White Paper

Performance Management in Process Plants: Seven Pitfalls to Avoid

Executive Summary

In today's process industries, the plant floor is awash in information. Harnessing that data - which means organizing and making it usable - is what yields meaningful performance gains.

Companies often use dozens of applications to manage complex production operations, monitor processes and make operating decisions. These systems are usually either completely isolated or connected with complex, custom-designed interfaces that make it difficult to use the data effectively and maintain its integrity.

The simple measurement of plant performance metrics can be a daunting task. Performance data is frequently locked up in disparate systems and must be normalized before analysis. Finally, most companies continue to rely on basic spreadsheet applications for metric tracking, limiting the ability to analyze large sets of data.

This whitepaper describes how to design an effective performance management system and avoid some of the common pitfalls.

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Background

Manufacturing companies employ a variety of information systems to allow employees to do their jobs. But how easy is it for different roles to access critical production data? Each worker is focused on the key performance indicators (KPIs) for his or her individual function. These performance targets and measurements are important for aligning employee decisions and actions with overall business objectives. They can range from safety, operations and reliability, to economics, energy and loss, plant expansion and personnel.

For example, operators monitor throughput and cycle time to keep production processes running continuously, while the maintenance team monitors asset performance and tries to predict and prevent downtime. Plant managers must keep their attention focused on profitability and utilization.

Traditional role-based information, held in isolated silos, hasn't been accessible to monitor the state of overall plant operations. In cases when data is shared among different departments, it is often distributed on spreadsheets containing manually keyed information. Not only does this pull people away from the tasks at hand, it also introduces human error into the process.

Many industrial organizations are discovering the value of harvesting data from the plant floor to respond to KPIs that influence important decisions at the highest levels. Data left dormant and isolated in disparate controllers, human-machine interfaces (HMIs) and other enterprise systems can provide vital information about overall process efficiency, system uptime, energy usage, cost of materials, environmental compliance and other KPIs.

Without question, metrics matter when it comes to optimizing operational and business performance.

What is Performance Management?

You can't manage what you don't measure. It is an old management adage that is accurate even today. Unless you measure something you don't know if it is getting better or worse. You cannot manage for improvement if you don't measure to see what is getting better and what is not. For this reason, manufacturers collect data (measurements), determine how those will be expressed as a standard (metric), and compare the measurement to the benchmark to evaluate progress.

For manufacturing operations, an appropriate and consistent set of easily-understood performance metrics needs to be within quick access. This requires comprehensive metrics frameworks and automated management capabilities.

Almost every organization has put in place metrics programs of some kind. Taking the next step to a comprehensive system for managing enterprise metrics has been daunting for a number of reasons:

- Metrics are a moving target.
- Visibility into metrics is uneven.
- There are no consistent frameworks of essential metrics.
- Analysis of data interrelationships—so vital to decision making—is complex.

Creating KPIs and aligning them with organizational objectives is key in establishing an effective monitoring system. A “scorecard” is a popular term for describing such a monitoring system, and mapping it to individual responsibilities.

Dashboards are particularly effective in delivering a scorecard to a wide audience. It is common to expect that different job roles and functions within an organization will require different sets of metrics and dashboards. Creation of a diverse and rich collection of KPIs makes dashboards an essential driver for change and positive transformation.

Understanding the Role of KPIs

KPIs are metrics that are used to assess the current state of a business, and to measure progress towards goals. For a manufacturing facility such as a refinery, KPIs are useful to measure performance in each benefit area. There are many possible KPIs, and each plant will need to come up with KPIs that are appropriate to the way it runs.

This paper refers **to** primary KPIs as metrics that directly measure performance in a benefit area. For instance, unit feed rate is typically a primary KPI because higher feed rate usually means more revenue and profit. Secondary KPIs are measurements that support or explain primary KPIs, and thus have an indirect influence on benefits. Tertiary KPIs are measurements that support or explain secondary KPIs, but do not have a direct or obvious relationship on benefits. These are loose definitions, and a metric that is a primary KPI at one plant can easily be a secondary KPI at another plant. It is also true that some metrics simply do not apply at some facilities. For instance, a plant that has plenty of spare capacity may decide that metrics based around throughput do not mean much. Each plant must come up with its own set of KPIs that are useful for it.

