CONTROL & OPTIMIZE

Transforming Production Optimization

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AGENDA

01 Introduction Advanced Control-Enhanced. Why do we need it?

02 Transforming CONTROL & OPTIMIZE- Use Cases walk-through

03 CONTROL & OPTIMIZE- Future Work

04 Conclusion and next steps

05 Q and A

01 Introduction – Advanced Control-Enhanced Why we need it?

ADVANCED CONTROL-ENHANCED
WHY DO WE NEED IT?

Advanced Control and Optimization benefits are field proven, generate high rates of return, and quick payback on investment

1

Typically, 1-3% improvement in Overall throughput

2

5-10% reduction in Energy Consumption

3

90-95% adherence to product quality Specs

4

Standard deviation of key variables reduce by 50% or more

ADVANCED PROCESS CONTROL DRIVES GREATER BUSINESS RESULTS

ADVANCED CONTROL -ENHANCED

WHY DO WE NEED IT?

What are limitations of today?

- APCs often optimize units at the expense of others. Doesn't see the "Bigger picture"
- Industrial plants are complex to model, control, and optimize with thousands of variables and constraints and their interdependency
- Overdependency on humans for decision making, by analyzing high volumes of data, made worse by loss of skilled workforce

How do we see the future?

- Closing the gap between business and process optimization - Fundamental to Autonomous plant*.
- Leveraging special techniques & guided workflows that help discover & control process input-output relationships**,** moving from "automated" to "autonomous" operations:
- Human brains augmented with AI/ML techniques, thereby enhancing cognitive abilities, improve decision-making to meet desired outcomes

* 'The Autonomous Plant: Entering a New Digital Era' (September 2021), McKinsey

MOVE FROM DETERMINISTIC TO AUTONOMOUS WITH ADVANCED CONTROL-ENHANCED

ADVANCED CONTROL -ENHANCED

WHY DO WE NEED IT?

ADVANCED ANALYTICS AND ADVANCED PROCESS CONTROL

- Historical results
- Plant Constraints
- Production Plan
- Global optimum
- Feed quality
- Asset availability

- Operational targets
- Operational ranges
- Optimized Tuning

Global Coordination and Optimization

Multivariate Control and Optimization

Advanced Regulatory Control

Regulatory Control

Sensors and Actuators

APC benefits rely on human decision-making, in a high-utilization, high-frequency, multi-variable environment

ADVANCED CONTROL -ENHANCED

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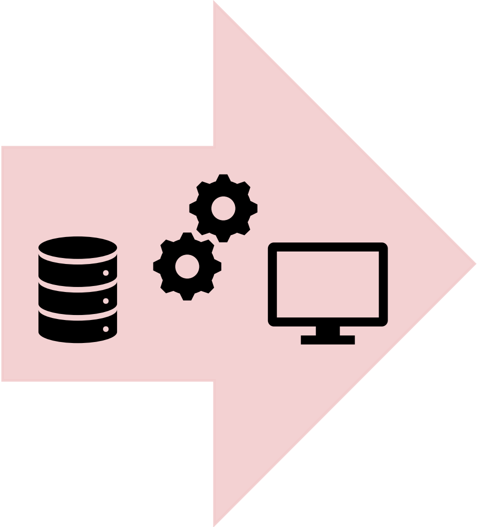

- Operational targets
- Operational ranges
- Optimized Tuning

- Global Coordination and Optimization
- Multivariate Control and Optimization
- Advanced Regulatory Control
- Regulatory Control
- Sensors and Actuators

Supervised and unsupervised machine learning models can reduce human load and provide adaptive tuning and optimal ranges for APC

02 Transforming CONTROL & OPTIMIZE Use Cases walk-through

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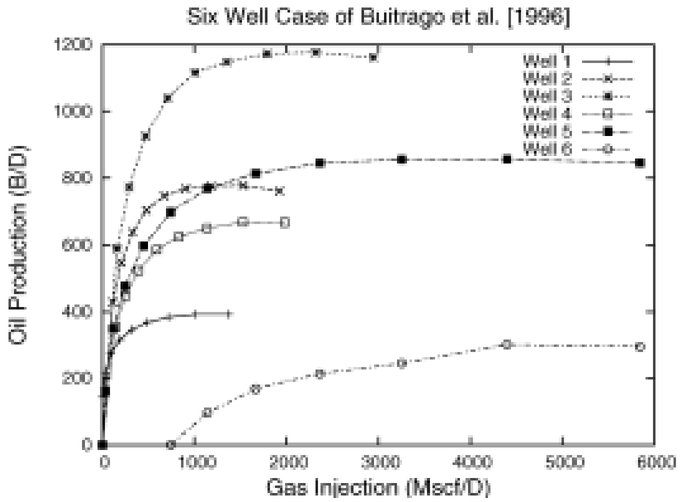
CONSTRAINED NON-LINEAR OPTIMIZATION
USE CASE: GAS LIFT OPTIMIZATION

APC Design

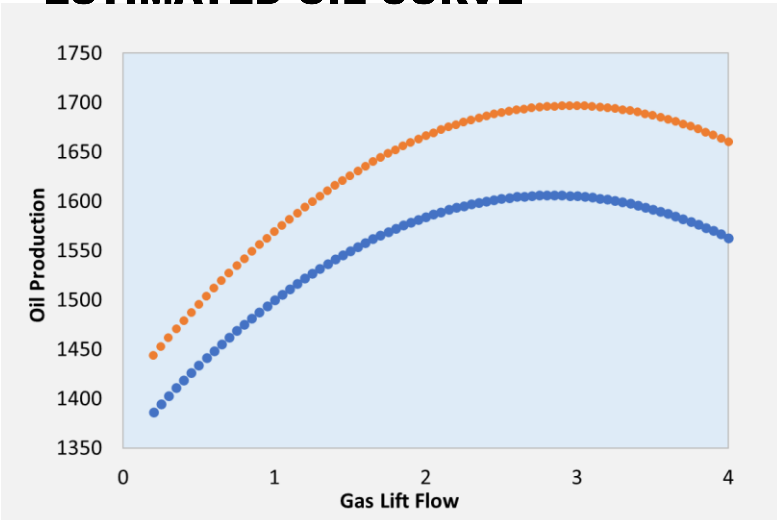
- Objectives: Maximize Oil production from the well
- Constraints - Availability of lift-gas, Topside water handling constraint, Topside compressor constraint
- Challenges: Non-linear (Prosper) lift curves, Interaction amongst the wells, Dynamic constraints



Key Considerations

- Oil production can be estimated as a function of Gas Oil Ratio, Water cut, Reservoir Pressure, Gas Lift Flow, Productivity Index, Well Head Pressure
- These can be derived from well models and updated periodically.
- Oil flow can be expressed as a function of the variable Gas Lift Flow

