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Calculating Sustainability Benefits of AI

A Discussion plus Case Study

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Agenda

AI at AVEVA

AVEVA Predictive Analytics & sustainability

Benefit capture methodology

Case study – Formosa Petrochemical Corporation (FPCC)

The next steps

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AI at AVEVA

The ‘5 Ps’ of artificial intelligence infusion

Artificial intelligence infused

Across AVEVA's broad product portfolio

Predictive

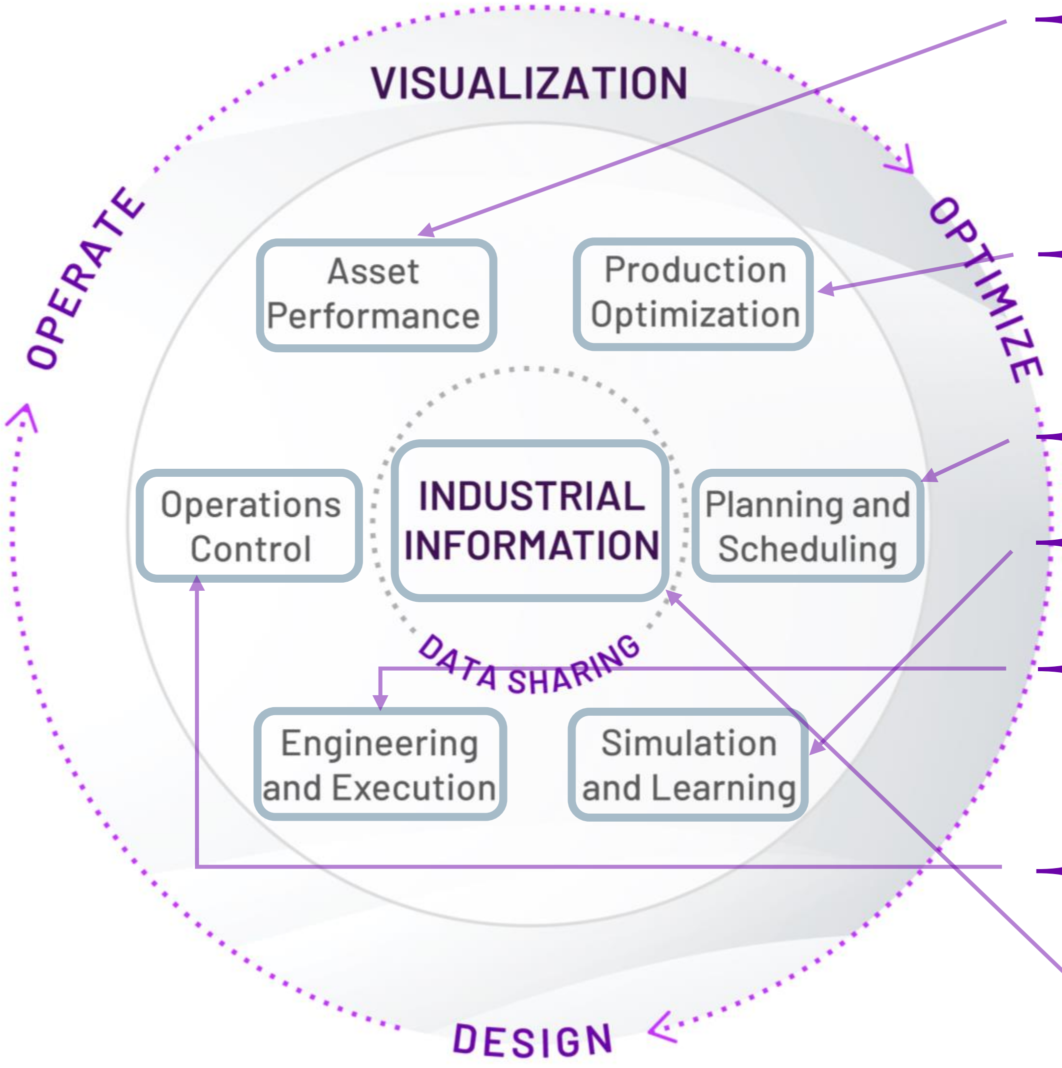
Performance

Prescriptive

Prognostic

Perceptive

17 commercially released AI products

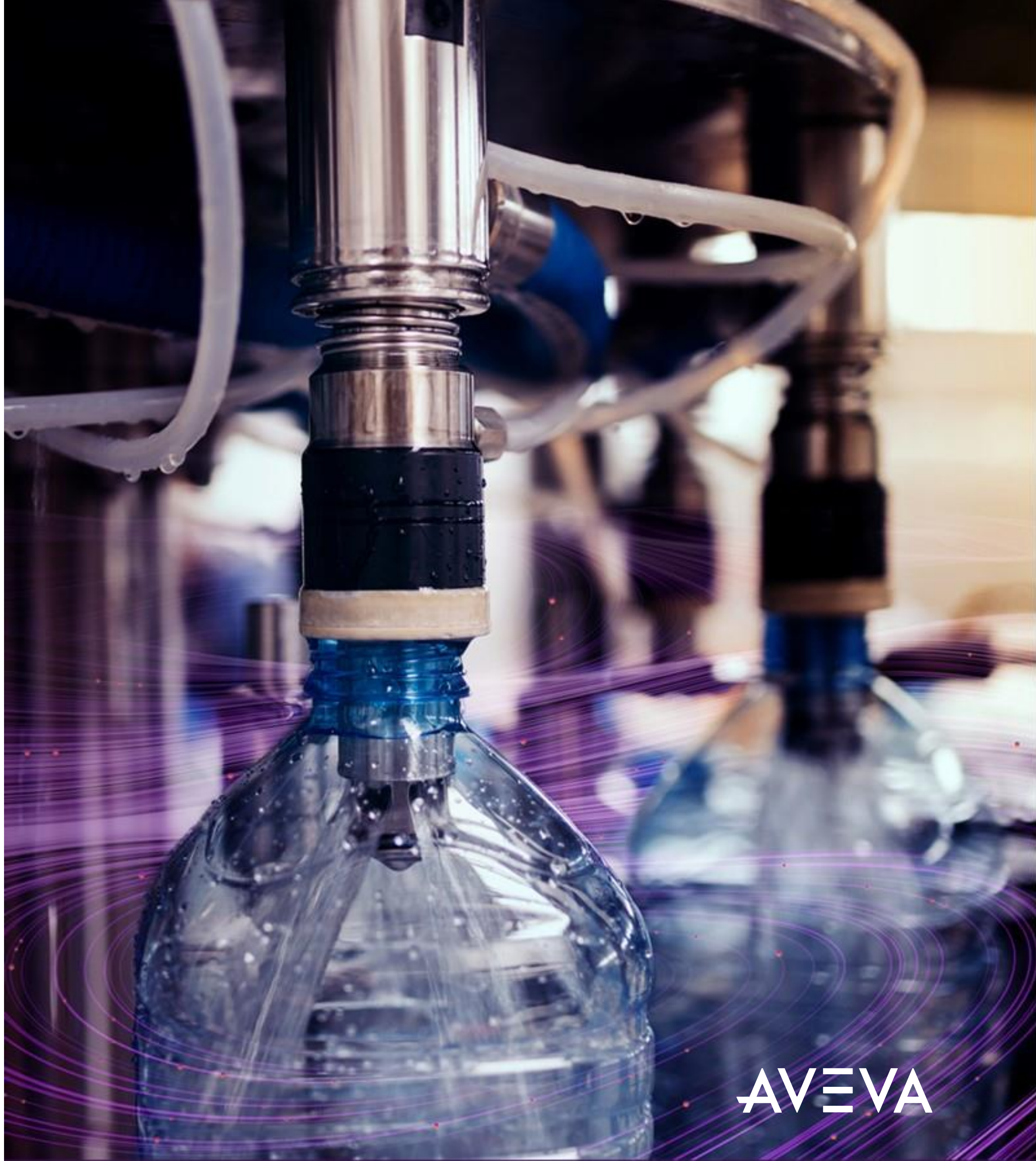


- Automated Analytics
- Guided Analytics
- Predictive Analytics/Maintenance
- Asset Prescriptive Analytics
- Process Optimization
- Predictive Quality/Throughput (batch)
- Remaining Useful Life Estimation (RULE)
- Predictive Asset Optimization (PAO)
- Schedule AI Assistant
- Realtime Crude
- AI-infused Process Simulation
- AI-infused Dynamic Simulation
- E3D Whitespace Optimizer
- E3D Suggestive Design Framework
- Point Cloud Manager
- Advanced Process Control (APC)
- InSight OMI App (native integration with System Platform SCADA)
- AI inferencing
- Vision AI Assistant
- Knowledge Linking

AI-driven sustainability

- Increase operational & energy efficiency
- Reduce carbon-based industrial waste
- Identify and improve underperforming assets

