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# Energy Management – Campaign

## Webinar 7 – From baseline management to forecasting



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# Overview webinar

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## Webinar 6:

**Last webinar:**

Turning data into information. Correctly displaying energy relationships and recognizing savings potential.

Webinar 6

Energy data management - from data into information

## Webinar 7:

**Goal of this webinar:**

Analysis of the energy baseline taking into account various influencing factors and energy forecast options derived from this analysis.

Webinar 7

Energy data management - from baseline management to forecasting

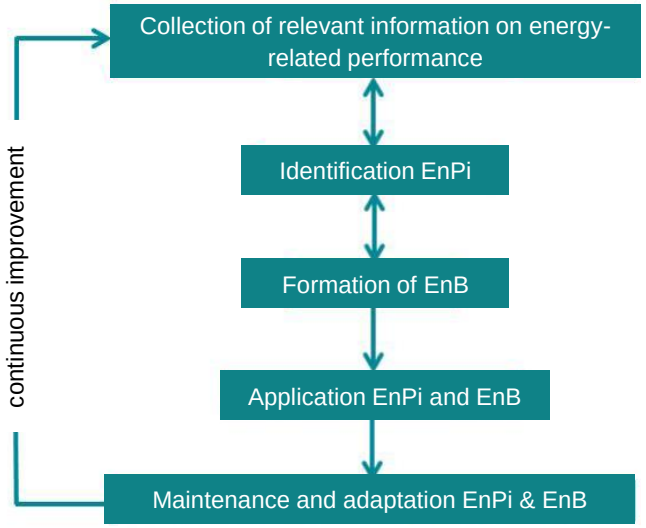
# ISO 50006 - KPIs and baseline (guideline)

ISO 50006 deals with the "**Measuring energy performance using energy baselines (EnB) and energy performance indicators (EnPI)**" as an extended practical application aid of ISO 50001.
EnPIs are used to evaluate the energy-related performance of the company or of subareas of the company.
**Four categories** of EnPIs are identified and a procedure is proposed to determine them (see figure):

- measured values (absolute KPI),
- the ratio between the measured values (relative KPI - energy efficiency),
- statistical model values or
- simulation values (technical model - mutual influence of different variables).

The respective energy baseline (EnB) is used as the quantitative reference point for the evaluation.

The guideline defines **two types of factors influencing energy-related performance** (so-called "relevant variables" and "static factors") and stipulates that they be quantified and taken into account when determining EnPIs and EnBs. **The objective is to adjust the EnPIs** so that **the baseline period can be compared to the reporting period**. If there are several relevant variables, it is recommended to normalize them by using an appropriate model. **Normalization** is a procedure **to model energy consumption data** taking into account relevant variables for future time periods. **Linear regression** is named here as an example.




Structured approach to the application of EnPIs and EnBs for the continuous improvement of energy-related performance in accordance with ISO 50006.

# What is the baseline and how can it be determined?

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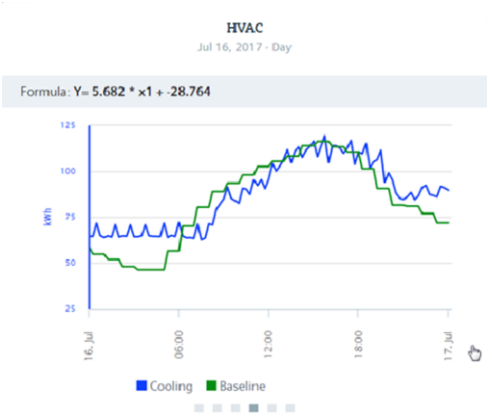
## Baseline = Energy-based starting point

**The energy baseline** essentially contains energy consumption data and serves as a basis for comparing energy-related performance and thus also **for evaluating the development of energy efficiency**. It usually refers to a **fixed period of time**, most often a year.
Monthly values are also often compared with each other. To compare this consumption line with other years (with climate data and production capacity utilization that normally differ from the base year), **this base should be normalized by variables** (factors influencing energy input and consumption). We then also speak of "adjustment factors".
In particular, the energy baseline is to be adjusted in the event of changes in energy performance indicators or significant process and/or energy system changes using a predetermined method.

<u>Different methods to determine the baseline:</u>

- **Total energy consumption of a previous period** (variants: annual comparison, heating period comp. ,..)
  Disadvantage: different production quantity is not taken into account
- **Specific energy consumption per production or other energy performance indicators**
  Disadvantage: Possible increased basic energy consumption is not taken into account
- **Calculated expected energy consumption taking into account production and various additional** influencing factors (calculation from regression lines of **multivariable regression** analysis over a reference period). Best method for deriving the baseline
  Disadvantage: Influencing factors must be available in the same measurement acquisition cycle of the reference period



# Baseline management vs. material-related consumption analysis

## Is the energy consumption dependent on the material and quantity produced?

Especially in the detailed energy consumption analysis of production plants, the **energy consumption** (of all media) is often **dependent on** the produced **material or product and quantity**.
Therefore, it is recommended to perform a **batch- or material-dependent energy consumption analysis** at this detailed level of the energy consumption evaluation.

An **energy consumption model** can be determined for the batches produced in the selected period on a **product/material basis**. This is also referred to as a material characteristic. The same methodology can be used to calculate the **carbon footprint** for a batch and thus for a product.

Furthermore, for each product the determined model parameters can be assigned per consumed medium. These parameters are used as the basis for the forecast.

It is thus possible to forecast **energy consumption on the basis of a planned production schedule**.
This also allows users to create a more accurate **energy schedule for the next few days** of their production facility.

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# The "correct" model for the respective task

Depending on the application, it has to be distinguished whether a **total energy consumption forecast (month)** over a defined observation period or a **detailed load profile forecast** (15 min) is necessary.

1. Total energy consumption forecast over a long period of time (planning horizon: up to several years on a monthly basis) for energy purchasing, to optimize energy procurement or budget planning.