ESTIMATED OIL CURVE

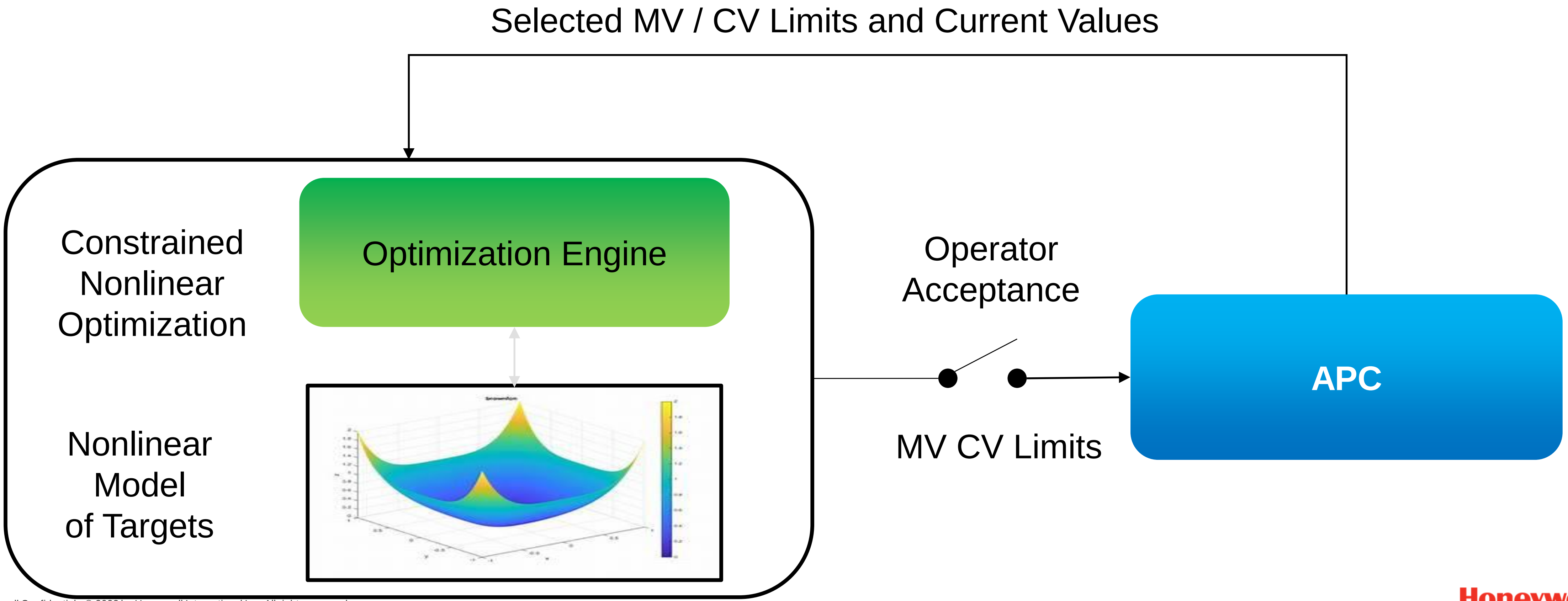


CAN BE EXTENDED TO A FIELD-WIDE OPTIMIZATION PROBLEM

SOLUTION: AI/ML BASED SMART APC SUPERVISOR

AI EMBEDDED

A supervisory layer Optimization solution based on machine learning models and optimization techniques that provide optimum targets to underlying APC controllers.



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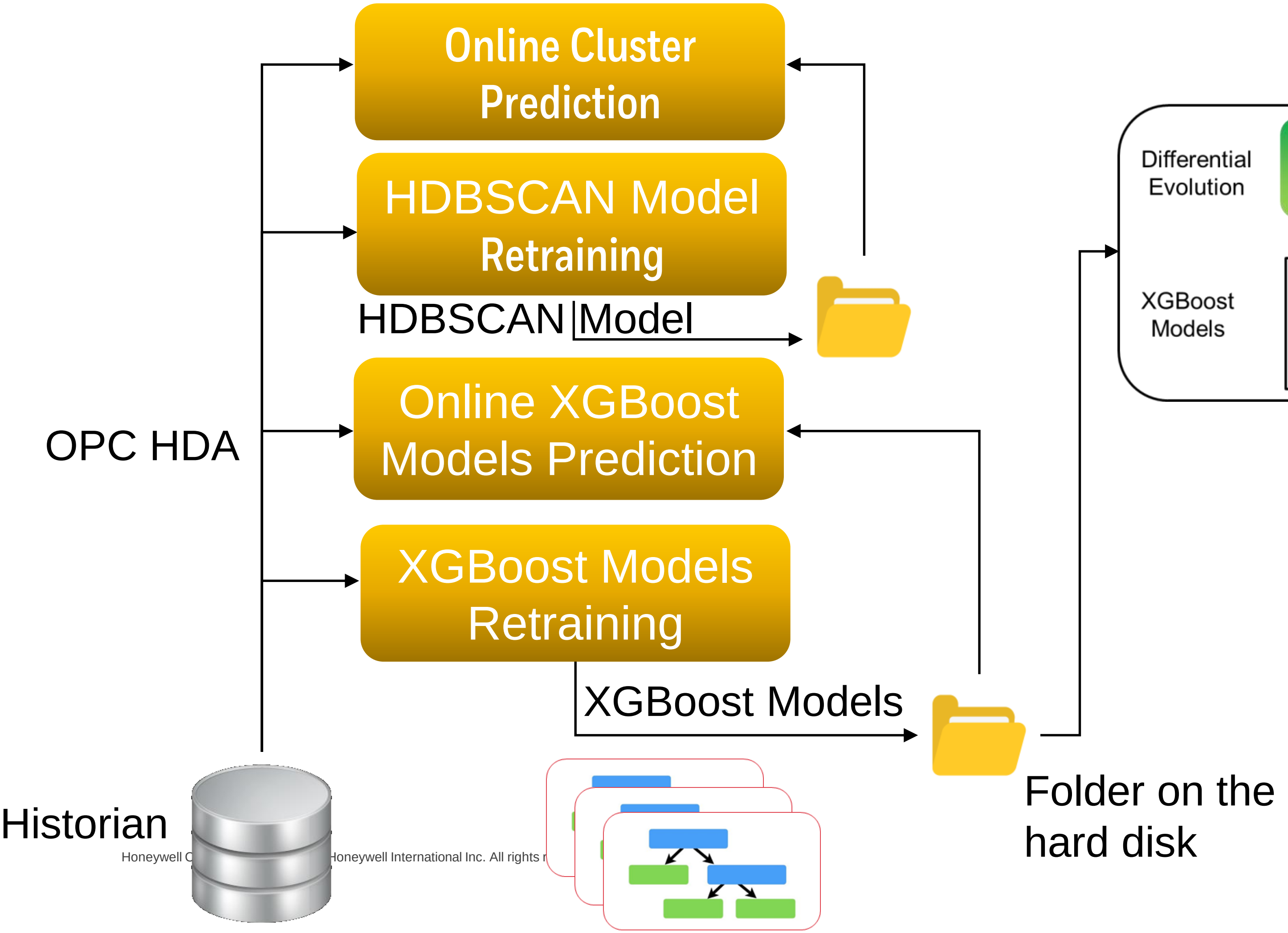

