CHEM SHOW | E 23

november 28-30, 2023 | moody gardens, galveston, tx

SOUTH TEXAS SECTION OF THE AMERICAN INSTITUTE OF CHEMICAL ENGINEERS

Gulf Energy

Accelerate Your Sustainability Program

Douglas White
Emerson Automation Solutions

Presenter

Doug White (doug.white@emerson.com)

Principal Consultant

Emerson Automation Solutions

Background: Many years of experience designing, justifying, installing and commissioning advanced real time automation / optimization/ digitalization and modeling applications in the process industries and assessing their financial and sustainability impact.

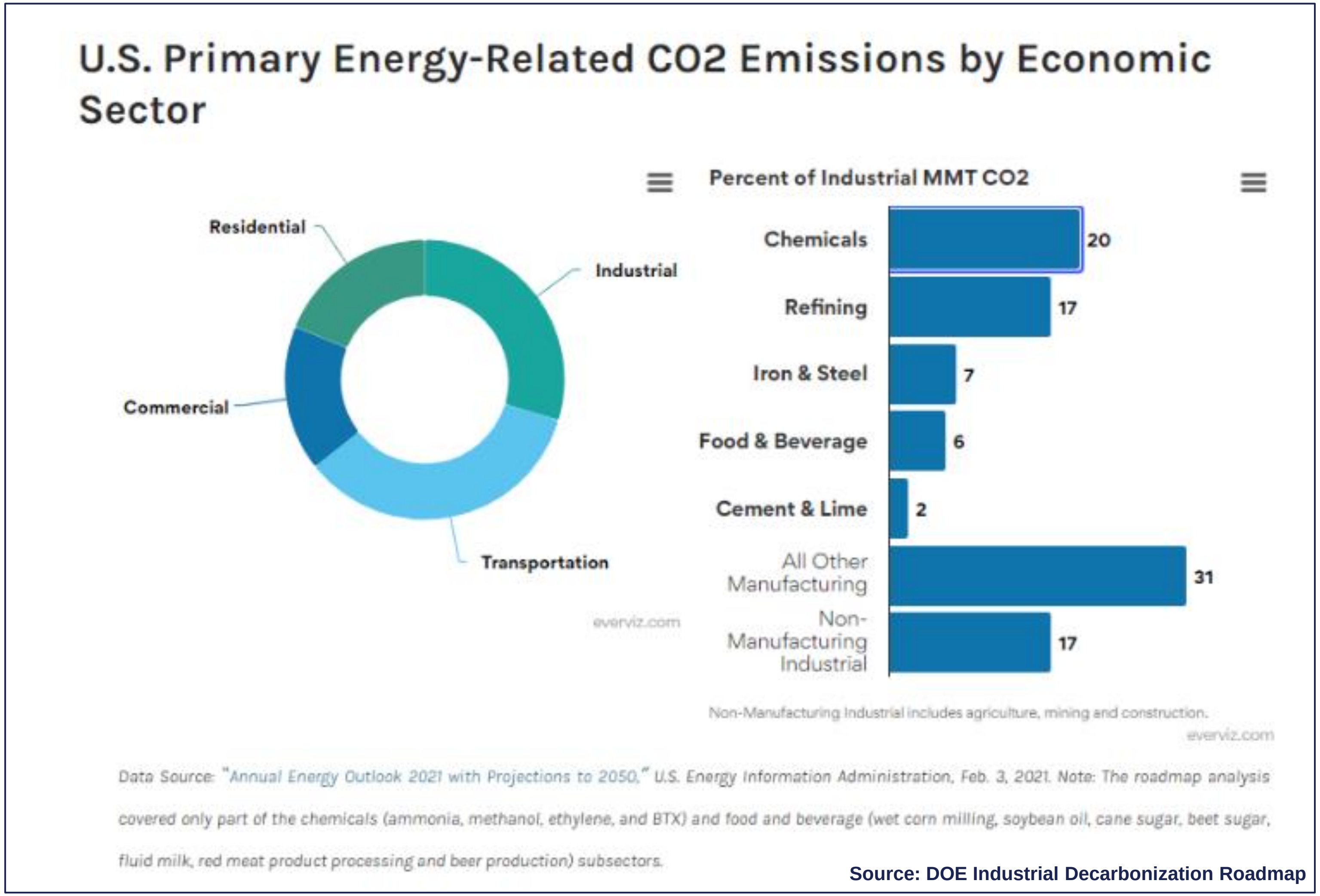
EMERSON

Sustainability Is Everywhere

Agenda

1	Introduction
2	Current Status of Refinery and Chemical Plant Greenhouse Gas Emissions
3	How Can Advanced Software and Automation Help Achieve Emission Reductions?
4	How Can Advanced Software and Automation Help With Evaluating Individual Emission Reduction Options?
5	Evaluating Overall Emission Reduction Programs
6	What Is The Next Step?
7	Summary

US Refining and Chemical Industry Scope 1&2 CO2 Emissions



Source: DOE Industrial Decarbonization Roadmap

Industrial Contribution To Meet 2050 Scope1 & 2 Greenhouse Gas Emissions

	World Population	Av yearly Energy Use per Capita	Total Yearly Energy Required	Industrial Total Energy Required	Industrial Energy From Fossil Fuels	Industrial Emissions
	20% Increase	22% Increase	48% Increase	41% Increase	41% Increase	3% Increase
2050	9.7 B	90 M BTU's	890 Qu BTU's	361 Qu BTU's	270 Qu BTU's	9.6 GT CO2e*
Current	8.1 B	74 M BTU's	600 Qu BTU's	256 Qu BTU's	190 Qu BTU's	9.3 GT CO2e*

World Population X Av yearly Energy Use per Capita = Total Yearly Energy Required ⇨ Industrial Total Energy Required ⇨ Industrial Energy From Fossil Fuels ⇨ Industrial Emissions

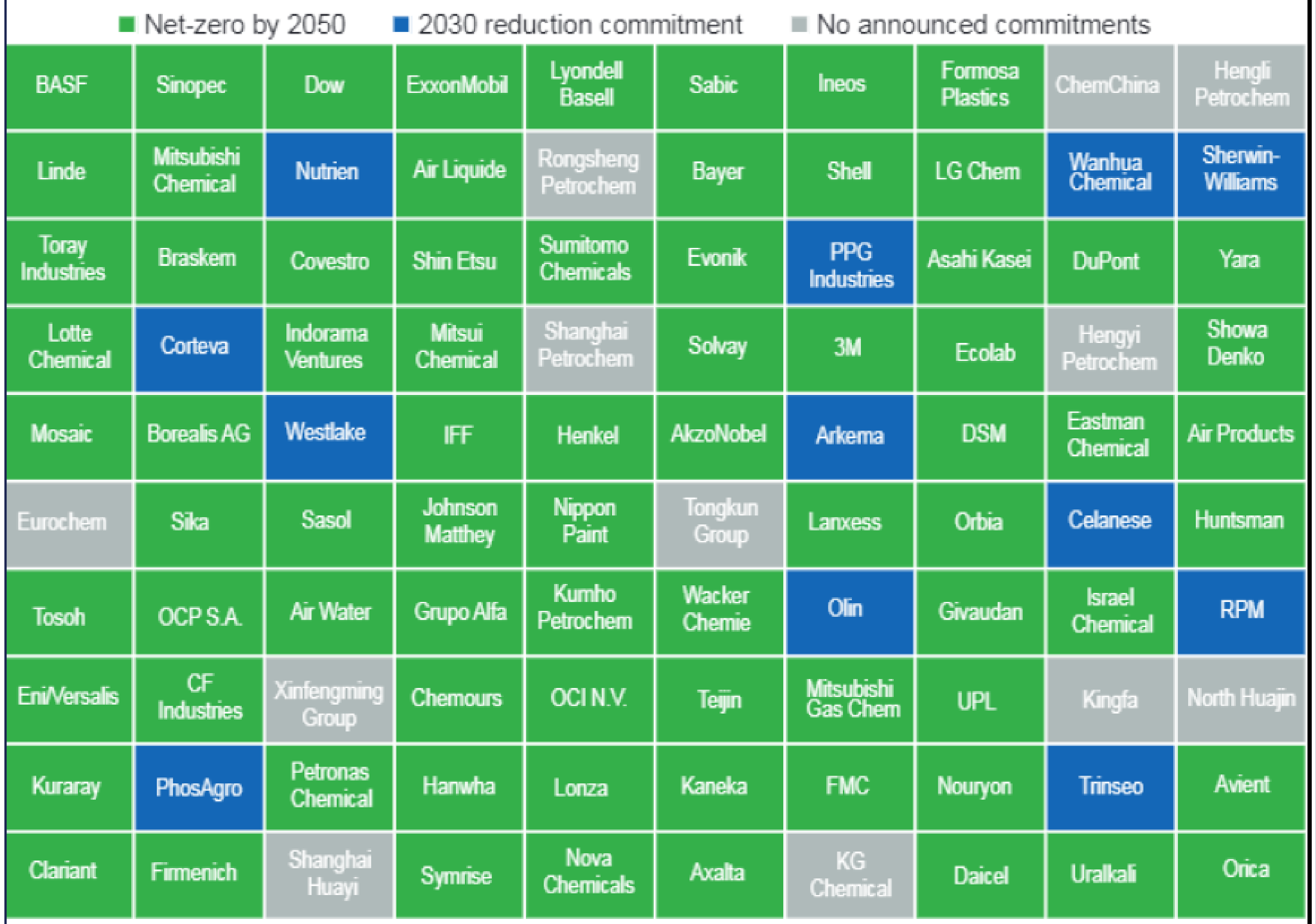
Source: US DOE EIA IEO2021; Reference Case – Scope 1&2

