Improving throughput
with PlantWeb® digital plant architecture

With its unique predictive intelligence and top-to-bottom integration, PlantWeb digital plant architecture enables you to increase throughput not only by reducing downtime, but also by improving both basic and advanced control so you can push setpoints closer to optimum operating levels.

The challenge: Revealing your "hidden plant"

Plants today can find themselves competing both for **market share** and for the **capital** needed to expand or improve. The challenge is even tougher when **global competitors** can gain an edge with newer plants and regional differences in material, labor, or transportation costs.

One way to come out ahead is to show a higher return on investment by **increasing plant throughput**.

For plants that are capacity-limited, increasing throughput enables you to meet more of the available demand without building new production facilities. That's a great way to increase margins and ROI, or to use your lower cost per unit of output as a competitive weapon.

Even some market-limited operations can benefit from higher throughput rates. For example, you may be able to achieve the same output with fewer operating units – so you can reduce operations and maintenance costs, utilize the most efficient units to meet your throughput goals, or use the extra units to make other products.

The good news is that most plants are capable of achieving higher throughput by moving closer to what the process and equipment are capable of:

$$\textbf{\% Throughput} = \frac{\textbf{Actual production}}{\textbf{Rated plant capacity}}$$

The difference between actual and optimum throughput is your "**hidden plant**" – and putting that additional capacity to work can be one of the most profitable moves you've ever made.

While you can recover some of this hidden capacity by **reducing process downtime or outages**, you can increase throughput even more by improving control so you can run the process and equipment **closer to their optimum operating points**.

Reducing downtime

When the process stops, so does throughput. In addition to **unexpected downtime** or forced outages caused by equipment failure or process upset, throughput can also suffer from **planned downtime** (such as scheduled maintenance shutdowns) that's longer or more frequent than necessary.

You can reduce both types of downtime by shifting maintenance practices more toward **predictive maintenance**, where equipment monitoring and diagnostic technologies predict when a problem is likely to occur. This advance warning lets you schedule service when it will have the least effect on production (such as during a planned shutdown) − but **before** the problem causes a process upset or equipment failure. Fully implementing predictive maintenance on existing equipment can result in a 1-3% increase in potential plant production by reducing unscheduled shutdowns.[1]

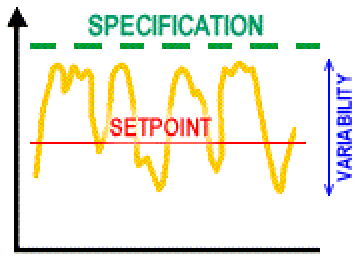
The same technologies can help shorten planned downtime – and extend the period between shutdowns − by enabling you to identify in advance which equipment really needs service, so you don't waste time working on anything that doesn't.

But for most processes, uptime far exceeds downtime. That's why the greatest opportunity for increasing throughput comes from **improving control** so you can wring more out of the process while it's running. As this paper explains, the **power to predict and prevent problems** makes a big difference there, too.

Moving closer to optimum

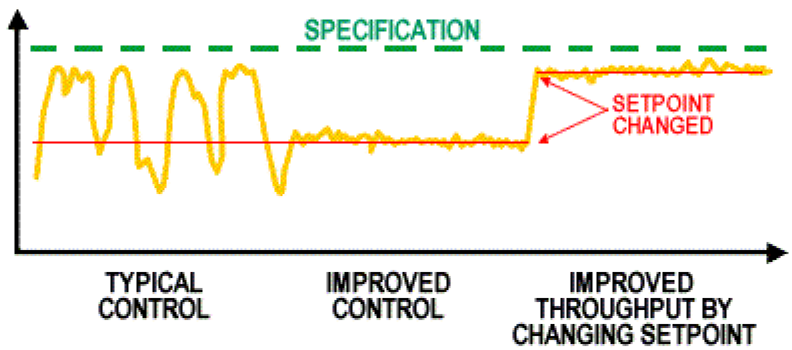
Each process has an **operating objective** chosen to achieve a desired outcome (such as maximizing throughput) while staying within process, equipment, or other constraints. The actual loop **setpoints**, however, are usually set conservatively − primarily to allow for process variability and unexpected disturbances.

