FASTEC
Software for Production

INDUSTRY 4.0

WHITEPAPER

Step 5 | Focus on Optimization: Key Figures and How to Work With Them

We digitalize factories

Understand and Work With Recorded Production Data

In the last whitepaper „Step 4 – Focus on Transparency" you got to know different MES modules. We looked at their benefits and additional synergy effects, and you learned that an MES is a valuable tool for production. With the help of the modules presented, production data is recorded and presented in clear evaluations in order to identify and eliminate weak points.

The Result: Transparent, Efficient Production

Various meaningful production key figures such as OEE, NEE, TEEP can be derived from the production data. But what do these key figures actually mean? How are they composed? And how can you use these key figures to increase the efficiency of your production? One thing is certain: The recording of production data alone will not improve production efficiency. Other essential factors for success are:

- Convincingly convey the purpose and benefits of using MES to production staff and ensure through training that the required data is recorded reliably, completely and correctly. This is the only way for employees to act appropriately in order to improve production performance in the long term.
- Trained lean managers who use the MES for the CIP on a daily basis. It is their responsibility to analyze the key figures, derive measures from them and take care of the successful implementation in order to achieve lasting improvements.

There are several methods that are used to optimize production. Generally accepted and widely used is Lean Production.

Lean Production

Lean Production is a form of work organization in manufacturing systems that aims to avoid waste – in other words, the both economical and time-efficient use of production factors such as operating resources, materials, and personnel in the planning, organization, and execution of all company activities.

Lean Production does not describe a fixed or prescribed procedure, but includes various methods that can be combined and used in different ways in manufacturing companies. An MES provides important key figures as a basis for optimization. On the following pages, you will learn how these key figures are calculated and how you can use them.

Dr. Karl-Heinz Gerdes, Founder of FASTEC GmbH

About the Author

Dr. Karl-Heinz Gerdes is the founder and former Managing Director of FASTEC GmbH and has been active in the field of computer-integrated production for over 30 years. During his studies he was already working on microprocessor-controlled automation solutions. The development of decentralized control and networking solutions for interlinked plants with master computers was ultimately the guiding principle for the founding of FASTEC GmbH. The MES solution FASTEC 4 PRO, which is distributed by FASTEC today, was developed on this basis and has become even more sophisticated due to the experience gained from many complex customer projects.

What Are the Principles Behind Lean Production?

Lean Production is based on a handful of basic principles. A comprehensive modular system of methods is available to users for implementation. As the backbone for a continuous flow of information, the MES creates the necessary transparency.

The Concept Is Essentially Based on Five Pillars:

- **Reproduction:** The basis for systematic optimization is created through accepted and stable standards that are consistently used across the entire process chain.
- **Flow principle:** In Lean Production, all material and information processes are coupled with each other to achieve a continuous flow of information. In this way, processes can be consistently aligned with the customer's needs – e.g. for lot size one. The aim of this is the consistent avoidance of idle power/waste of resources of any kind and increased flexibility throughout the entire production process. The combination of the various modules of an MES provides the basis for precisely this continuous flow of information in production companies.
- **Tact principle:** The work content of all sections of the production process run harmoniously and work „in the same cycle," whereby an efficient and rhythmic workflow is achieved.
- **Pull principle:** The downstream process only picks up the parts it needs. This also defines the capacity requirements needed in the upstream processes.
- **Zero-error principle:** The aim of process optimization is to eliminate errors in the production process. There are different methods (e.g. Six Sigma, see page 4) that are dedicated to the continuous improvement and stabilization of all processes in the company so that unnecessary rework is avoided and process costs are minimized.

From these five pillars, it can be seen that Lean Production methods often lead to major changes for the entire company – often even to a change in entire production systems. However, it is not always necessary or practicable to redesign the previous production. There are various approaches (such as CIP or Kaizen) that focus on continuous improvement, i.e. the adaptation of production systems and process chains in small, manageable and reversible steps.

These measures are closely linked to the approaches of lean management and strive for the best possible added value, especially through the combination of the various tools. However, the objective is continuous and gradual improvement, which precisely does not seek a radical redesign of the previous production systems. It therefore makes sense for production companies to be familiar with these measures and to integrate some of them into everyday production.

Using a Mix of Established Approaches Has the Following Advantages:

- **Reliable return on investment (ROI):**
  Experience has shown that the introduction of Lean Production in connection with an MES brings a high ROI after a short period of time, since the analysis of the data from the MES effectively reveals weak points and targeted measures to improve processes can be initiated. The more data and the better the data from the MES, the more effectively weak points can be can be analyzed.
- **Higher chance of success:**
  The higher the acceptance of those responsible and the entire production team, the higher the probability of success for a sustainable increase in efficiency.
- **Tried and tested:**
  Working with an established, well-researched method that has been practiced successfully for decades means benefiting from the mistakes of others. By not making these mistakes yourself, you can save time and money, among other things. At the same time, it also means that the path to efficient production is shortened. However, there are no universal solutions for manufacturing companies, as each has its own specific characteristics, requirements and goals.

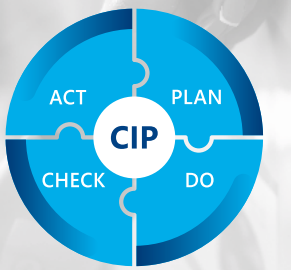
Approaches to Process Improvement

The two methods presented here are probably the best-known strategic approaches with which production companies can achieve targeted and successful process improvements today. To be successful, both approaches require key figures for analyses and performance control. An MES provides you with exactly these key figures.

Kaizen/CIP

The Japanese term "Kaizen" is made up of "Kai" = "change" and "Zen" = "for the better." In this context, Kaizen stands for the permanent improvement of activities, processes, procedures or products by employees. The decisive factor here is the involvement of all employees of a company, the conscious and active encouragement of suggestions for improvement, as well as the rapid implementation of resulting measures and the visibility of the successes.

