ADVANCED PROCESS CONTROL IMPLEMENTATION CHALLENGES AND SUCCESS ON MEGA LNG TRAINS

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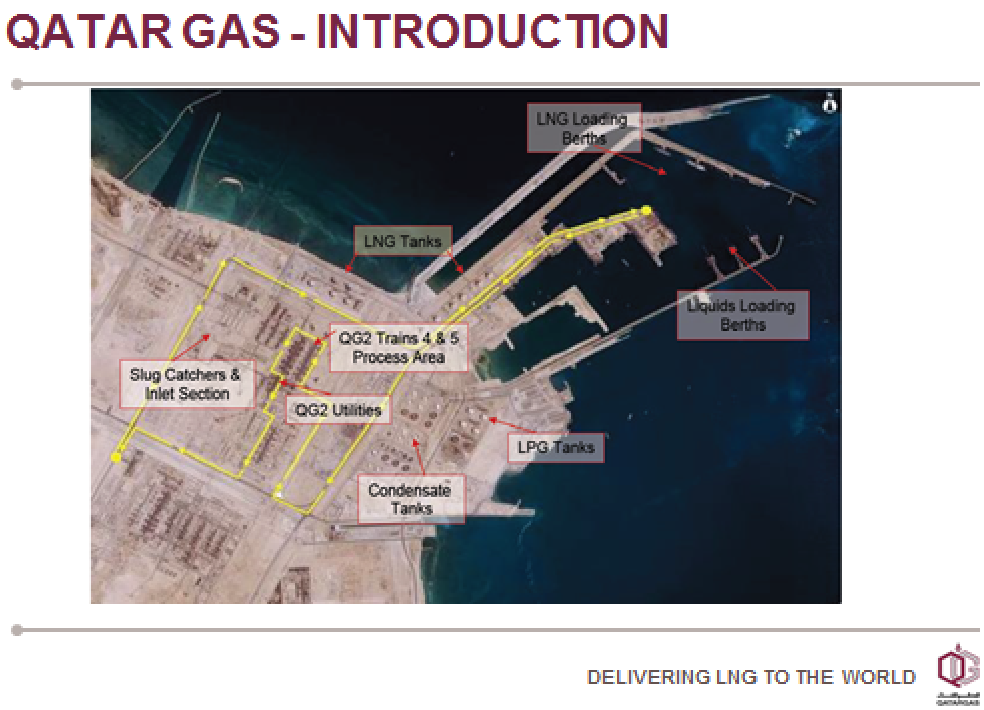
Background

LNG Industry is in next era of optimizing and maintaining huge LNG capacities, where Qatargas is contributing 42 MMTPA out of Qatar's Visionary delivery of 77 MPTA LNG. Mega trains also brings together range of complex technologies and a challenge to automate and cruise control these technologies with emphasis on reduction in emissions, better asset utilizations, energy efficient operations and controlled product specifications.



Methods

The methodology adopted outlined as below

- USE OF LINEAR OPTIMIZATION TOOLS FOR APX@ PROCESS
    - Profit Optimiser is based on a linear programming technique which is used to derive the objective function (which is basically maximum profits) by maximising the product make, minimising the utility consumption and minimising the waste/emissions.