Compensating for variability by using a setpoint lower than the specification can reduce overall process performance and operating efficiency.



Although all processes have some variability, the vast majority have **excess** variability that can be reduced with better control. And with less variability, you can move setpoints **closer to operating targets** − for better process performance, and thus better throughput.

Reducing variability makes it possible to move setpoints closer to specification.



You may even be able to move operating targets closer to theoretical operating limits, and get even more from your plant.

How do you make this happen?

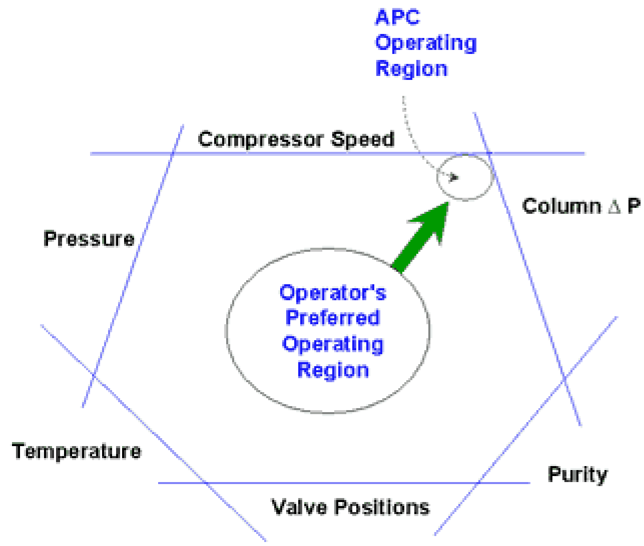
Start with the basics. Improvements begin with basic control – tuning loops, making sure they're being run under automatic control, and ensuring that field devices such as valves and instruments are delivering the performance needed.

One service company has shown that analyzing a plant's basic regulatory control, tuning loops and putting them back into Auto, and replacing or servicing control valves and transmitters where necessary can result in throughput rate increases of more than 10%. [2]

Once process equipment and basic regulatory control are working properly, you can add techniques such as advanced process control and real-time optimization.

Add advanced capabilities. Advanced process control (APC) technology further smoothes out variability even in complex, interrelated loops. Some advanced controls, such as Model Predictive Control with built-in Linear Programming, can find the best combination of multiple setpoints to satisfy a particular goal – such as maximizing throughput.

Advanced controls can help you push setpoints closer to optimum without violating constraints



Advanced control can be especially valuable when even incremental improvements in plant performance offer large financial benefits. According to Solomon Associates, for example, olefin plants using advanced process control typically have fewer unplanned slowdowns and shutdowns and operate about 2% better than plants without this level of control. The resulting throughput increases can bring in an additional $10 million annually.[3]

Keep up with changing conditions. For many processes, frequent (or even continuous) changes in feedstock and product slates, equipment performance, fuel quality, emissions, ambient conditions, and operating costs make the "best" operating point a moving target.

For operations like these, real-time optimization software can constantly evaluate process, equipment, and economic factors to find the "sweet spot" for maximizing throughput … then find it again as conditions change.

Achieving the maximum potential benefits can require both real-time optimization and advanced control – the former to calculate the new setpoints and the latter to implement them. Such combinations have resulted in throughput gains of 2-3% or more.

Why it doesn't always work

These approaches aren't new. But many plants that added advanced control and optimization systems to existing controls have been disappointed in the results. Some have even turned off or ignored the applications, losing both their investment and the potential benefits.

A shaky foundation. Often these failures can be traced to the limitations of underlying controls and automation – valves, instruments, and control systems that can't deliver the accurate, reliable performance needed.

In a recent survey, advanced process control specialists said that users can expect APC applications to deliver sustainable, measurable benefits only when those applications build on a **solid foundation** of basic process measurement and control.[3] Otherwise, there's no assurance that these advanced applications' control actions will be carried out accurately and reliably – or even that the information the applications are using is valid.

