

*Remodeling using Temperature as manipulated  
variable in Advance Process Control to increase  
products and control quality*



# Agenda



● What is APC?

● Why select Temperature as MV?  
And  
Conceptual Design

● Benefit from best practice

● Best practice for base layer of  
plantwide optimization

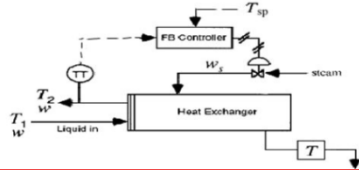


**What is APC?**

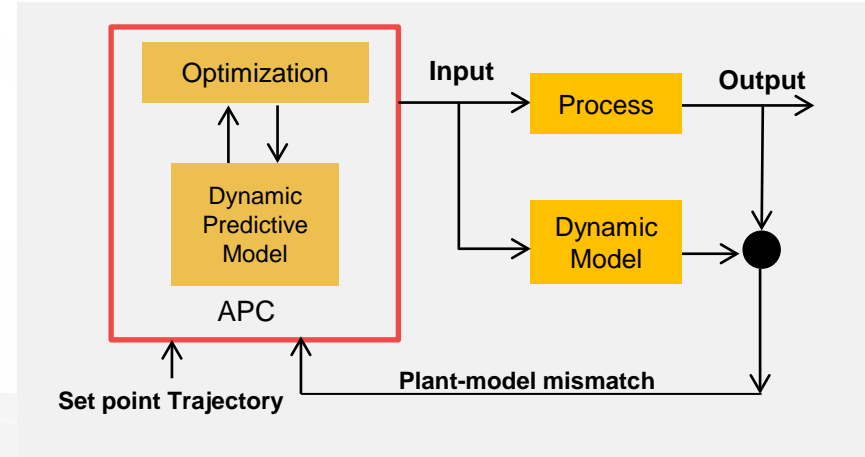
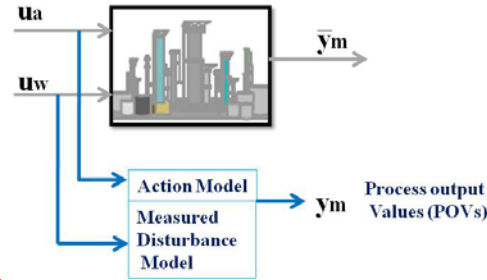
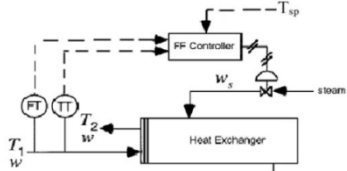
# Advanced Process Control (APC)

Single loop control

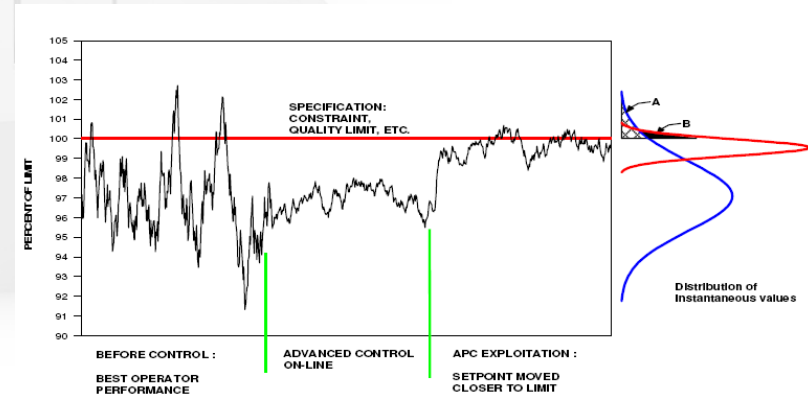
## Feedback Control



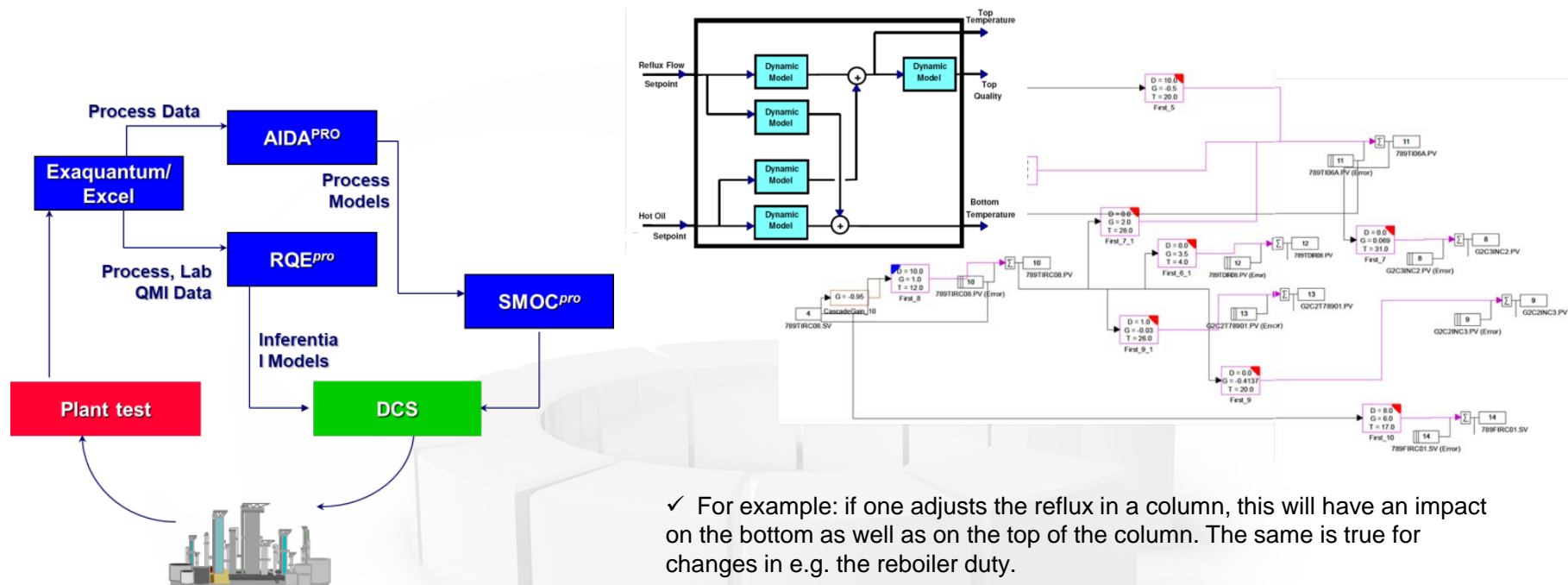
## Feedforward Control



Advanced Process Control (APC) is a general term for control applications that are more advanced or complex than the typical control schemes found in DCS systems. Generally, APC applications are designed to reduce the variability of key unit operating variables. The reason for using a multi-variable controller for this is that there are quite often **strong interactions between the different 'handles' on these processes.**



# Advanced Process Control (APC)



✓ For example: if one adjusts the reflux in a column, this will have an impact on the bottom as well as on the top of the column. The same is true for changes in e.g. the reboiler duty.