Sustainability and Profitability are not opposing forces



CASE STUDY

AVEVA Predictive Analytics & sustainability

Proven tool – new dialogue

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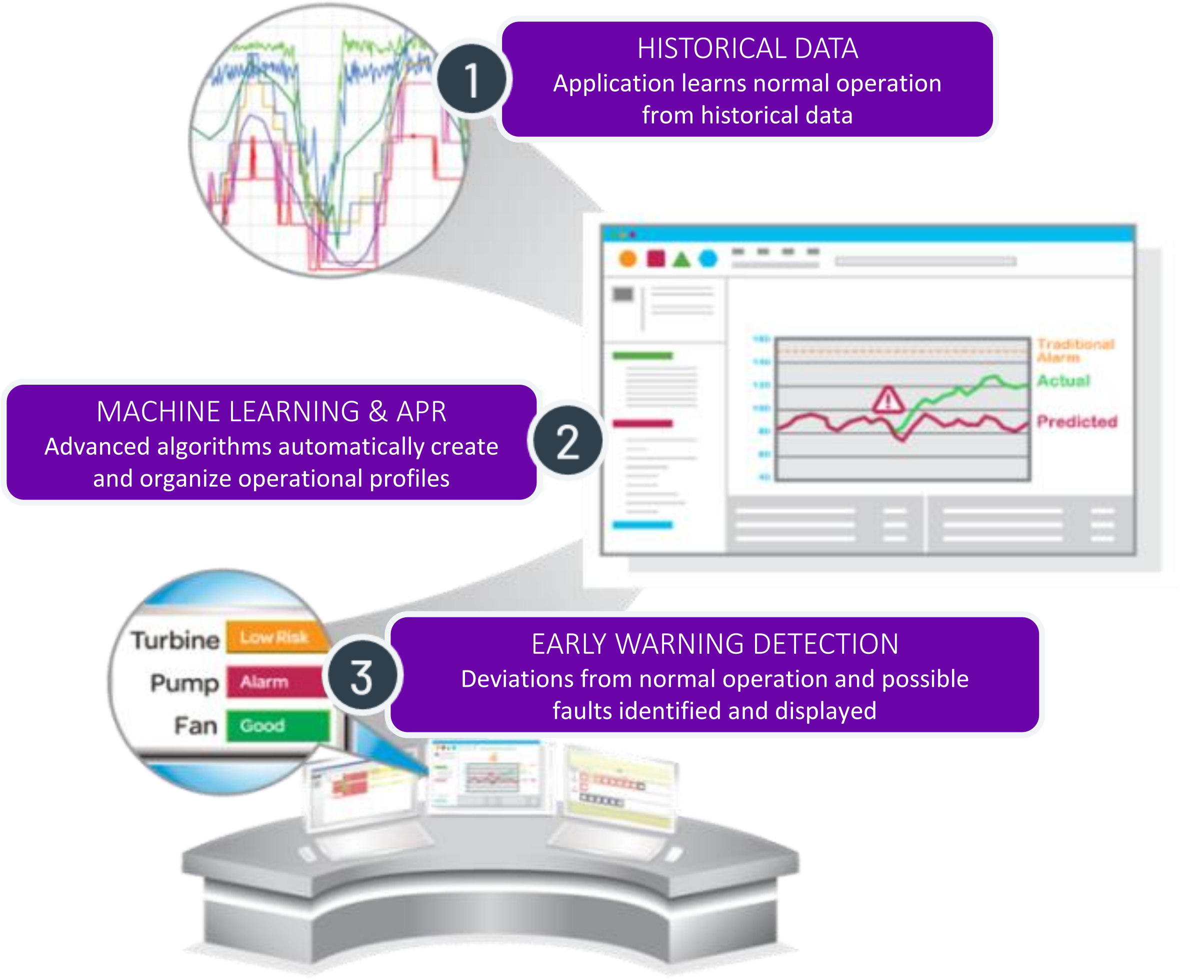
AVEVA Predictive Analytics

How does it work?

- Uses historical data to describe how a piece of equipment normally operates and build a model (*patented AI algorithm for optimized results*)
- Continuously monitors behavior in real-time
- Alerts when the operation differs from the historical norm
- Early warning detection of equipment problems
- Advanced analysis capabilities including problem identification and root cause analysis



Benefits of Predictive Analytics program for OEE/maintenance

OEE / PERFORMANCE

- Energy per product optimized at constant capacity
- Waste reduction through quality improvement
- Rework rate optimization
- Inventory improvement

RELIABILITY / FAILURE RATE

- Energy per product optimized at constant capacity
- Scrap rate improvement linked to:
  - Reduction of amount of material used during breakdown of the system
  - Spare parts reduction
- Inventory improvement

SCRAP RATE / YIELD

- Material reduction
- Water savings due to scrap reduction
- Energy savings due to scrap reduction
- Defect reduction on customer side
- Inventory improvement