Unsuspected problems. Over time, even the best equipment can degrade or fail because of wear, damage, or changing conditions. Unless you can detect or predict such problems in time to take corrective action, variability will increase – prompting operators to move setpoints even farther from operating targets, or to switch loops into Manual. Some studies indicate that 20-40% of control loops are typically in Manual mode.[4]

If a problem continues to grow undetected, you may even find yourself facing unplanned downtime (and the accompanying loss of throughput) caused by process upset or equipment failure. The desire to avoid such surprises can also lead operators to add a throughput-and-profit-robbing extra margin of conservatism to setpoints.

A limited view. These potential problems can be difficult or impossible to detect with traditional control architectures, which provide only a limited view of what's happening in the process and the equipment running it − typically, not much more than the process variables and any associated trends or alarms. There's no way to directly monitor or evaluate equipment health.

Unvalidated data. This limited view also puts the control system and any advanced controls at risk of using faulty information. Any analog signal between 4 and 20 mA is assumed good, when in fact there could be any number of problems: the sensor could be fouled, the signal could have drifted, or a valve may not be responding correctly to control signals. Unless there's a way to validate the information, the control algorithms and advanced control applications will continue to use the bad data until an operator notices or a process upset highlights the problem.

With these limitations, it's no wonder that simply adding a layer of advanced control to traditional automation systems often fails to meet expectations.

What's needed is a way to access real-time information about what's happening throughout the process and the thousands of pieces of equipment running it – then use that information to predict and head off problems and ensure you're getting the performance you need at every level, from instruments to advanced controls.

The answer: Predictive intelligence

Emerson's PlantWeb® digital plant architecture offers **predictive intelligence** that enables you to see what's happening in your process and equipment, identify potential problems, and take action before they increase variability – so you can improve control performance and confidently push setpoints to optimum operating levels.

A better view. Digital technology makes it possible to access and use new types of information that go far beyond the process-variable signals available through traditional automation architectures. With PlantWeb architecture, both the breadth and depth of this information are unprecedented.

It starts with intelligent HART and FOUNDATION fieldbus instruments – including transmitters, analyzers, and digital valve controllers – that use embedded microprocessors and diagnostic software to monitor their own health and performance, as well as that of the process, and signal when there's a problem or maintenance is needed.

But PlantWeb doesn't stop with valves and instruments. It also captures information on the condition of rotating equipment, such as motors and pumps, to identify potential problems like misalignment, imbalance, gear defects, and bearing faults. And it monitors the performance and efficiency of a broad range of plant equipment, from compressors and turbines to heat exchangers, distillation columns, and boilers.

Information integration. PlantWeb uses communication standards like HART, FOUNDATION fieldbus, and OPC, as well as integrated software applications, to make this new wealth of process and equipment information available wherever it's needed for analysis and action – at every level of the architecture.

What makes PlantWeb different from other automation architectures?

- It's engineered to efficiently gather and manage a new wealth of information – including equipment health and diagnostics – from a broad range of field devices and other process equipment.
- It provides not only process control, but also asset optimization and integration with other plant and business systems.
- It's networked, not centralized, for greater reliability and scalability.
- It uses standards at every level of the architecture − including taking full advantage of FOUNDATION fieldbus.
- It's the only digital plant architecture with proven success in thousands of projects across all industries.

For more about the architecture and what it can do for you, visit **www.PlantWeb.com.**

For example, PlantWeb integrates information on many types of equipment in a single, browser-based application, **AMS™ Suite: Asset Portal**™. The information is accessible by anyone who needs it, including technicians in the maintenance shop, operators in the control room, or other personnel throughout the plant and business. When potential problems arise, targeted online alerts help ensure that the right people get the right information right away, so they can take corrective action to keep the process running smoothly.