✓ Base-layer controllers in the DCS cannot handle these interactions. **APC can!!!**

# **Why select Temperature as MV?**

## **And**

## **Conceptual design**



# WHY SELECT TEMPERATURE AS MV?



## Controllability

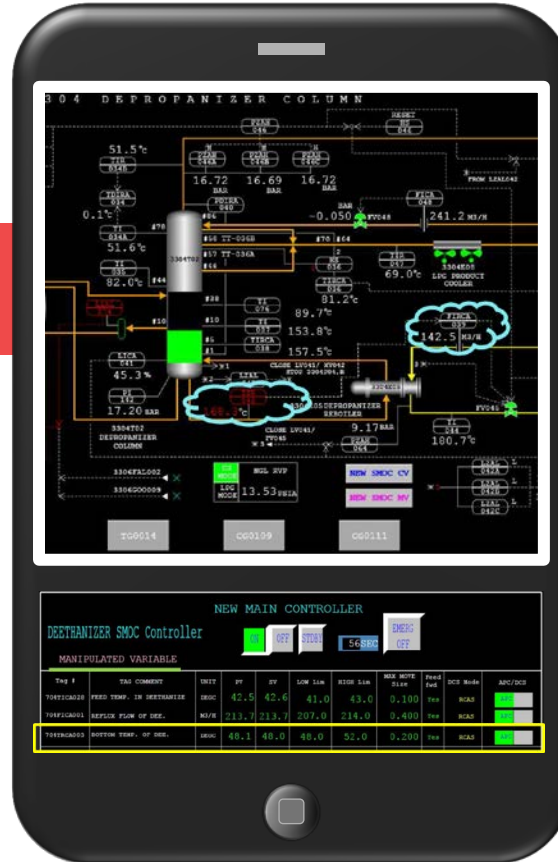
Because these controllers are relatively large and involve a **lot of calculations**, they are **not being executed every few seconds** like a base-layer controller, but often only **once per minute**.

## Robust Quality Estimator (RQEs)

Temperature is direct function of product quality

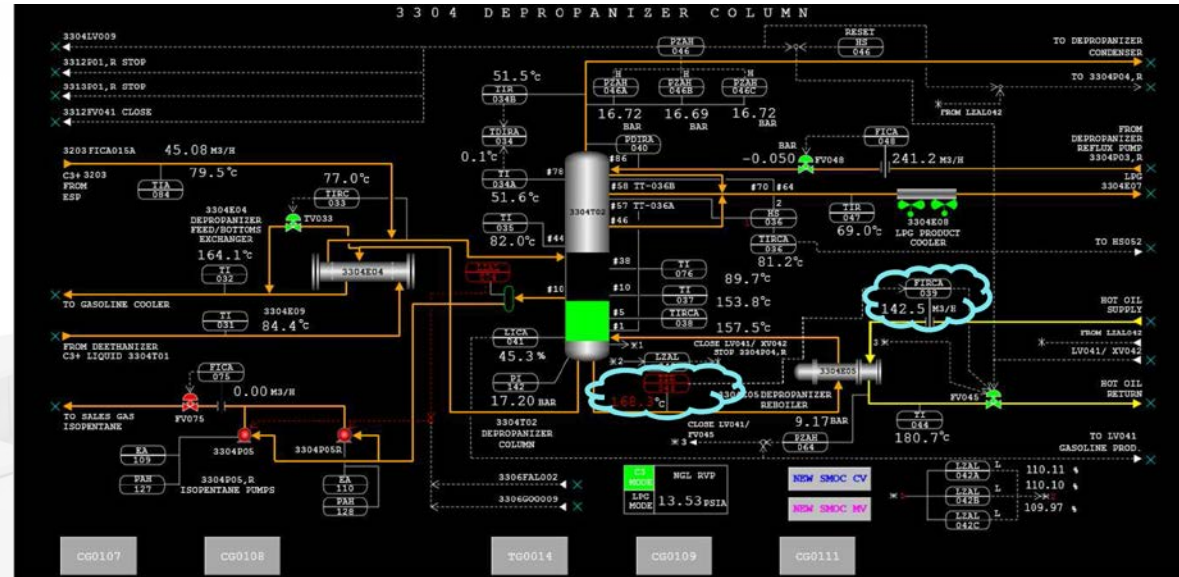
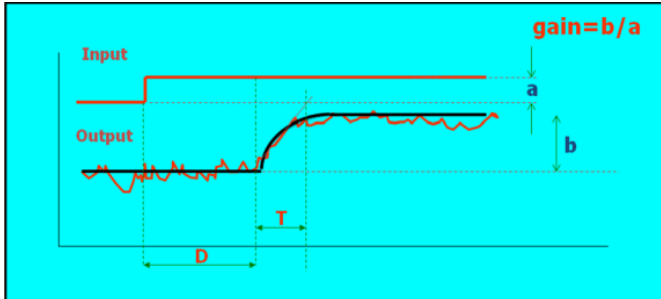
i.e.