Sustainability KPIs for AVEVA Predictive Analytics

Measuring the impacts in areas other than profitability/loss

What are we measuring?	How do we measure?
Power Usage (kWh)	Power expended in Startup activities; Power utilized in repairs; Power utilized in Maintenance activities/travel
Materials (kg)	Maintenance material usage/scrap loss that can not be recycled; Material connected to Spare Parts replacement
Water Use (m3)	Water used in flushing activities, equipment refill, etc.
Greenhouse Gases (tCO2e)	Emissions due to malfunction/restart/replacement power

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Benefit capture methodology

Proven method – new ‘currency’

An older method, a newer application

EPRI Report 1004015 (November 2001) is our Guide Map

EPRI

Guideline on Proactive Maintenance

Technical Report

B

COST BENEFIT CALCULATION

Occurrence Assumption Worksheet				
Plant Name:	Waukegan Sta. 16	Unit Number:	7	
Definition of detected fault:	#7 Main Transformer, B phase bushing significantly hotter than adjacent phases			
Occurrence No.:	WAK-008	Max. Rated Load:	353	
Occurence Assumption:	**(a)Catastr.**	**(b)Moderate**	**(c)Loss of Perf.**	**(d)Actual**
Occurrence Description	Transformer destroyed, forced	Bushing failure, transformer		Bushing replaced.
Loss of Generating Revenue				
Power Reduction (MW)	353	353	0	353
Hours	3456	100	0	48
Capacity Factor (%)	60	60	0	
Forced Outage (Yes =1 No =0)	1	1	0	0
Maintenance Costs				
Cost of Parts ($)	$1,250,000	$20,000	0	2000
Labor Hours (Hrs)	2160	1008	0	72
Percent Probability of Fault Occurrence	10	90		

Definitions:
OCCURRENCE - any detected or diagnosed fault which the station takes action, whether the action was proactive or reactive.
When the station schedules repairs or modifies plant operation to minimize the fault's impact, a cost benefit analysis will be conducted.
If maintenance is deferred based on a PDM technology, the CBA, based on the deferral, will be calculated on the time-value of $$$ saved.
CATASTROPHIC - Total equipment failure requiring full repalcement.
MODERATE - System failure resulting in some repairable equipment damage.
LOSS OF PERFORMANCE - Reduction of operating capacity due to fault.
ACTUAL - Actual cost of outage.

			Input Data
	Calculated Values		
Total Cost Benefit - This Occurrence	$855,637	Average Replacement Power	9
Maintenance Costs Savings ($):	$177,792	Costs ($/MWH)=	
Impact on EFOR (%):	4.97		
		Average Labor Rate ($/HR) =	35

Figure B-1
Cost benefit calculation example

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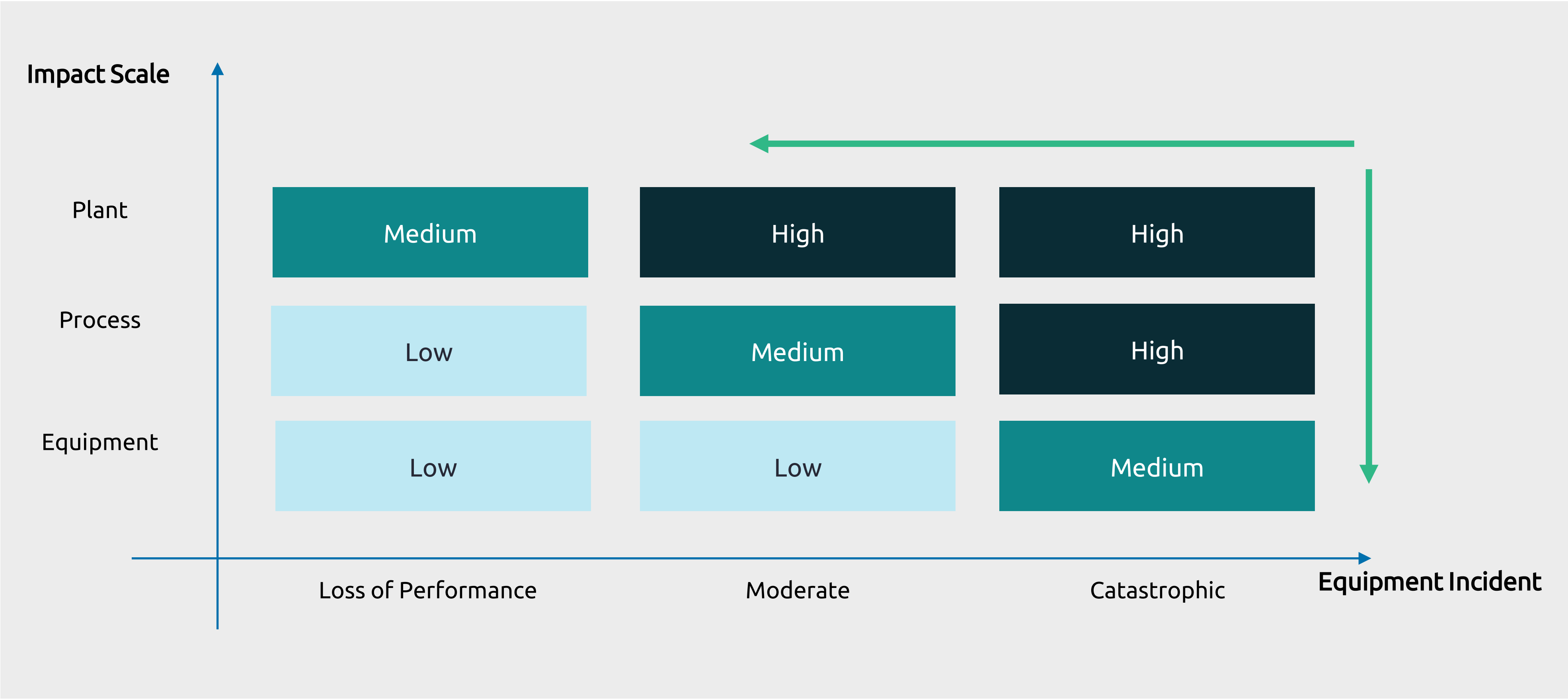
Converting EPRI cost calculation to sustainability KPIs