PlantWeb's DeltaV™ and Ovation® automation systems also use information about process and equipment condition (as well as process variables) for both regulatory and advanced control. As a result, you can be confident that control and optimization are based on an accurate picture of what's happening – and never control off bad data.

The power of prediction. With the ability to detect and deal with problems before they happen, you can keep instruments and equipment working at their best – not only avoiding conditions that could cause downtime, but also reducing opportunities for variability to creep into your process.

In addition, knowing that you'll get **advance warning** of potential problems can also give you (and your operators) the confidence to push setpoints closer to theoretical operating limits, for even greater gains in throughput.

Let's look at some examples of how PlantWeb uses these capabilities to help you improve throughput by…

- Reducing downtime
- Building on a solid foundation
- Bringing advanced control into the architecture
- Optimizing continuously to sustain the gain.

Reducing downtime

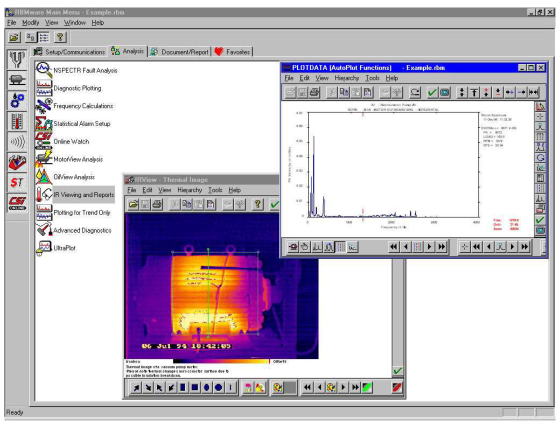
PlantWeb's monitoring and diagnostic capabilities help you head off problems before they cause equipment failure or process upsets – and **unexpected downtime** or forced outages cut into throughput.

In pressure transmitters, for example, impulse-line plugging can block the instrument from reading actual process pressure, leaving you and your control system "blind" and at risk of a process trip if the actual pressure changes beyond what's allowable. PlantWeb uses special **diagnostics** to detect plugged lines and immediately alert you to the problem.

One refinery found that diagnostics like these could detect conditions leading to a catalyst circulation upset in a fluidized catalytic cracker (FCC) unit – 30 minutes before it happened.[5] Without this opportunity to take corrective action, such an upset (and the resulting repairs) can subtract as much as five days from available production time.

Planned downtime can also be shorter and less frequent when you have a better view of actual equipment condition.

For example, **AMS Suite: Intelligent Device Manager** software manages diagnostic and maintenance information for valves and instruments throughout your plant. **AMS Suite: Machinery Health Manager** tracks the condition of rotating equipment (such as motors or pumps) so you can see which will need service soon, and which won't. And **AMS Suite: Equipment Performance Monitor** evaluates economic factors as well as the performance of a wide range of equipment to help you determine the optimal time for maintenance.



AMS Machinery Manager uses vibration monitoring, IR thermography, oil analysis, ultrasonics, and motor diagnostics to give you a better view of actual equipment condition.

By automating startup procedures, PlantWeb's **DeltaV** and **Ovation** automation systems can also help you resume full production more quickly after shutdowns.

*This is only small sampling of the ways PlantWeb reduces downtime. For an in-depth look at this topic–including the opportunities and challenges of increasing process availability–please download our **free whitepaper** at http://plantweb.emersonprocess.com/Operational_Benefits/Availability_index.asp.*

Building on a solid foundation

PlantWeb provides rock-solid basic control − and the predictive intelligence to keep it that way.

For the base of the foundation, you can choose from a broad range of instruments and valves that consistently deliver the measurement, analytical, and control performance you need. They include transmitters with fast dynamic response, digital valves that respond to signals of 1% or less, and the world's most accurate Coriolis flowmeters.

More important, these intelligent HART and FOUNDATION fieldbus devices can alert you to potential problems. All have onboard diagnostics, including a **variability index** to help detect whether their performance is deteriorating to the degree that the process could be affected. Other diagnostics can alert you to device-specific types of problems.