*Source: IEA; WEO2022: Table4a; STEP Case

All Major Chemical Companies Have Announced 2050 Carbon Reduction Targets

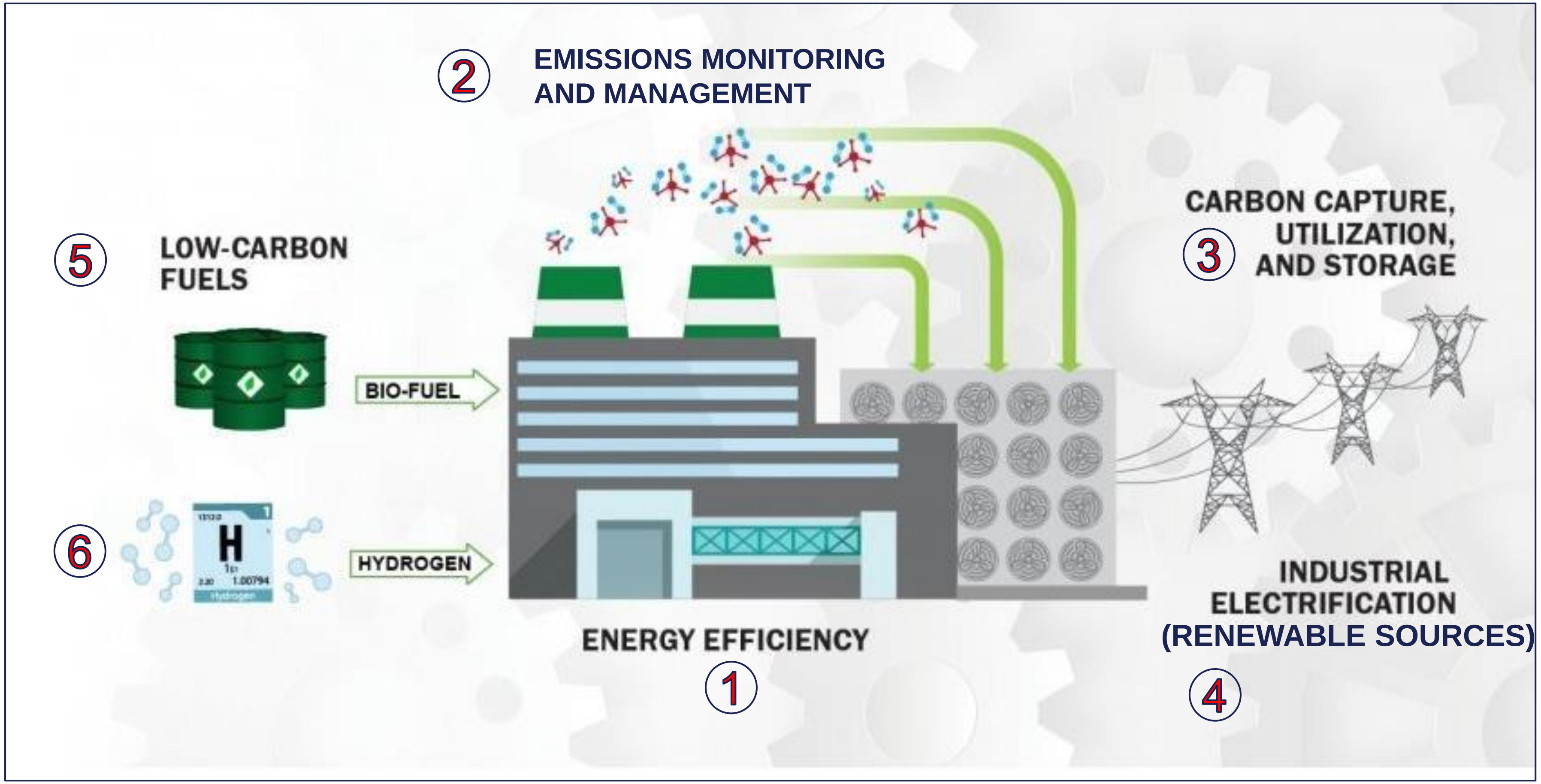
Net-zero heat map

(announced net-zero or carbon reduction commitments)



Source: *Chemical Week*; company reports; S&P Global Commodity Insights.

Strategies To Reduce Scope 1&2 Refining and Chemical Plant Emissions



Source: OS DOE; Industrial Decarbonization Roadmap

The Challenge:

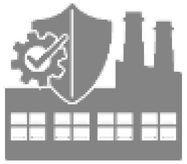
Meeting Sustainability Goals While Simultaneously Improving Safety, Availability, and Profitability In A Constrained Capital Environment

Answer:

Using Modern Software and Automation Technology To Dramatically Reduce Emissions while Improving Planning, Operations and Maintenance

DESIGN ↔ OPERATE ↔ MAINTAIN

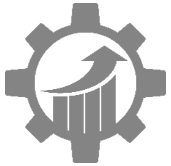
Connected Enterprise	*Integrated operations connected to business outcomes*
Optimized Operations	*Drive towards autonomous self-optimizing operations*
Intelligent Field	*Results-oriented pervasive sensing and intelligent edge*



Safer Operation

More Sustainable

Increased Profitability



Improved Reliability

Modern Advanced Automation/Industrial Software /Analytics Capabilities Support Sustainability Across the Facility Lifecycle