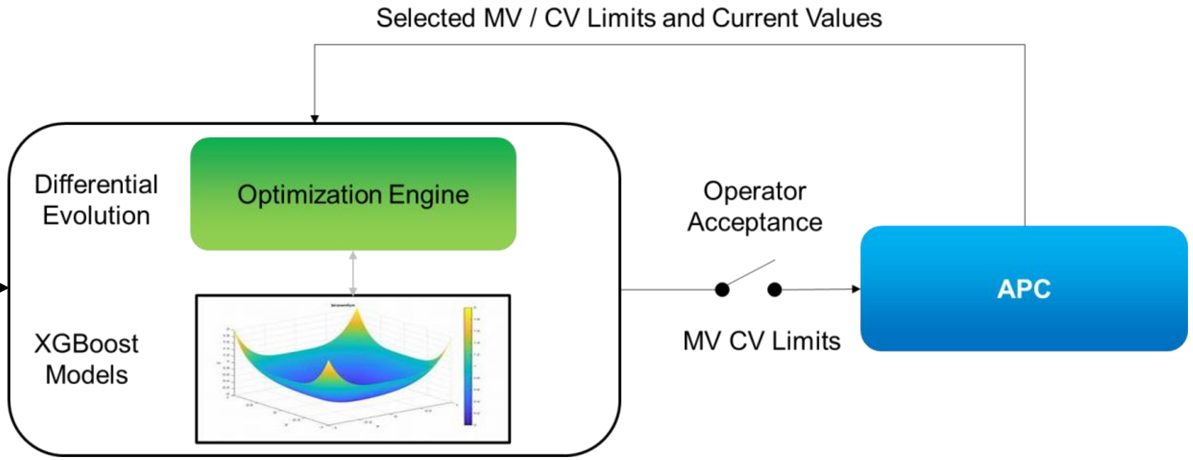

$$\min_{xd_i} J = \sum C_i * \ XGB(xd_i, xf_i)$$

Where:

xd_i are decision variables

xf_i are other input variables

C_i are cost coefficients

$xdl_i <= xd_i <= xdh_i$

$abs(\Delta xd_i) <= \Delta xdss_i$

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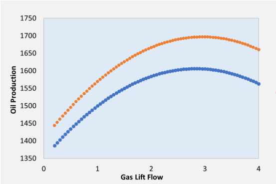
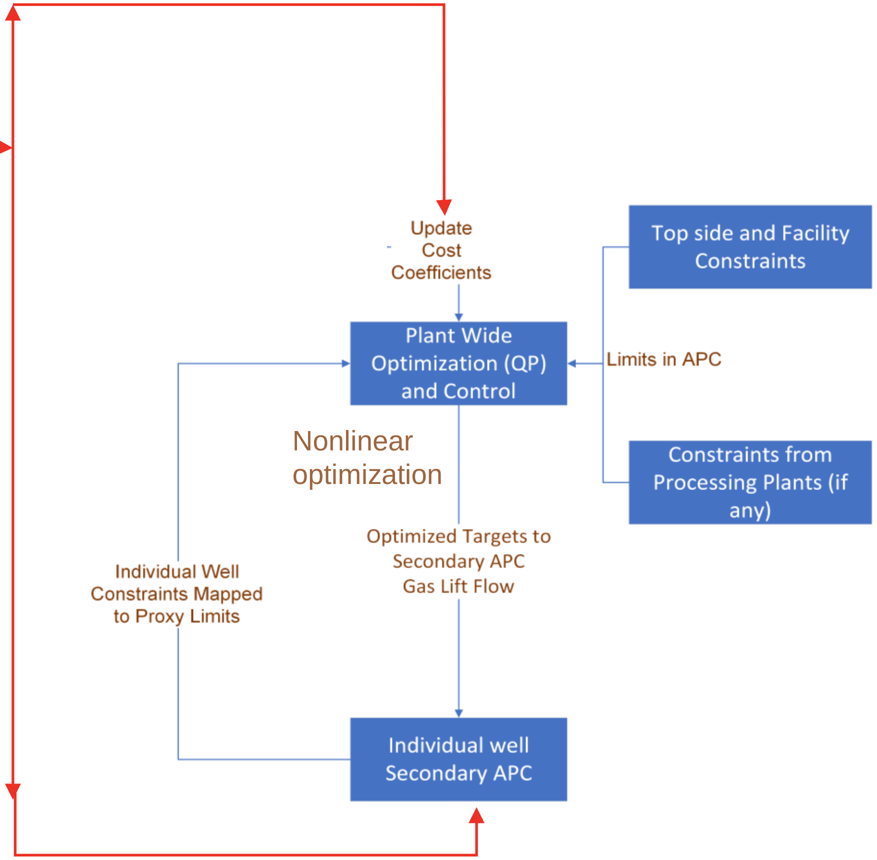
SOLUTION: ECONOMIC LOAD ALLOCATOR (ELA) -WELL

ADVANCED APPROACHES

Economic Load Allocator (ELA)- Well





- Plots online Oil Curves based on Oil variables Oil model parameters
- Allows entries for Oil model parameters through ,CSVs.
- Fits a quadratic equation to the Oil curve, thereby generating Cost (QP, LP) coefficients.
- Updates cost targets into APC, Field-wide Optimizer

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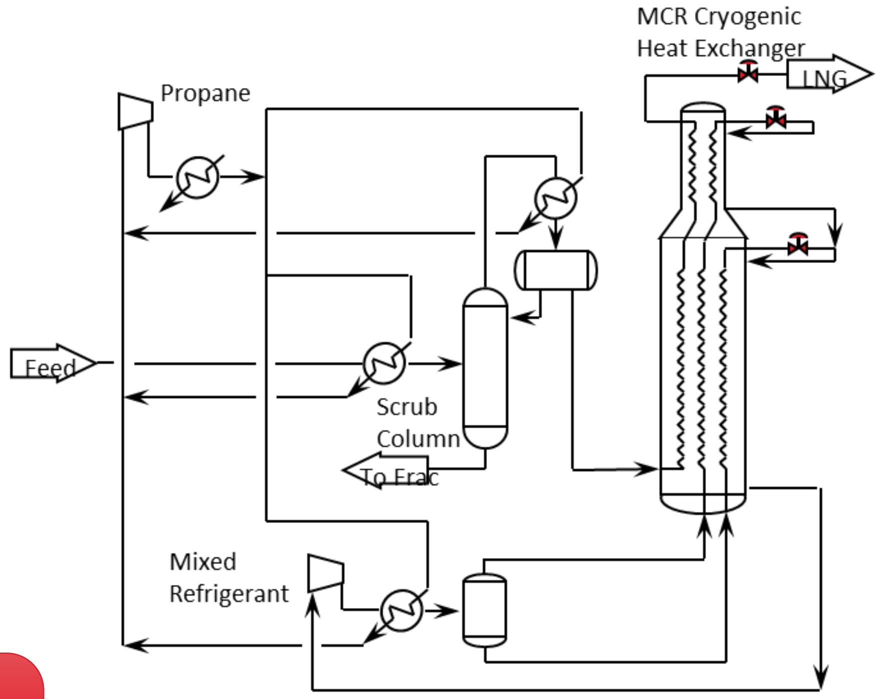
SMART INFERENTIALS
USE CASE: MR OPTIMIZATION IN LNG PLANT