SUSTAINABILITY KPIS	SUSTAINABLE VALUATION FORMULA
GHG EMISSIONS Overall & per unit produced	**Scope 1 GHG emissions reduction[1] + scope 2 GHG emissions reduction[2] + scope 3 upstream GHG emissions reduction[3]** [1]Scope 1 GHG emissions = core process + by-process direct GHG emissions [2]Scope 2 GHG emissions = energy related emission = energy consumption x energy CO_2 footprint [3]Scope 3 upstream GHG emissions = quantity of feedstock x feedstock upstream CO_2 footprint
ENERGY Overall & per unit produced	**Utilities direct consumption reduction in core process (electricity…) + by-process utility consumption reduction**
MATERIALS Overall & per unit produced	**Reduced scrap amount per unit produced x number of units produced + reduced amount of not qualified units**
WATER Overall & per unit produced	**Water consumption reduction in core process + water consumption reduction in by-process**

AVEVA sustainability impact analysis for Predictive Analytics



Energy

Material (Feed, Product, Waste)

Water

Emission (Scope 1, 2, 3)

Calculated outcomes

Sustainability KPI	Type of incident		
	High	Medium	Low
Energy cost	**… kWh**	**… kWh**	**… kWh**
Energy for Shutdown & Restart Energy needed to shut down the plant/process/equipment if a failure arises and energy needed to restart the plant/process/equipment after maintenance actions	… kWh	… kWh	… kWh
Energy required for Maintenance team transportation As the maintenance team goes back and forth between the plant and home, energy is consumed in the form of gasoline to travel. To calculate it: • Average distance travelled by the maintenance team • Maintenance work duration	… km … hours	… km … hours	… km … hours
Energy used for Maintenance equipments Specific equipment such as welding station or crane may be used to carry out maintenance, hence consuming energy. To calculate it: • Power consumption of the equipment (welding station, crane, etc.) used for maintenance • Duration of use of the equipment	… kW … hours	… kW … hours	… kW … hours
Material cost	**…kg**	**…kg**	**…kg**
Spare parts It accounts for the new spare parts used to fix the equipment(s) and for the defective parts that have been replaced	… kg	… kg	… kg
Maintenance scrap As maintenance implies a shutdown of the equipment, work-in-progess material may be wasted (at process-level)	… kg	… kg	… kg
Water cost	**… m^3**	**… m^3**	**… m^3**
Flushing water Water used to clean plant/process/equipment during incidents	… m^3	… m^3	… m^3
Other maintenance water Water consumed during maintenance that is not flushing water (for eg, to cool down an equipment)	… m^3	… m^3	… m^3
GHG Emissions (direct & indirect)	**… tCO_2e**	**… tCO_2e**	**… tCO_2e**
Emissions directly released Direct emissions that occur because of the incident ((for eg, flared gas)	… tCO_2e	… tCO_2e	… tCO_2e
Emissions due to energy consumption Indirect emissions related to energy consumed during maintenance during (for eg, electricity or gasoil to fuel maintenance equipment)	Calculated	Calculated	Calculated
Upstream emissions from material consumption Emissions linked to the material cost. It accounts for the emissions due to production, transportation, etc. of material	Calculated	Calculated	Calculated

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Case study –
Formosa Petrochemical Company

Formosa Plastics Group

Founded in 1954, FPG aims for creating diversified and globalized enterprises

$29bn	$143bn	$87bn
Total Capital	Total Assets	Total Sales

Source: Website of Company Overview (Link)