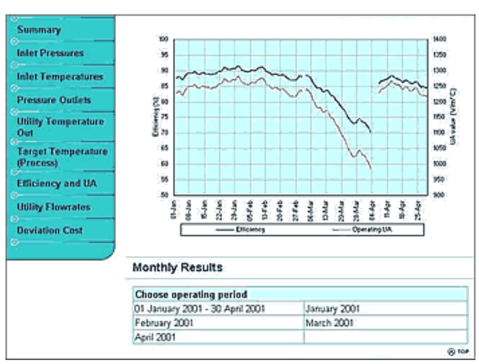
- AMS Device Manager's **valve signature diagnostic** can (among other things) alert you to a condition called *stiction*, which causes the valve to stick in one position as actuator force increases, then suddenly move as much as several percent of travel at once. As a result, the valve spends much of its time in the wrong position, with an obvious effect on variability.

  In the past, detecting stiction required taking the valve off-line to perform a "bump test." With PlantWeb, valve friction is measured and alarmed while the valve is still in service – making it that much easier to detect and correct potential problems before they grow.

- The **sensor fouling detection** diagnostic helps maintain the accuracy of pH measurements by providing early warning of fouling and triggering a maintenance request or even automatically initiating cleaning of the sensor.

- PlantWeb diagnostics can also trigger **advisory alerts** when the device is still healthy but conditions indicate the potential for future problems – such as a valve that's traveled beyond its recommended cumulative stroke distance, or a transmitter that's being used outside its recommended operating range.

You'll also get early warning of potential problems in other types of equipment. For example, AMS Performance Monitor can monitor heat exchangers, compressors, pumps, turbines, boilers, and other process equipment to detect and track performance changes that can affect variability and throughput. When one gas-processing facility used this application to identify a poorly-performing compressor, the resulting repairs reversed their slumping production rates – for a $3 million gain.

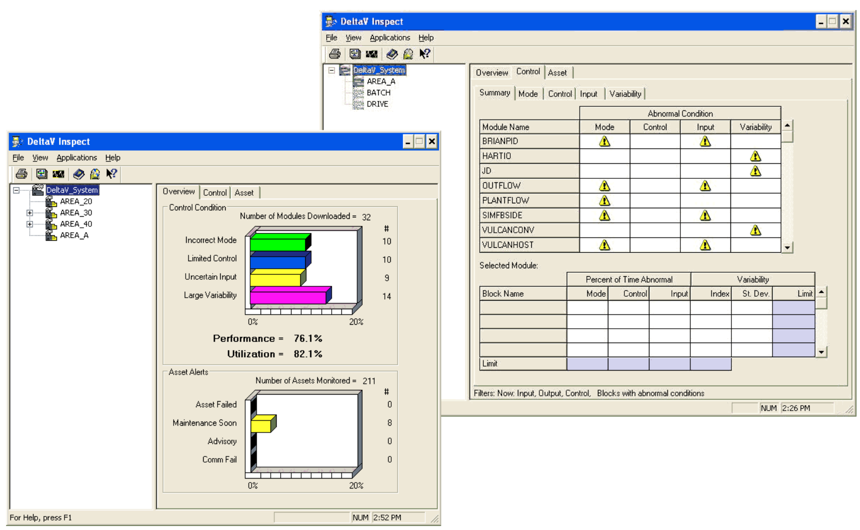


AMS Performance Monitor alerts you to long-term changes in equipment performance.

PlantWeb's **information integration** multiplies the power of these predictive diagnostics.

As our intelligent FOUNDATION fieldbus devices constantly check for problems, they use what they learn to automatically label the data they send the automation system as good, bad, or uncertain. PlantWeb's **DeltaV** and **Ovation** systems monitor this signal status (something not every system can do) to constantly verify that the data is valid for use in control algorithms. If it's not, the systems can automatically modify control actions as appropriate – minimizing or eliminating any increase in variability.