APC Design

- MR composition Control- Nitrogen, Methane, Ethane, Propane
- MR Optimization -Optimal composition ensure minimum compressor energy for the given LNG production target and no-pinch in cryogenic heat exchangers.
- Needs development of inferentials/soft sensors
- Tackle impact of gas drier change over on upstream and downstream plant



Key Considerations

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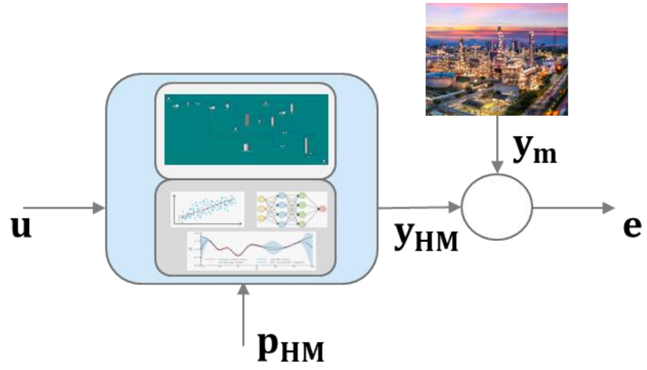
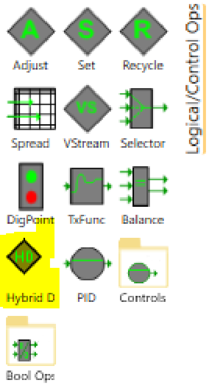
Need for Robust Inferential structure Hybrid Models (UNISIM), ML/DL based inferentials.

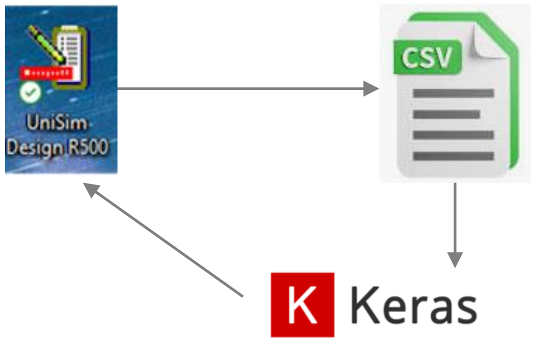
SOLUTION: AI/ML ENABLED UNISIM HYBRID MODEL

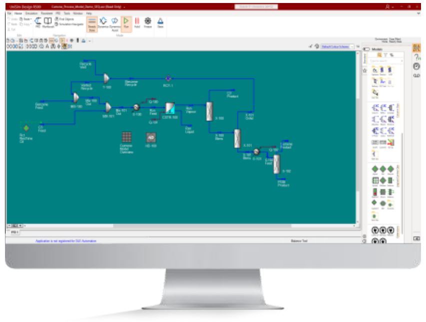
AI EMBEDDED

- Combination of first principles and data driven (AI/ML) models designed to achieve specific goals
- Supplements first principles model with additional structure to improve accuracy of predictions when calibrated with process data
- Workflow supported for both UniSim Design sequential and UniSim EO based process flowsheet models
- Hybrid Developer (HD) unit operation is added to the object palette to support hybrid model configuration
- Contains a configurable data-driven model types (Machine Learning Evaluator) that supports linear and neural network models
- Option to train ML model with externally using an open-source tools such as TensorFlow Keras, Scikit-Learn or PyTorch









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SOLUTION: ML AND DL BASED INFERENTIALS

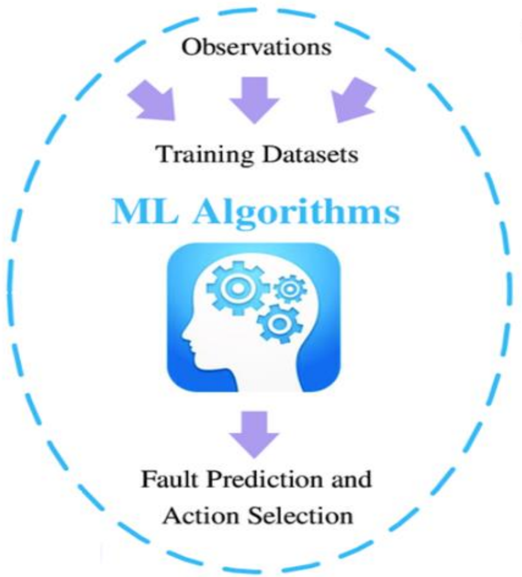
AI EMBEDDED

What are Inferentials? Data-driven models, used to predict the variables (like Quality)based on available parameters.

Limitations with traditional approaches? User is expected to choose a modeling technique based on a prior knowledge OR try manually each modeling technique and select the best model based on the provided results and statistics.

Why ML and DL-Based Algorithms (Models)?

- Nonlinear models and cover wide range of operating conditions.
- Ability to learn and capture more complex features and nonlinear relationships.
- Ability to learn dynamic relationships among process variables (DL Models).



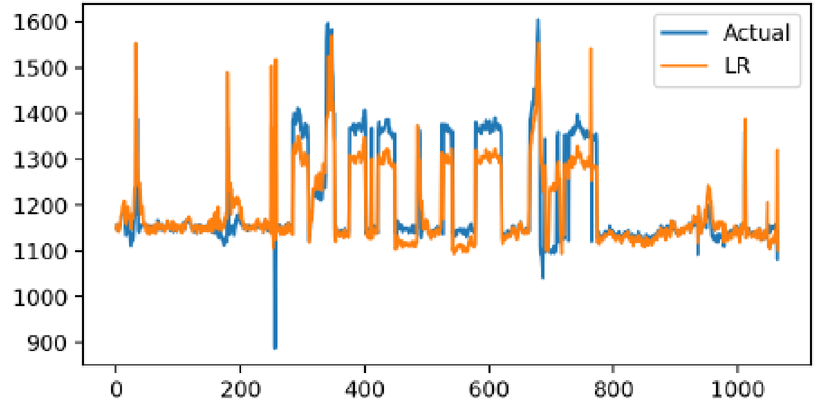
Highlights of New Approach

- Automatic data preprocessing (missing data, outlier) approach based on ML techniques.
- Automatic input selection approach for selecting relevant input variables using ML techniques.
- Automatic modeling approach selection, build different ML models and selects the best model that suits the given data and deploys that best model for prediction.