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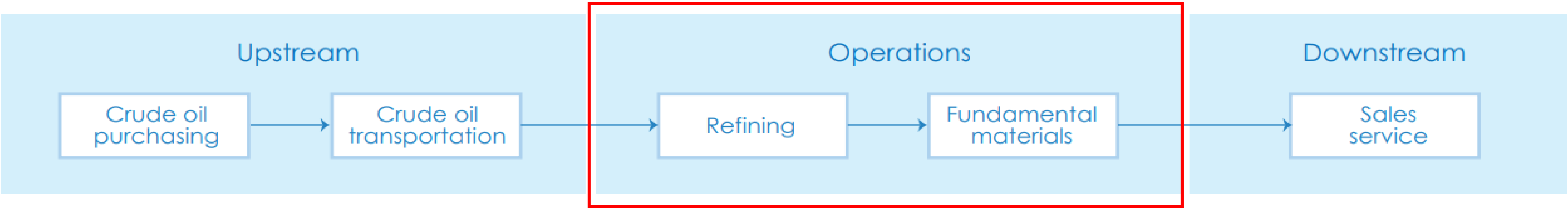
Formosa Petrochemical (FPCC) Key Business Overview

台塑企業
FORMOSA PLASTICS GROUP

FPCC refined crude oil to produce aromatics and olefins for downstream businesses



Refined Crude Oil
540,000
barrels per day

Ethylene Production
2,935
thousand tons per year

Power Production
2.75
GW

NOTE:
1. Source: Website of Company Overview (Link) , and Formosa Petrochemical Corporation Sustainability Report 2021, Link

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We developed the roadmap to carbon neutrality

2025

Target emissions (10,000 tons)

2,467

↓22%

Action Plans

1. Energy conservation and carbon reduction improvement measures
2. Establish and develop renewable energy, such as solar power and wind power
3. Replace coal with refuse derived fuel for mass burning in boilers

2030

Target emissions (10,000 tons)

2,271

↓28%

Action Plans

1. Reduce the amount of electricity purchased from Taiwan Power Company
2. Process technology optimization and improvement
3. Evaluate using biomass fuel to replace 5% of coal consumption by coal-fired power plants

2050

Target emissions (10,000 tons)

Carbon neutrality

Action Plans

1. Evaluate energy transition
2. Evaluate recycling and reuse of waste oil and plastic
3. Evaluate the development of energy storage systems, hydrogen power industry, ammonia industry, high quality, and investment in innovative industries
4. Evaluate the adoption of CCS technology