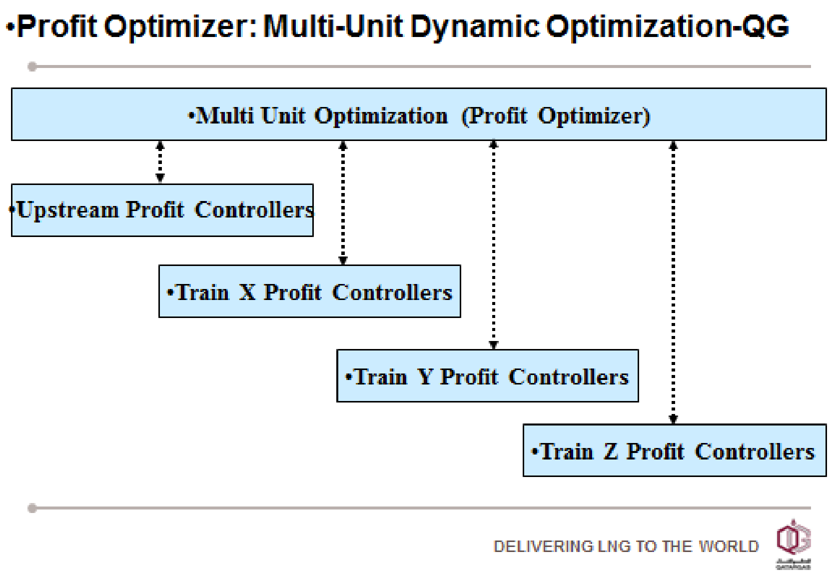
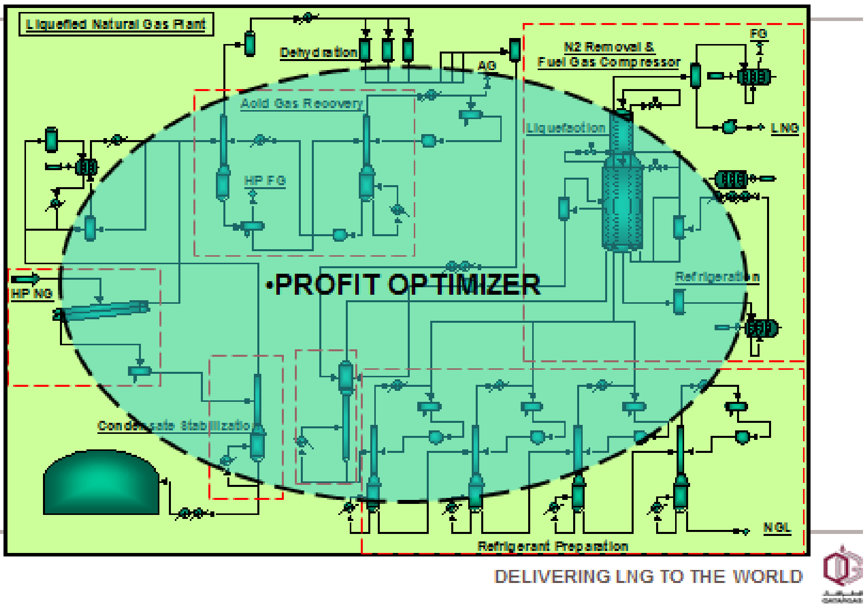


Figure 1

    - The specific technique is utilized on entire plant with emphasis on each of the sub processing units as sub controllers covered by umbrella of overall plant optimiser. The structure of the optimiser is depicted as above figure 1.

•Dynamic Multi-Unit Optimization Application



- Units being covered under automatic control are as follows:-
    - Acid Gas Regenration Units
    - Fractionation Units
    - Liquefaction and Refrigration Units
    - NGL Recovery Units
    - Inlet Gas Reception Units
    - Overall Feed Maximiser
- A method, comprising: controlling the process of gas chilling and liquefaction using advanced process control techniques on APCI design AP-X hybrid cycle technology.

- A method, comprising: MCHE (Main Cryogenic Heat Exchanger) temperature control effectively by maintaining optimum Mixed Refrigerant Flow circulation.

- A method, comprising: MCHE (Main Cryogenic Heat Exchanger) temperature control effectively by varying the composition of mixed refrigerant by way of changing the Vapour to Liquid Mix of mixed refrigerant.

- A method, comprising: MCHE and SCHE temperature profile is controlled by manipulating N2, MR and C3 Refrigeration systems.

- A method, comprising: To maximize LNG production subject to maintaining LNG rundown temperature. The constraints would be on MR, C3 and N2 Compressors loading i.e.; Power Available (PW) for each of the Compressors. Special variable created to calculate the total spare power available for LNG production also considering the Gas Turbine and Electrical motor power.