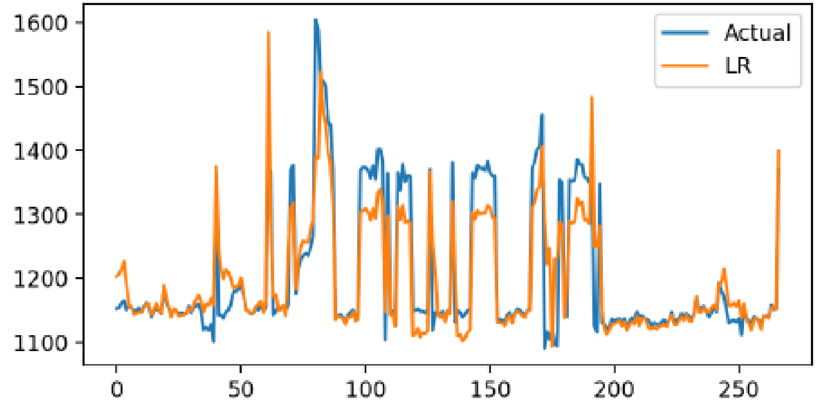
SOLUTION: ML AND DL BASED INFERENTIALS

AI EMBEDDED

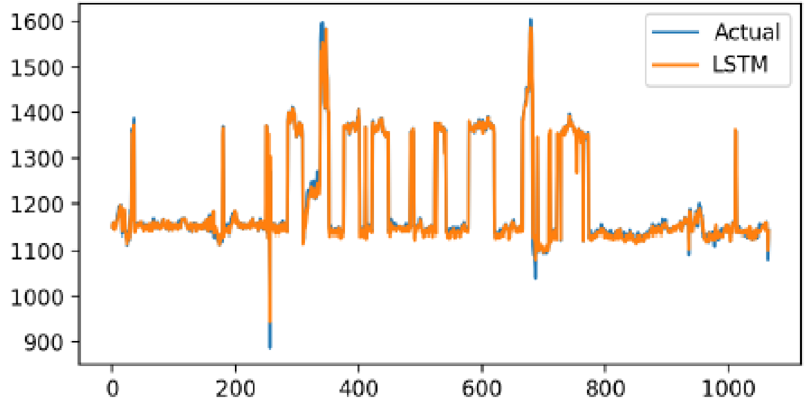
CASE STUDY BASED ON CUSTOMER DATA



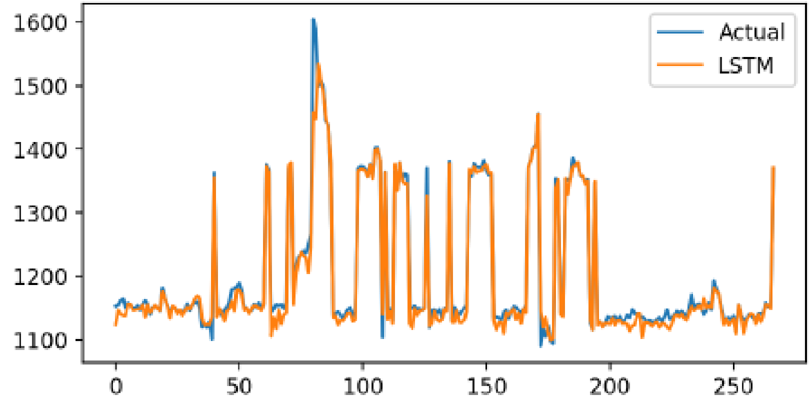
(a) Train-Linear Model



(b) Test-Linear Model



(c) Train-AI Model



(d) Test-AI Model

Model	MSE
LM	0.00482
RF	0.00091
XGB	0.00102
MLP	0.00120
LSTM	0.00072
GRU	0.00075

WIDE AREA OPTIMIZATION
USE CASE: FIELD-WIDE OPTIMIZATION

Optimization Objective

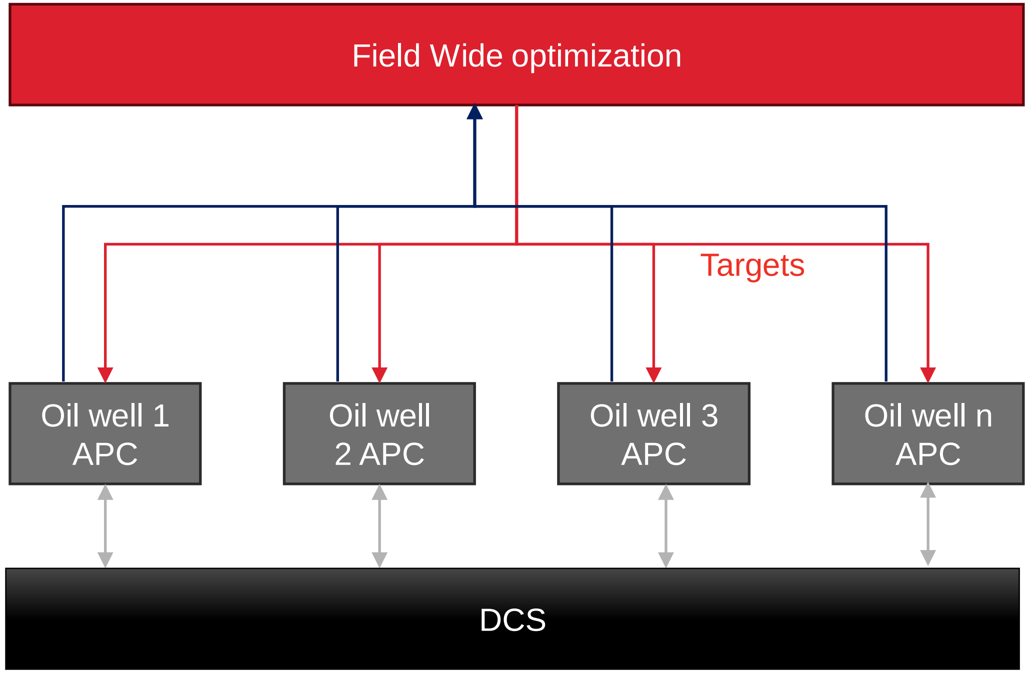
Maximizing the operating margin of the oil production across multiple wells, while-

Selecting the choke and gas lift valve opening of the different wells

Allocating shared resources such as available lift gas

Ensure that the process and operating constraints are satisfied for well and Topside