   → Forecasting based on multivariable regression analysis (cf. baseline management) is applied for this task

1. Detailed energy load profile forecast (planning horizon: the next few days in a 15 min grid) for applications in which the load profile is very volatile and the power supplier wants to avoid peaks in its balance group.
   → The following procedures can be used for this task.
   - Forecast based on multivariable regression analysis (cf. baseline management)
   - Production plan-related forecast if the energy consumption depends on the product and the quantity
   - Comparison principle: For areas whose energy consumption follows a weekly/shift profile

# SIMATIC Energy Management – Transparency and efficiency from machine to company

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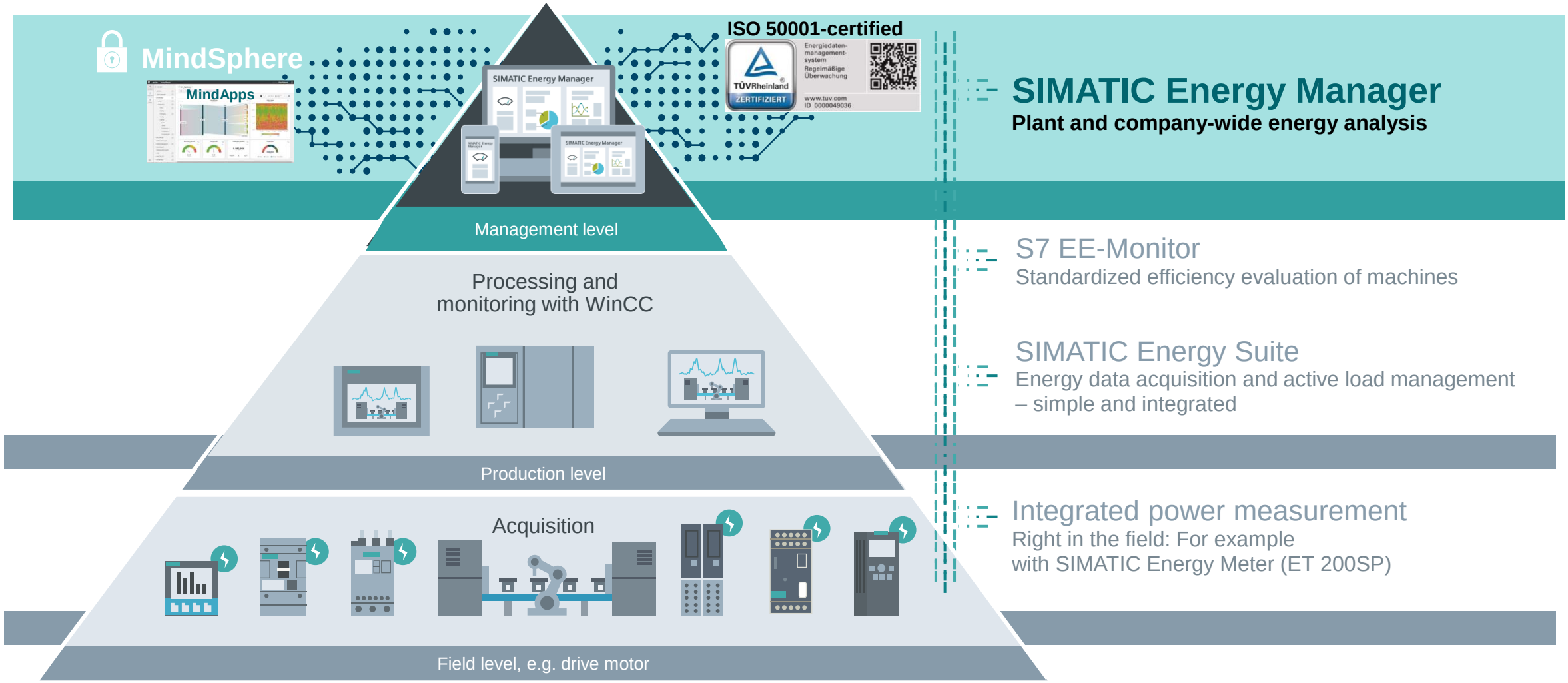

# SIMATIC Energy Manager PRO
# Baseline management with multivariable regression analysis

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## Determination of the baseline and forecast for your plant

- Calculating the theoretical energy consumption under the determined general conditions (influencing factors)
- Checking the deviation
- Cumulative deviation to identify general efficiency deterioration or improvement.
- Energy forecast by model basis with available cyclic planning data/predicted values of influencing factors.


**Intelligent limit values allow you to quickly detect inefficiencies.**

# SIMATIC Energy Manager PRO
# Multivariable regression analysis

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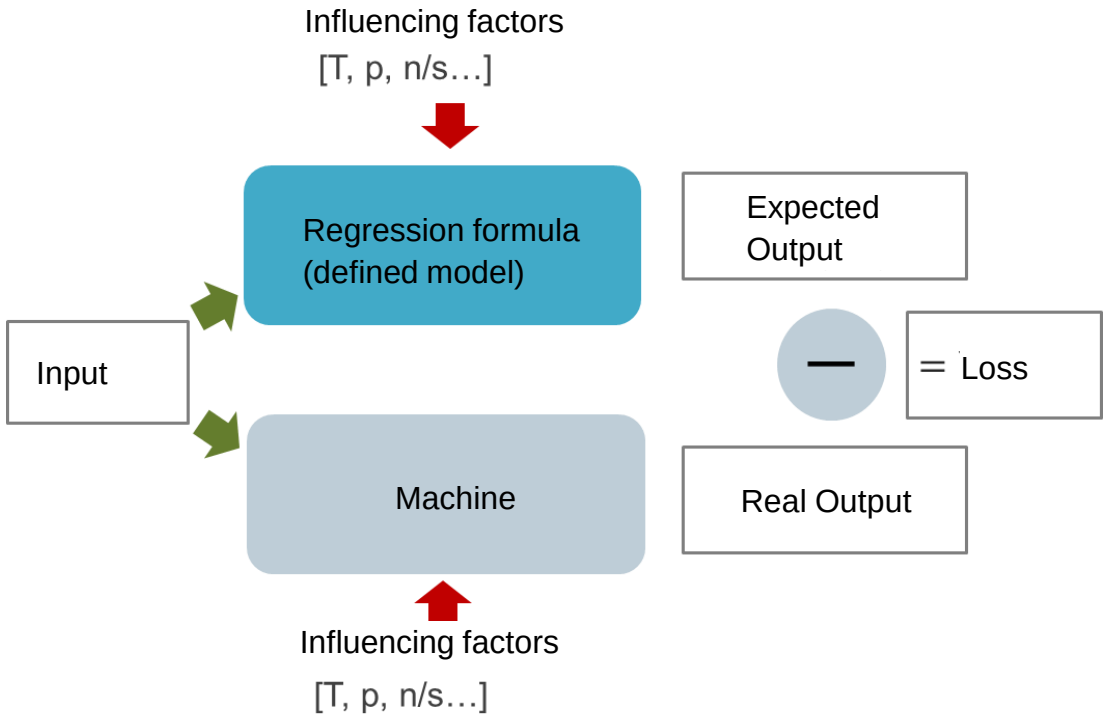
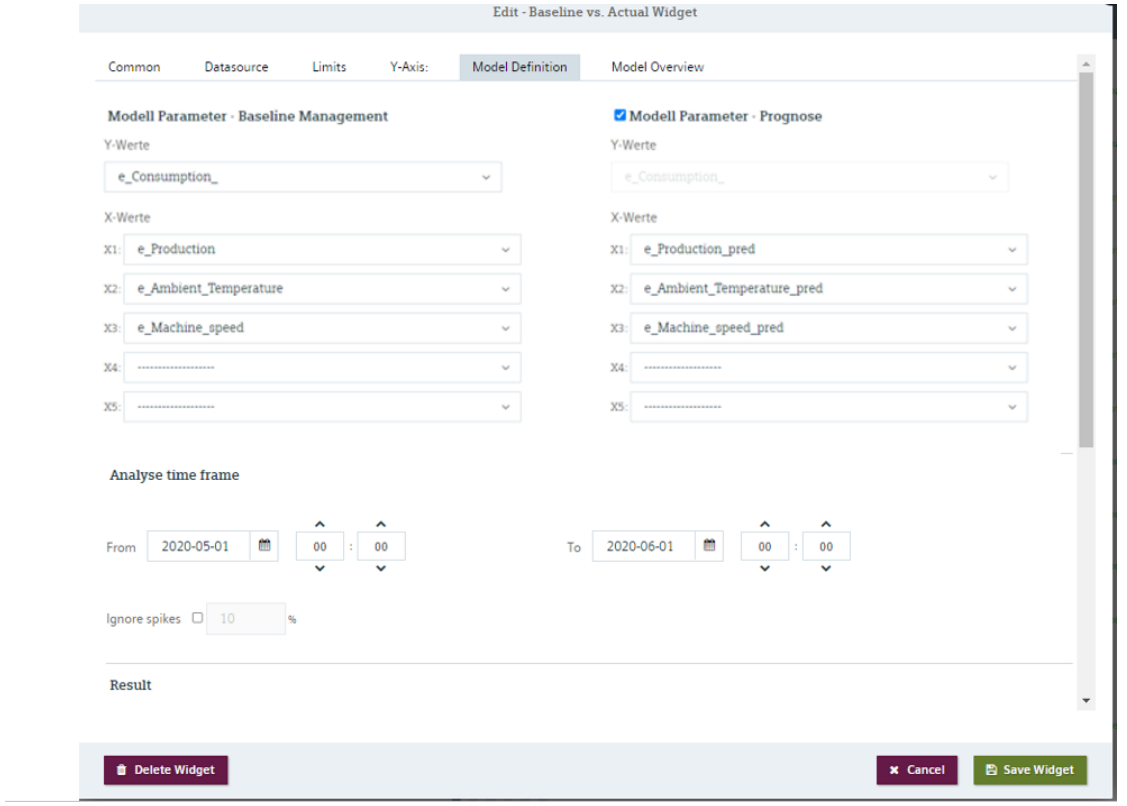
## Baseline management in accordance with ISO 50006