COLLECT & VISUALIZE

IIoT Platform to Securely Connect & Communicate with All Devices

Operational Historian / Data Platform

Enterprise Collaboration & Workflow Automation

SCADA

Digital Grid Management

Subsurface Science & Engineering

Actionable Analytics

Real-Time Modeling System

Cost Estimation & Engineering Tools

Planning & Scheduling

Process & Knowledge Management

Procedural Automation & Production Accounting

Asset Reliability Modeling

Advanced Control & Dynamic Optimization

Multivariate Analysis

Process Simulation & Operator Training System

Alarm and Operations Management

Asset Performance Management

Control Software

DESIGN & PLAN

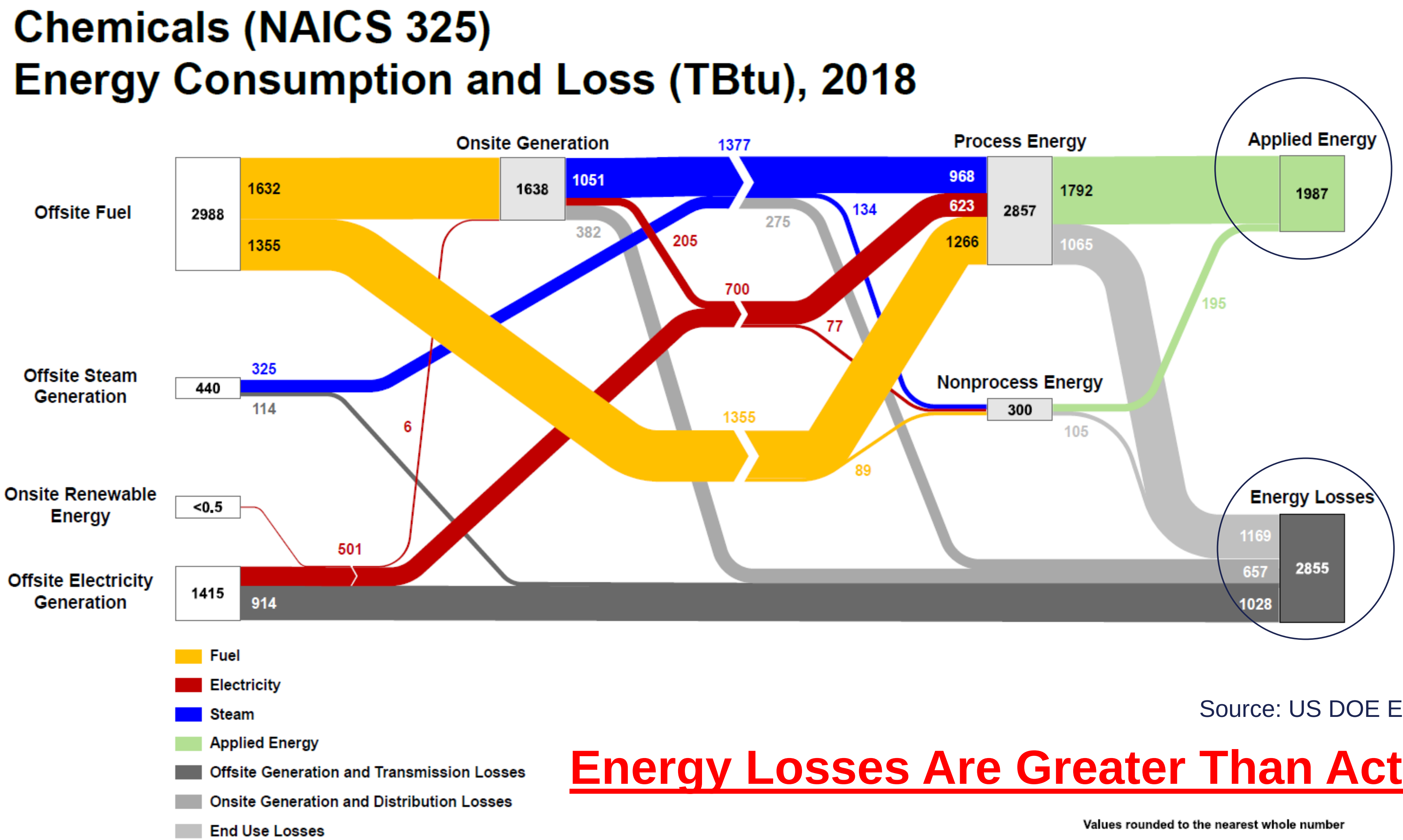
OPERATE

MAINTAIN

Continuous Effortless Updates & Anytime, Anywhere Access

How Can Advanced Automation and Software Help Reduce Emissions

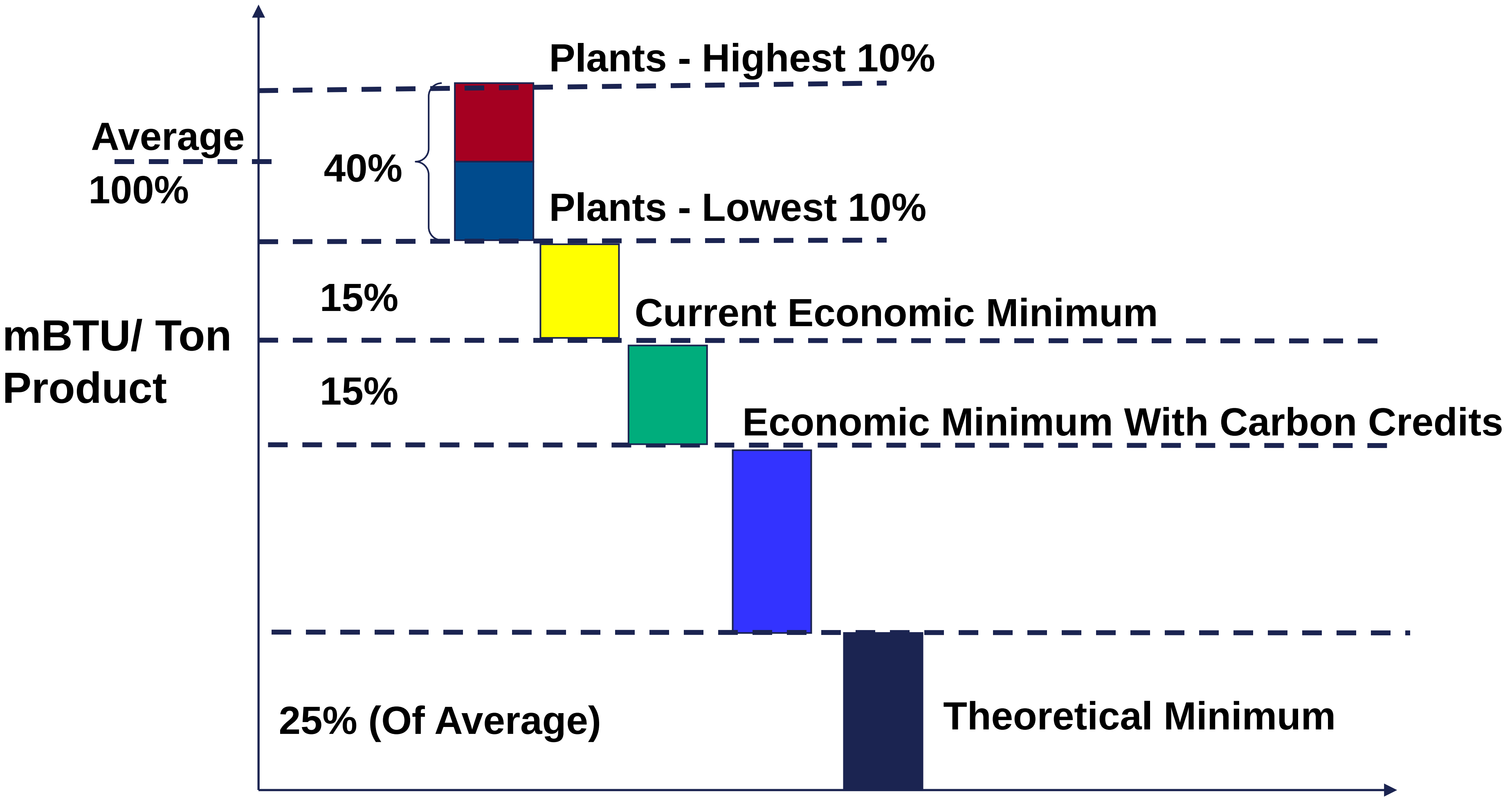
Typical Chemical Plant Sankey Diagram



Source: US DOE EIA

Energy Losses Are Greater Than Actual Use!

Opportunities For Energy and Emission Savings in Existing Plants



Corrected to Standard Conditions for Process Configuration, Product Grades, and Feed Quality

Refining and Chemical Plant Life Cycle: How Can Advanced Automation And Software Technology Help Reduce Emissions?

Techno-Economic Assessment	Production Optimization	Enterprise Energy & Emissions Management

Feedstock Replacement

- Evaluate integration of new feedstocks in new & existing process
- Support design decisions regarding new energy efficient feedstock, processes or equipment

Process & Equipment Design

- Accelerate effective scale-up of new processes for reduced emissions

Production Planning for Alternate Feedstocks

- Optimize feedstock selection for emissions
- Evaluate new feedstock economics

Process Optimization

- Optimize to ensure consistent production and emissions management
- Energy network optimization
- Avoid disruptions – identify problems early

Enterprise Optimization

- Improve system economics
- Optimize regional supply chains to maximize margins and minimize carbon intensity

Incorporate new feedstock

- Track feedstock usage
- Prioritize end market opportunities

How Can Advanced Automation/ Software/ Analytics Reduce Emissions In Existing Plants?

Reduce plant Emissions

Reduce Process Energy Demand

- Advanced Control/ Optimization
  - Furnaces
  - Fractionation
  - Compressors
  - Distillation
- Improved Control Loop Performance
- Minimize Pressure Drop
- Maximize Process Heat Recovery /Minimize Losses
  - Maximize Recov Steam/ Condensate
- Minimize standby turbines and boilers
- Better control at low rates

Increase Internal Utility Production Efficiency

- Improve Combustion Efficiencies
- Steam System Management
  - Steam Header Management (minimize venting, letdown, pressure)
  - Maximize Recovered Steam/ Condensate
- Steam vs Electric Turbine Optimization
- Energy Management System
  - Power, Fuel, Steam purchase

Increase Renewable Energy Supply

- Increase green or blue hydrogen use as fuel
- Increase biofuels
- Carbon Capture

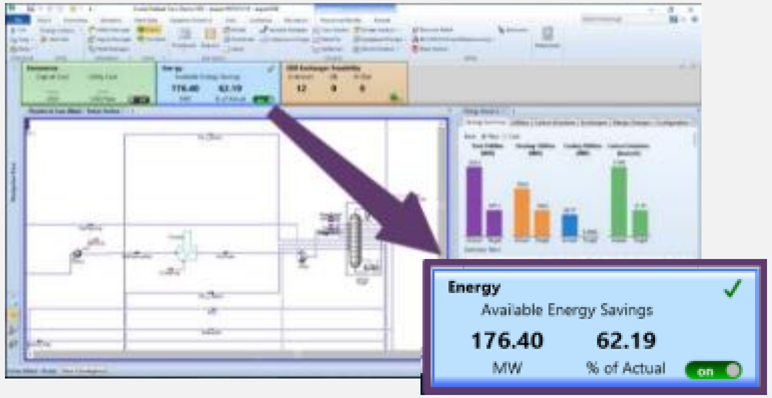
Case Study – Petrochemical Complex Energy Management and Optimization

Production Challenges

- Volatility creating need for flexibility in energy use
- Energy market deregulation allowing more leverage in electricity/gas supply contracts.
- Need short term tactical planning/optimization (1 - 30 days)
- Longer term strategic planning (1 month - 5 years)
  - Future contracts selection & future investments

Value Improvement Practice

- Decision support solution for making long-term business decisions on supply contract, tariff selection, and investment plans
- Simulation and optimization across 55 plants at the site
- Optimization of energy supply in real-time



Impact on Operations

2-3% less energy use and emissions

"… we achieved millions of Euros of savings through the utilities optimization of our 55 plants, with recurring annual benefits."

– Site Engineer

Case Study - Downstream Energy and Emission Management Information Systems

Production Challenges

- Complicated utility systems limit ability of operators to optimize across site
- Energy pricing varies by time of day
- Hard to tell when an asset or process is operating inefficiently
- Monthly energy reports are after-the-fact and too late to do something

Value Improvement Practice

Energy Management Information System

- Dashboards to monitor real time energy usage against expected
- Flag, track and categorize over-consumption events
- Easily build either rigorous or statistical energy consumption models
- Understand the financial impact of inefficient operations
- Optimize utility operation

Impact on Operations

$22M per year annual energy savings with associated emission reductions

2-7% reduction in total site energy usage and emissions

Improved visibility of energy and emission metrics across the site

Case Study - Heat Integration Project

Production Challenges

- Address the loss in production capacity at the plant unit during summer season.
- Enable stable operation, capacity maximization and energy recovery in the NHT (Naphtha Hydrotreater) from better heat recovery.

Value Improvement Practice

Used a plant Model, with all HXs modeled rigorously, to

- Determine the cause of the issue.
- Evaluate alternative HX network based on cost estimates
- Check for any vibration or pressure drop issues.

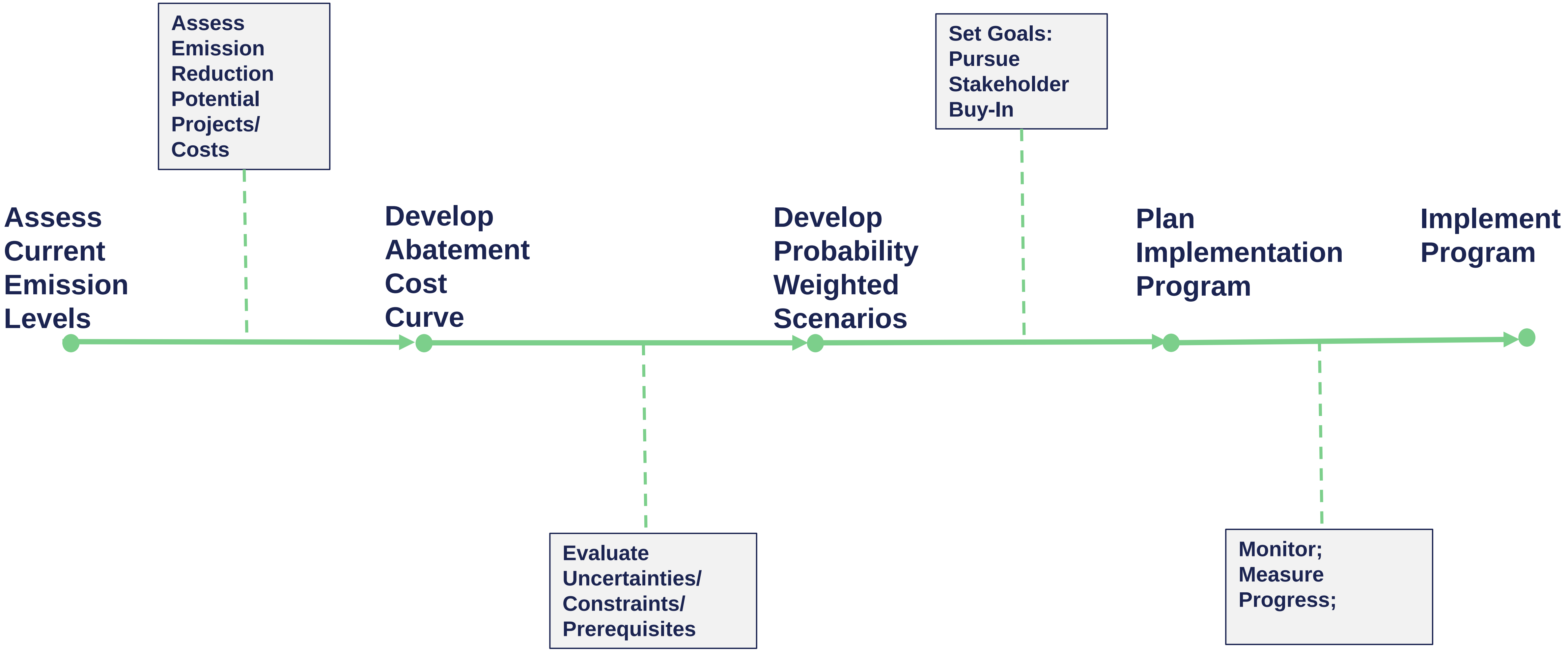
Impact on Operations

20% reduction in fuel consumption from higher energy recovery with accompanying emission reduction.