$$RQEC3inC2.PV = -0.5 \times 704TRA027.PV + 704PICA002.PV + 1.3568$$



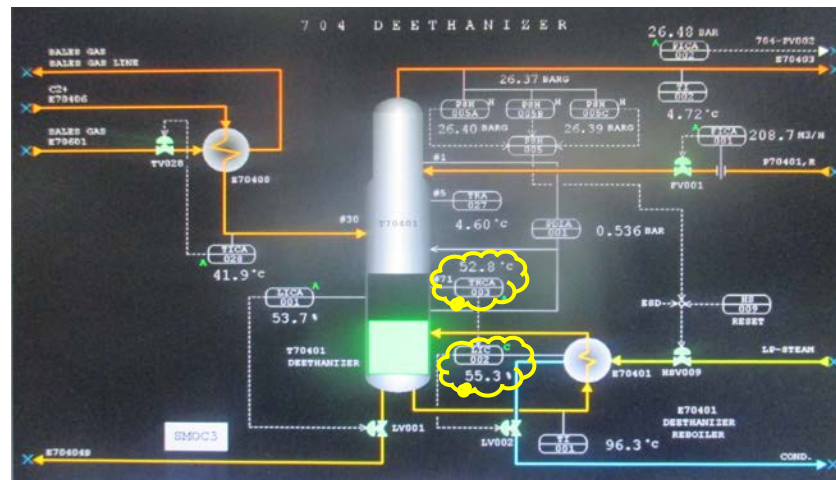
# Conceptual design

## Relation parameters





# Redesign Base layer PTT GSP1 for DeEth & DePro



NEW MAIN CONTROLLER

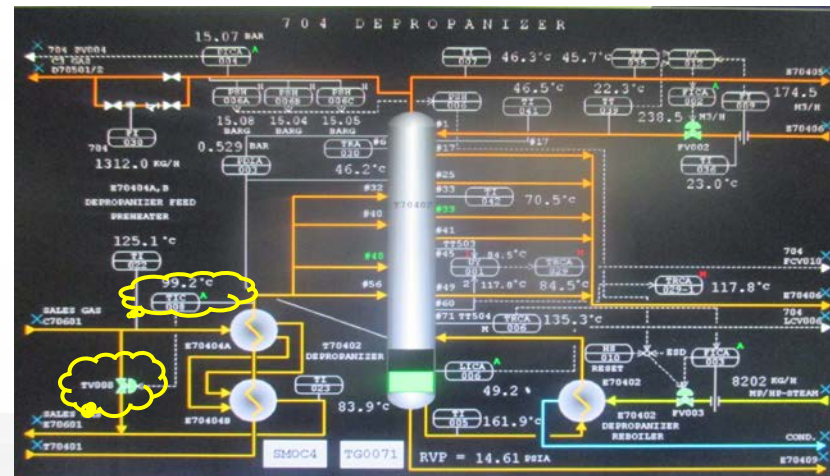
DEETHANIZER SMOC Controller

MANIPULATED VARIABLE

Tag #	TAG COMMENT	UNIT	PV	SV	LOW Lim	HIGH Lim	MAX MOVE Size	Feed fnd	DCS Mode	APC/DCS
704TICA028	FEED TEMP. IN DEETHANIZE	DEGC	42.5	42.6	41.0	43.0	0.100	Yes	RCAS	ON
704FICA001	REFLUX FLOW OF DEE.	M3/H	213.7	213.7	207.0	214.0	0.400	Yes	RCAS	ON
704TRCA003	BOTTOM TEMP. OF DEE.	DEGC	48.1	48.0	48.0	52.0	0.200	Yes	RCAS	ON

Manipulate the set point value of temperature controller 704-TRCA-003 on tray #71 in the column.

This temperature controller subsequently controls the LP-steam flow to reboiler E-70401.



NEW MAIN CONTROLLER

DEPROPANIZER SMOC Controller

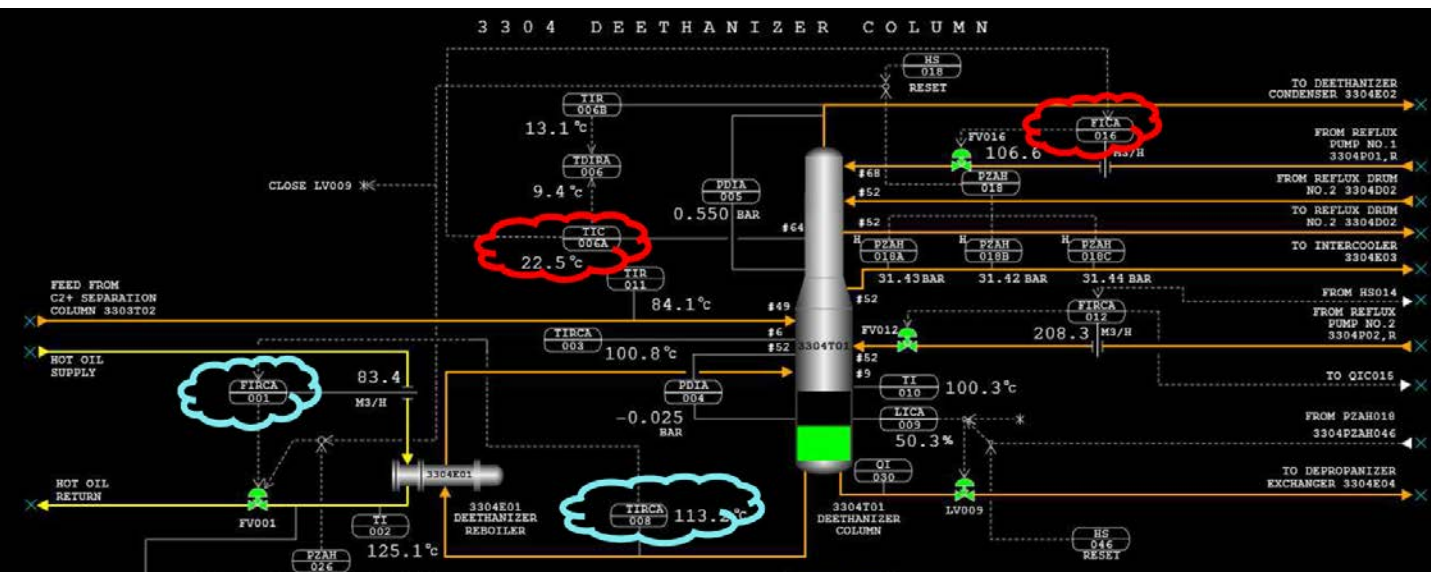
MANIPULATED VARIABLE

Tag #	TAG COMMENT	UNIT	PV	SV	LOW Lim	HIGH Lim	MAX MOVE Size	Feed fnd	DCS Mode	APC/DCS
704FICA002	REFLUX FLOW OF DEPRO.	M3/H	233.1	232.2	232.0	238.0	0.500	Yes	RCAS	ON
704FICA003	REBOILER FLOW OF DEPRO.	EG/H	6861	6870	6800	7400	50.000	Yes	RCAS	ON
704FIC010	SIDE DRAW FLOW OF DEPRO.	M3/H	90.9	90.9	90.9	93.0	0.100	Yes	RCAS	ON
704TIC008	FEED TEMP OF DEPRO.	DEGC	101.0	100.4	96.0	102.0	0.050	Yes	RCAS	ON

Manipulate the set point value of temperature controller 704-TIC-008 of feed inlet of depropanizer.

This temperature controller subsequently controls RVP of NGL.