# SIMATIC Energy Manager PRO
# Multivariable regression analysis

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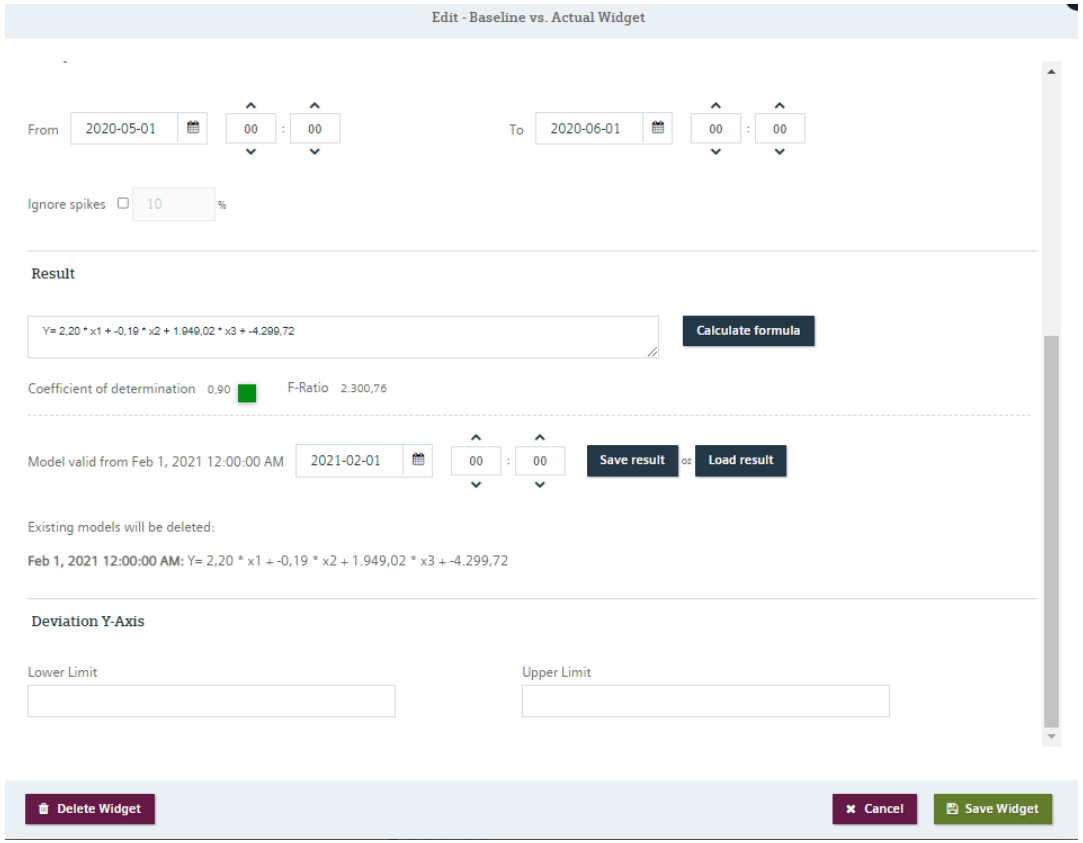
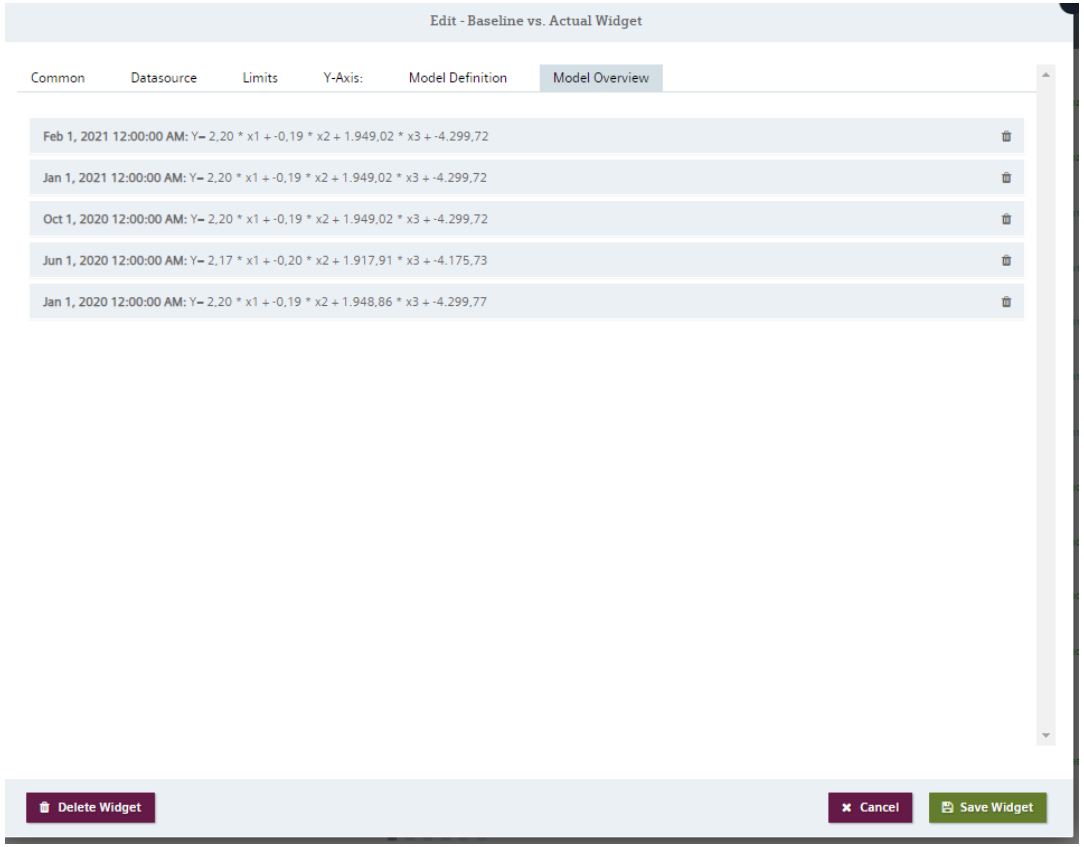
## Baseline management in accordance with ISO 50006