DeltaV Inspect software monitors not only device performance, but also overall loop performance and variability, and automatically flags any degradation or abnormal condition in a measurement, actuator, or control block. It also tracks how much time each loop that should be in Auto is actually in Manual – pinpointing trouble spots where operators are struggling to control variability.



DeltaV Inspect integrates process and equipment information to track overall performance and highlight potential problems.

When the problem is a poorly tuned loop, easy but powerful **DeltaV Tune** software uses patented relay oscillation principles that minimize process disturbances and minimize tuning time. **OvationTune**, a system-wide tuning package, smoothes out variability by monitoring and adaptively tuning loops for optimal performance.

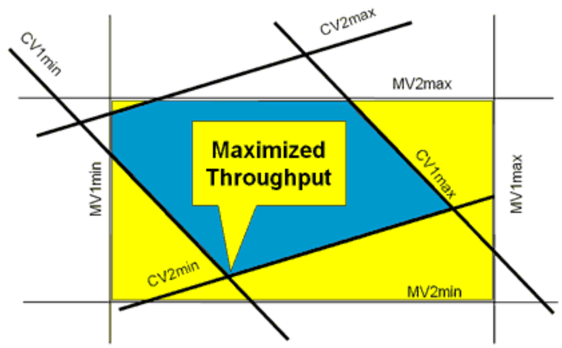
If you prefer, Emerson can provide expert **loop audit and tuning services** to find and fix your most troublesome loops – a real benefit when your own staff is stretched thin just dealing with day-to-day problems.

Bringing advanced control into the architecture

Once lower-level controls are operating optimally, you can increase throughput even more by using advanced process control to further reduce variability and move setpoints closer to optimum. With PlantWeb, advanced control isn't "layered on" – it's part of the architecture, with access to the same **validated** process and equipment information used for basic control. For example…

- The **Ovation Fuzzy PID** uses fuzzy logic to provide fast response times with virtually no overshoot. It can provide better performance than traditional PID on loops that experience frequent setpoint changes or load disturbances by adapting to different process dynamics at varying operating points. That's especially useful where overshoot can ruin the product, reducing total throughput.
- The multivariable Model Predictive Control in **DeltaV Predict** easily handles excessive deadtime, long time constants, and loop-to-loop interactions. As process conditions change, it automatically adapts to allow maximum throughput without violating operating constraints.
- You can also use the even more powerful (but still easy-to-use) **PredictPro** to find the best combination of **multiple setpoints** for maximizing throughput.

Its embedded linear program enables DeltaV PredictPro to find the best combination of multiple setpoints.



The technology continuously finds the right combination of setpoints that can shift the process **closer to theoretical limits** without violating constraints – and boost throughput even more.

Because these easy-to-use advanced controls are **embedded** in the DeltaV and Ovation controllers rather than a separate workstation, they run at the controller cycle time − typically 1-2 seconds − rather than the longer cycle times common in supervisory MPC systems. This enables them to solve problems with faster dynamic response, so you can run closer to constraints.

EMERSON. Process Management

Optimizing continuously to sustain the gain

As factors that affect your process change, so does the best operating point for maximizing throughput. **AMS Suite: Real-Time Optimizer** software helps you keep up by continuously monitoring those factors and − using a sophisticated mathematical model of the process − identifying the new setpoints that will bring performance back to optimum without violating constraints.

Like PlantWeb's other advanced controls, AMS Optimizer is an integral part of the architecture, using the same **validated, real-time** information about the process and equipment to constantly update its mathematical model of the plant. Integration also makes it easy for the controls to implement the new setpoints determined by AMS Optimizer.

For power applications, **SmartProcess®** plant optimization software improves throughput and efficiencies by maximizing boiler performance, improving heat rate, and minimizing steam temperature variations. It uses both neural network and linear technology to model the plant processes. Each module dynamically optimizes, sending new setpoints and biases directly to the controller even as the plant moves through load changes. SmartProcess can also operate in advisory-only mode, alerting operators to change settings and take actions to achieve targeted objectives.

Proven results

Better throughput is one of the reasons users have chosen PlantWeb digital plant architecture for thousands of automation projects – in plants, mills, and refineries all over the world.