# Redesign Base layer GSP2 & 3 for DeEth



MVs & DVs of Deethanizer Sub-Controller - GSP3 ESP Mode

Emergency Off

WATCH DOO TIMER

23 SEC

C2-

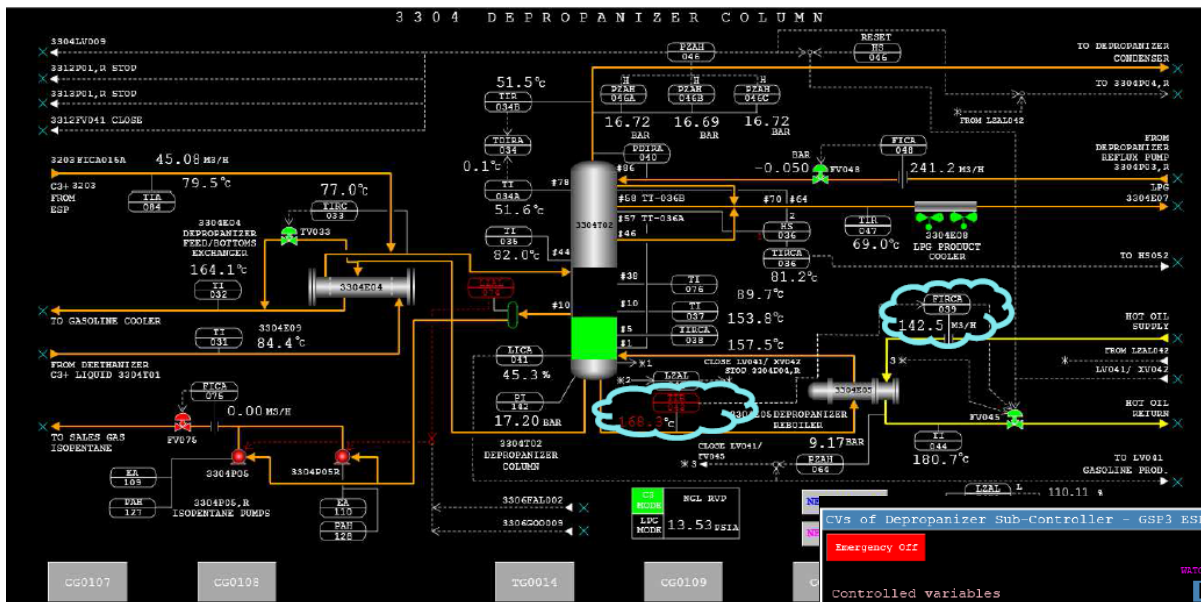
DEF

DEP

Manipulated variables

Tagname	Tag Description	Unit	Current Value	Set Value	Low Limit	High Limit	Max Move	Calculate move	DCS Mode	APC/DCS
3304FICA016.SV	Deethanizer Reflux Flow	M3/H	94.46	93.63	84.00	121.00	0.50	0	CAS	<span style="background-color: green; color: white;">OK</span>
3304TIRCA008.SV	Deethanizer Bottom temp	DEGC	113.53	113.30	111.30	113.30	0.05	0	RCAS	<span style="background-color: green; color: white;">OK</span>
3304E03DCSP.MV	Deethanizer Reflux No.2 Fan Fan Speed	DEGC	34.70	34.70	10.00	95.00	0.10	0	MAN	<span style="background-color: green; color: white;">OK</span>
3304E03DCSP.MV	De-ethanizer Reflux No.2 Fan Fan D speed	DEGC	22.50	17.00	15.00	18.00	2.00	0	MAN	<span style="background-color: red; color: white;">OK</span>
3304TIC006A.SV	Deethanizer Top Temp	DEGC	22.40	22.71	14.00	23.00	0.05	0	RCAS	<span style="background-color: green; color: white;">OK</span>

# Redesign Base layer GSP2 & 3 for DePro



CVs of Depropanizer Sub-Controller - GSP3 ESP Mode

Emergency Off

WATCH DOG T

15SEC

Varieties operating

MAX C3

MAX LPG

LPG MODE

C3 RWEL

OFF

STBY

TEST

OPTM

SUB OFF

SUB ON

Controlled variables

Tagname	Tag Description	Unit	Current Value	Low Limit	High Limit	SS Prediction	CV Status	CV Service
63C4IMC3.FV	C4 in C3 Product	PPM	0.00	0.00	10.00	2.31	ACTIVE	<div><div></div></div>
63C5IMLP.FV	C5 in LPG Product	MOLA	0.93	0.40	1.40	1.26	ACTIVE	<div><div></div></div>
63C3IMLP.FV	C3 in LPG Product	MOLA	60.89	61.76	56.00	62.49	ACTIVE	<div><div></div></div>
63RVP.FV	RVP in NGL Product	PSIA	13.91	13.52	13.20	13.45	ACTIVE	<div><div></div></div>
3304TI034A.FV	Depropanizer Top Temperature	DEGC	51.63	50.50	52.00	51.63	ACTIVE	<div><div></div></div>
3304TI034B.FV	Depropanizer Bottom Temperature	DEGC	169.03	168.20	168.90	168.90	ACTIVE	<div><div></div></div>
3304PID040.FV	Depropanizer DE-PRESSURE	BAR	-0.050	0.000	0.500	-0.034	INACTIVE	<div><div></div><div></div></div>
3304TI0347.FV	Middle Temp. in depropanizer	DEGC	67.31	67.00	71.00	67.00	ACTIVE	<div><div></div></div>
3304FIC039.FV	DEP Hot Oil Flow	MG/H	139.6	130.0	155.0	142.2	ACTIVE	<div><div></div></div>

# Benefit from best practice



# Varieties Operating from using Temp. as MV in APC

CVs of Deethanizer Sub-Controller - GSP3 ESP Mode

Emergency Off

WATCH DOG TIMER

Controlled variables

Tagname	Tag Description	Unit	Current Value	High Limit	SS Prediction	CV Status	CV Service
G3C3INC2.PV	Propane Composition in Ethane Product 0.87	MOLA	0.89	0.06	1.50	0.93	ACTIVE
G3C2INC3.PV	Ethane Composition in Propane Product 0.19	MOLA	0.21	0.00	0.05	0.12	ACTIVE
3304TI006A.PV	Deethanizer Top Temperature	DEGC	22.45	15.00	23.00	23.18	ACTIVE
3304TDIA003.PV	Deethanizer Bottom Differential Temperature	DEGC	0.60	0.40	1.30	0.40	ACTIVE

MAX C2 MAX C3

OFF STBY CTRL OPTM

SUB OFF SUB ON

MVs & DVs of Depropanizer Sub-Controller - GSP3 ESP Mode

Emergency Off

WATCH DOG TIMER 15SEC

Manipulated variables

Tagname	Tag Description	Unit	Current Value	Set Value	Low Limit	High Limit	Max Move	Calculate move	DCS mode	APC/DCS
3304FICA048.SV	Depropanizer Reflux Flow	M3/H	242.86	241.43	238.00	243.00	0.50	0	RCAS	APC
3304TIRC043.SV	Depropanizer Bottom Temp.	DEGC	169.04	168.77	168.20	169.50	0.10	0	RCAS	APC
3304FIQC060.SV	LPG Side Draw Flow	M3/H	122.94	123.07	120.00	125.00	0.20	0	RCAS	APC

MAX C3 MAX LPG

OFF STBY CTRL OPTM

LPG MODE C3 MODE

SUB OFF SUB ON

LPG Side Draw Flow Target 123.00 M3/H

Improve control ability

# Benefit

## GSP2

### ☐ C2+ Separation column

- Stabilize unit operation
- Maximize C1 in C2 product up to its specification

### ☐ Deethanizer Column

- Maximize C3 in C2
- Minimum C2 in C3
- Stabilize process operation

### ☐ Depropanizer column

- Maximize C5 in LPG
- Maintain NGL RVP within control specification
- Stabilize process operation

## GSP3

### ☐ C2+ Separation column

- Stabilize unit operation
- Maximize C1 in C2 product up to its specification

### ☐ Deethanizer Column

- Maximize C3 in C2
- Minimum C2 in C3
- Stabilize process operation

### ☐ Depropanizer column

- Maximize C5 in LPG
- Maintain NGL RVP within control specification
- Stabilize process operation

## GSP1

### ☐ Deethanizer Column

- Maximize C3 in C2
- Minimum C2 in C3
- Stabilize process operation

### ☐ Depropanizer column

- Maximize C5 in LPG
- Maintain NGL RVP within control specification
- Stabilize process operation