Stable operation of the unit and project payback period of less than a year

Evaluating Individual Emission Reduction Options

Developing An Emission Reduction Program



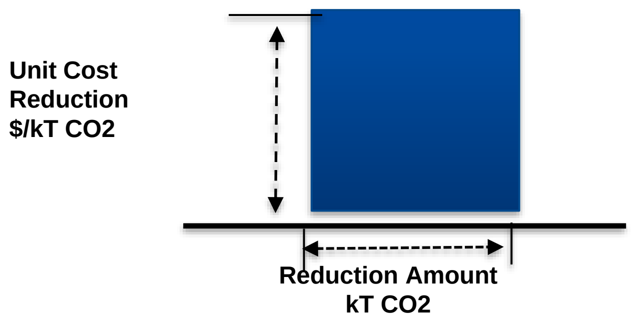
Example: Typical Possible Emission Reduction Project Selection For An Olefin Plant

	Energy Efficiency
EE1	**Pyrolysis Furnace Advanced Control and Energy Optimization**
EE2	**Improved Measurements and Advanced Control For Recovery Section**
EE3	**Overall Site Energy Management and Real Time Optimization**
EE4	**Reducing Point Emissions Through Monitoring (Steam Traps; PRV's; etc.)**
EE5	**Improved consensate recovery and cooling tower availability/ efficiency**
EE6	**LP Steam Recompression**
EE7	**Process Modifications For Increased Heat Integration and Recovery**
EE8	**Flare gas recovery**
	Carbon Capture and Sequestration
CCS1	**Pyrolysis Furnace Post Combustion CCS**
	Electrification
EL1	**Renewable power substitution for exisiting power usage**
EL2	**Refrigeration Compressors Electrification with Pyrolysis Furnace Air Preheating**
EL3	**Cracked Gas Compressor Electrification**
EL4	**Tank Heaters and Heat Tracing Elecrification**
EL5	**Column Reboiler Electrification**
EL6	**Electric Steam Boiler**
EL7	**Electric Pyrolysis Furnaces**
	Hydrogen as fuel
H1	**Blue Hydrogen**
H2	**Green Hydrogen**
	Feed Sustitution
BI1	**Coprocessing Bionaphtha**

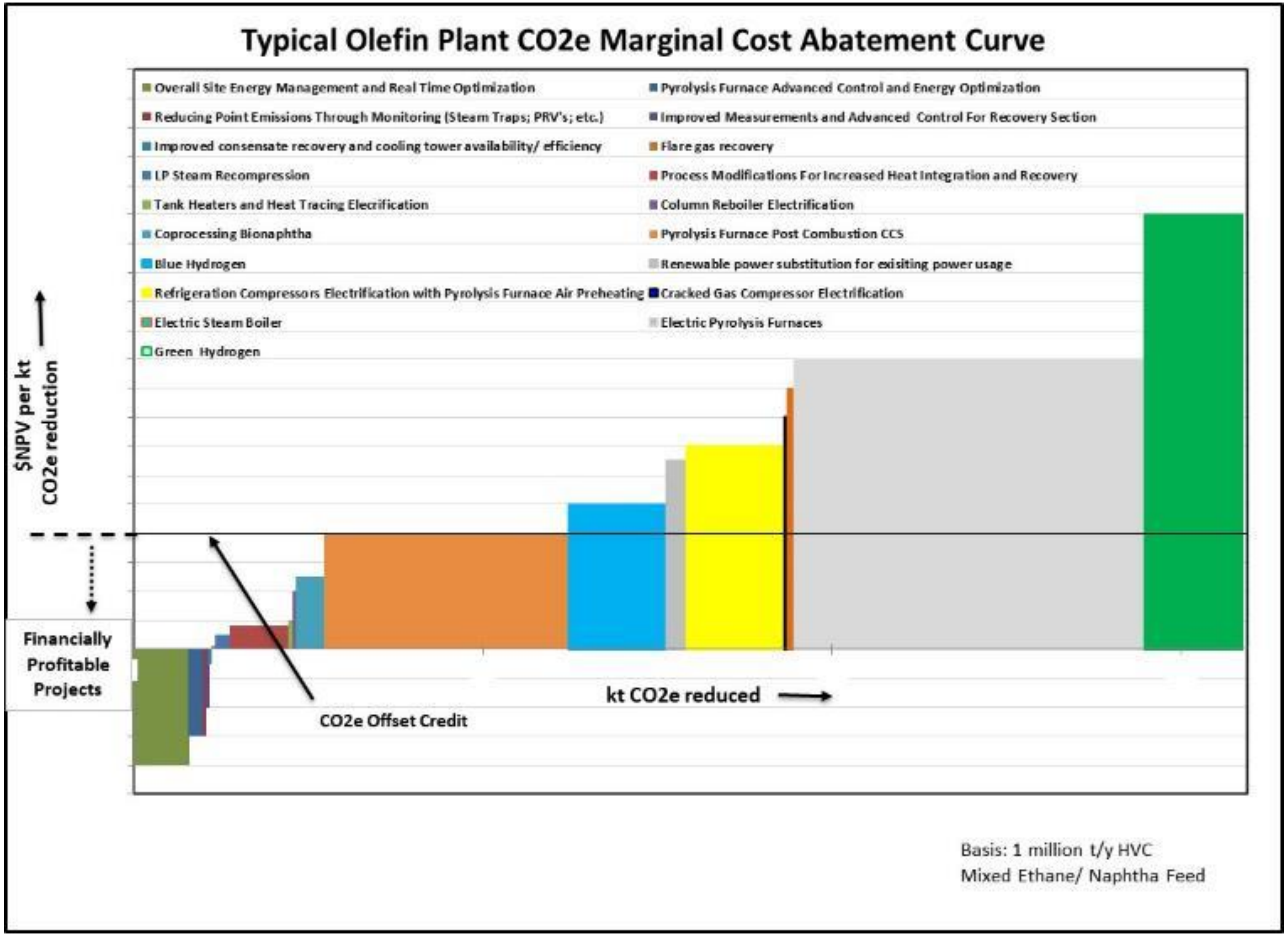
What Should Be The Order of Investment / Installation?

Investment Order – Maximize CO2 Removal Amount Per Marginal Investment Cost

- **Develop a list of potential abatement projects with CO2e reduction estimates and project net present value (NPV)**
- **Rank all potential projects based on cost per tCO2e**
- **Some projects will have a positive NPV (non-financially profitable) and some negative**
- **Add credits from Carbon Offsets**
- **Implement profitable (cost-negative) projects first**
- **Segregate into short-term and medium-term projects**
- **Initiate FEED studies for capital-investment projects**



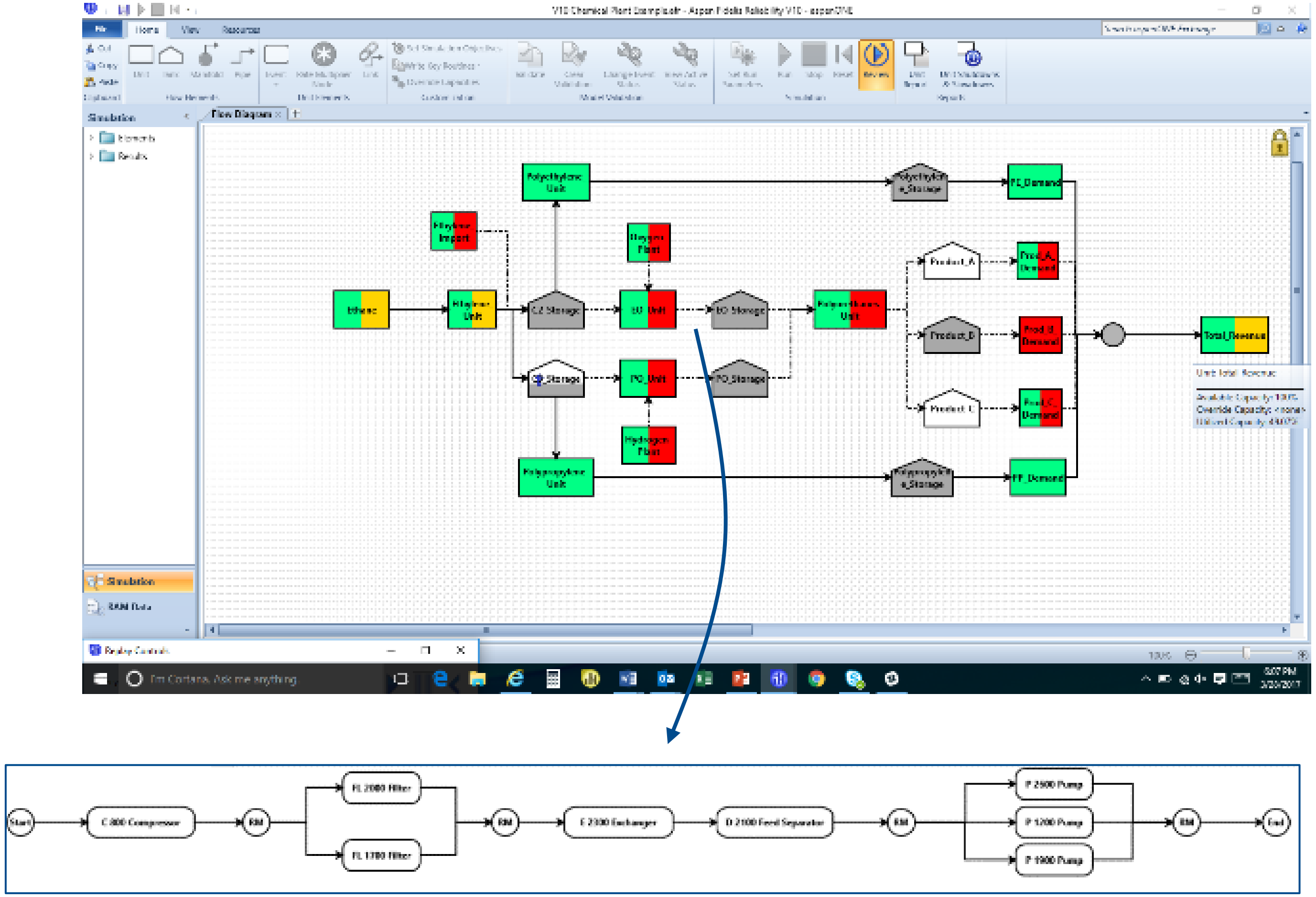
Which Investment Options Should Be Chosen First? – Marginal Abatement Cost Curve