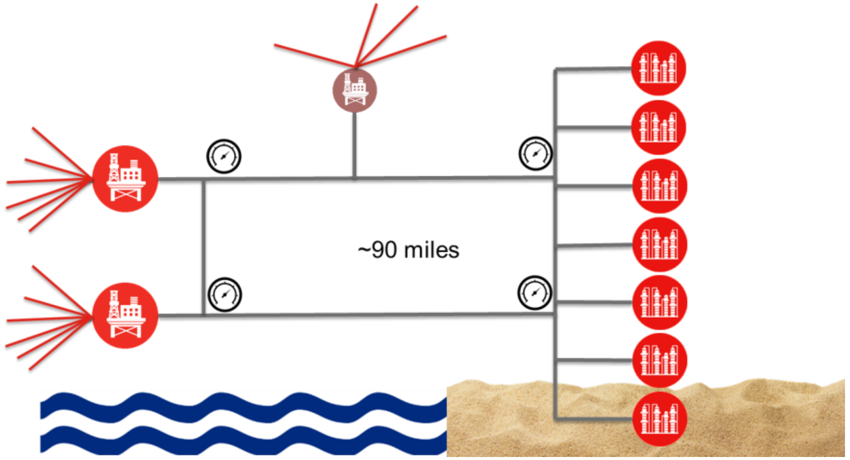
Honouring additional constraints of oil and gas processing facilities (if any)



WIDE AREA OPTIMIZATION
USE CASE: WELL TO LNG PLANT OPTIMIZATION

Problem Overview

Managing onshore plant demand changes and balancing flow from wells



Traditionally

Offshore gas suppliers together provided enough gas for the onshore LNG production trains to maximize

One chosen offshore platform “swung” production to meet LNG production variations due ambient temperature changes

Currently

Offshore gas supplier output is decreasing as gas reserves reduce. Constraints moving from onshore to offshore

Transitioning daily between onshore and offshore current constraint with ambient temperature

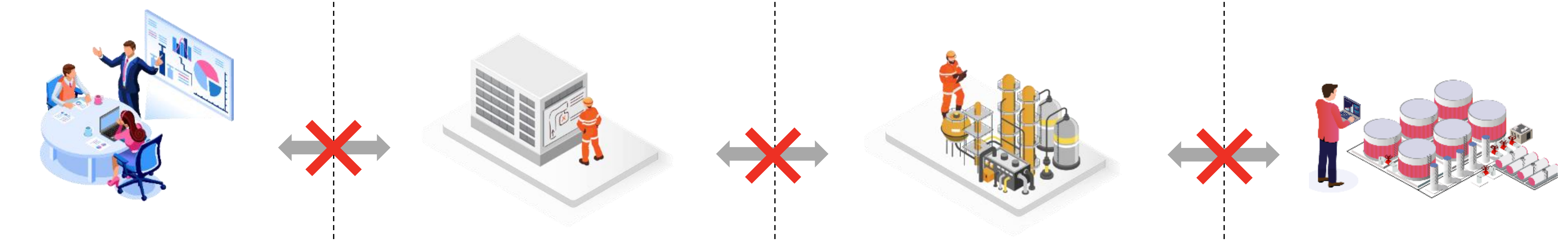
WIDE AREA OPTIMIZATION
USE CASE: OPTIMIZATION IN FRAGMENTED SILOS

CHALLENGE

Fragmented view of operations & profits

Localized Optimization

Slow, inefficient decision making



PLANNING
"I want to maximize feed & product opportunities but I don't know what the plant is capable of"

PROCESS ENGINEERING
"All I do is chase people down to make the plan. I never have time to figure out if we can make it to the next turnaround!"

OPERATIONS
"I need to make sure the plant keeps running, and try to respond to all these changes"

BLENDING
"I am trying to meet product demand, but I don't know if I'll have enough inventory!"

HISTORICAL ATTEMPT TO SOLVE

Real-Time Optimizer (RTO) idea:

Plant-wide rigorous model

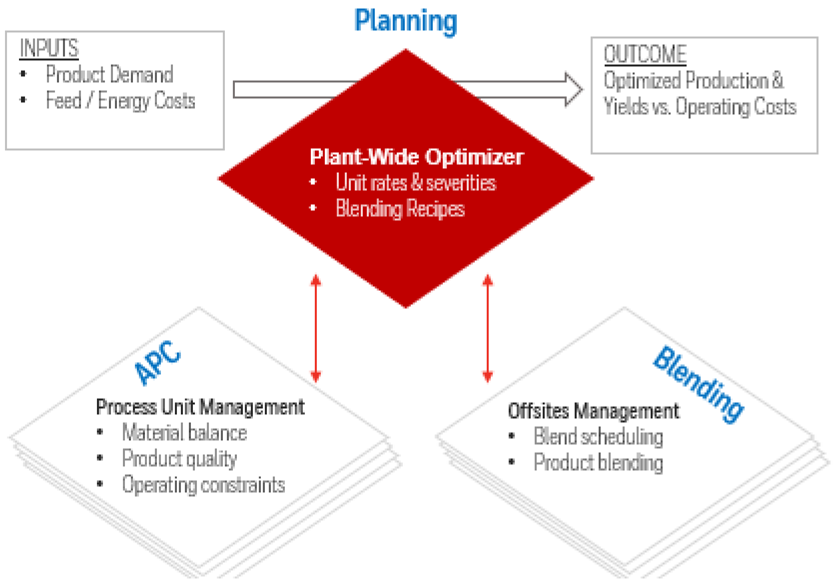
Promises full scale molecular management

It has failed because:

Deep expertise & resources required to build & maintain

Unreliable results due to robustness & speed issues

SOLUTION: DYNAMIC REAL-TIME OPTIMIZATION
THRU PLANT-WIDE OPTIMIZER



PLANNING DEPT.
"I am trying to set the operating conditions to maximize the site profitability while meeting product demand"

PLANT OPERATIONS
"Am trying to run my plant but I can't even implement the plan I received!"

SHIPPING & RECEIVING
"I am trying to meet product demand but I don't have sufficient inventory!"

A **multi-layer** solution which inherits a **business planning model**, acquires underlying **operating constraints through a unit level APC model** and delivers a **combined multiscale end-to-end optimization solution** in real-time.

What makes this solution unique?

1 | Speed & Agility

Run every minute, using dynamic models, resulting in real-time feedback and precise control

2 | Comprehensive Scope

Manage inventory & deliver optimal material routing across the enterprise by integrating process optimization with planning and blending operations

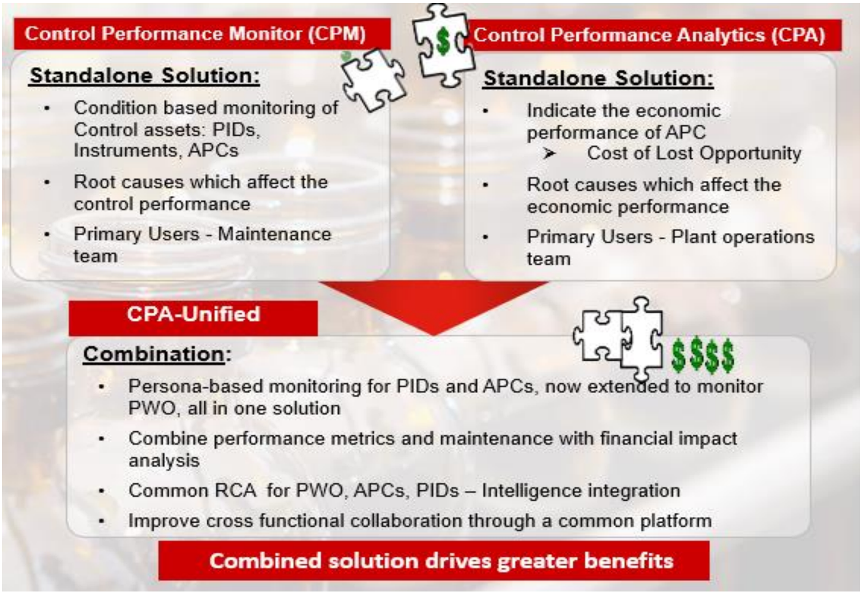
3 | Feasible Solution

Ensures that the solution can be run from enterprise planning to individual process units by using patented technology proxy limit and decision variables for any vendor's APC technology