## ESP

### ☐ Demethanizer Column

- Stabilize unit operation
- Maximize the C1 in C2
- product up to its specification
- CO2 Stabilize

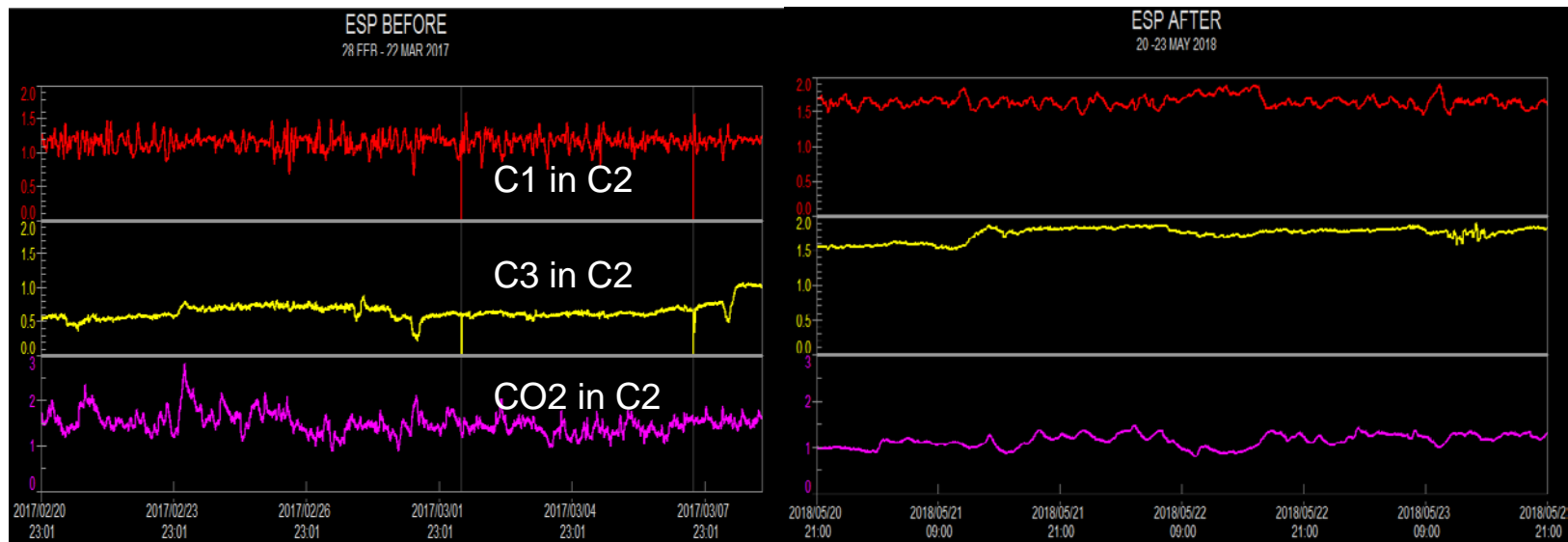
### ☐ Deethanizer Column

- Maximize propane in ethane
- Minimum ethane in propane up to its specification
- Stabilize process operation

# ESP

- ❑ Maximize Ethane product
- ❑ Shift target C1 and C3 in Ethane product

TAG	AVG NEW	AVG BS	STD NEW	STD BS	IMPROVE	SHIFT TARGET
C1 in C2	1.645	1.164	0.081	0.114	29.097	↑ (MAX)
C3 in C2	1.736	0.645	0.095	0.113	15.986	↑ (MAX)
CO2 in C2	1.135	1.500	0.139	0.239	41.667	

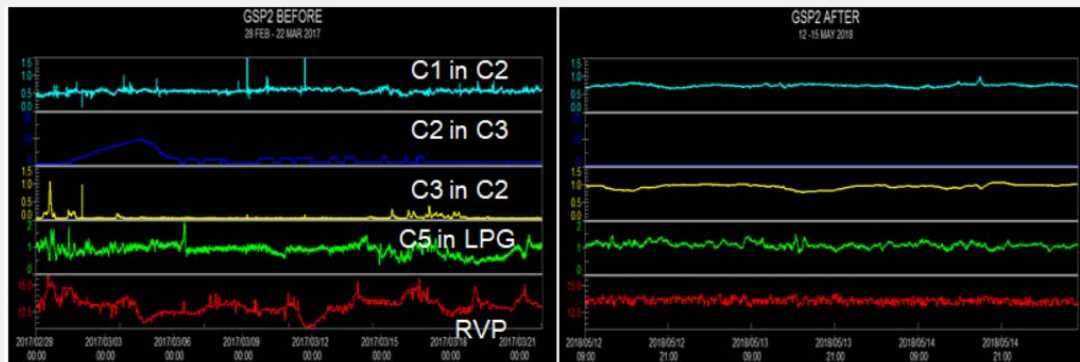
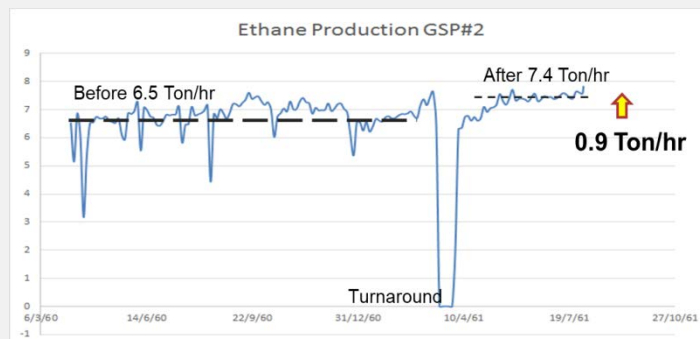




# GSP#2

- ✓ Maximize Ethane product
- ✓ Shift target C1 and C3 in Ethane product

TAG	AVG NEW	AVG BS	STD NEW	STD BS	IMPROVE	SHIFT TARGET
C1 in C2	0.733	0.564	0.039	0.078	50.193	↑ (MAX)
C2 in C3	0.083	2.351	0.012	2.218	99.477	↓ (MIN)
C3 in C2	0.935	0.058	0.060	0.064	5.799	↑ (MAX)
C5 IN LPG	1.100	0.887	0.124	0.226	51.713	↑ (MAX)
RVP	13.596	13.061	0.247	0.761	67.508	↑ (MAX)