- A method, comprising: To Maximise LNG production by way of maximising the Lean Gas Recompressor discharge pressure to the limit.

- A method, comprising: To maintain and maximise the N2 content in LNG subject to heating value constraint in the LNG.

- A method, comprising: To balance the load of N2 Cold companders and warm Compander.

- A method, comprising: To maintain the cold box Delta T across Hot and cold sides by way of flow control on Hot and cold side.

- A method, comprising: To maximise the LNG production by way of sealine pressure minimisation subject to individual trains process constraints.

- A method, comprising: To minimise the cost of production of LNG by way of minimising the amount of liquefaction power used per tonne of LNG produced.

- **USE OF RANGE OF BASE LAYER TECHNOLOGY MODIFICATIONS WITH FOCUS ON INTEGRATION OF VARIOUS COMPLEX SYSTEMS.**
    - Integration of the advanced control system with base layer technologies such as Rotary System (GE- Mark VI Controls), DCS System, Electrical Controls for Variable speed drives. The real essence was in integrating these technologies and getting them to synergise to achieve common objective of maximum LNG Make.
    - Interface to all these systems are being handled thru an OPC Protocol.

- **IDENTIFY DESIGN ISSUES BY DYNAMIC SIMULATION MUCH BEFORE STARTUP OF PLANT.**
    - Control performance related issues were identified during simulation stage as compared to design. Long dead time were identified in large dead time loops and the corrective strategy is formulated to address the dead time and use multiple handles to control vis a vis single output control mechanism.
    - Undertake master control verification study to make sure all the technology interfaces are functioning as expected.
    - Identify the design issues related to possible liquid nitrogen formation in Cryo Heat Exchanger(Sub Cooler)

- **CHANGE MANAGEMENT FOR IMPLEMENTATION.**
    - Operator Training simulator system was integrated with advanced process control system and operators were given hands on training scenarios for handling typical plant situations to encourage confidence and readiness for cruise control.
    - Separate classroom and on panel training sessions conducted for each shift of operation round the clock.