Evaluating Overall Emission Reduction Programs

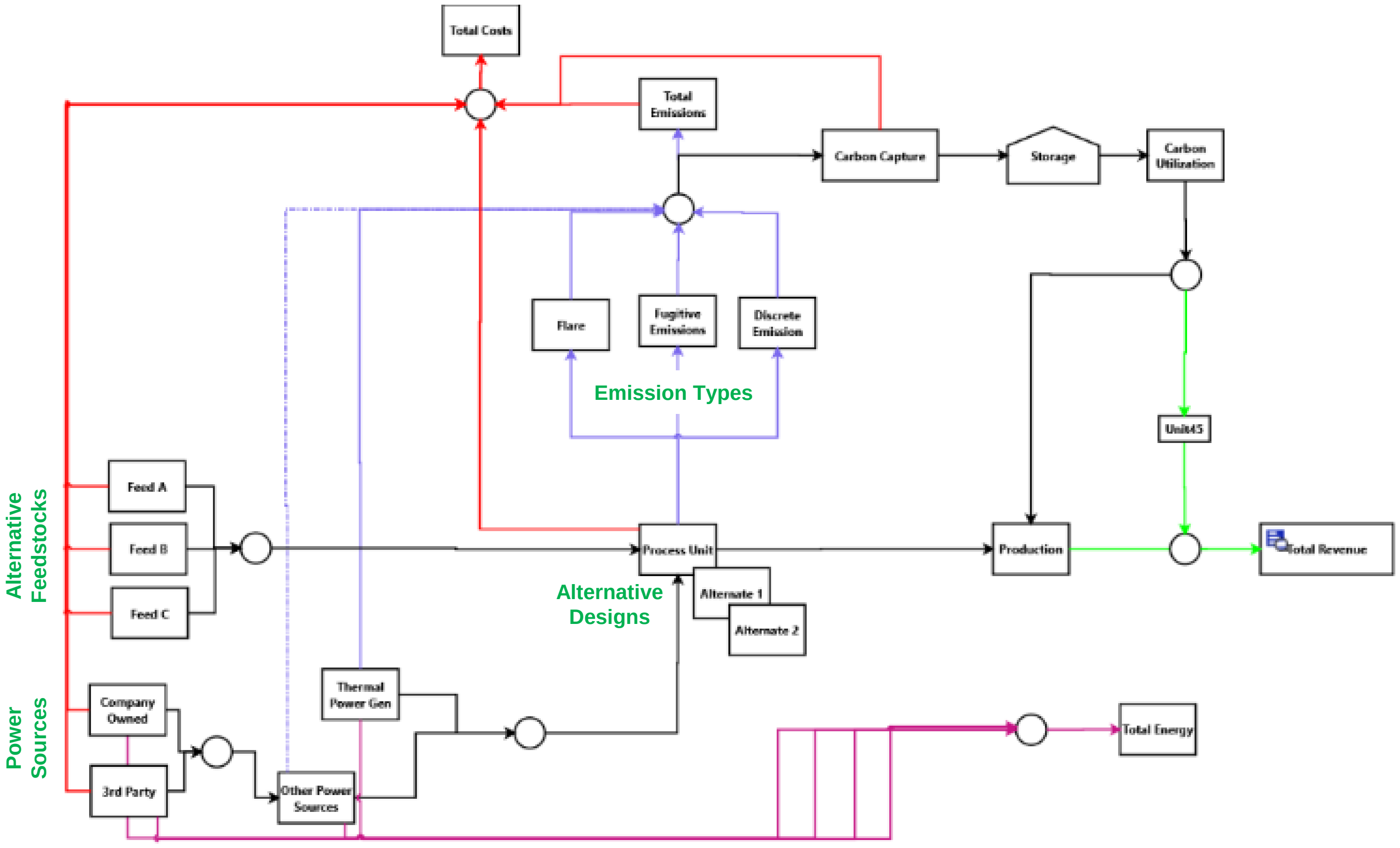
After MACC, What Next?

- MACC ranks which projects should be pursued, but does NOT
  - Define the sequence of projects
  - Consider credit overlaps between projects
  - Evaluate technology options
  - Consider budgets and corporate constraints
  - Ensure meeting emissions reduction timelines
  - Evaluate risks or probabilities
- Strategic Planning Tools
  - Holistic approach to business performance
  - Quantifies expected (probabilistic) value of improvement projects
  - Uses simulation to quantify contribution to non-performance
    - Impacts on revenue, production, emissions, energy use



Uncertainty in Sustainability Solutions

- **Availability of Process Technology – Timing**
- **Efficacy of Technology – Yield (actual reduction of emissions vs. advertised)**
- **Reliability of Technology – more frequent maintenance - MTTF? Longer repair times - MTTR?**
- **Supply Chain Uncertainty (feedstock type, quality, availability)**
- **Power Sources (type – green? Blue?), timing, availability, storage needed?**
- **Costs – process tech, power, capital**
- **Regulatory – Emission limit changes**
- **Carbon Tax/Credit Issues – timing, magnitude**
- **Climate – affect on energy needs, power sources, prices, demands, etc.**
- **Feed & Product Pricing – Demand variations, feed availability**
- **Other – COVID type impacts**



Choosing The Most Cost Effective Investments To Increase Availability

Operational Challenges

- Chemical and Refining Plants have highly varying feedstocks, hydrogen demand and product quality
- High profitability means large incentives for highly reliable plants
- Complex designs makes investment decisions complicated

Value Improvement Practice

Scenario based modeling which explicitly considers uncertainty

- Understand The *Entire* System – Holistic, Interdependent Model
- Reduce Risk on All Decisions – All Uncertainties Included
- Prioritize CAPEX / OPEX spending – Quantify ROI for all options
- Continuous Improvement of System over the Entire Life-Cycle
- Most Accurate Predictions of Future Performance - Confidence

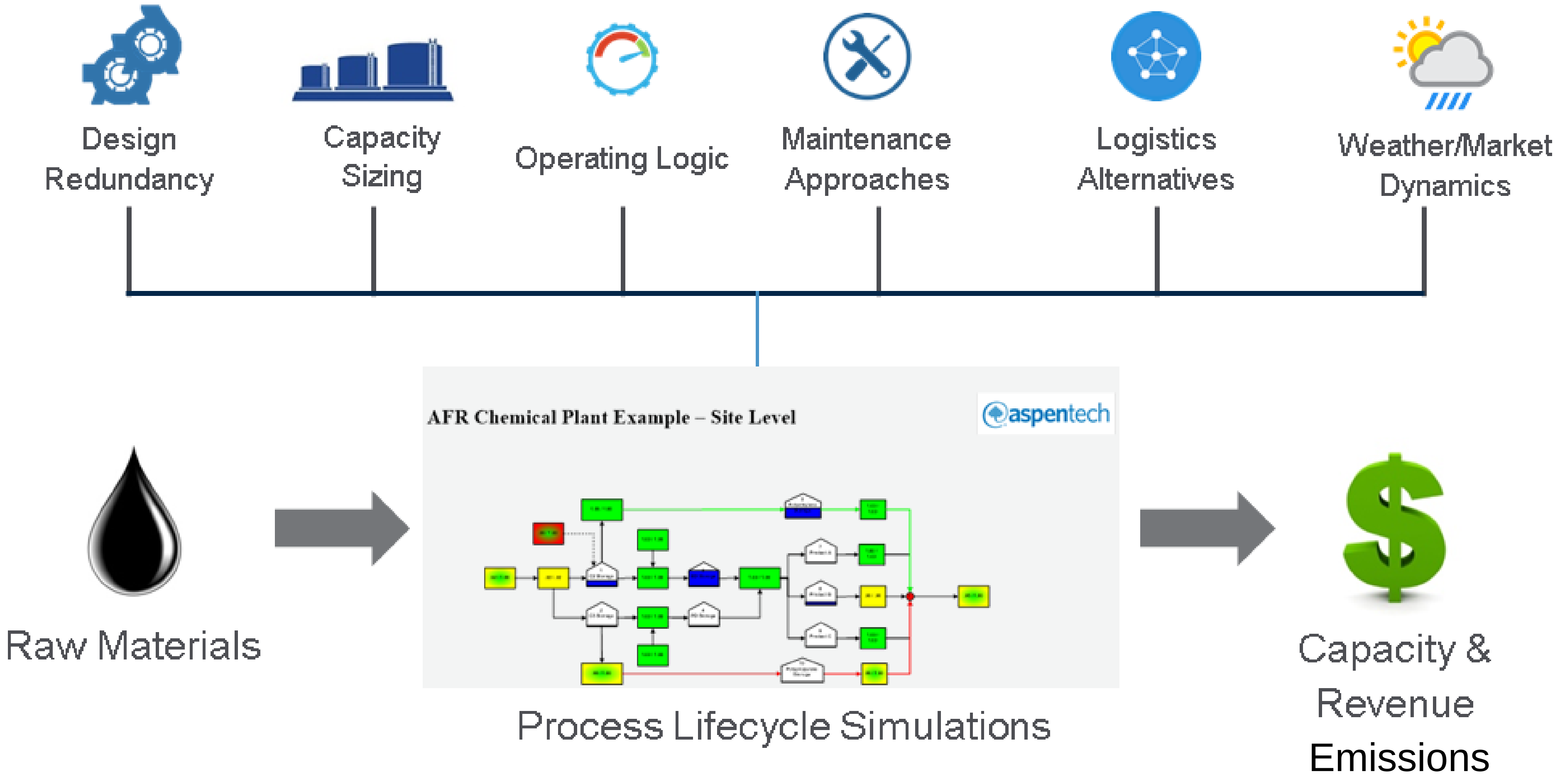
Impact on Operations

Enabling the best data driven decisions to mitigate cost and risk

100 + **Plants modelled**

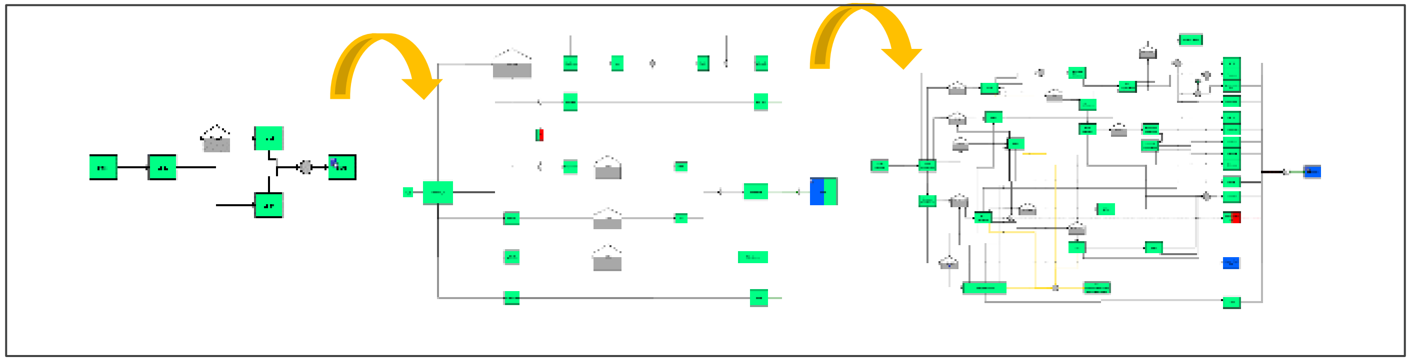
$20 M **Typical Benefits from optimized capital expenditures**

