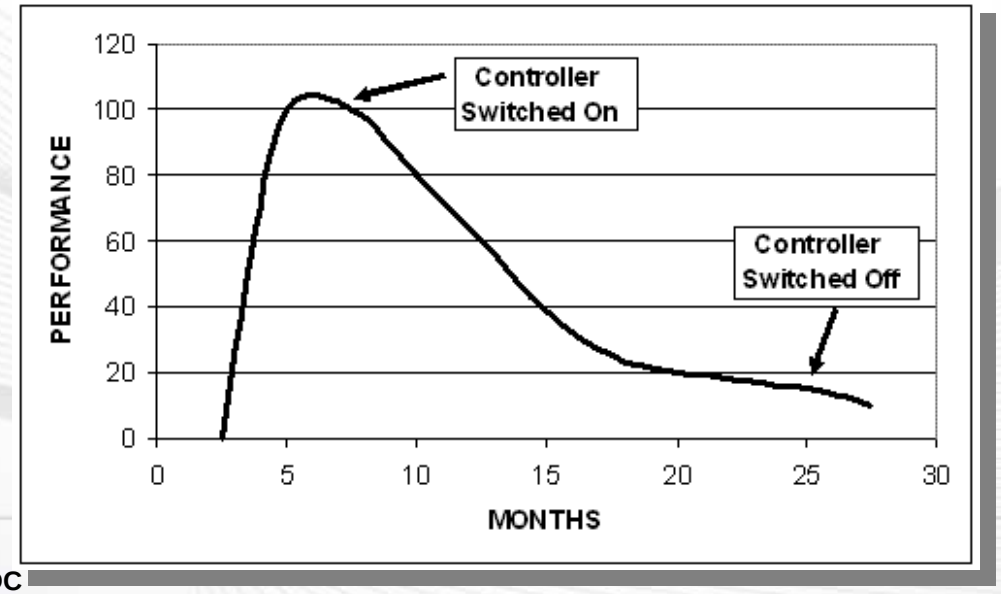


- Controller tuning still consume time and is a critical point for controller performance
  - Different tuning scenarios depending on which constraints are active.
  - How to define the priorities in the several operating points of the controller?
  - Is it possible to use dynamic simulation to get plant model and to define MPC tuning?

Trial and error methodology

MPC Maintenance is a big challenge

- MPC performance can decay throughout time due to:
  - Changes in the units operational objectives;
  - Equipments efficiency losses (fouling);
  - Changes in the feed quality;
  - Problems in instruments and in the virtual sensors;
  - Lacks of qualified personnel for the controller's maintenance.



Conclusion

- Control technologies are an important tool for increasing energy efficiency, profitability and sustainability of industrial processes.
- The process of implementing an advanced control system is very rich because it allows to rethink how to operate the equipment available, to question the paradigms, constraints, etc.
- Importance of the multidisciplinary interactions (control experts, process engineers, operators) in order to have a successful implementation.

Conclusion

- Engineers should know very well the process in order to define and implement good control and optimization system
- Human Resource: formation and train of engineers is the greatest challenge for the universities in the advanced control and optimization area.
- Better tools are necessary but they will not substitute a good control engineer

References

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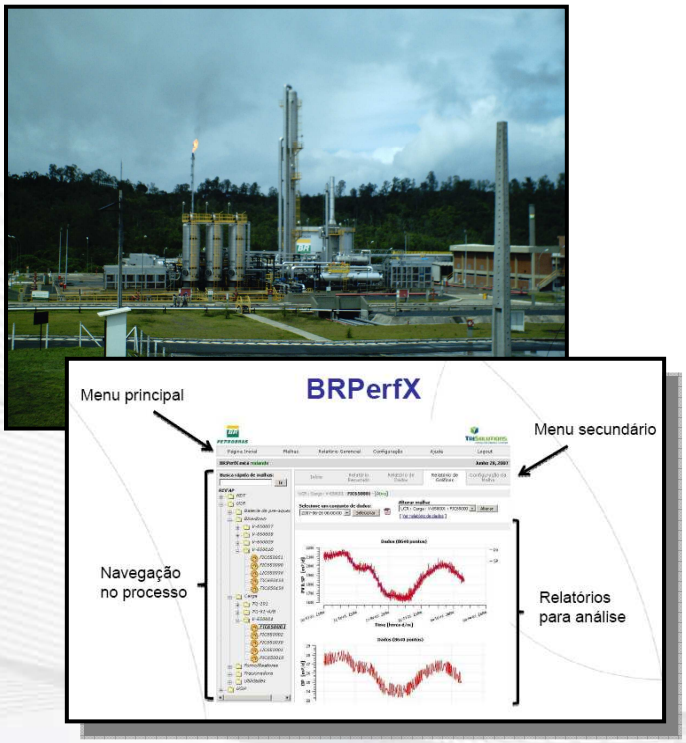
Thanks for your Attention



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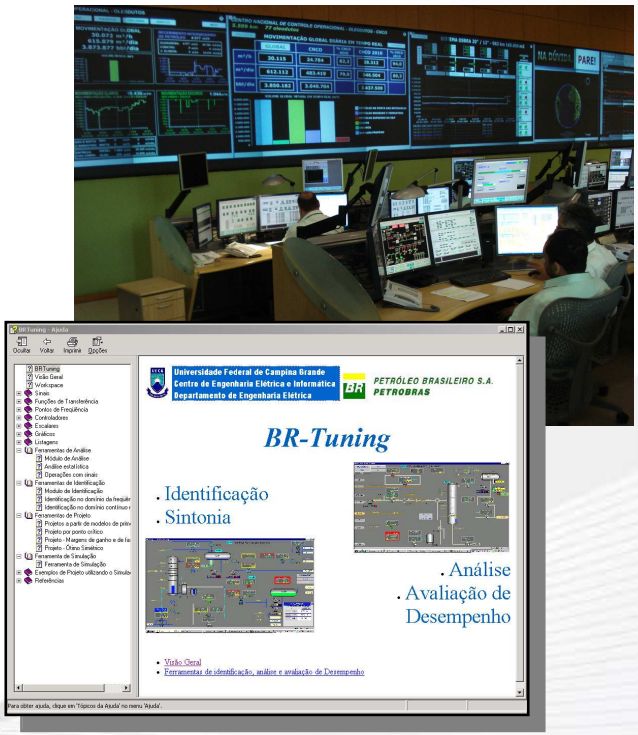

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