The term Kaizen is often equated with CIP (continuous improvement process). Kaizen or the CIP are linked to a number of principles that are intended to guide employees in their daily work.



CIP (Continuous Improvement Process) stands for the entrepreneurial goal of consistently and continuously improving organizational structures and processes in the company with the help of step-by-step optimization.

The main principles are:

- Daily improvements in all areas of a company, avoiding any waste of materials, time and money.
- Constant improvements are made gradually and on a small scale; in the process, improvements are always possible, there is no end.
- All downstream process steps are considered from the customer's point of view in order to improve performance.
- Everything can be improved: No restrictions in the area of application (products, services, processes, activities, technology, workplace).
- Use of different methods and tools. Workplaces, work areas and the situation are viewed "on site," everything is tracked and analyzed live.
- The constant improvements set higher standards.

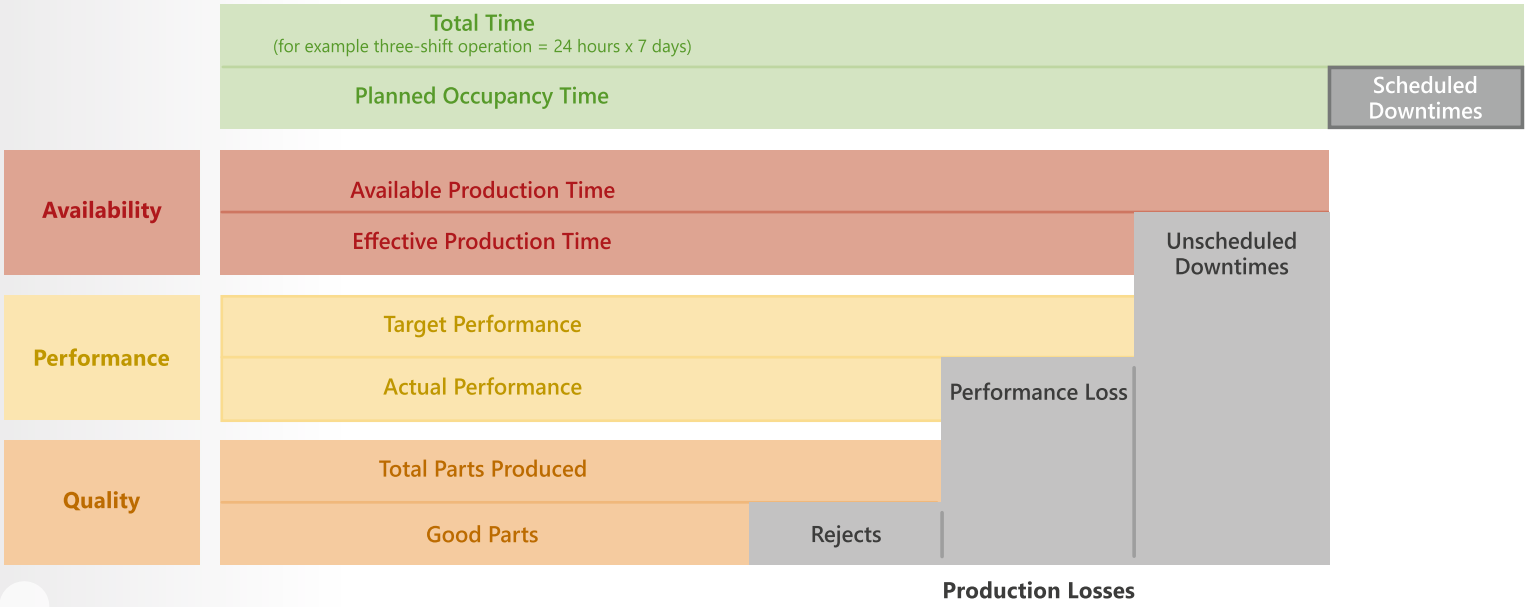
Due to the universal principles, there are almost unlimited possible applications for Kaizen/CIP. For example, product quality or processes can be improved, errors avoided, performance increased, delivery dates met and costs saved. Likewise, activities can be facilitated and health aspects, occupational safety, occupational health and teamwork can be improved.

Six Sigma

Six Sigma is a highly data-oriented approach with the goal of harmonizing and optimizing business processes. The aim is to increase quality in all areas of the company: Reduction of errors in the interest of the customer and the company's benefit. The tools used are by no means groundbreaking, because most of them were already used in some companies before Six Sigma – whether this was done correctly, however, is a controversial question. Six Sigma prevents an unsystematic combination of tools, since a link and combination of the principles is specified against the background of a benefit-oriented process optimization. This establishes a certain course of action: The DMAIC cycle (see figure). Collaborative and targeted work in project teams is one of the most important tools in Six Sigma, just as it is in Kaizen/CIP. Under the guidance of a project leader (black or green belt), not only possible but also decisive improvements are determined and implemented in order to make the company stand out from the competition. Ongoing innovation and improvements are also the key to sustainability and continuity.

The DMAIC cycle is the core process of the Six Sigma quality management approach.

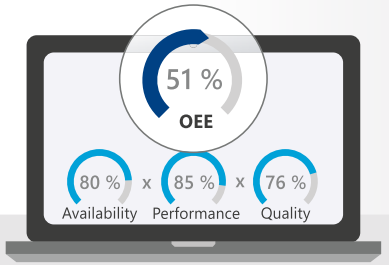
Key Figures: The OEE Value*



The OEE value is a central key figure for evaluating the productivity of a machine, plant or line. The abbreviation OEE stands for "**Overall Equipment Effectiveness**."

The OEE value is the product of the degree of **availability, performance and quality**. When calculating the OEE value, production losses due to unplanned downtime, deviations from the planned number of pieces, and defective parts and parts that need to be reworked are thus included.