# SIMATIC Energy Manager PRO
# Multivariable regression analysis

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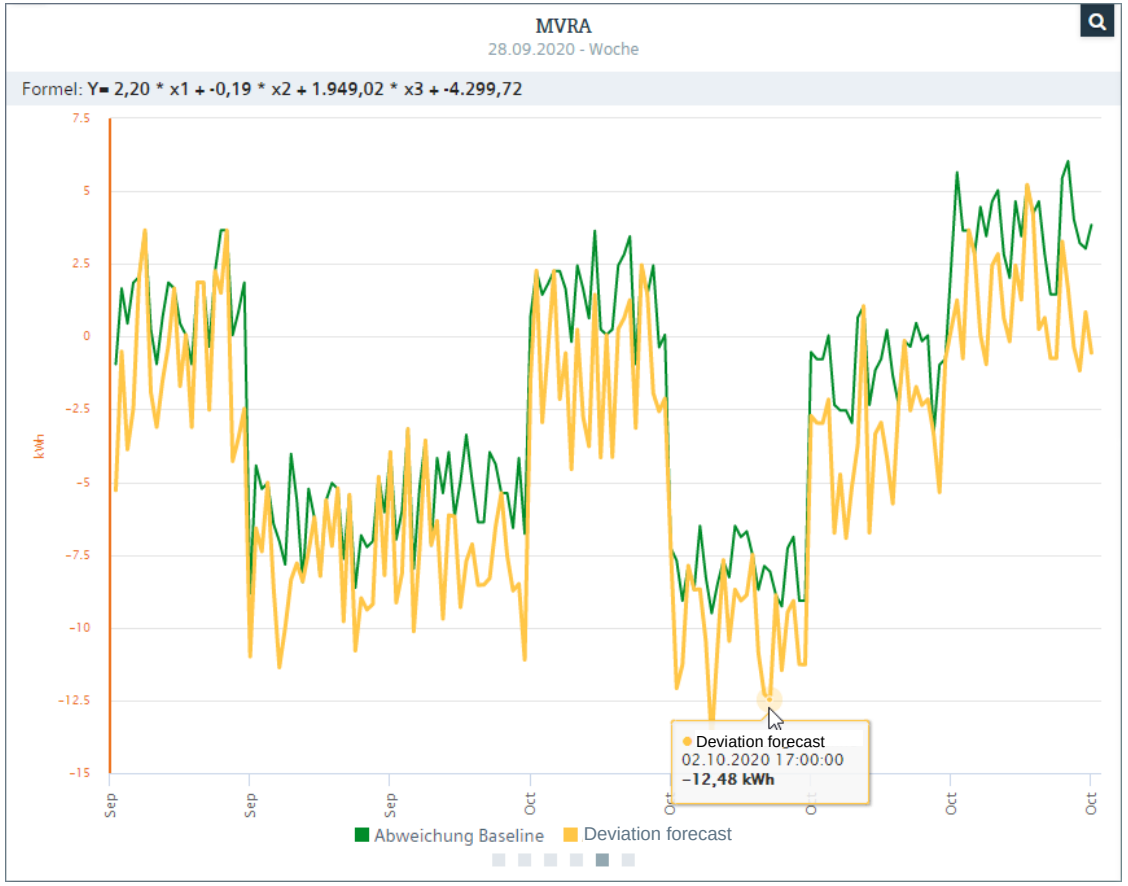
## Baseline management in accordance with ISO 50006