Potential benefits can be estimated in several ways:

- The benchmark method compares current performance to some external benchmark or standard. Benefits are estimated from the difference between actual and target performance.
- The similar plant method compares current performance with similar plants. Benefits are estimated from differences in metrics at the two plants.
- The variability method analyzes the variability in historical data. Benefits are estimated from reducing the variability, thus allowing operating more consistently at a more desirable target.
- Experience**.**

The following table presents some benefit areas and metrics for a typical refinery. Metrics for other industries will differ but the general type and organization of metrics will be similar. These metrics are generally primary KPIs, which have a direct measurable link to business value and therefore improving the KPIs will normally result in measurable benefits. The last column shows the method recommended for estimating potential future benefits from historical data.

Area	Process Unit	Metric	Estimate Benefits Using
Yield Management & Capacity Utilization	All	Effectiveness = actual/target feed rate	Variability, valued at gross margin
		All	Variability
	All	Unit material balance	Benchmark for mass balances, Variability for volume balances
	CDU	Actual/target atmospheric uplift (AGO and lighter)	Variability, valued at yield shift

Area	Process Unit	Metric	Estimate Benefits Using
	Reformer	Actual/target C5+ yield	Variability, valued at gasoline – natural gas spread
	FCC	Conversion = (feed – cycle stock)/feed	Variability
	FCC	Selectivity = naphtha yield/feed	Variability
	Hydrocracker	Conversion = (gas through kero)/feed	Variability
	Hydrocracker	Reactor WABT	Variability
	Coker	Gas yield/feed rate	Variability
	Coker	Actual/target drum outage	Variability
Product Cost and Quality	Offsites	Octane giveaway in gasoline pool	Variability
	Offsites	Gravity, cetane, sulfur, and pour point giveaway	Variability
	Offsites	Effectiveness = measured/target production	
Inventory, Losses, and Working Capital	Refinery	Unaccounted loss as % of throughput	Variability, valued at cost of crude oil
	Refinery	Flaring as % of throughput	Benchmark, valued at fuel or alternate use
	Refinery	Days of crude oil supply	Variability. Difference between actual and lowest sustained inventory, valued at cost of crude oil
Logistics & Transportation			
Fixed & Variable Operating Costs	Refinery	Solomon calculation of total maintenance spending	Benchmark - difference between actual and Solomon target
	Refinery	Solomon calculation of catalyst, chemicals & industrial consumables	Benchmark - difference between actual and Solomon target
Energy Efficiency	Refinery	Solomon target for energy intensity	Benchmark - difference between actual and Solomon target, valued as % of total energy budget
	Process units	Actual energy use / target usage adjusted for actual process conditions	Variability, valued at marginal fuel
Reliability & Plant Performance	Refinery, each process unit	Service factor, unplanned slowdown or downtime, or downtime using OEE definitions	Benchmark – use actual downtime valued at refinery gross margin
	Each console	Alarm metrics compared to ASM or other benchmarks	Benchmark
Safety & Regulatory Compliance	Refinery	Safety statistics, such as OSHA's Recordable Incident Rate (IR)	Benchmark
	Refinery, each process unit	Emissions, such as quantity flared or conformance to EPA standard 40 CFR	Benchmark
Staff, System Productivity	Refinery	(Productivity metrics tend to be specific to individual plants)	Benchmark

The primary KPIs shown above will be supported by secondary and tertiary KPIs. Primary KPIs relate directly to business results, while secondary and tertiary KPIs are easier to understand how to improve. The next table shows a typical set of KPIs that relate to the yield management and capacity utilization benefit area for a typical process unit, in this case an FCCU.