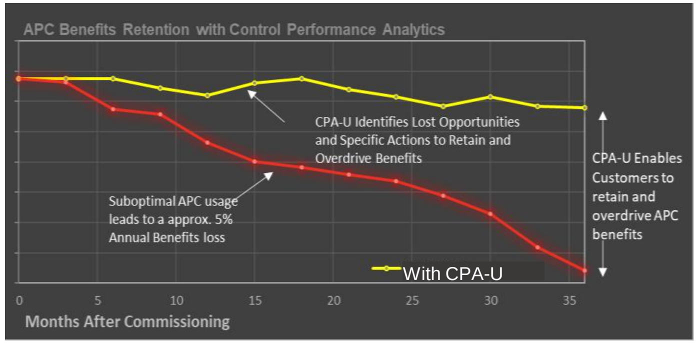
SECRET SAUCE: Honeywell's **patented** techniques which dynamically optimize across the scope of the whole enterprise and always ensures a **feasible** solution **driving Enterprise decision making in real-time.**

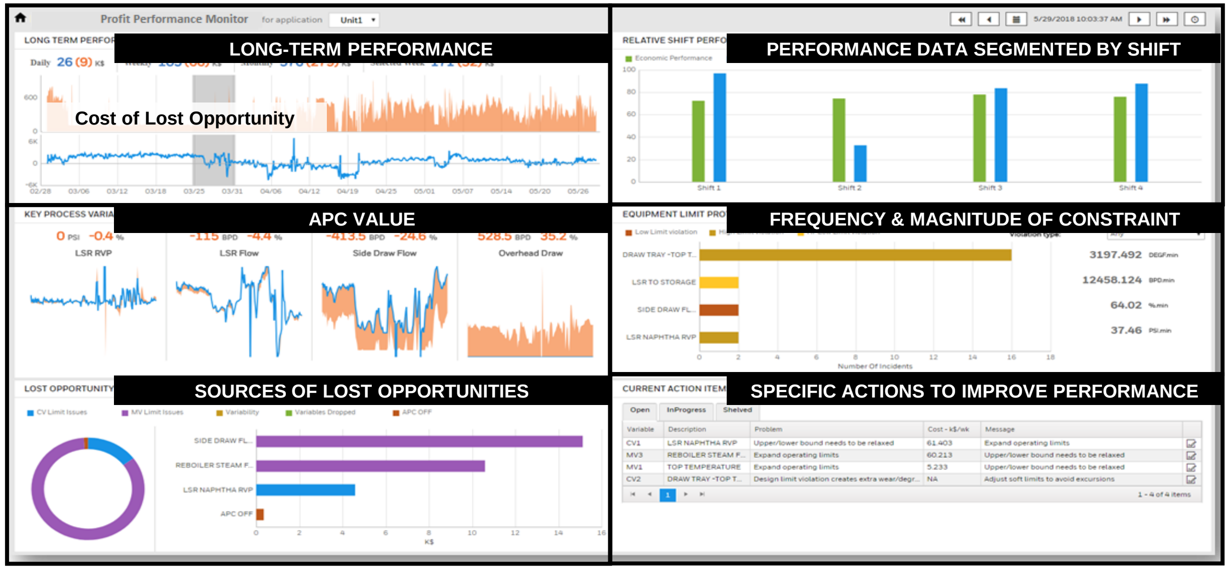
ENTERPRISE WIDE

SUSTAIN CONTROL AND OPTIMIZATION BENEFITS
CONTROL PERFORMANCE ANALYTICS- UNIFIED



- Comprehensive monitoring applicable to all levels of control hierarchy- instrument, PIDs, analyzers, APC, and PWO
- Combine control performance monitoring and maintenance with economic impact analysis within one platform. Improve cross-functional collaboration.
- Go beyond KPIs through actionable insights and prioritization of issues and recommendations by financial impacts
- Reduce engineering effort with guided automated workflow and embedded intelligence





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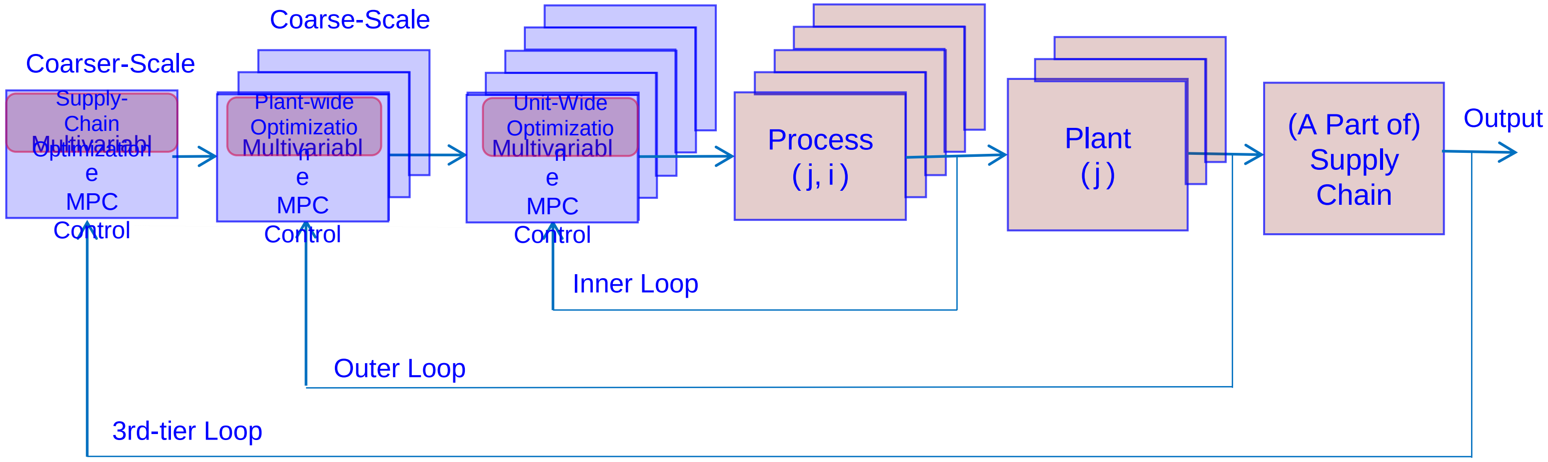
03 CONTROL & OPTIMIZE- Future Work