# SIMATIC Energy Manager PRO
# Multivariable regression analysis

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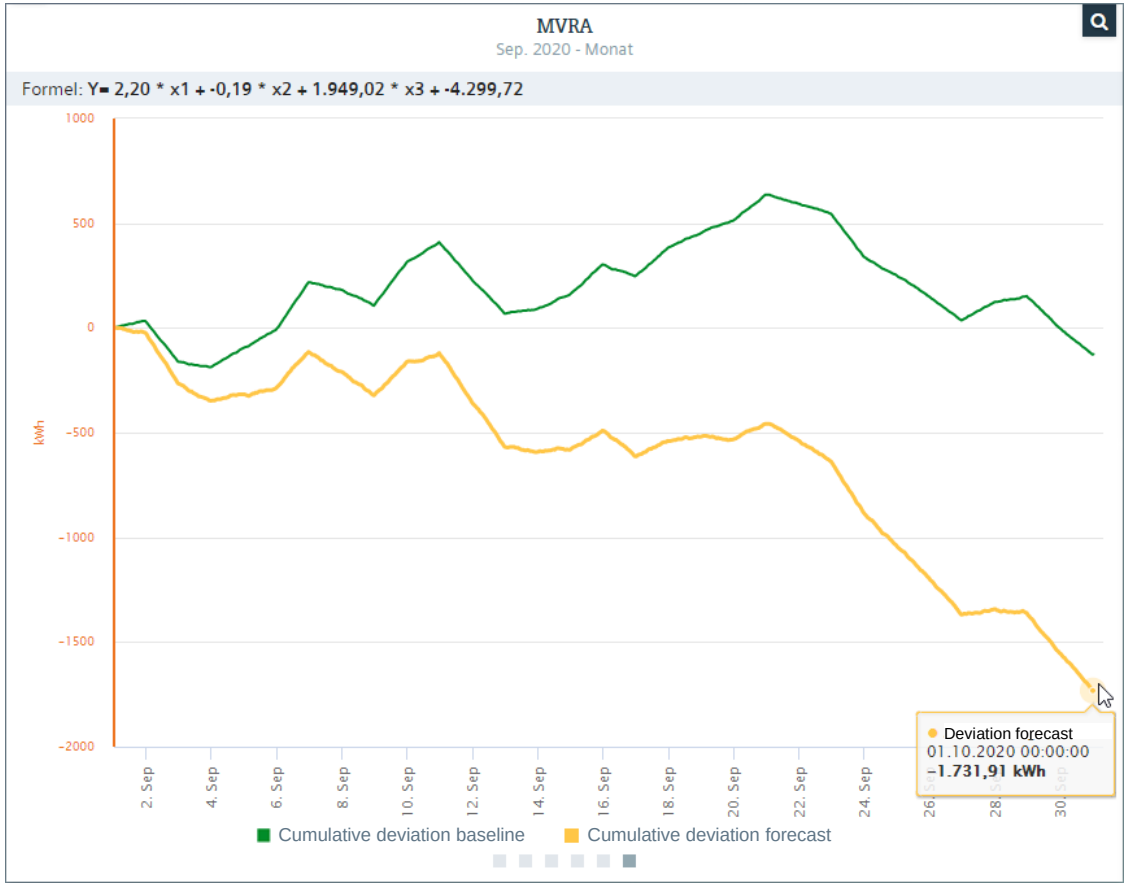
## Baseline management in accordance with ISO 50006




Cumulative representation:

This representation **shows how far the model calculation** of the model active in this period of the previous analysis agrees with the **real energy consumption measurement**.

If the trend of the "**cumulative deviation of the baseline**" fluctuates to positive or negative over the observation period and returns to a deviation around 0 at the end, it would mean that the selected model is basically quite close to reality and thus suitable for the baseline calculation.

In the trend of the "**cumulative deviation of the forecast**", the deviation depends on the forecast values entered.
The cumulative deviation thus provides conclusions about the quality of the forecast influencing factors

# SIMATIC Energy Manager PRO
# Multivariable regression analysis

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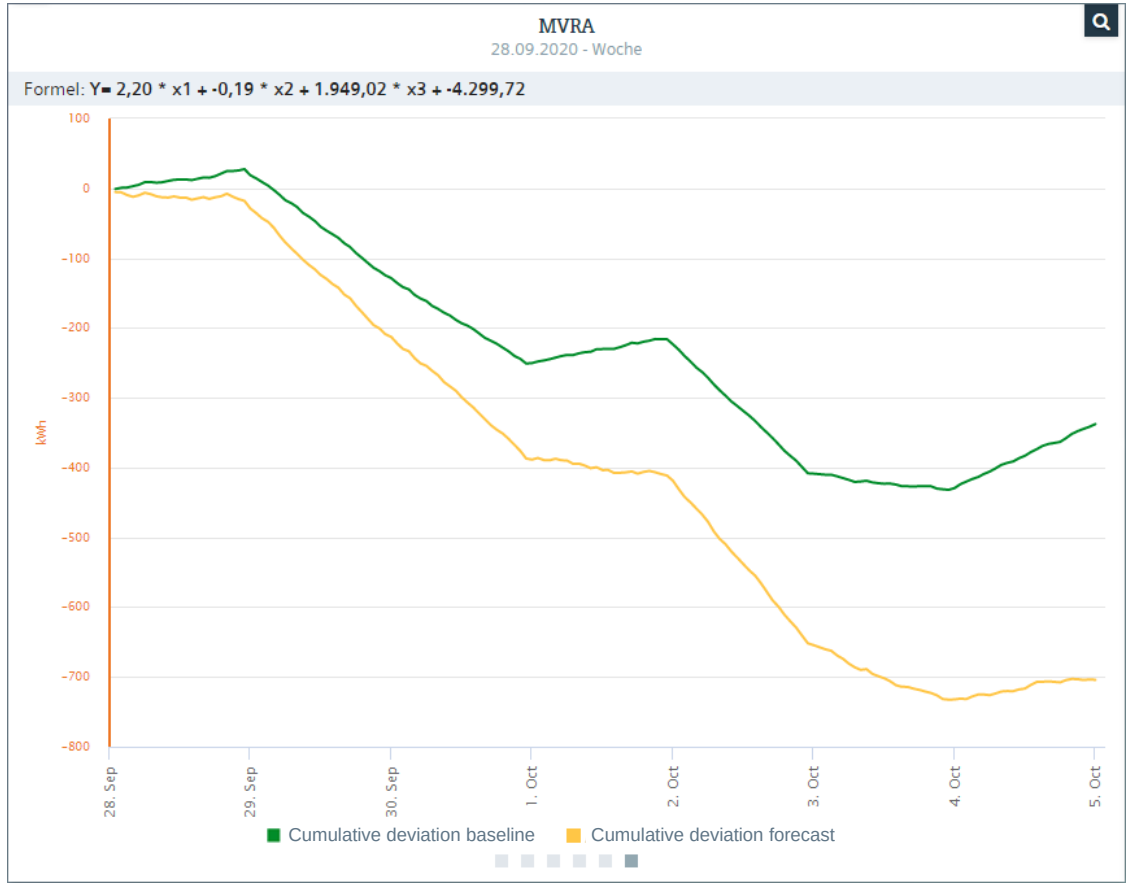
## Baseline management in accordance with ISO 50006




Cumulative representation:

If both cumulative deviations show **a drift into positive consumption in the longer term**, this could indicate a **problem in the plant** that has led to higher energy consumption compared to the model recording period.

If, in contrast, **energy optimization measures** have taken place in the plant, the cumulative representation of the baseline as well as the forecast with the existing model should **change to the negative** (falling trend) (representation on the left).

For this reason, **a new model calculation analysis should be performed after a plant optimization**.
The prerequisite is the availability of a new analysis time window for the new model calculation after the optimization (e.g. 1 month)

# SIMATIC Energy Manager PRO
# Multivariable regression analysis - Possible applications

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## Production: Consumption dependence on...