Modeling Emissions and Uncertainty



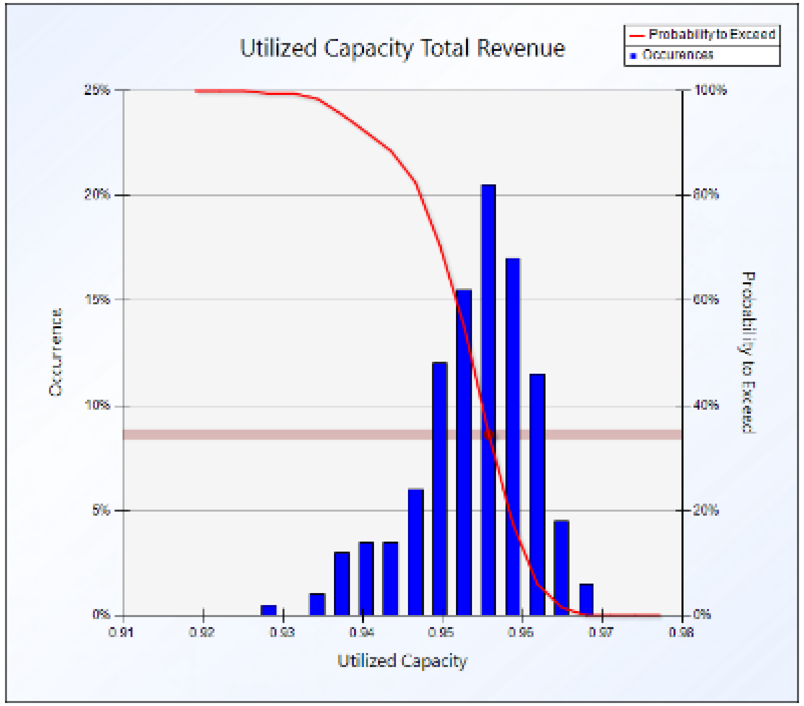
Sustainability Program Evaluation Software

- Discrete event simulation
- Models include probabilistic events such as equipment failures
- Models evaluate future scenarios, dates and durations such as new investment commissioning
- Typical single model run is over an extended calendar, i.e. 10 years; alternately to 2050
- Uses Monte Carlo simulation
  - Random probability generator sets probabilities for each case
  - Run thousands of cases with random probabilities
  - Produces probability distribution of likely outcomes



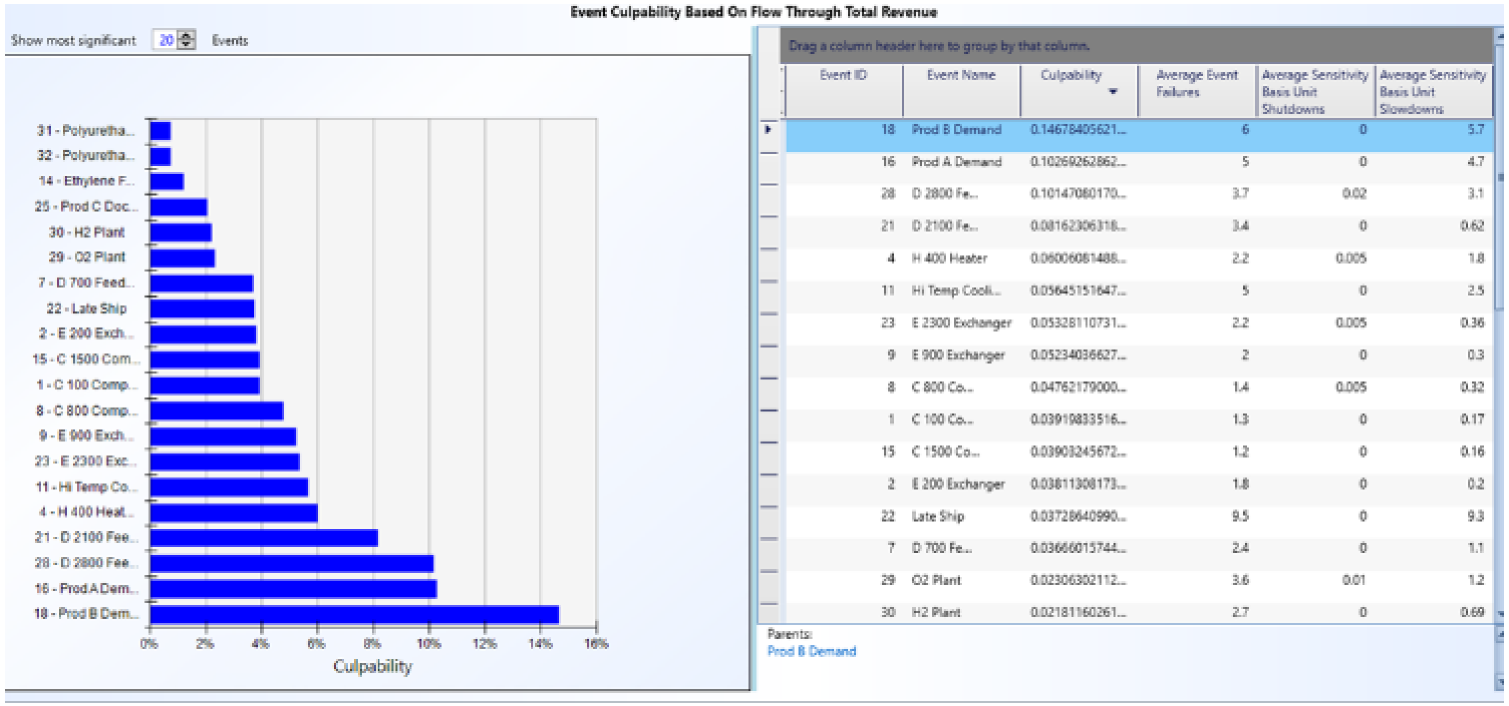
Probabilistic Performance – What the Future Likely Looks Like

Probability to Exceed Histogram



What is the probability that the specified plant design will meet the utilization and emissions targets?

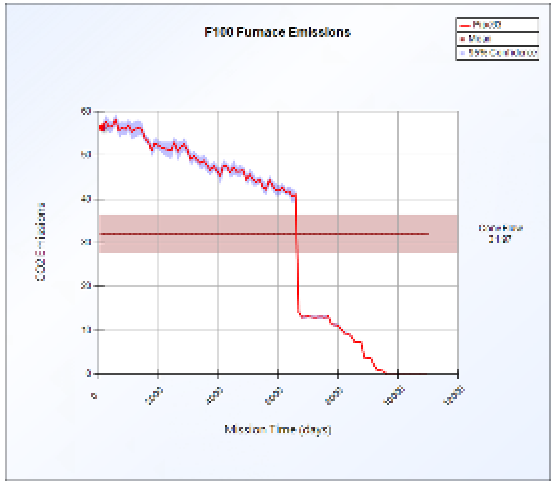
System Culpabilities Histogram

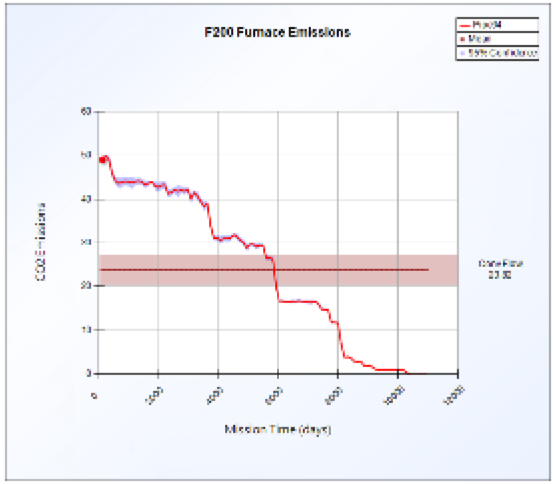


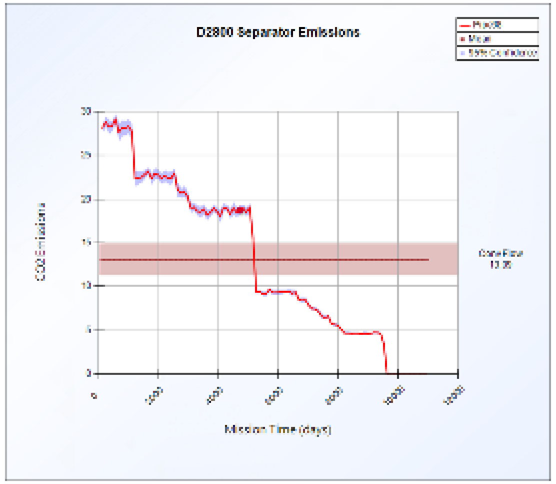
Event ID	Event Name	Culpability	Average Event Failures	Average Sensitivity Basis Unit Shutdowns	Average Sensitivity Basis Unit Slowdowns
18	Prod B Demand	0.14678405621...	6	0	5.7
16	Prod A Demand	0.10269262862...	5	0	4.7
28	D 2800 Fe...	0.10147080170...	3.7	0.02	3.1
21	D 2100 Fe...	0.08162306318...	3.4	0	0.62
4	H 400 Heater	0.06006081488...	2.2	0.005	1.8
11	Hi Temp Cooli...	0.05645151647...	5	0	2.5
23	E 2300 Exchanger	0.05328110731...	2.2	0.005	0.36
9	E 900 Exchanger	0.05234036627...	2	0	0.3
8	C 800 Co...	0.04762179000...	1.4	0.005	0.32
1	C 100 Co...	0.03919833516...	1.3	0	0.17
15	C 1500 Co...	0.03903245672...	1.2	0	0.16
2	E 200 Exchanger	0.03811308173...	1.8	0	0.2
22	Late Ship	0.03728640990...	9.5	0	9.3
7	D 700 Fe...	0.03666015744...	2.4	0	1.1
29	O2 Plant	0.02306302112...	3.6	0.01	1.2
30	H2 Plant	0.02181160261...	2.7	0	0.69

