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
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
Al-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
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

1. **HISTORICAL DATA**
   Application learns normal operation from historical data

2. **MACHINE LEARNING & APR**
   Advanced algorithms automatically create and organize operational profiles

3. **EARLY WARNING DETECTION**
   Deviations from normal operation and possible faults identified and displayed
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

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

Proven method – new ‘currency’
An older method, a newer application

EPRI Report 1004015 (November 2001) is our Guide Map
## Converting EPRI cost calculation to sustainability KPIs

<table>
<thead>
<tr>
<th>SUSTAINABILITY KPIS</th>
<th>SUSTAINABLE VALUATION FORMULA</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>GHG EMISSIONS</strong>&lt;br&gt;Overall &amp; per unit produced</td>
<td>Scope 1 GHG emissions reduction(^1) + scope 2 GHG emissions reduction(^2) + scope 3 upstream GHG emissions reduction(^3)</td>
</tr>
<tr>
<td></td>
<td>(^1)Scope 1 GHG emissions = core process + by-process direct GHG emissions &lt;br&gt;(^2)Scope 2 GHG emissions = energy related emission = energy consumption x energy CO2 footprint &lt;br&gt;(^3)Scope 3 upstream GHG emissions = quantity of feedstock x feedstock upstream CO2 footprint</td>
</tr>
<tr>
<td><strong>ENERGY</strong>&lt;br&gt;Overall &amp; per unit produced</td>
<td>Utilities direct consumption reduction in core process (electricity...) + by-process utility consumption reduction</td>
</tr>
<tr>
<td><strong>MATERIALS</strong>&lt;br&gt;Overall &amp; per unit produced</td>
<td>Reduced scrap amount per unit produced x number of units produced + reduced amount of not qualified units</td>
</tr>
<tr>
<td><strong>WATER</strong>&lt;br&gt;Overall &amp; per unit produced</td>
<td>Water consumption reduction in core process + water consumption reduction in by-process</td>
</tr>
</tbody>
</table>
AVEVA sustainability impact analysis for Predictive Analytics

Impact Scale

Equipment
- Low
- Medium
- High

Process
- Loss of Performance
- Moderate
- Catastrophic

Plant
- Energy
- Material (Feed, Product, Waste)
- Water
- Emission (Scope 1, 2, 3)
Calculated outcomes

<table>
<thead>
<tr>
<th>Sustainability KPI</th>
<th>High</th>
<th>Medium</th>
<th>Low</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy cost</td>
<td>... kWh</td>
<td>... kWh</td>
<td>... kWh</td>
</tr>
<tr>
<td>Energy for Shutdown &amp; Restart</td>
<td>... kWh</td>
<td>... kWh</td>
<td>... kWh</td>
</tr>
<tr>
<td>Energy required for Maintenance team transportation</td>
<td>... km</td>
<td>... km</td>
<td>... km</td>
</tr>
<tr>
<td>Energy used for Maintenance equipments</td>
<td>... hours</td>
<td>... hours</td>
<td>... hours</td>
</tr>
<tr>
<td>Material cost</td>
<td>... kg</td>
<td>... kg</td>
<td>... kg</td>
</tr>
<tr>
<td>Spare parts</td>
<td>... kg</td>
<td>... kg</td>
<td>... kg</td>
</tr>
<tr>
<td>Maintenance scrap</td>
<td>... kg</td>
<td>... kg</td>
<td>... kg</td>
</tr>
<tr>
<td>Water cost</td>
<td>... m³</td>
<td>... m³</td>
<td>... m³</td>
</tr>
<tr>
<td>Flushing water</td>
<td>... m³</td>
<td>... m³</td>
<td>... m³</td>
</tr>
<tr>
<td>Other maintenance water</td>
<td>... m³</td>
<td>... m³</td>
<td>... m³</td>
</tr>
<tr>
<td>GHG Emissions (direct &amp; indirect)</td>
<td>... tCO₂e</td>
<td>... tCO₂e</td>
<td>... tCO₂e</td>
</tr>
<tr>
<td>Emissions directly released</td>
<td>... tCO₂e</td>
<td>... tCO₂e</td>
<td>... tCO₂e</td>
</tr>
<tr>
<td>Emissions due to energy consumption</td>
<td>Calculated</td>
<td>Calculated</td>
<td>Calculated</td>
</tr>
<tr>
<td>Upstream emissions from material consumption</td>
<td>Calculated</td>
<td>Calculated</td>
<td>Calculated</td>
</tr>
</tbody>
</table>
Case study – Formosa Petrochemical Company
Formosa Plastics Group

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

$29_{bn}$
Total Capital

$143_{bn}$
Total Assets

$87_{bn}$
Total Sales

Diversified and Globalized Enterprises

With over 60 years of development, FPG has established a steady base and started to operate diversified and globalized enterprises. Except for our solid strength in petrochemical industry, we also built up a successful development in electronics industry. Looking forward, we embrace the world with roots in Taiwan. Committed to sustainable business development as well as social health and prosperity, we will continue in our work to build a better tomorrow for all.

Source: Website of Company Overview (Link)
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

Day 1
3 am – 9 am
Compressor scattered alert signal recognized by software, high alarm not reached in control system

Day 1
12 pm – 9 pm
Compressor continuous alert signal recognized by software

Day 2
7 am – 9 am
Compressor warning generated by software

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

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

Avoid compressor trip and more severe damage to the equipment & equipment
## Impact Calculation Inputs

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

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

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

<table>
<thead>
<tr>
<th>Category</th>
<th>KPIs</th>
<th>Units</th>
<th>Without Predictive Analytics (Baseline)</th>
<th>With Predictive Analytics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mean Value</td>
<td>Mean Value</td>
</tr>
<tr>
<td>GHG emissions</td>
<td>Total CO2_eq emissions</td>
<td>t_CO2eq</td>
<td>226.74</td>
<td>28.00</td>
</tr>
<tr>
<td></td>
<td>Of which scope 1</td>
<td>t_CO2eq</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>Of which scope 2</td>
<td>t_CO2eq</td>
<td>0.04</td>
<td>23.58</td>
</tr>
<tr>
<td></td>
<td>Of which scope 3 upstream</td>
<td>t_CO2eq</td>
<td>226.70</td>
<td>4.42</td>
</tr>
<tr>
<td>Energy</td>
<td>Energy consumed</td>
<td>kWh</td>
<td>52.59</td>
<td>28,016.33</td>
</tr>
<tr>
<td>Material</td>
<td>Total material consumed</td>
<td>kg</td>
<td>25,575.00</td>
<td>5,455.00</td>
</tr>
<tr>
<td></td>
<td>Of which hydrogen</td>
<td>kg</td>
<td>20,335.00</td>
<td>335.00</td>
</tr>
<tr>
<td></td>
<td>Of which industrial plastics</td>
<td>kg</td>
<td>240.00</td>
<td>120.00</td>
</tr>
</tbody>
</table>
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
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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Interested in participating in an impact analysis?

Please contact sustainability@aveva.com

Scan QR code for more details in the Report
Questions?
Please wait for the microphone.
State your name and company.

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

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