With the OEE value, all plant losses can thus be systematically identified, analyzed and observed and eliminated in the ongoing improvement process.



Calculation of the OEE Value:

OEE = Degree of Availability x
Degree of Performance x Degree of Quality

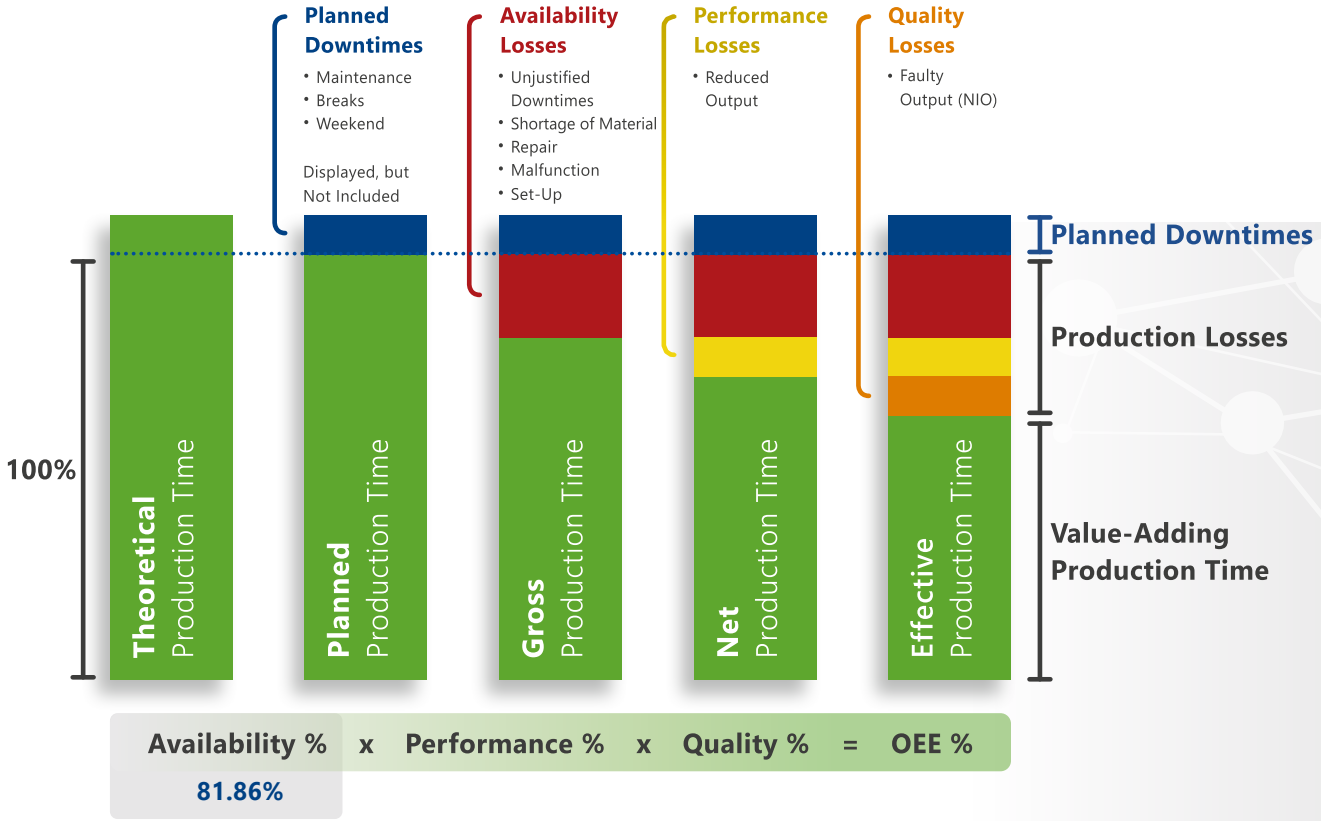
** Also read our detailed "OEE Guide." You can find it in the download area under "Brochures and Other Media."*

Current Practice:

The Degree of Availability

In the following, the individual key figures that serve as the basis for the evaluations in FASTEC 4 PRO and their calculation are explained in more detail.

The degree of availability considers unplanned losses and results from the ratio between the actual (gross production time) and the planned production time. The latter results from the theoretical production time, reduced by unoccupied shifts, production-free weekends and other planned downtimes such as maintenance and breaks. The level of availability is reduced by malfunctions and the time spent on eliminating them. Preparing and reprocessing a plant, machine or line also reduce the degree of availability.



$$\text{Degree of Availability} = \frac{\text{Actual Production Time}}{\text{Planned Production Time}}$$

Practical Example: Consideration for One Shift

Total time: 480 minutes

Planned downtimes: 50 minutes

Planned production time: 430 minutes

Availability: Of 430 minutes of planned production time, the machine is at a standstill for
- 27 minutes due to malfunction
- 11 minutes due to exceeded breaks
- 28 minutes due to set-up
- 12 minutes due to tool breakage