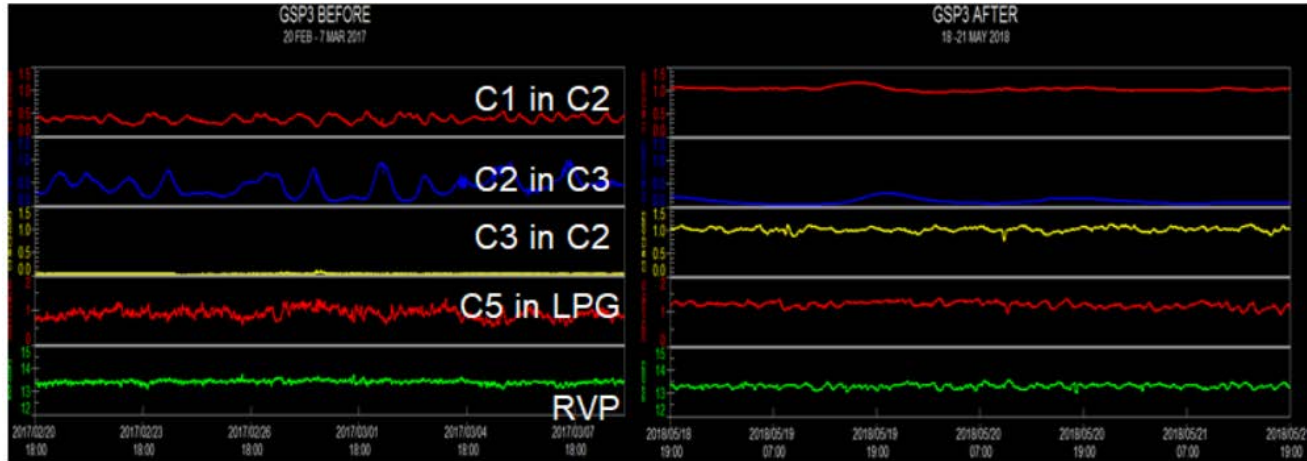




# GSP#3

- ✓ Maximize Ethane product
- ✓ Shift target C1 and C3 in Ethane product

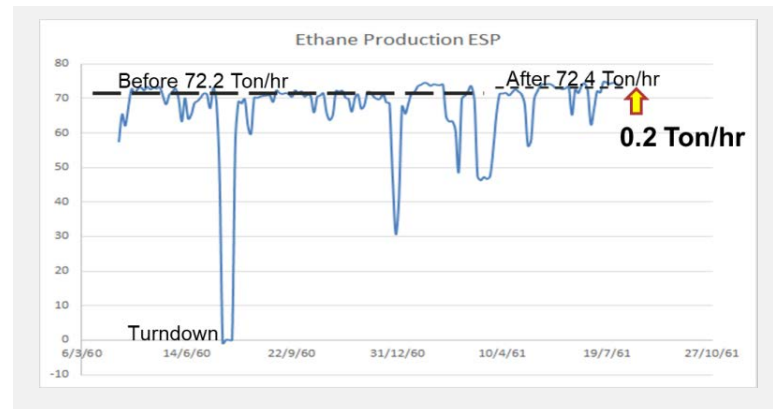
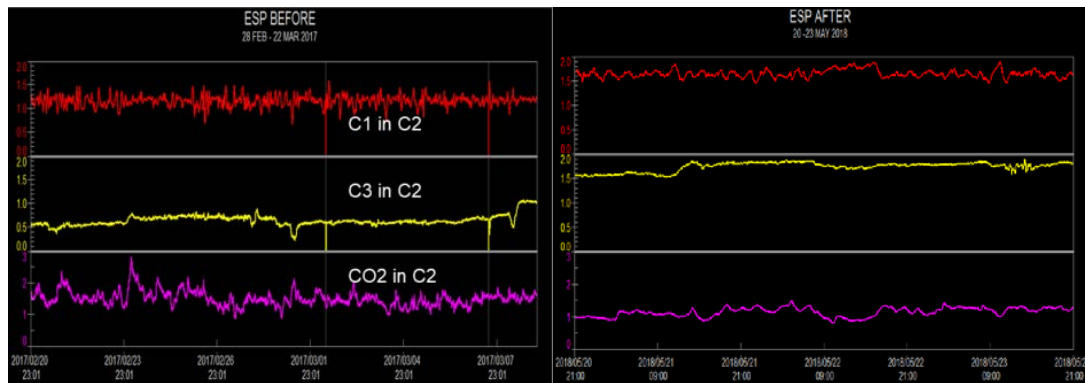
TAG	AVG NEW	AVG BS	STD NEW	STD BS	IMPROVE	SHIFT TARGET
C1 in C2	1.0055	0.3698	0.0356	0.0686	48.105	↑ (MAX)
C2 in C3	0.079	0.4342	0.0306	0.2016	84.821	↓ (MIN)
C3 in C2	<b>0.9857</b>	<b>0.0275</b>	<b>0.045</b>	<b>0.0092</b>	<b>-389.130</b>	↑ (MAX)
C5 IN LPG	1.1679	0.8972	0.0449	0.07155	53.698	↑ (MAX)
RVP	<b>13.2611</b>	<b>13.4075</b>	<b>0.0996</b>	<b>0.0886</b>	<b>-12.415</b>	↑ (MAX)



# ESP

- ✓ Maximize Ethane product
- ✓ Shift target C1 and C3 in Ethane product

TAG	AVG NEW	AVG BS	STD NEW	STD BS	IMPROVE	SHIFT TARGET
C1 in C2	1.645	1.164	0.081	0.114	29.097	↑ (MAX)
C3 in C2	1.736	0.645	0.095	0.113	15.986	↑ (MAX)
CO2 in C2	1.135	1.500	0.139	0.239	41.667	



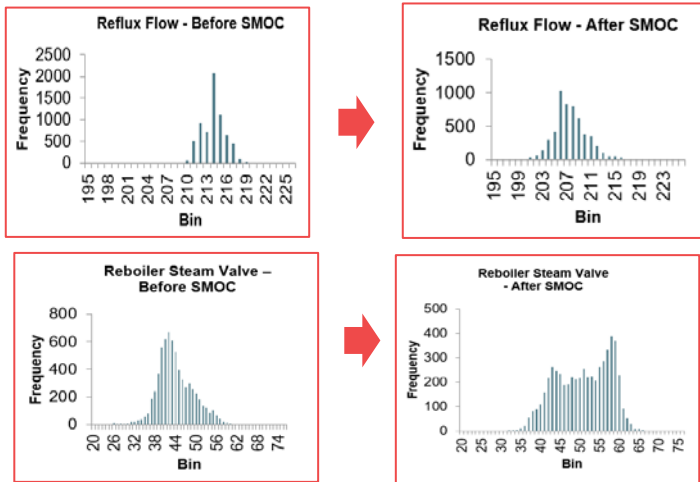
# GSP#1

- ✓ Reduce standard deviation
- ✓ Reduce Energy consumption

## • Deethanizer

-Build up new optimization model.