**General:** Production speed, cycle

**Injection molding**: Material quantity (shot weight), temperature, cycle

**Machining process**: Feed rate, rotational speed, drill/milling head size, tool life, cycle

**Presses:** Material thickness, stroke length, cycle,

**Chemicals:** Pressure, temperature, concentration, load

**Steam:** Pressure, temperature, load

**Cold**: Flow temperature, condenser temperature, load

**CHP** Ambient temperature, electrical & thermal load, flow temperature

**Compressed air** Pressure level, load, ambient temperature, air pressure, humidity

**Baking, cleaning, refrigeration:** Cycle, process temperature, ambient temperature

**Pumps & blowers:** Pressure, load, ambient temperature

**Drives, general losses:** Ambient temperature, torque, speed

## Buildings & Infrastructure (no focus)

**HVAC:** Flow temperature, condenser temperature, load, number of persons, ambient temperature, inside temperature, hours of sunshine, humidity => individual daily profiles needed

**District heating:** Ambient temperature, hours of sunshine, => individual daily profiles needed

**District cooling:** Ambient temperature, hours of sunshine, humidity => individual daily profiles needed

# SIMATIC Energy Manager PRO
# Batch and material analysis

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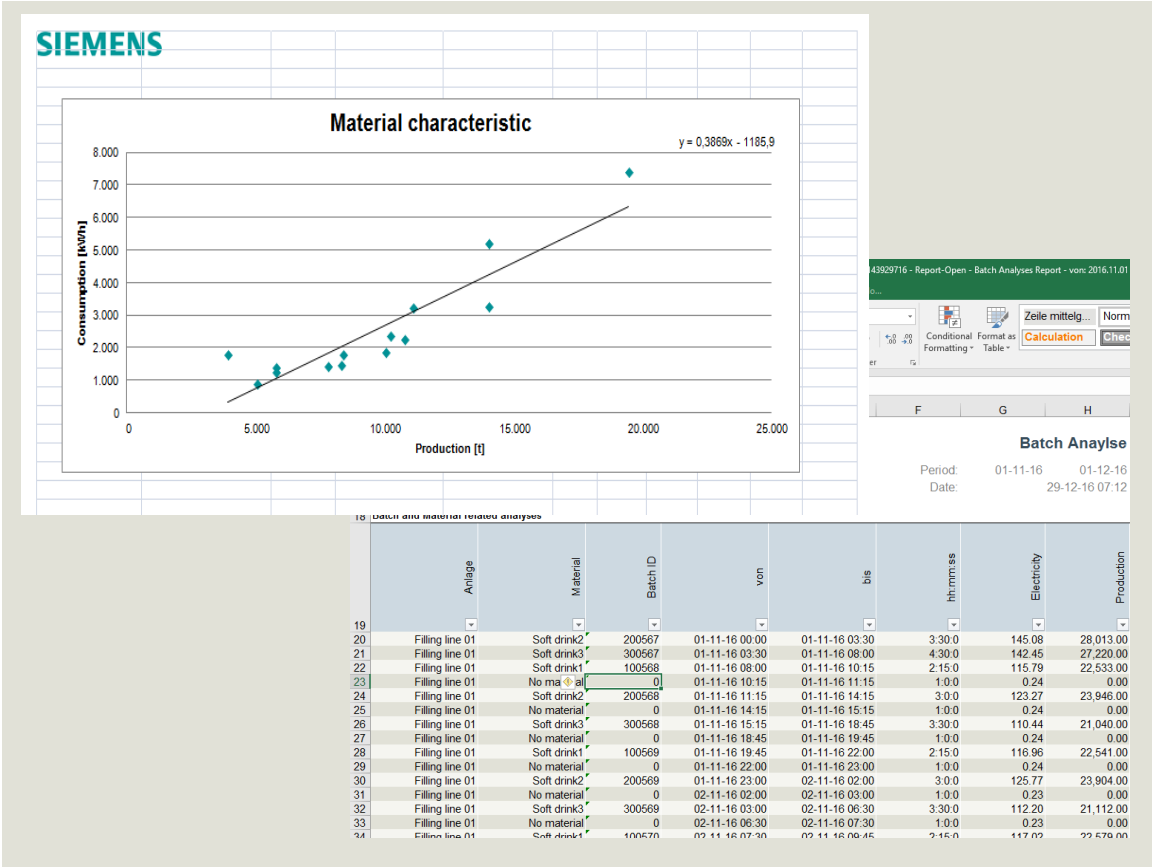
## Data analysis in the context of a batch or the product

- Material/product-related analysis across all measurable consumption media
- Possibility to compare different products or one product on different lines/production facilities
- Batch balance over the entire manufacturing process




| | Anlage | Material | Batch ID | von | bis | hh:mm:ss | Electricity | Production |
|---|---|---|---|---|---|---|---|---|
| 19 | | | | | | | | |
| 20 | Filling line 01 | Soft drink2 | 200567 | 01-11-16 00:00 | 01-11-16 03:30 | 3:30:0 | 145.08 | 28,013.00 |
| 21 | Filling line 01 | Soft drink3 | 300567 | 01-11-16 03:30 | 01-11-16 08:00 | 4:30:0 | 142.45 | 27,220.00 |
| 22 | Filling line 01 | Soft drink1 | 100568 | 01-11-16 08:00 | 01-11-16 10:15 | 2:15:0 | 115.79 | 22,533.00 |
| 23 | Filling line 01 | No material | 0 | 01-11-16 10:15 | 01-11-16 11:15 | 1:0:0 | 0.24 | 0.00 |
| 24 | Filling line 01 | Soft drink2 | 200568 | 01-11-16 11:15 | 01-11-16 14:15 | 3:0:0 | 123.27 | 23,946.00 |
| 25 | Filling line 01 | No material | 0 | 01-11-16 14:15 | 01-11-16 15:15 | 1:0:0 | 0.24 | 0.00 |
| 26 | Filling line 01 | Soft drink3 | 300568 | 01-11-16 15:15 | 01-11-16 18:45 | 3:30:0 | 110.44 | 21,040.00 |
| 27 | Filling line 01 | No material | 0 | 01-11-16 18:45 | 01-11-16 19:45 | 1:0:0 | 0.24 | 0.00 |
| 28 | Filling line 01 | Soft drink1 | 100569 | 01-11-16 19:45 | 01-11-16 22:00 | 2:15:0 | 116.96 | 22,541.00 |
| 29 | Filling line 01 | No material | 0 | 01-11-16 22:00 | 01-11-16 23:00 | 1:0:0 | 0.24 | 0.00 |
| 30 | Filling line 01 | Soft drink2 | 200569 | 01-11-16 23:00 | 02-11-16 02:00 | 3:0:0 | 125.77 | 23,904.00 |
| 31 | Filling line 01 | No material | 0 | 02-11-16 02:00 | 02-11-16 03:00 | 1:0:0 | 0.23 | 0.00 |
| 32 | Filling line 01 | Soft drink3 | 300569 | 02-11-16 03:00 | 02-11-16 06:30 | 3:30:0 | 112.20 | 21,112.00 |
| 33 | Filling line 01 | No material | 0 | 02-11-16 06:30 | 02-11-16 07:30 | 1:0:0 | 0.23 | 0.00 |