- **Development of new innovative graphic interface for better operator guidance with focus on optimization, identifying and displaying real plant constraints.**
    - To give same look and feel of the system to operator as specific interface module was developed with functionalities of color coding when the variable is at high limit, low limit, approaching high limit, approaching low limit and indicating future moves with the direction of optimization and control to the operator.
    - All control variables and the manipulated variable in the plant were grouped in collective displays which are process related and interdependent on each other.
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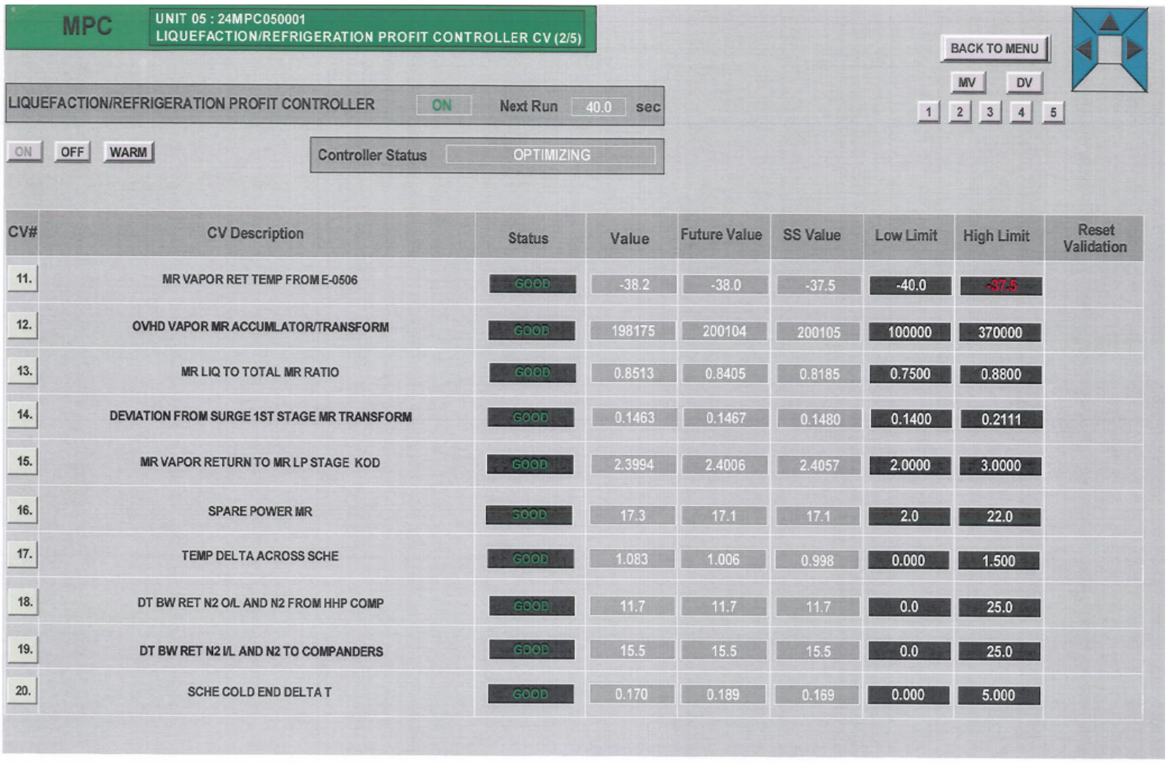
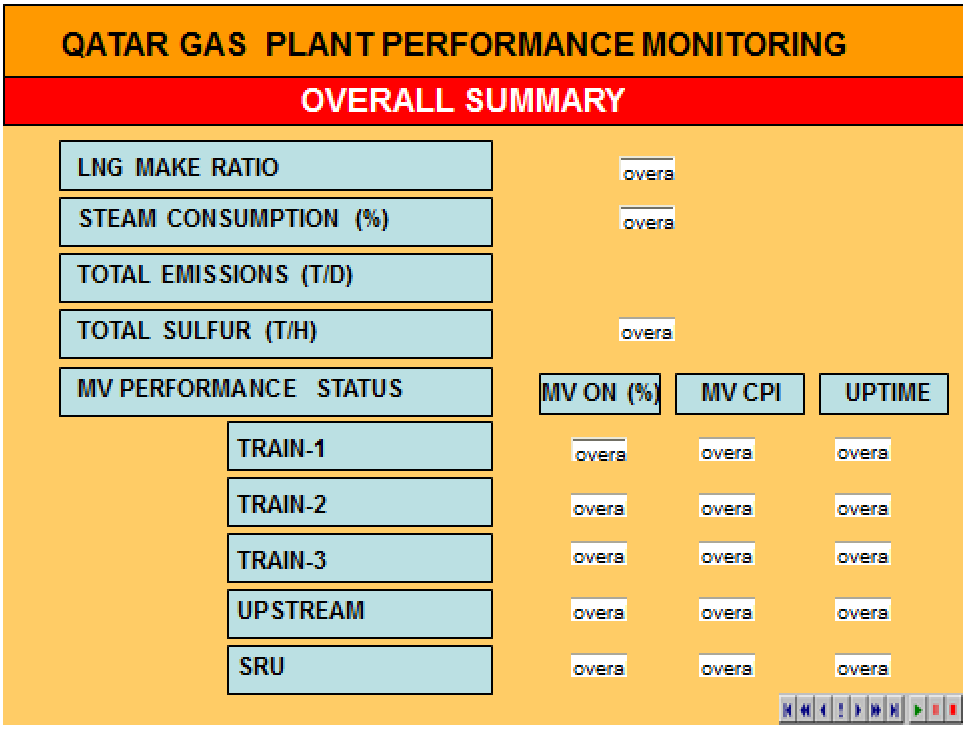