Std. Deviation Reduction 58%

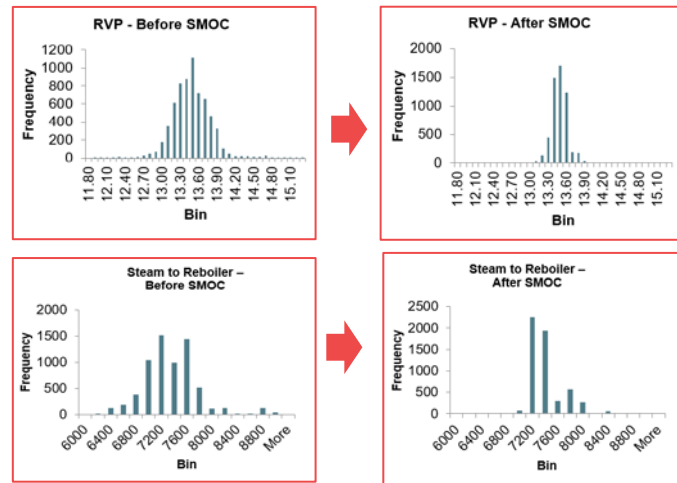


Decrease Steam Consumption = **7,200 T/Y**  
or Saving = **4.1 mB/Y**

## • Depropanizer

-Build up new optimization model

Std. Deviation Reduction 58%



Decrease Steam Consumption = **1087 T/Y**  
or Saving = **0.6 mB/Y**

## Direct Benefit

- Ethane product increase 1.1 Ton/hr



10,512 Ton/year



- คิดเป็น 47,304,000 ล้านบาท/ปี\*



\*Note : Ethane product margin 4,500 Baht/ton

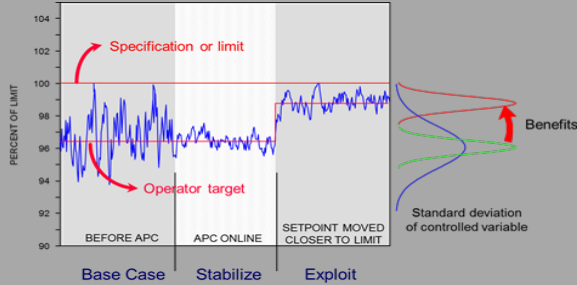
# Indirect Benefits

- ❑ ควบคุมและรักษากระบวนการผลิตให้มีเสถียรภาพ ( More Ability)
- ❑ เพิ่มกำลังการผลิตและปรับปรุงประสิทธิภาพการดำเนินกระบวนการเพื่อได้ผลิตภัณฑ์ที่มีมูลค่ามากที่สุด (Optimization)
- ❑ ลดปริมาณการใช้พลังงานในกระบวนการผลิตให้เหมาะสม (Energy Reduction)
- ❑ ควบคุมคุณภาพผลิตภัณฑ์ให้ตรงตามความต้องการของลูกค้า (Customer Satisfaction)
- ❑ ควบคุมการกระบวนการผลิตให้เหมาะสมทุก Mode ของผลิตภัณฑ์ (Operation excellent)
  - Maximize ethane product
  - Maximize C3 product
  - LPG / Propane mode
- ❑ ควบคุมและรักษาเป้าหมายรวมของการผลิตให้สามารถดำเนินกระบวนการให้ได้ตามข้อกำหนดของอุปกรณ์ และใช้อุปกรณ์ได้เต็มประสิทธิภาพ (Equipment Utilization)

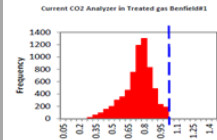
# PLANTWIDE OPTIMIZATION

## Paradigm shift

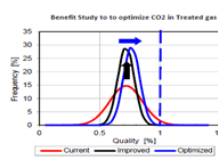
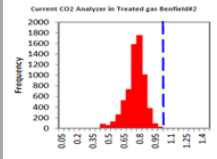
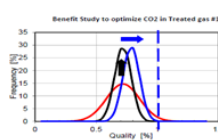
### LOCAL APC



### Before



### After



## Advanced process Control (APC)

### GLOBAL APC

Global Economics and Ranges

### Profit Optimizer

Limits

SS MV Targets  
Gains  
MV Economics

### QP Override 1

### QP Override 2

### QP Override 3

Local Feasible SS MV targets

Local Feasible SS MV targets

Local Feasible SS MV targets

### Profit Controller 1

### Profit Optimizer Link Other Controller 2

### Profit Controller 3

Optimal  
Dynamic Path

Optimal  
Dynamic Path

Optimal  
Dynamic Path

Gas Separation  
Plant No. 1

Gas Separation  
Plant No. 2

Gas Separation  
Plant No. N..