**Energy consumption at product level provides the basis for a carbon footprint**

# SIMATIC Energy Manager PRO
# Batch and material analysis - Basic consideration

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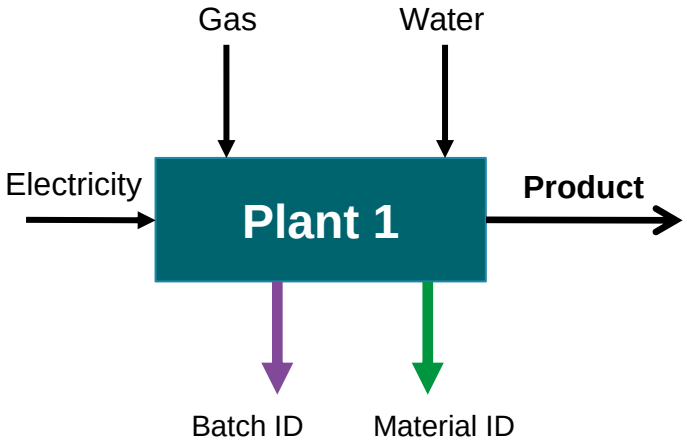


| Time stamp | Batch ID | Material ID |
|---|---|---|
| 01.04.2018 14:32:15 | B1234 | M123 |
| 01.04.2018 14:48:30 | B1236 | M162 |
| 01.04.2018 15:16:15 | B1242 | M166 |
| 01.04.2018 16:50:10 | B1258 | M162 |
| 01.04.2018 18:20:35 | B1277 | M123 |
| 01.04.2018 21:30:15 | B1298 | M166 |

- A batch designation (batch ID) is required for the batch- and material-related analysis. This designation can be either a string of numbers or a string of characters
- A batch is a produced quantity of a material (or a variety). This quantity is produced on plant 1. The material itself is defined via a second designation (material ID)
- For the production of this quantity, for example, electricity, gas and water are required
- In the batch- and material-related analysis, the consumption of the individual media in each batch is calculated.
- The batches can then be output in a report. Batches or materials/products can also be compared with one another there

# SIMATIC Energy Manager PRO
# Batch and material analysis - Basic consideration

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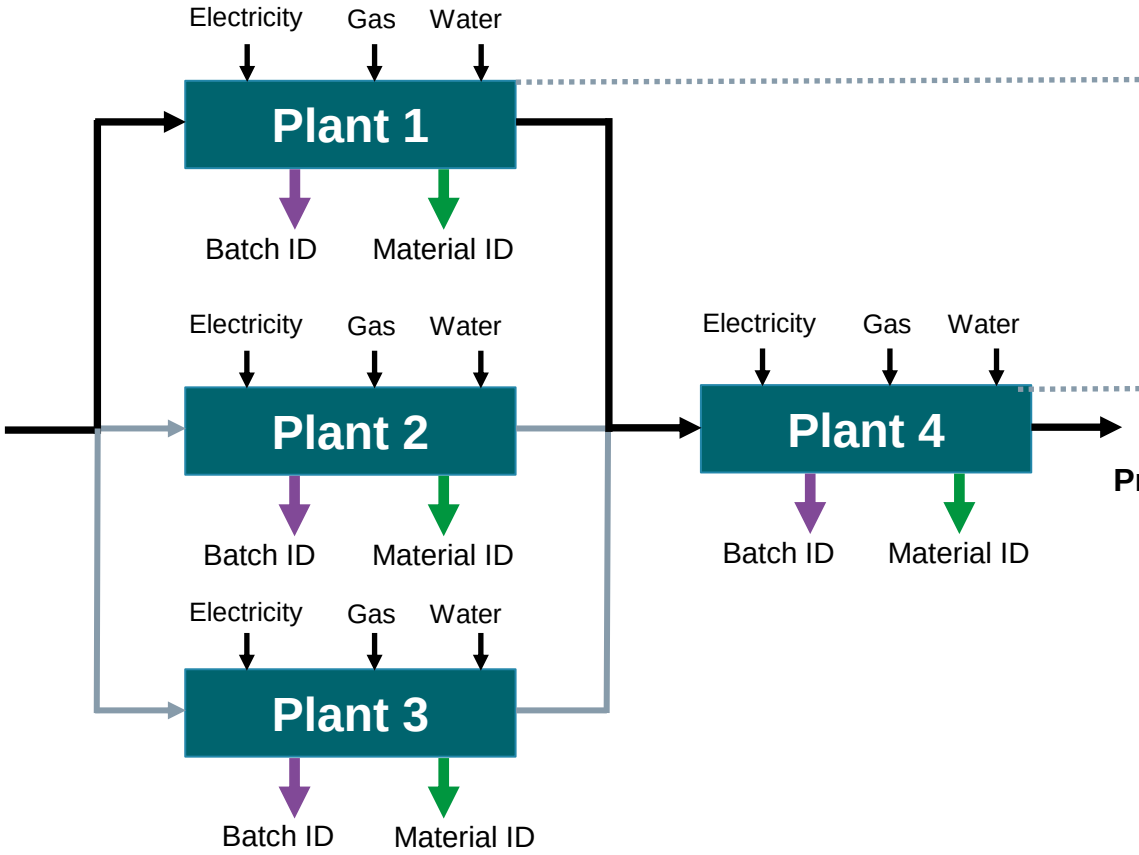


| Time stamp | Batch ID | Material ID |
|---|---|---|
| 01.04.2018 14:32:15 | B1234 | M123 |
| 01.04.2018 14:48:30 | B1236 | M162 |
| 01.04.2018 15:16:15 | B1242 | M166 |
| 01.04.2018 16:50:10 | B1258 | M162 |
| 01.04.2018 18:20:35 | B1277 | M123 |
| 01.04.2018 21:30:15 | B1298 | M166 |

| Time stamp | Batch ID | Material ID |
|---|---|---|
| 01.04.2018 16:32:15 | B1234 | M123 |
| 01.04.2018 16:48:30 | B1236 | M162 |
| 01.04.2018 17:16:15 | B1242 | M166 |
| 01.04.2018 18:50:10 | B1258 | M162 |
| 01.04.2018 20:20:35 | B1277 | M123 |
| 01.04.2018 23:30:15 | B1298 | M166 |