FUTURE WORK IN PLANT-WIDE OPTIMIZER
EXPAND TO ENTERPRISE-WIDE OPTIMIZATION

- ✓ Expand multiscale MPC cascade to 3 tiers –APC->PWO->EWO
- ✓ An enterprise-wide optimization for a larger part of the supply chain.
  - ➢ For example: Improving coordination between multiple refineries (or multiple Gas Plants) and fuel/crude depots (inventory) within the same network
  - ➢ Increase supply chain agility, optimize and/or reduce inventories within the enterprise
  - ➢ Optimize order transfers and intermediates cross-shipping between plants



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EMBRACING AI/ML

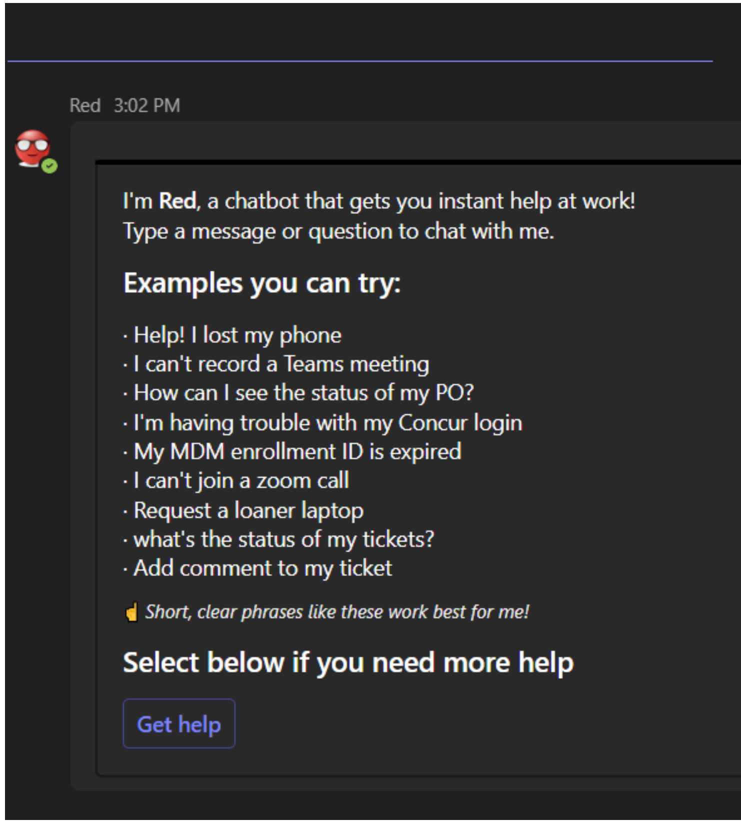
AI CHAT BOT

AI EMBEDDED

Definition	Purpose	Interaction
Simulate human conversation and interaction using artificial intelligence and natural language processing	Developed to perform tasks, answer questions, or provide assistance to users through human-like conversation	Users communicate with chatbots through text, voice, or graphical interfaces, making them accessible and user-friendly.

Applications

Customer support, virtual personal assistants, e-commerce, Training assistants, process automation.



EMBRACING AI/ML

AI CHAT BOT AND APC

AI EMBEDDED

OBJECTIVES

- **Improved decision making** for Operators and engineers in real-time based on insights from the chatbot.
- **Reduced downtime** due to quick issue detection and troubleshooting guidance
- **Enhanced Process Control** due to assistance o fine-tuning control parameters.
- **24/7 Availability** of CHATBOT, ensuring continuous monitoring and support,
- **Reduced Knowledge & Experience gap** as most of the information and actions on APC can be obtained just by asking.
- **Validate decisions, Check actions** by integrating with What-If? Scenario manager (planned in August 2024).
- **Train Operators** based on the easy availability of information
- **Predictive Capabilities** as CHATBOTs can provide predictive insights, helping prevention before occurrence
- **Scalability** as CHATBOTs can handle multiple tasks simultaneously thereby managing various processes and systems

04 Conclusion and next steps

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WHAT DOES THIS LEAD TO?

SUPPLY CHAIN CAPACITY OPPORTUNITIES

Oil and Gas production platforms and subsequent multi-train processing are often operated and managed independently with their own objectives and have to manage what other sites are doing, which negatively impact overall supply chain capacity utilization.

All-inclusive real-time **end-to-end optimization** coordinates large scale multi-site production and processing facilities, manages dynamic constraints and shifting priorities, and optimizes feed distribution for maximum capacity and profitability. Large optimization problems are simplified to key parameters, easier to implement, use and maintain.

OFFSHORE & ONSHORE LNG PLANT CAPACITY MAXIMIZATION
Coordinate offshore and onshore operation, automate system constraints transition, maximize capacity, and increase gas export.

NGL FACILITY FEED GAS DISTRIBUTION OPTIMIZATION
Maximize product recovery, minimize energy consumption, maximize profit margin

1% ↑	10% ↓	1-2% ↑
INCREASED GAS EXPORT	ENERGY REDUCTION	GROSS MARGIN EXPANSIOIN

WHAT DOES THIS LEAD TO?

NEW MARGIN THROUGH POOL OPTIMIZATION

Coordination of Plant-wide production, inventory and blending and bridging the gap between planning and control with real-time **end-to-end optimization** allow the plant to maximize profit, meet the demand, and eliminate quality giveaways.

GASOLINE POOL OPTIMIZATION
Giveaway reduction, component cost reduction

DIESEL POOL OPTIMIZATION
Giveaway reduction, component cost reduction

CRUDE RATE OPTIMIZATION
Multiple optimization scenarios driven by economics

CRUDE MIX OPTIMIZATION
Enable steadier crude quality, increase average (sustainable) crude rate, determine optimum mix for maximum profit

Make the RIGHT PRODUCT
at the RIGHT AMOUNT,
at the RIGHT QUALITY,
at the RIGHT TIME
ALL THE TIME

3-5% ↑
INCREASED PRODUCT PRODUCTION

5-50% ↓
INVENTORY REDUCTION

$4-6M ↑
YIELD IMPROVEMENT[1]

[1]Depending on Refinery Size

NEXT STEPS….

PRIORITIZATION WORKSHOP

- Understand key value drivers & challenges
- Benchmark optimization capability maturity
- Identify key stakeholders & sponsors
- Ranking of options to fill gaps- identify pilots

OPTIMIZATION VALUE ASSESSMENT (OPTIONAL)

- Quantify business case & refine scope within business-backed objectives
- Define Adoption Program: products, architecture and implementation timeline
- Identify Stage-gated success criteria, risks & mitigations

INITIAL/PILOT SCOPE DELIVERY

- Deliver initial project/pilot scope
- Ensure original hypothesis validation
- Deploy over-arching program management
- Outline change mgmt. needs / skill gaps
- Program continuity into subsequent phases

….LET US COLLABORATE

Q&A
THANK YOU!

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