352 minutes value-added (gross) production time
Degree of availability: 81.86%

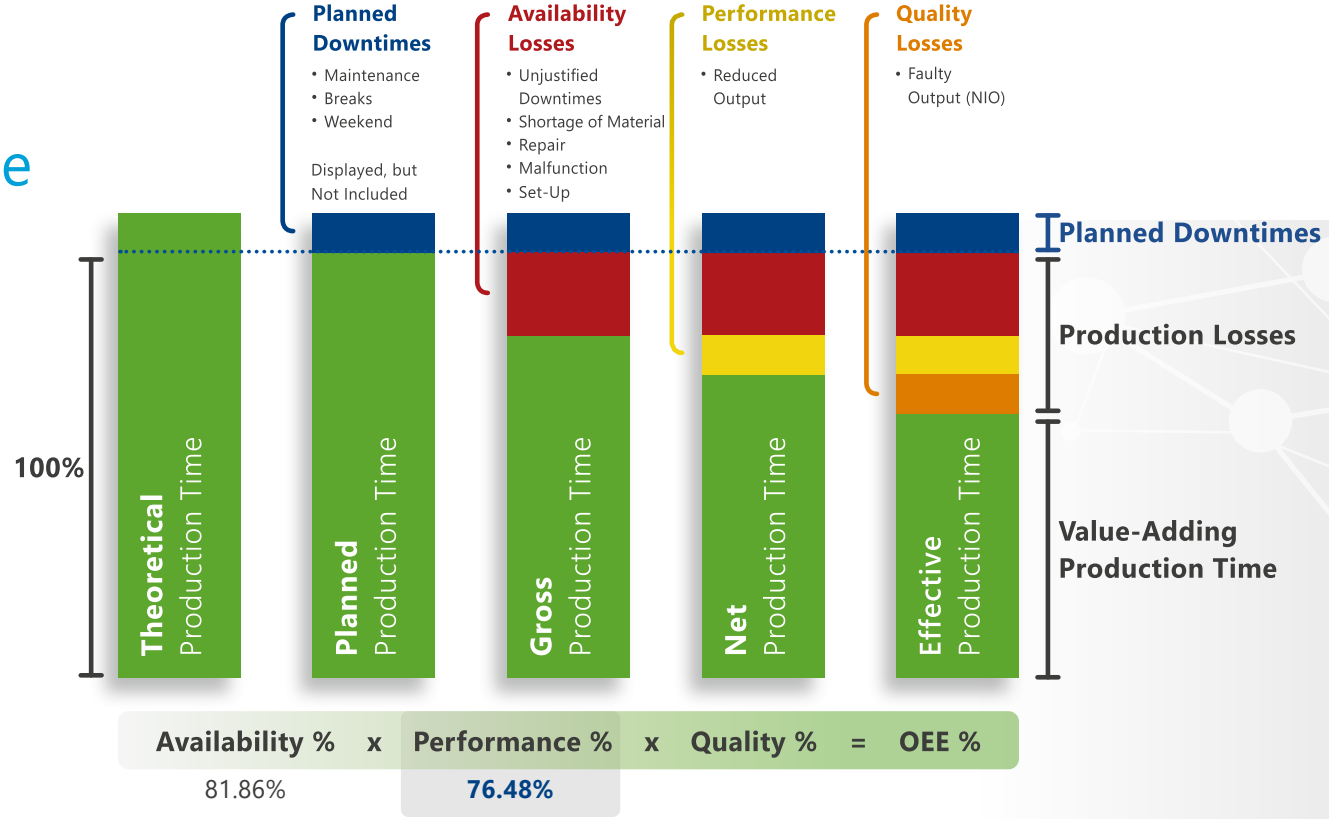
Current Practice:

The Degree of Performance

The performance level of a plant, machine or line results from the ratio between the parts actually produced and the technically possible parts per unit of time. This is because a plant, machine or line cannot always be operated at the highest speed according to the manufacturer's specifications. The cycle times depend, among other things, on the manufacturing processes, on the products to be processed and also on the operating personnel.

Thus, idling and minor interruptions (short stops) as well as reduced operating speeds lead to the minimization of the degree of performance.

The degree of performance is calculated based on the actual production time only.



$$\text{Degree of Performance} = \frac{\text{Actual Performance}}{\text{Target Performance}}$$

Practical Example: Consideration for One Shift

Target cycle/cycle time:
6 seconds, 600 pieces/hour
with optimal performance

Actual cycle/cycle time:
7.85 seconds, 459 pieces/hour
as measured performance

Degree of performance: 76.48%

Current Practice:

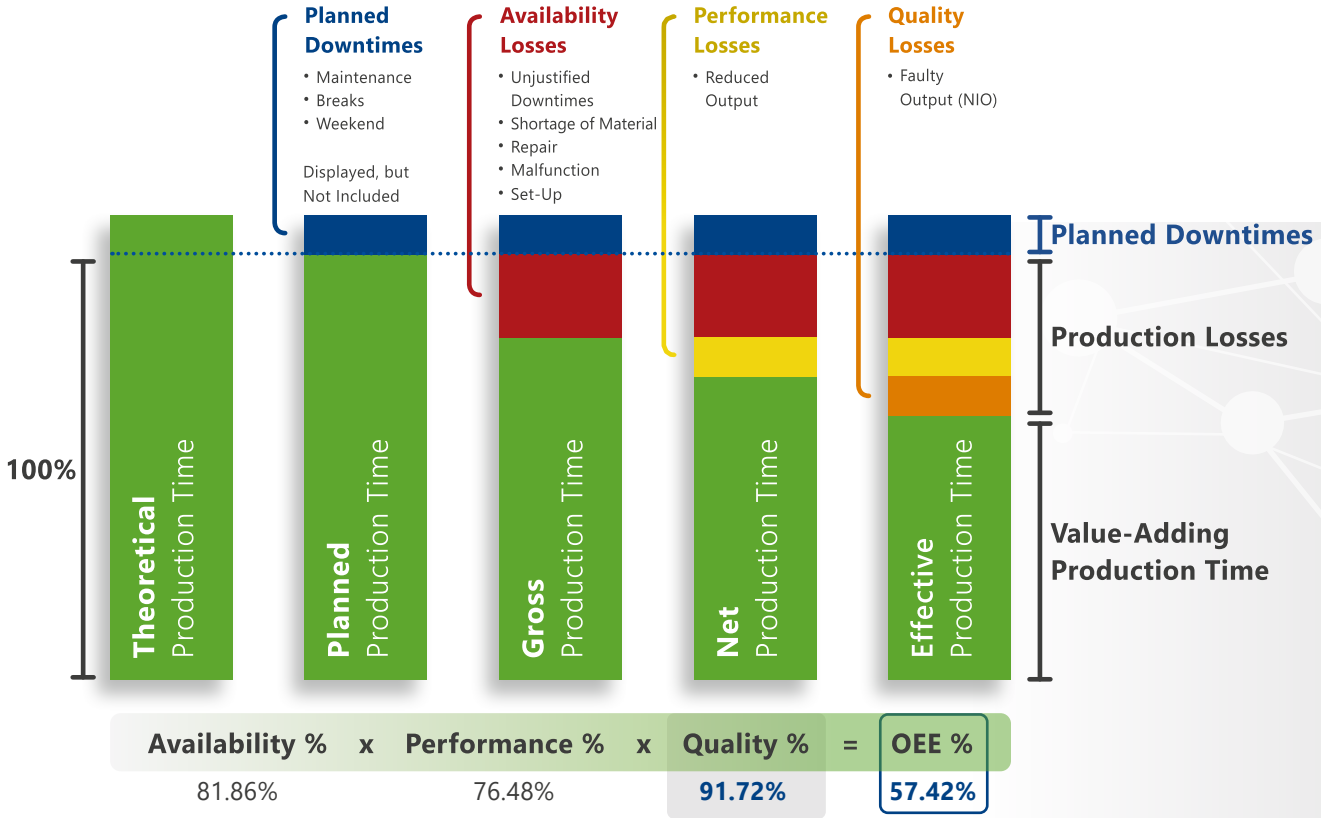
The Degree of Quality

The OEE-relevant degree of quality of a plant, machine or line results from the proportion of good parts produced in relation to the total number of parts produced. The greater the number of good parts achieved, the better the quality of the production processes.

Process errors that cause scrap and rework minimize the degree of quality just as much as, for example, reduced output due to start-up losses during production start-up.

This results in the following formula for calculating the degree of quality:

Degree of Quality = Good Parts / Total Parts Produced



$$\text{Degree of Quality} = \frac{\text{Good Parts}}{\text{Total Parts Produced}}$$

Practical Example:
Consideration for One Shift

Total parts produced: 2692 pieces

Good parts: 2469 pieces

Rejects: 223 pieces

Degree of quality: 91.72%

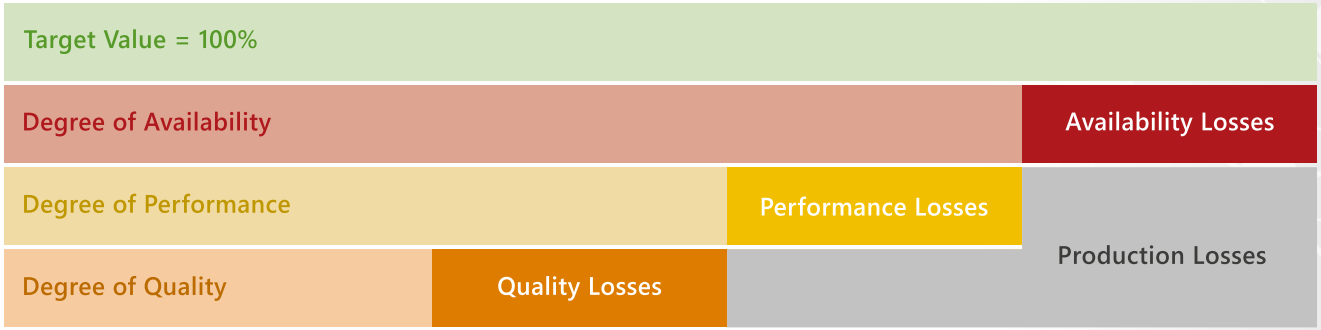
Current Practice:

Loss Calculation

A target OEE of 100% is assumed when calculating the losses. The availability level is first subtracted from this 100%, which then results in the availability loss.

Since the degree of performance of a machine, plant or line is calculated for the actual time of use, the degree of availability must be included when calculating the performance losses.

The same applies to the calculation of quality losses. The degree of quality is calculated depending on the actual performance of a machine within the actual time of use. Therefore, it is necessary to include the degree of availability and the degree of performance in the calculation of quality losses.



On one machine, a degree of availability of 81.86%, a degree of performance of 76.48% and a degree of quality of 91.72% were achieved. The OEE value of this machine is therefore 57.42%.

In the loss calculation, the degree of availability is now subtracted from the target OEE value of 100%:
Availability loss = 100% - degree of availability
18.14 = 100% - 81.86%

When calculating the performance loss, the actual availability must be taken into account:
Performance loss = (100% - degree of performance) x degree of availability
19.26 = (100% - 76.48%) x 81.86%

The loss of quality, in turn, depends on the degree of availability and performance:
Quality loss = (100% - degree of quality) x degree of availability x degree of performance
5.19 = (100% - 91.72) x 81.86% x 76.48%

The sum of all losses for the machine results in a total loss of 42.58%.

Current Practice:

NEE Value Calculation

The NEE value was based on the OEE value. The abbreviation NEE stands for "Net Equipment Effectiveness."

Like the OEE value, the NEE value is calculated from the product of the degree of availability, degree of performance and degree of quality. **In this context, the states relating to set-up and retrofitting are not included in the calculation.** The NEE value cannot fall below the OEE value.