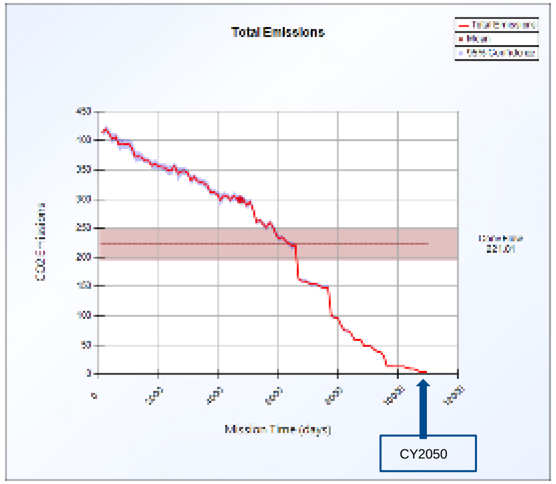
Which systems or equipment is responsible for most of the emissions over time?

Defining the Path to Short Term and 2050 Goals









Deploy various options on similar equipment

F1 Furnace Plan
- Series of small investments
- Followed by a major capital project

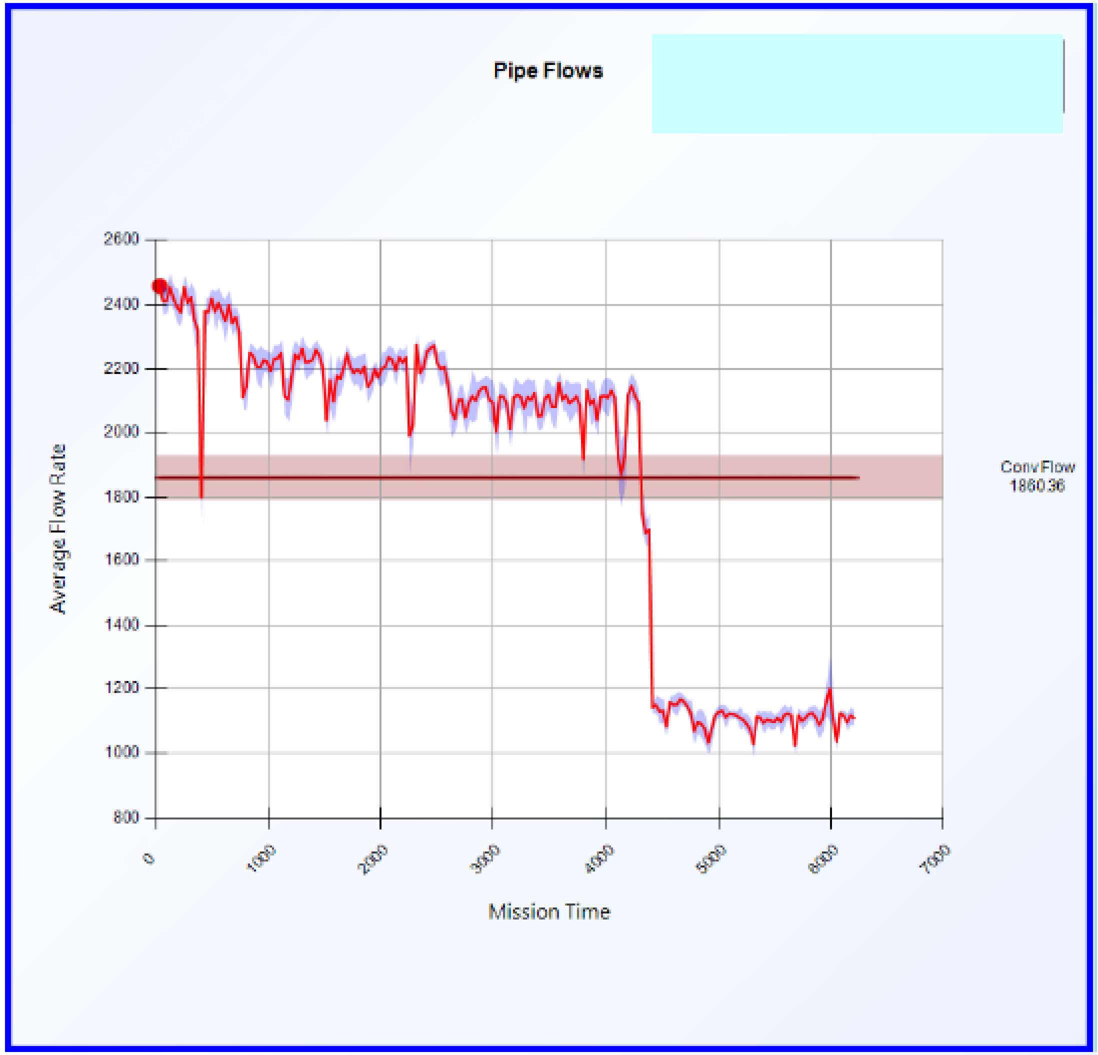
F2 Furnace Plan
- Small capital projects combined with small wins

Combined Equipment Plans
- Small wins combined with capital projects

Total Emissions Reduction Plan
- Short Term goals
- Long Term goals
- Sum of the Individual Plans (i.e., supply chain or equipment plans)

Continuously validate and improve the model and plan based on results and emerging technologies

Site Probability Weighted Overall Projected CO_2 Emissions

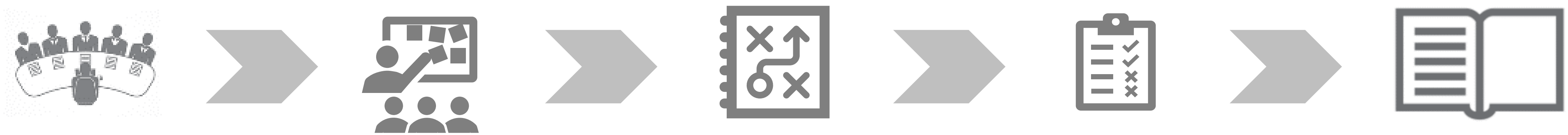


What Is The Next step?

What Is The Next Step? – Sustainability Assessment Workshop

- **Structured COLLABORATIVE process to build consensus on top priorities and sustainability impact**
- **Engagement from multiple disciplines at the plant and headquarters**

Through a collaborative approach, we help our customers develop their Roadmap and Marginal Abatement Cost Curve (MACC) for low carbon transition