Type	Metric	Measures to Monitor
Primary KPIs	Unit feed rate	Measured, actual value Actual/target (effectiveness) Actual/capacity (utilization)
	Unit mass balance, unit volume balance	% gain/loss
	Gas yield	% unit feed rate
	Naphtha yield (debutanizer bottoms)	% unit feed rate
	Cycle stock yield (LCO and heavier; portion not converted to naphtha)	% unit feed rate
	Conversion = (feed-cycle stock)/feed	Calculated value
	Selectivity = naphtha yield/feed	Calculated value
	Efficiency = selectivity * conversion	Calculated value
Secondary KPIs	Advanced control utilization	% time APC is active
	Active constraints	Number active APC constraints % time selected CVs are active constraints
	Catalyst circulation rate	Calculated value
	Catalyst/oil ratio	Calculated value
	Propylene yield (C3 splitter overhead)	% unit feed rate
	Propane yield (C3 splitter bottoms)	% unit feed rate
	Flash zone temperature	Measured value
	Riser outlet temperature	Measured value
	Regenerated Catalyst Slide/Plug Valve Differential Pressure	Measured value
	Regenerator cyclone temperature	Measured value
	Regenerator O2	Measured value
	Air blower discharge pressure	Measured value
	Wet gas compressor inlet pressure	Measured value
	Main fractionator differential pressure	Calculated value
	Naphtha (debutanizer bottoms) 90% point	Inferred property calculation, as employed for APC
	Main fractionator LCO 90%	Inferred property calculation, as employed for APC
Tertiary KPIs	Analyzer availability	% time unit analyzers are online
	Analyzer repeatability	% of lab sample results within normal precision of lab and analyzer results
	Absorber column differential pressure	Calculated value
	Debutanizer column differential pressure	Calculated value
	Debutanizer overhead C5+	Inferred property calculation, as employed for APC
	Naphtha (debutanizer bottoms) RVP or C4-	Inferred property calculation, as employed for APC

Type	Metric	Measures to Monitor
	Naphtha (debutanizer bottoms) octane	Inferred property calculation, as employed for APC
	Depropanizer Bottoms C3-	Inferred property calculation, as employed for APC
	Depropanizer column differential pressure	Calculated value
	Depropanizer overhead C4+ content	Inferred property calculation, as employed for APC
	C3 Splitter overhead C3 content	Inferred property calculation, as employed for APC
	C3 Splitter bottoms C3 olefins content	Inferred property calculation, as employed for APC
	C3 Splitter column differential pressure	Calculated value

Critical Information Requirements

Manufacturers know that to be competitive in today's marketplace, they need access to the right information, at the right place, at the right time. This requires the tools to make better decisions by eliminating guesswork and managing what is measured. It is not acceptable to find out tomorrow that you should have changed some things yesterday to improve profit margins.

Plant managers at industrial facilities face a host of operating challenges:

- How do I better manage my assets?
- How do I ensure safe and stable operations?
- How will demand influence my production?
- How can I comply with industry and government regulations?
- How can I enable my workforce to achieve improved performance?

Process industry operations around the world struggle under the sheer volume of data they generate. There is simply too much information to process, understand and act on quickly, leading to poor decision-making. With the power to access the right data—when and where it's needed most—and collaborate across business units, users can take informed actions to achieve operational excellence.

At modern industrial facilities, it's not uncommon to find a hodgepodge of information that does not allow a complete picture of plant performance. Separation and segregation of departments is also a hindrance to complete information and display, both within a site and over multiple sites.

Although technological barriers have been removed between automation, operations and maintenance, business practices enabling companies to truly benefit from this newfound freedom have been slow to change. Breaching the walls can allow common access to floods of data, but typically doesn't improve communication.

It is more important than ever to find a solution for managing plant metrics. But part of the task of implementing these metrics is determining how they are defined and calculated. This necessitates the involvement of people from a number of departments, who may have had little contact previously, to reach consensus on the metrics requirements.

At the plant level, organizations need data collection and reporting tools to assemble data on equipment status, process performance, resource consumption and other critical KPIs. Once captured, this data must be properly contextualized based on operating parameters that render the information either significant or insignificant. Plant managers, maintenance departments and operations staff then need the ability to view performance data in a meaningful way to determine which KPIs are being achieved within their span of control.

Seven Pitfalls to avoid in Performance Management

The effectiveness of the performance management program based on the KPIs relies on various factors. In order to have an effective performance management program using KPIs, sufficient care must be taken throughout the program to look out and eliminate the following seven pitfalls.

1. **KPIs are not really KPIs**: Many times KPI's are confused with measurements or metrics. While all KPI's are metrics, all metrics are not KPI's. A good KPI has following characteristics
    - **Well defined** – The KPI must be defined without ambiguity and in clear terms.
    - **Consistent** – The KPI need to be applied consistently across functions/departments.
    - **Measurable** or computed accurately – The KPI must be measurable, and any computation documented clearly.
    - **Responsive** to change – The KPI must be able to indicate result of any actions being taken.
    - **Timely** - The KPI must be for appropriate time window like daily, weekly or monthly.
    - **Owned** – The KPI must be assigned a clear ownership to a specific role/function.