Practical Example: Consideration for One Shift

Total time: 480 minutes

Production: 352 minutes

Planned downtime: 50 minutes

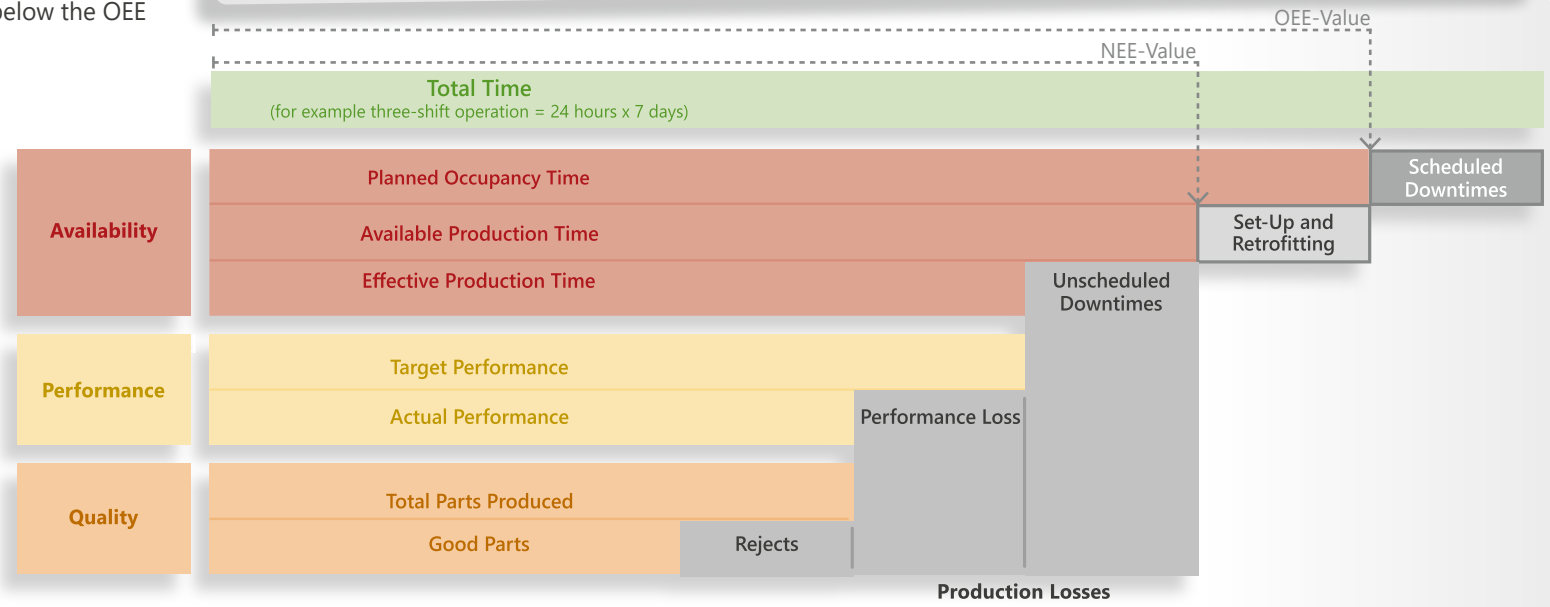
Unplanned downtime: 78 minutes
Of which preparation or follow-up: 28 minutes of set-up

Which states correspond to set-up or retrofitting can be configured in the software.

Degree of Availability Without Set-Up/Retrofitting = Actual production time / (Planned production time - set-up time)

= 352 minutes / 430 Minutes - 28 minutes

= 87.56 %



NEE Value Calculation:

Degree of Availability (Without Set-Up/ Retrofitting) x Degree of Performance x Degree of Quality = NEE

87.56% 76.48% 91.72% 61.42%

Current Practice:

TEEP Value Calculation

TEEP is a key figure for performance measurement with which the equipment effectiveness and utilization of a machine, plant or line can be displayed and compared over a period of time.

The abbreviation TEEP stands for "Total Effective Equipment Performance."

This value is a measure of the actual productivity of a machine, plant or line. It is the product of plant capacity utilization and OEE. By recording the TEEP, hidden optimization potentials in the production process become visible and also assessable.

The TEEP value is always between 0% (no utilization) and 100% (full utilization) and cannot exceed the OEE value.

Practical Example: Consideration for One Shift

Total time: 480 minutes

Production: 352 minutes

Planned downtime: 50 minutes

Unplanned downtime: 78 minutes

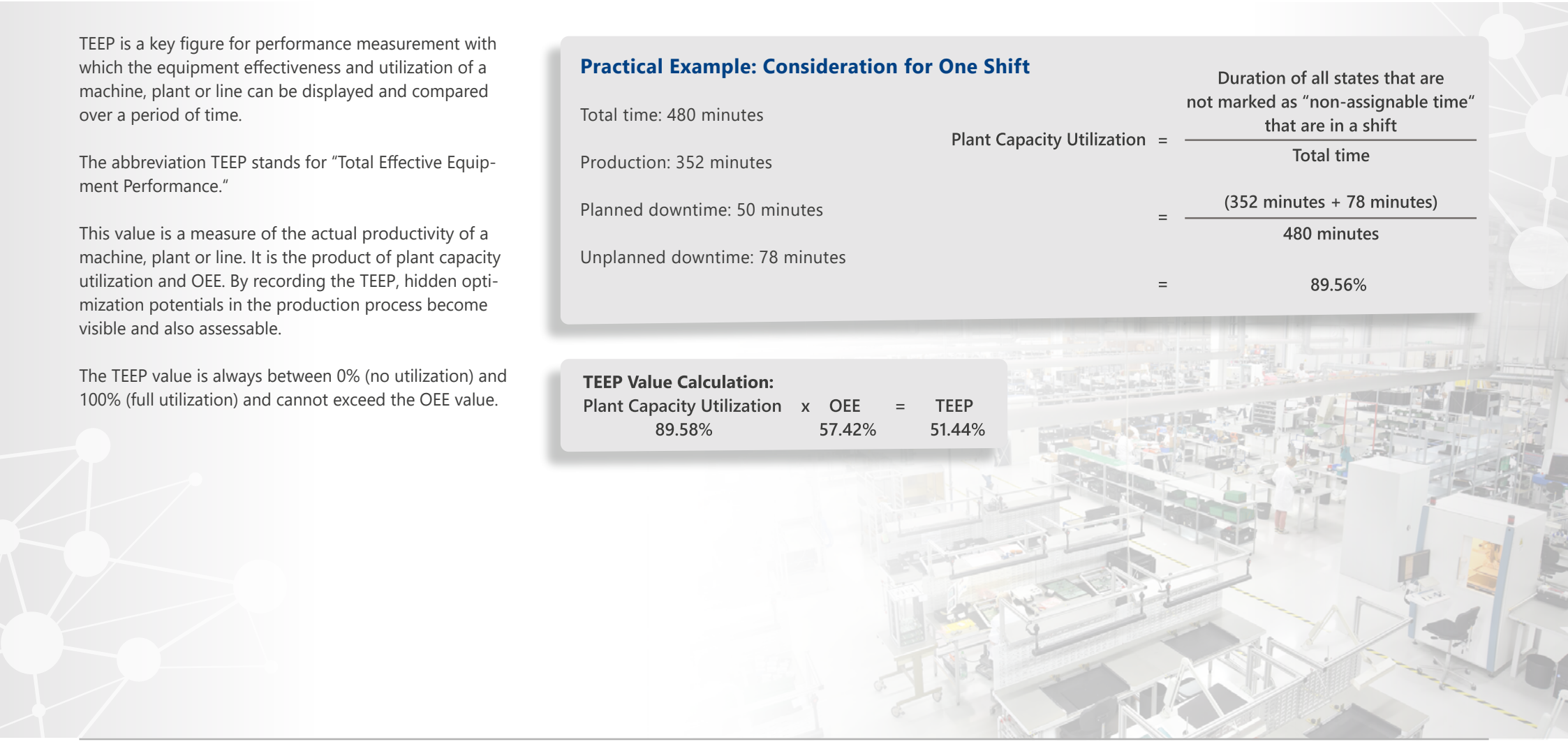
$$\text{Plant Capacity Utilization} = \frac{\text{Duration of all states that are not marked as "non-assignable time" that are in a shift}}{\text{Total time}}$$