CV#	CV Description	Status	Value	Future Value	SS Value	Low Limit	High Limit	Reset Validation
11.	MR VAPOR RET TEMP FROM E-0506	GOOD	-38.2	-38.0	-37.5	-40.0	-37.5	
12.	OVHD VAPOR MR ACCUMLATOR/TRANSFORM	GOOD	198175	200104	200105	100000	370000	
13.	MR LIQ TO TOTAL MR RATIO	GOOD	0.8513	0.8405	0.8185	0.7500	0.8800	
14.	DEVIATION FROM SURGE 1ST STAGE MR TRANSFORM	GOOD	0.1463	0.1467	0.1480	0.1400	0.2111	
15.	MR VAPOR RETURN TO MR LP STAGE KOD	GOOD	2.3994	2.4006	2.4057	2.0000	3.0000	
16.	SPARE POWER MR	GOOD	17.3	17.1	17.1	2.0	22.0	
17.	TEMP DELTA ACROSS SCHE	GOOD	1.083	1.006	0.998	0.000	1.500	
18.	DT BW RET N2 O/L AND N2 FROM HHP COMP	GOOD	11.7	11.7	11.7	0.0	25.0	
19.	DT BW RET N2 I/L AND N2 TO COMPANDERS	GOOD	15.5	15.5	15.5	0.0	25.0	
20.	SCHE COLD END DELTA T	GOOD	0.170	0.189	0.169	0.000	5.000	

<u>**Operator's Graphical User Interface (GUI)**</u>

- **Measure and sustain by defining real-time KPI's on utilization and benefits.**

○ 

Results

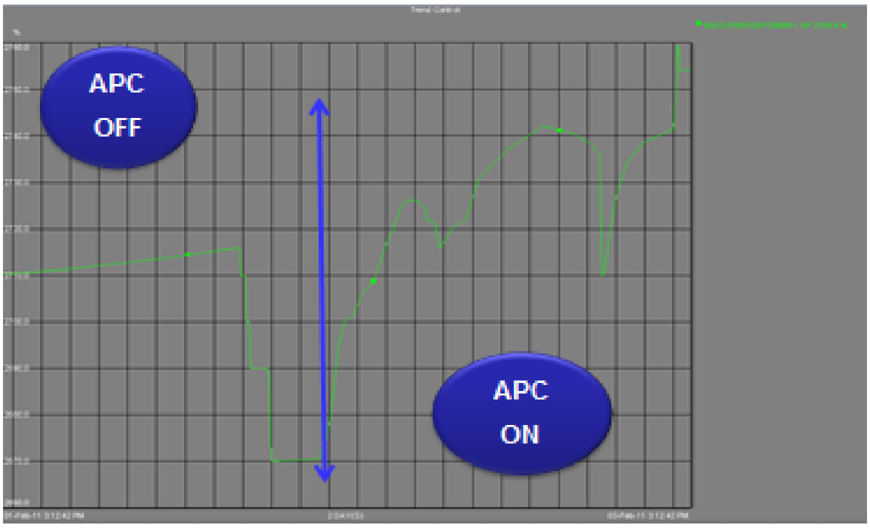
Successfully implemented advanced optimization tool and controlling First Mega LNG Train fully automated resulting in substantial improvement in yields of LNG molecules by approx. 2% and decrease in power required to achieve above. Tangible and intangible benefits are as below:-

- APC as Best operator.
- Steady and Reliable Operations.
- Increased Profitability.
- Reduction in Energy.
- Increased Throughput.
- Balancing of feeds.

Summary/Conclusions

The above tool and methodologies adopted brings efficiency, reduces emissions, training operators, improves reliability, and improves product specifications, using least energy. QATARGAS is in process of implementing the above in all its mega trains.

APC- ON OPERATION



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DELIVERING LNG TO THE WORLD