SOURCE: Formosa Petrochemical Corporation Sustainability Report 2021, Link

We invested in smart solution and AI is critical element

Smart Factory

66ktCO2e/year

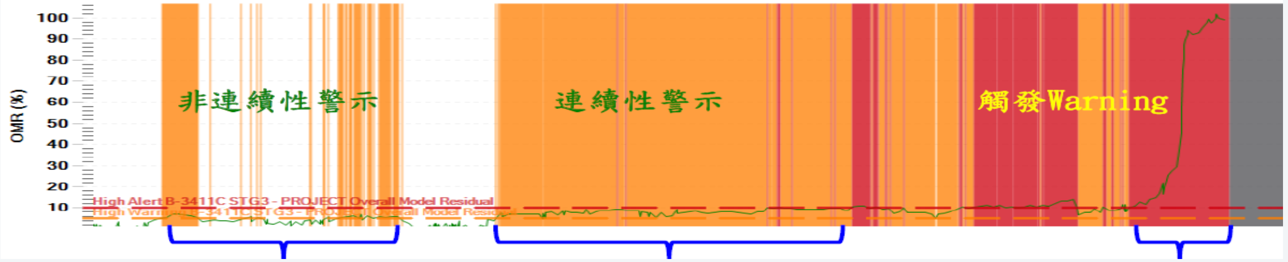
By 2021 through AI Projects

98ktCO2e/year

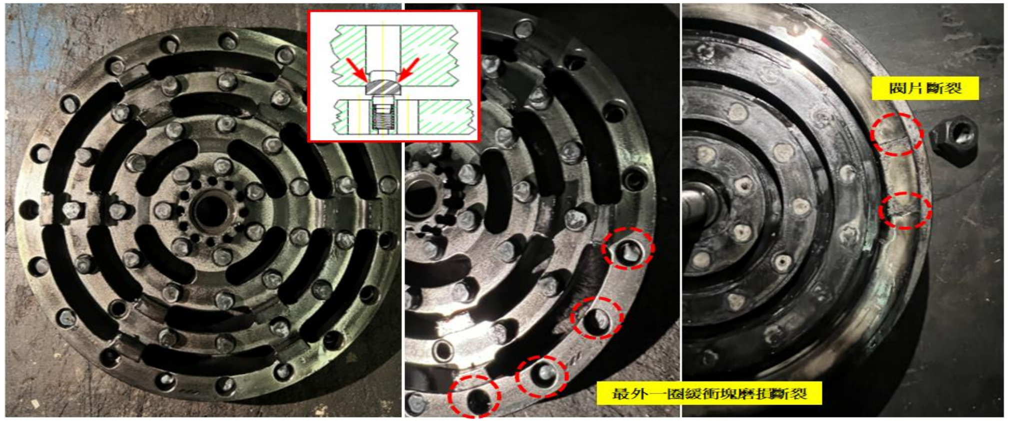
Mid-term target

Case Study: Early catch of compressor sealing breakage

AI – Predictive Compressor Monitoring



Day 1 3 am – 9 am	Day 1 12 pm – 9 pm	Day 2 7am – 9 am
Compressor scattered alert signal recognized by software, high alarm not reached in control system	Compressor continuous alert signal recognized by software	Compressor warning generated by software

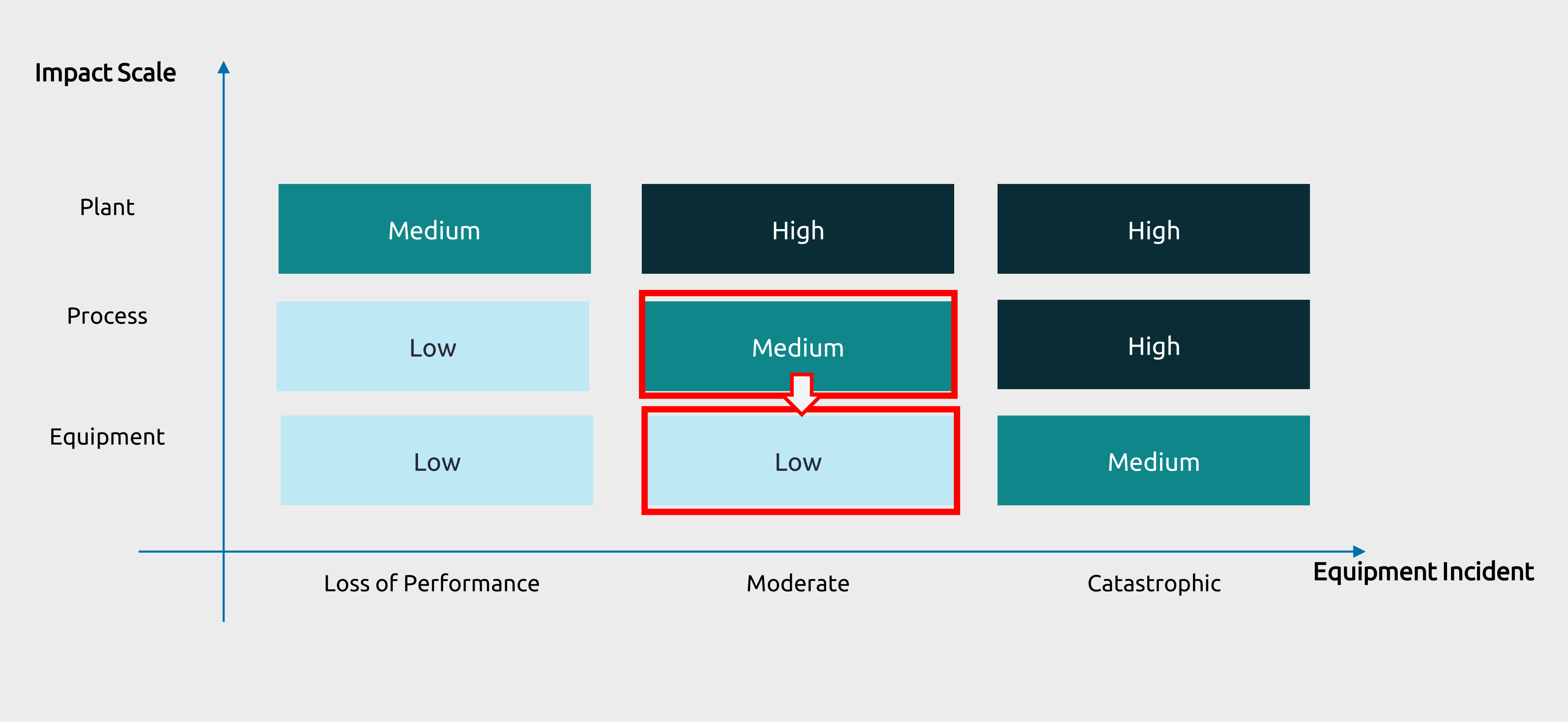


Avoid process hydrogen flaring & spare parts scrap
Equivalent to ~199t/yr tCO2e saving