$$= \frac{(352 \text{ minutes} + 78 \text{ minutes})}{480 \text{ minutes}}$$

$$= 89.56\%$$

TEEP Value Calculation:

Plant Capacity Utilization	x	OEE	=	TEEP
89.58%		57.42%		51.44%

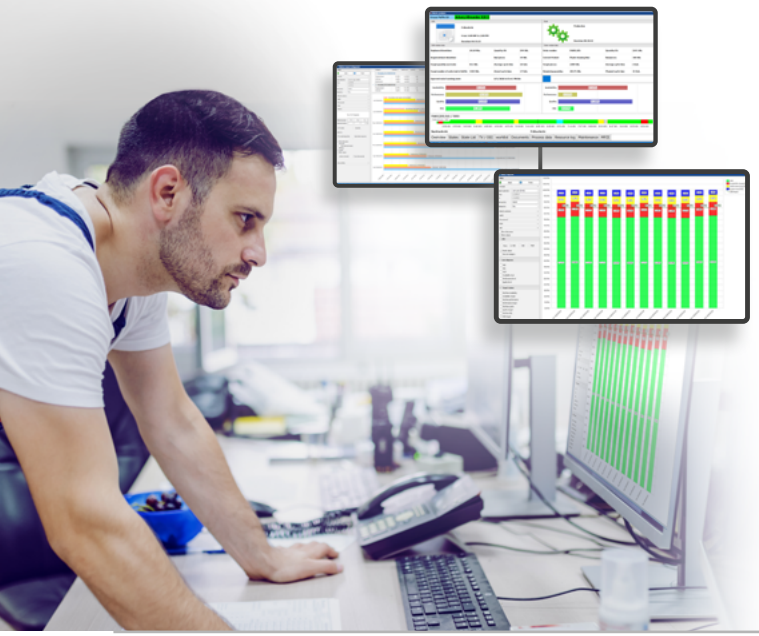


Key Figures for Analyses and for Monitoring Success

Implementation & Use in Everyday Production Using the Example of MDA From FASTEC 4 PRO

Let us focus on machines which produce parts in series and which have to be set up before production begins. When introducing MDA, a catalog of possible reasons for downtime and malfunctions must first be drawn up for each (machine) workstation. The catalog doesn't have to be perfect at first; start from everyday experience.

If machines automatically give out reasons for downtimes in the event of production interruptions, these can be recorded directly by the MDA via a machine interface.



Reasons that only a machine operator can assign must be entered via an operator terminal. Talk to the machine operators about what downtime reasons should be recorded. It has proven useful to divide downtime reasons into categories: e.g. technical and organizational malfunctions, often also set-up. The reasons are then further detailed within these categories. But be careful – do not overwhelm your machine operators. If you are introducing MDA for the first time, you should proceed carefully and start with a few reasons for downtime that can be clearly identified by every machine operator. Reasons for downtime that the machine itself supplies to the MDA are not subject to any restrictions. But here, too, in case of doubt the rule applies, "less is more."

Downtimes that a machine cannot automatically classify are initially recorded by the system as unfounded interruptions (UI). Here, the machine operator must take action and enter the reason. Make sure from the beginning that UIs disappear from your machine logbooks. Be absolutely consistent – interruptions can only be eliminated if you know the causes. Anyone who does not take action here fails. Work continuously with the machine operators and maintenance personnel on improvement measures. The MDA supports you in this and documents every progress; the full involvement of employees creates additional motivation.

A Few Final Notes:

Start with the bottleneck machines and start with employees who are the most motivated. This is the quickest way to see success. Downtimes differ in frequency and duration. Often the priority is given to the ones with the longest duration and the overlooked ones, which are short but frequent. Pick the „low hanging fruits" first. There are often reasons for downtime that can be eliminated without much effort – once you have noticed them. The best example of this are machines that are at a standstill due to a lack of materials. Automatic alerting can help here.