2. **Everyone wants everything:** There is a general tendency in organizations to provide available data to most users as not providing the information may be construed as lack of information availability. But it overloads the user and the most relevant information is buried in the pile of information. It is important the most relevant and actionable information for that particular user is presented in the most meaningful form first. A good strategy for this is to organize information in form of dashboards and drill-downs. The main dashboard should contain key information and highlight exceptions easily. The drill downs should contain any detailed information. There is significant benefit in working with users to make the transition and to rationalize reporting and information delivery

3. **Not enough leading indicators :** Particular attention should be paid to leading indicators. Focus on KPIs that are actionable not those reporting history. Avoid too much emphasis on Lagging indicators. A Lagging indicator tends to be a measured output. A Leading indicator is a measure that predicts how another measure, potentially a lagging indicator, might behave in the future. Leading indicators let you react to influence a lagging indicator. Safety incidents may be influenced by
    - Number of High risk jobs being performed
    - Bypassed safety equipment
    - Follow-up safety audits not completed
    - Financial cost performance may be impacted by
        - Number of cost saving opportunities identified but not yet implemented

4. **Lack of data quality:** Lack of confidence in the numbers can seriously undermine a KPI program. Data Sources should use standard maintainable integration methods OPC, Web Services. Access methods need to perform and provide timely, reliable information. Identification of stale data is important. Need to accommodate recalculations for corrections or late arriving data. Master data needs to be managed to ensure systems are in sync

5. **Inconsistencies across organization:** Lack of consistency across the organization should be avoided. Step one is to identify that you have inconsistencies.
    - Requires an audit of the KPIs, calculations and data collection methods
    - Beware the manual entry spreadsheet
    - To ensure consistency drive your dashboards as model-driven templates
        - Drive KPI calculations the same way
        - Implement Management of Change process
        - Where Excel is still required apply controls

6. **One and done:** All the effort spent on creating a KPI program can be wasted if attention is not give to
    - Change management process – How to effectively introduce changes in business processes

- Sustainment – Ensure processes are in place to maintain the systems and data
- Support for users – Provide support for user in using the system
- Continuous Improvement – Ensure the system is flexible enough to evolve.
- Empower Users – Empower users to make their own changes to tune the system to meet their specific needs

7. **Don't do anything:** Not doing anything is the biggest pitfall. Effective performance management while needs of attention and care to be successful, the benefits are immense and it allows organizations to take a step change in their current performance. Hence, it is critical to institutionalize performance management and obtain business benefits.

	Pitfall	Recommendation
1	KPIs are not really KPIs	KPIs need to be aligned with business goals, be measureable and actionable
2	Everyone wants everything	Deliver concise exception based dashboards with drilldowns to details as required
3	Not enough leading indicators	Focus on leading indicators that can allow action before problems occur
4	Lack of data quality	Ensure data quality with standard interfacing and data management processes
5	Inconsistencies across organization	Enforce consistency across the organization with standards and templates
6	One and done	Empower users and set up management of change processes to facilitate continuous improvement
7	Don't do anything	Define the KPIs to drive business benefits now and for the future

Benefits to End Users

A well-defined performance management program can help a manufacturer improve its production efficiency, reduce operating costs, increase throughput, and improve compliance with government and industry standards, as well as ensure good staff morale. Employees want to do their best and it is important to ensure they have the right tools and sponsorship. They also need to know how they are performing and where they can improve.

Automation of metrics management can help users capture metrics/KPI data, perform analysis against the minimum thresholds they have set, automatically issue alerts when warranted and deliver scheduled reports to subscribers. In essence, most of the process can be automated so the administrative burden in managing a KPI/metrics program is kept to a minimum.

Conclusion

A growing number of industrial organizations are implementing collaborative strategies intended to correlate performance metrics with real-time KPI information. Implementing an effective KPI management system will require avoiding certain pitfalls and the same have been discussed in this whitepaper. Designing, implementing and maintaining an effective performance management system results in bottom line benefits to an organization.

For More Information
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