SOURCE: Unveling Impact: How Industrial Software Advances Net-Zero Ambitions, Link

A medium-level impact was mitigated to low-level impact

Avoid compressor trip and more severe damage to the equipment & equipment



Impact Calculation Inputs

Parameter	Units	Medium	Low
Shutdown & Restart			
Power of equipments for shutdown/restart	horsepower	15000	15000
Shutdown/Startup Unusual Operation Time	hours	0	0.5
Maintenance team			
Average distance travelled by the maintenance team between plant and home	km	10	10
Daily Travel Frequency	#	2	2
Maintenance work duration	days	1	1
Number of workers	#		
Maintenance equipments			
Power consumption	kW	3.5	3.5
Duration of use	hours	3	3
Materials			
Nitrogen consumption	ton	1	1
Spare parts	kg	24	12
Equipment scrap	kg	24	12
Process scrap (hydrogen purge/flare)	ton	4.067	0.067

Calculation Parameters and Emission Factors

Category	Plant	Unit	Value
Time	Numbers of hours / year	h	8,760
Conversion	Power of 1 hp (horsepower) in kW	kW	0.75
Emission factors	Electricity mix footprint (Taiwan)	kg_CO2eq/kWh	0.84
	Gas oil footprint	kg_CO2eq/L	3.10
	Footprint of plastics supply	kg_CO2eq/kg	2.35
	Footprint of plastics incineration	kg_CO2eq/kg	2.178
	Footprint of hydrogen	kg_CO2eq/kg	0
	Footprint of production of hydrogen (SMR)	kg_CO2eq/kg	11.10
	Emission factor of a van	kg_CO2eq/km	0.55
	Footprint of nitrogen (production & distribution)	kg_CO2eq/kg	0.08
Gasoil data	Gasoil enrgy mass density	GJ / t	42.60
	Gasoil mass density	kg/m3	832.00
	Gasoil consumption of a VAN	L/km	0.09

Impact Results

Scale up impact to annual results reflecting average frequencies of successful early catches

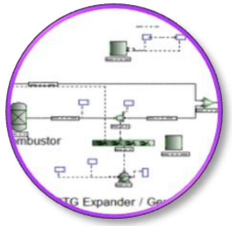
Category	KPIs	Units	Without Predictive Analytics (Baseline)	With Predictive Analytics	
			Mean Value	Mean Value	Delta (absolute)
GHG emissions	Total CO2_eq emissions	t_CO2eq	**226.74**	**28.00**	**-198.74**
	Of which scope 1	t_CO2eq	0.00	0.00	0.00
	Of which scope 2	t_CO2eq	0.04	23.58	23.53
	Of which scope 3 upstream	t_CO2eq	226.70	4.42	-222.27
Energy	Energy consumed	kWh	**52.59**	**28,016.33**	**27963.75**
Material	Total material consumed	kg	**25,575.00**	**5,455.00**	**-20120.00**
	Of which hydrogen	kg	20,335.00	335.00	-20,000.00
	Of which industrial plastics	kg	240.00	120.00	-120.00

FURTHER APPLICATIONS

The next steps

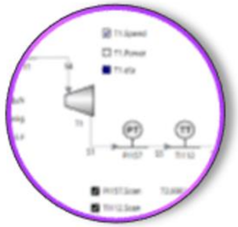
Predictive Asset optimization & beyond

AVEVA Predictive Asset optimization



PAO Performance Optimisation

Real-time **PLANT** end to end rigorous first principles data reconciliation and optimization



PAO Performance Simulation

Real-time **SUB SYSTEM** rigorous first principles data reconciliation

PAO Performance Equations

Real-time **COMPONENT** KPI calculations using thermodynamic properties data

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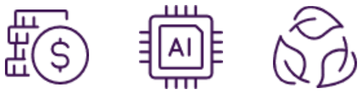
New horizons; same ocean

You are likely further along your journey than you thought…

- For most Industrial Software, the emphasis in the past has been on business impact, based upon effects of this utilization as translated to costs and potential savings - $$$

- The landscape has changed, and now there is a clarion call to also achieve your organization's stated Sustainability Goals. This means new drivers of 'success'

- You need not start at 'zero'. Fortunately, many of the same industrial software tools that you are currently using, and that are being developed with cutting-edge AI features, can be used to help you quantify these new goals.



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Scan QR code for more details in the Report

Interested in participating in an impact analysis?

Please contact sustainability@aveva.com

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Questions?

Please wait for the microphone.

State your name and company.

Please remember to…

Navigate to this session in the mobile app to complete the survey.

Thank you!

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