- Located near Lake Charles, Louisiana, the **Calcasieu refinery** was built in 1977 and its capacity upgraded over the years to about 15,000 barrels per day. Its main processing facilities consisted of a single atmospheric crude tower known as Unit #2 and a naphtha stabilizer unit. The original 5,000-bpd Crude Unit #1 had been decommissioned in 1980.

  Calcasieu wanted to increase the refinery's capacity to 22,000 bpd by putting Unit #1 back into service and enhancing Unit #2. They chose PlantWeb to control both crude units and the naptha stabilizer, as well an 800,000-barrel tank farm and a five-mile product pipeline.

  The decision paid off. Now loops that would otherwise be operating in Manual stay in Automatic. As a result, processes run closer to optimum operating conditions than they could with less-advanced control technology – for lower operating costs, better product quality, and higher throughput.

For instance, tighter column control now allows use of high-capacity trays, at elevated throughputs of liquid and vapor that would otherwise result in frequent flooding upsets. And an advanced control scheme for the naphtha stabilizer has reduced loss of valuable naphtha with the LNG byproduct.

Bottom-line results? These and related enhancements have increased the throughput of Crude Unit #2 by about 2,000 bpd – and total plant capacity not just to the originally planned 22,000 bpd, but **30,000 bpd**.[6,7]

That's just one example. Here's what other users have said:

- "Since we installed PlantWeb and FOUNDATION fieldbus, we are making better quality products at a lower cost. We have cut raw material usage by approximately 20%, and have 10% greater throughput. We operate more efficiently than ever before." ***- Potassium processor***

- "With PlantWeb, we were able to increase our capacity by 25% without adding headcount." ***- Specialty chemical maker***

- "PlantWeb provides a cost effective platform to control our new plant, from raw material to final product. Features like one-button startup help us optimize uptime. We also experiment by altering setpoints to find how output and efficiency are affected. We've learned a lot about how our equipment runs best, allowing us to maximize profits. We have realized more than 15% improvement in our operating efficiency." ***- Feed-additives producer***

- "Since we installed PlantWeb throughout our plant, we have increased our power output by 6.4% for the same amount of fuel, reduced our maintenance staff by 33%, and reduced our operations staff 33%. We are running more efficiently than ever." ***- Electrical utility***

For additional case histories and proofs of PlantWeb architecture's capabilities, visit **www.PlantWeb.com** and click on "Customer Proven."

Taking the next steps

Improving throughput by putting your "hidden plant" to work can be well worth the effort. But how do you get started?

Begin by assessing where you are. How does your current throughput compare to your rated plant capacity? How much downtime did you have in the past year? Where are your production bottlenecks? Which loops give your operators the most trouble? Have you tried using advanced control or optimization systems to increase throughput? With what results?

Next, evaluate the potential. If you're currently capacity-limited, how much more could you sell if you could make it? What would each incremental hour, ton, or barrel of production be worth? If you're market-limited, would increasing throughput enable you to consolidate production in your most efficient units? How much would that save? If prices for fuels, feedstocks, and products change frequently, what advantage would you gain by re-optimizing your process more quickly than your competitors?

Finally, work with your local Emerson team to identify the applications where PlantWeb can have the greatest impact. If you'd like, we can even help with the assessment and goal-setting portions of this process, from performing loop audits to developing the business case for increased throughput.

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Other resources

- Improving throughput is just one of the ways PlantWeb helps improve process and plant performance. It can also help increase availability and quality, as well as reducing cost for operations and maintenance; safety, health, and environmental compliance; energy and other utilities; and waste and rework.
  www.PlantWeb.com – click on **“Operational Benefits”**

- Throughput is closely related to the “productivity” component of Overall Equipment Effectiveness, a structured metric for process performance. Emerson Process Management’s free online learning environment, PlantWeb University, offers a 5-course introduction to OEE. A course on throughput will be available in the near future.
  www.PlantWebUniversity.com

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