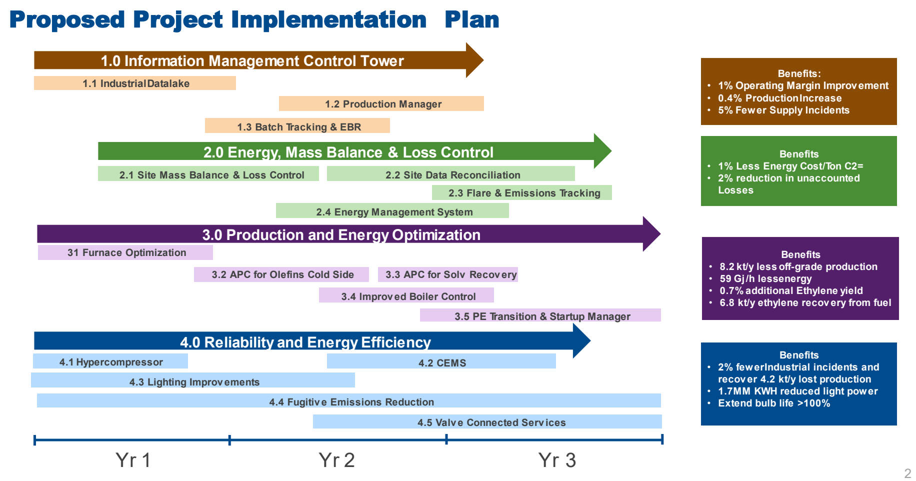
Executive Meeting

Workshop

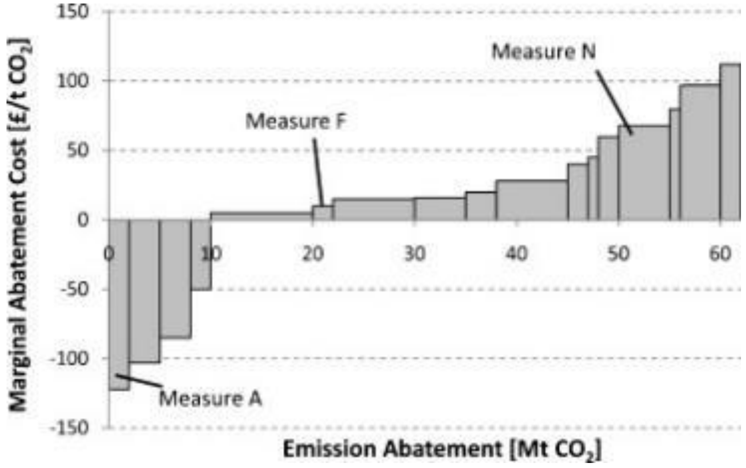
3-5 yr Roadmap

On-Site Global Assessment

Proposals for MACC Analysis



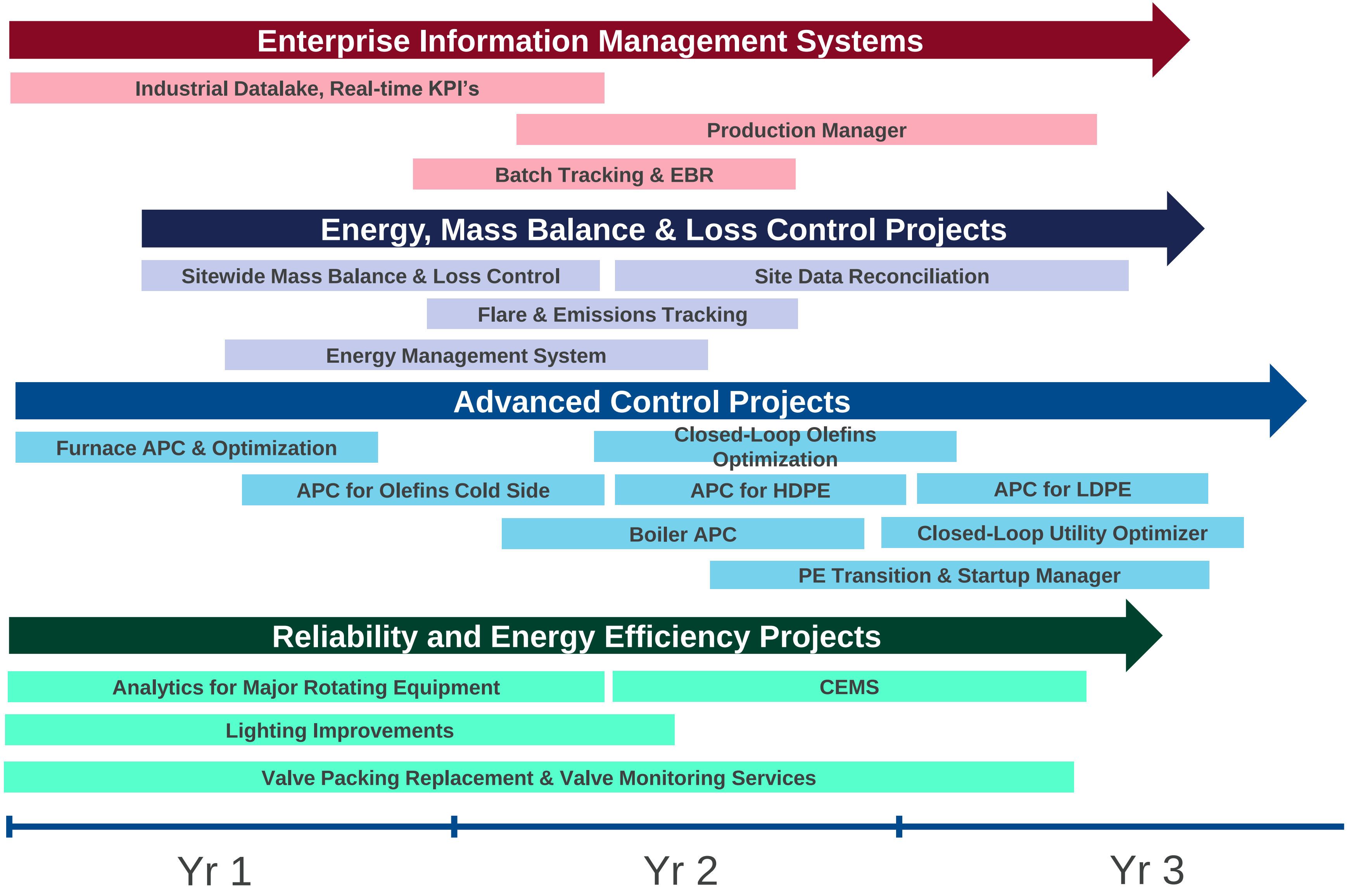
3-5yr Enabling Technology Roadmap



Source: ScienceDirect

Marginal Abatement Cost Curve (MACC)

Example Sustainability and Operational Efficiency Program



Benefits
- 1-2% Operating Margin Improvement
- Improved Customer Service
- Improved Supply Chain Capacity

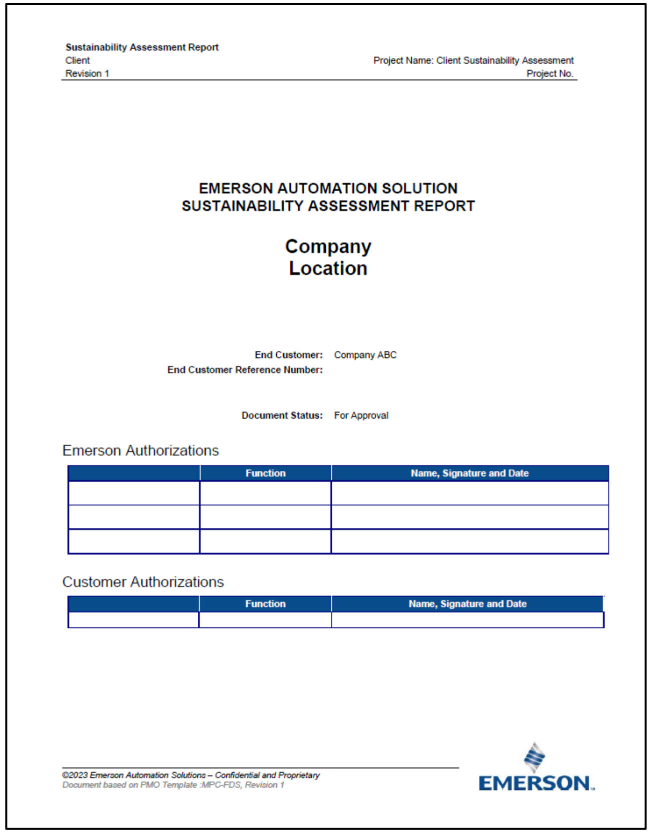
Benefits
- 1-2% Less Energy Cost And Emission/Ton Ethylene & PE
- <1.5% Unaccounted Losses

Benefits
- 3-8% More Production
- 3-5% Utilities Cost And Emission Reduction
- Increase Average Furnace Yield 0.25-0.5%
- 10% Reduced Transition And Startup Material

Benefits
- Reduced Compressor Maintenance Cost 3-5%
- 40% Reduction In Valve Stem Emissions
- 60% Reduction In Lighting Costs And Associated Emissions

Typical Result - Investment Options Evaluation

Preferred sequence of projects, expected costs and expected emission reduction per date


Sustainability Assessment Report
Client
Revision 1

Project Name: Client Sustainability Assessment
Project No.

EMERSON AUTOMATION SOLUTION
SUSTAINABILITY ASSESSMENT REPORT

Company
Location

End Customer: Company ABC
End Customer Reference Number:

Document Status: For Approval

Emerson Authorizations

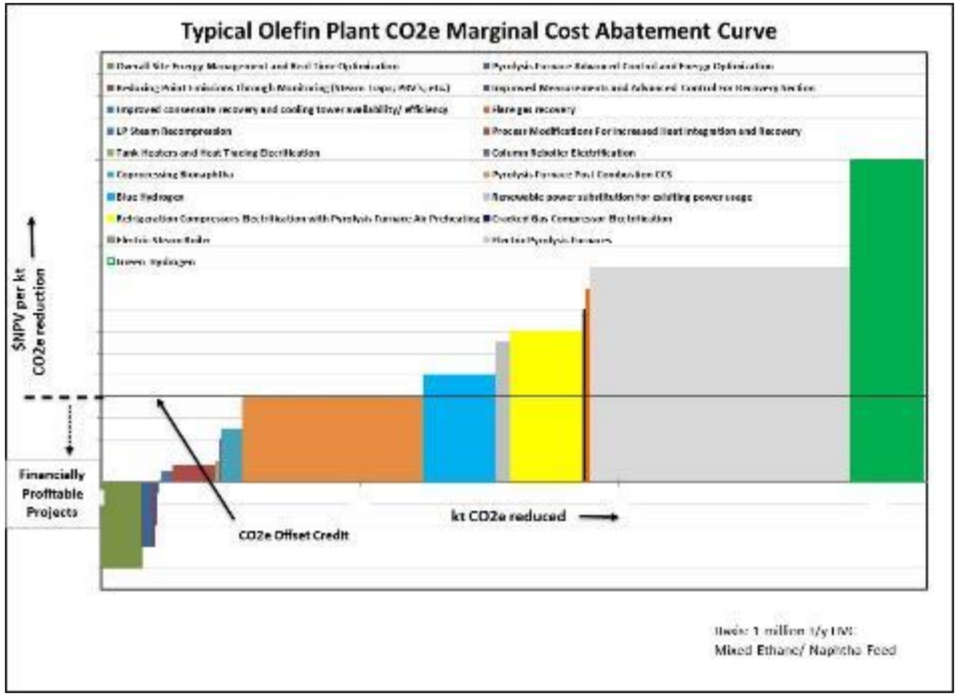
	Function	Name, Signature and Date

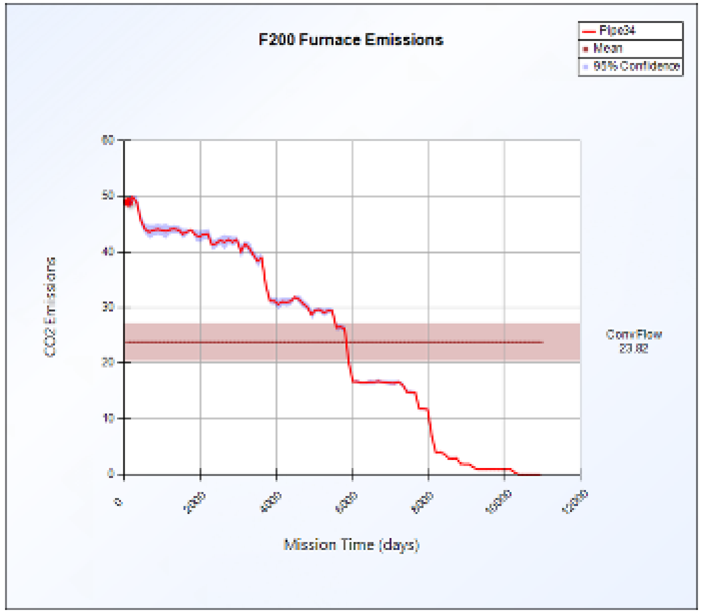
Customer Authorizations

	Function	Name, Signature and Date

©2023 Emerson Automation Solutions – Confidential and Proprietary
Document based on PMO Template :MPC-FDS, Revision 1

EMERSON.





Summary

- Sustainability investments in the chemical and refining industry are very important..
- Choosing the correct set of investments is complex.

ENERGY EFFICIENCY | **CARBON CAPTURE** | **HYDROGEN FUEL** | **BIO BASED FEEDSTOCKS** | **RENEWABLE POWER** | **EMISSIONS MANAGEMENT**

- Next Steps

PATHWAY PRIORITIZATION
Prioritize high impact technology pathway opportunities supporting emission reductions

VALUE ASSESSMENT
Assess current status and deliver a plan focused on meeting sustainability goals with minimum capital investment

Thank You

Questions?

doug.white@emerson.com

EMERSON