Ensures Optimal Dynamic Global Path

ADAPTIVE

PERFORMANCE

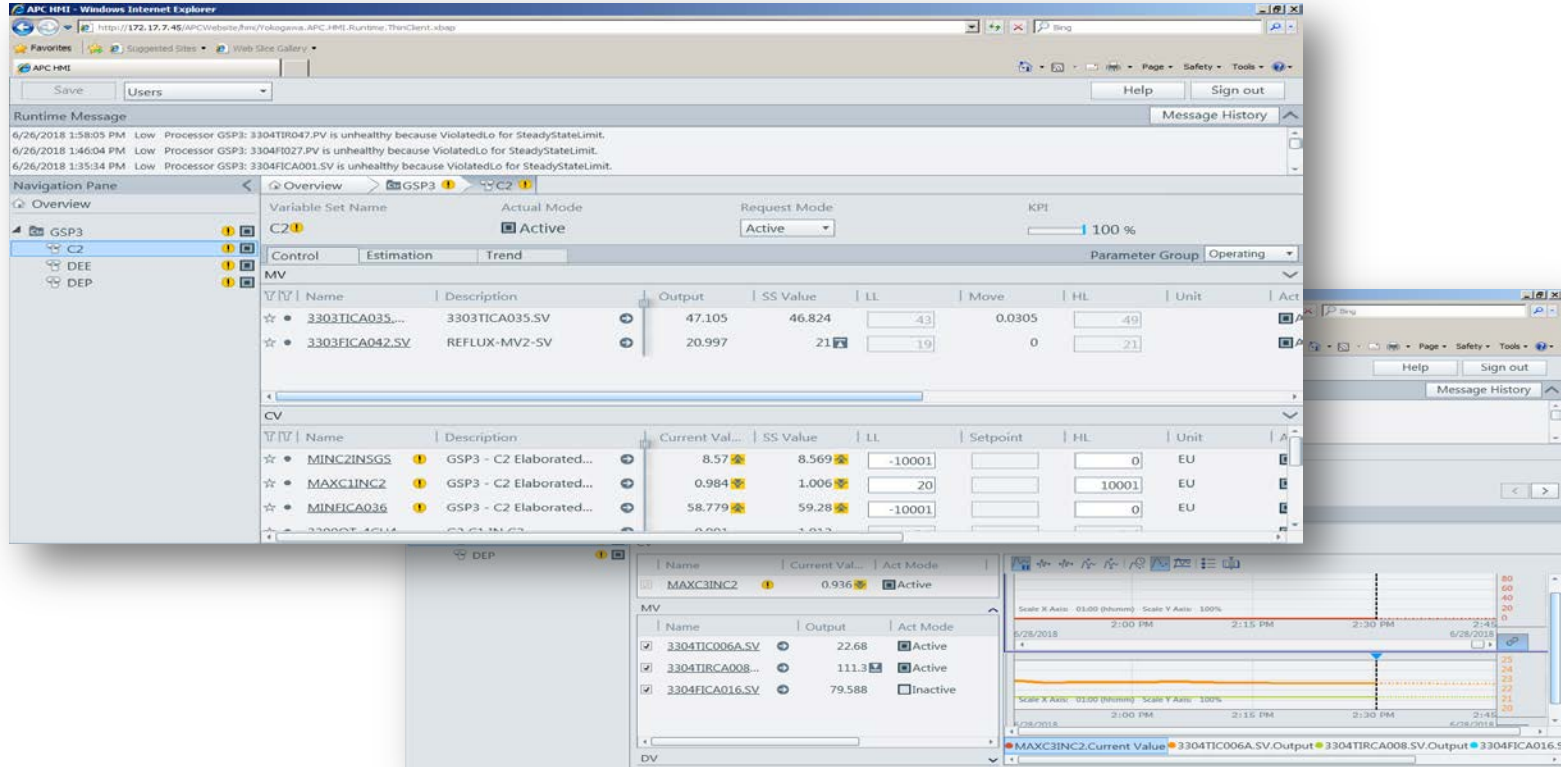
OPTIMIZATION

PLANTWIDE OPTIMIZATION

PREDICTION

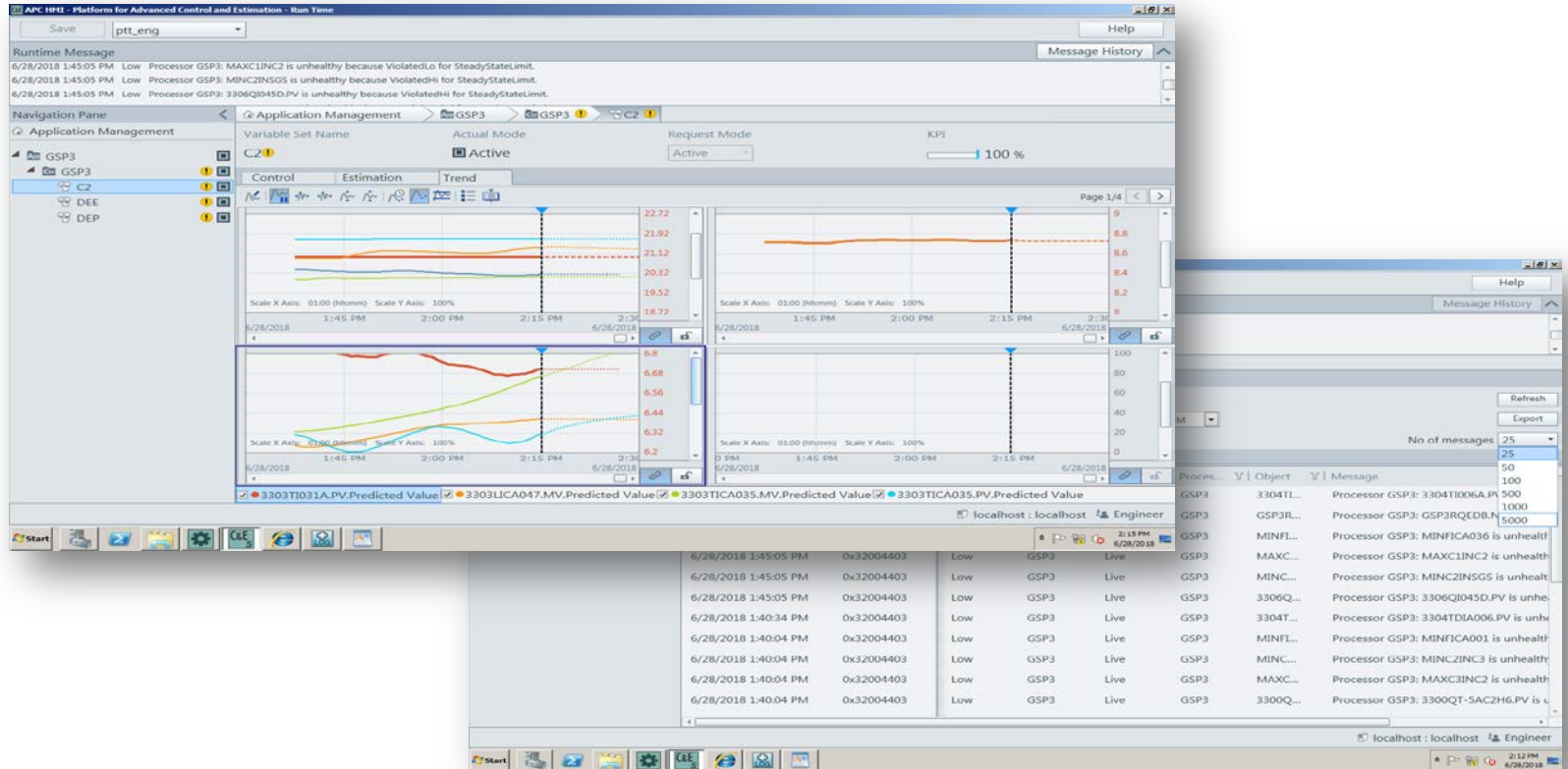
# Standardization

- การใช้ program ในการควบคุมเป็นระบบอัตโนมัติ



# Standardization

- การใช้ program ในการควบคุมเป็นระบบอัตโนมัติ





# Standardization

- การใช้ program ในการควบคุมเป็นระบบอัตโนมัติ

APC HMI - Platform for Advanced Control and Estimation - Run Time

Save | ptt\_eng | Help

Runtime Message

6/26/2018 10:30:13 AM Low Processor GSP3 has moved from inactive to Standby.  
6/26/2018 10:30:13 AM Low Processor GSP3 is unhealthy because it has unhealthy Variable Set(s).  
6/26/2018 10:30:13 AM Low Processor GSP3: VS DEE is unhealthy because it has unhealthy VS Member(s).

Application Management > GSP3 > C2

Variable Set Name: C2 | Actual Mode: Active | Request Mode: Active | KPI: 100 %

Control | Estimation | Trend | Parameter Group: Operating

MV

Name	Description	LL	Output	Move	HL	SS Value	Unit	Meas Value
3303TICA035.SV	3303TICA035.SV	43	45.498	-0.0018	49	45.368		45.5
3303FICA042.SV	REFLUX-MV2-SV	19	20.997	0	21	21		20.997

CV

Name	Description	LL	Current Val...	SS Value	HL	Unit	Act Mode	Pred Bias	Raw Pred V
MINC2INSGS	GSP3 - C2 Elaborated...	-10001	8.57	8.573	0	EU	Active	-0.1004	8.67
MAXC1INC2	GSP3 - C2 Elaborated...	20	0.944	0.953	10001	EU	Active	-0.0935	1.03
MINFICA036	GSP3 - C2 Elaborated...	-10001	58.152	58.021	0	EU	Active	0.2055	57.94
3300QT-4CH4.PV	G3 C1 IN C2	0.4	0.943	0.951	1.4		Active	-0.0951	1.03
3303TIO31A.PV	CV2-TOPTEMP	3	5.733	5.732	8		Active	0.019	5.71

localhost : localhost | Engineer | 10:30 AM 6/26/2018

Help

Message History

Staged | Reconcile | Archive | Copy | Date

Reconcile | Archive | Copy | 6/25

Reconcile | Archive | Copy | 6/26

localhost : localhost | Engineer | 10:30 AM 6/26/2018

Thank you for your attention