Machine comparisons can also provide valuable information. FASTEC 4 PRO enables these comparisons at order level; so you can quickly see whether an order is overwhelming an older machine, for example. Set-up times also often differ significantly, and experience has shown that there is a lot of potential for optimization here. With MDA, many weak points become transparent and can be eliminated. Make sure that machine faults are eliminated immediately. If you expect higher productivity but do not act immediately, you will frustrate your employees.

The Complete Industry 4.0 Whitepaper Series From FASTEC

FASTEC provides manufacturing companies with MES solutions for discrete manufacturing. As a leading MES provider, FASTEC has implemented a wide range of customized solutions in many projects since it was founded in 1995 – each unique in terms of the production processes and manufacturing methods involved. Our systems are used nationally and internationally in various industries.

We work in a practice-oriented, efficient manner and ensure that our projects lead to lasting benefits for our customers. Together with you, we develop suitable solutions for your requirements, which we then implement precisely, quickly and cost-effectively on the basis of our MES standard software, which can be configured in many ways. Our customers benefit from our wide range of experience. In the end, there is a result that convinces our customers: A flexible and easily expandable system with sophisticted functions. FASTEC users are enthusiastic about the numerous features of the software and its usability in everyday use.

Decide on FASTEC 4 PRO – for a custom-fit MES solution with maximum customer benefit.

We take you on a journey into digital manufacturing; our whitepaper series serves as a guide.

Step 1: What Is Industry 4.0? Where Is the Journey Heading?

Step 2: How Do I Find the Right Partner on the Way to Industry 4.0?

Step 3: 10 Tips for MES Implementation – What You Should Keep in Mind.

Step 4: Focus on Transparency: The Modules MDA, PDA, Monitoring Etc.

Step 5: **Focus on Optimization: Key Figures and How to Work With Them.**

Step 6: Focus on Traceability: The Many Unknown Benefits.

Step 7: Focus on Planning: Save Time and Resources With Effective Planning.

Step 8: Functional Networking as the Basis of the Self-Regulating Factory.

Stay Competitive in the Long Term – With Us.

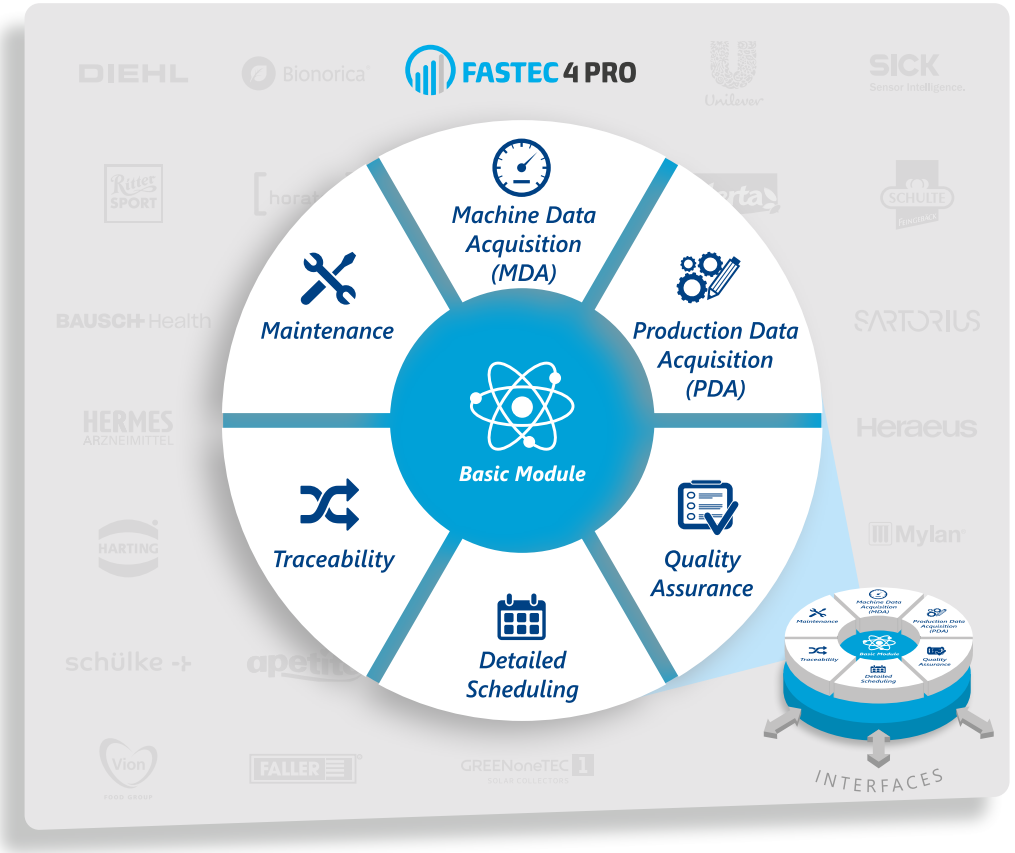
FASTEC GmbH is based in Paderborn, Germany and specializes in the digitalization of production processes based on the in-house developed Manufacturing Execution System (MES) FASTEC 4 PRO. The modular standard software can be configured across industries, is compatible with future releases and operated intuitively.

FASTEC has been accompanying its customers on their way to digital transformation since 1995. Around 400 companies in over 20 countries use FASTEC 4 PRO in over 10,000 production facilities. Work processes are optimized and costs are reduced in the long term thanks to the holistic digitalization of production.

We would also like to give you a good advice personally!

Our sales department will be happy to provide you with further user reports and information material! Or else, make an appointment with our sales department for a presentation at your location, in our company or via web. Of course, you can also experience FASTEC 4 PRO live and on site with our customers.
vertrieb@fastec.de or by phone at +49 5251 1647-0

Additionally, we offer videos of our software and customer solutions in our YouTube channel:
www.youtube.com/FASTECGmbH



FASTEC GmbH
Technologiepark 24
D-33100 Paderborn

+49 5251 1647-0

info@fastec.de
www.fastec.de

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SAP Silver Partner