**A batch can also run on different lines or plants**

# SIMATIC Energy Manager PRO
# Batch and material analysis - Evaluation

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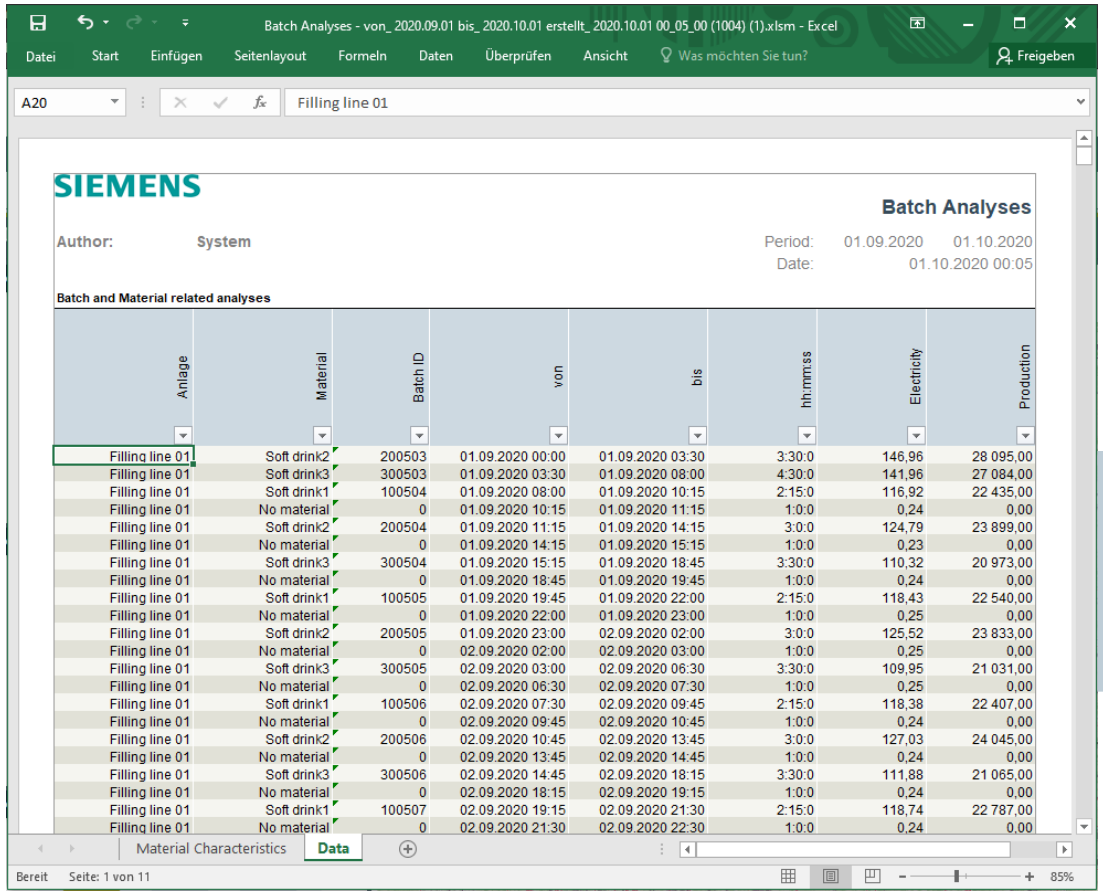
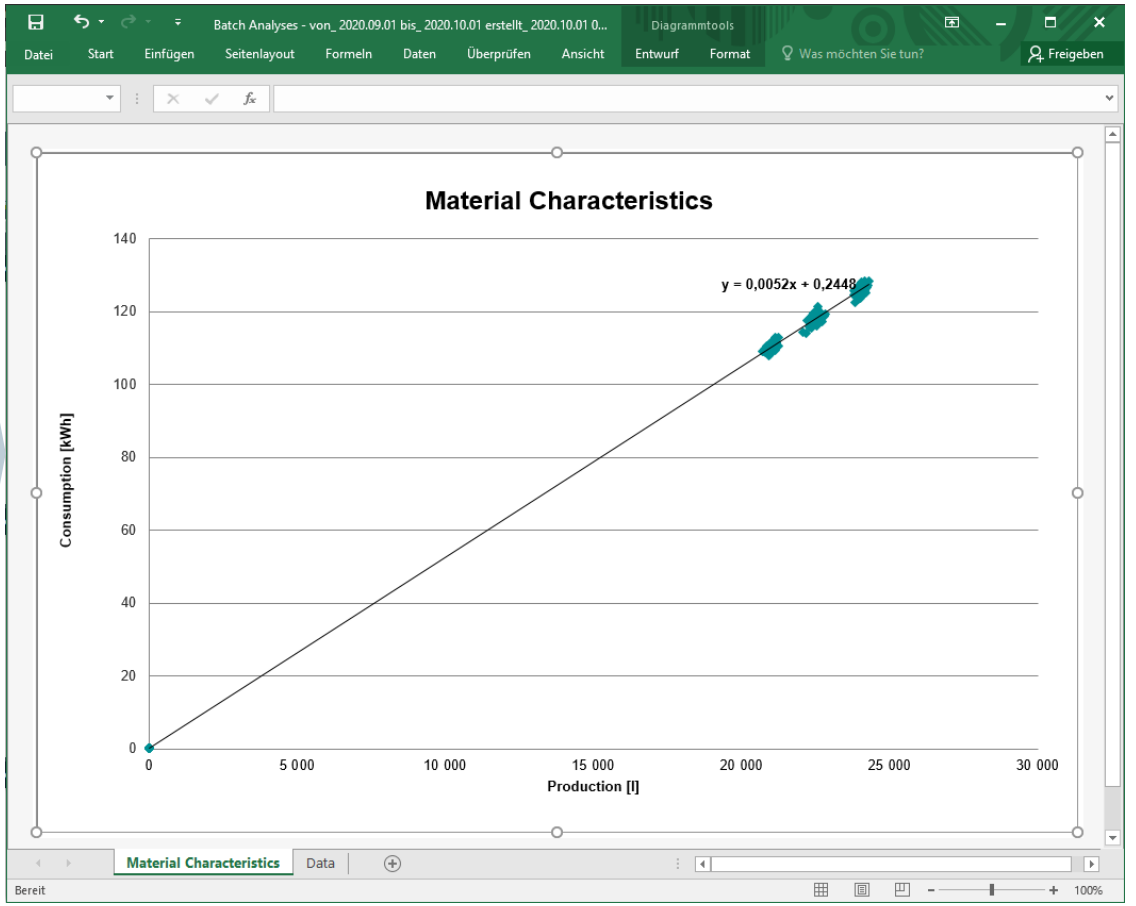



| Anlage | Material | Batch ID | von | bis | hh:mm:ss | Electricity | Production |
|---|---|---|---|---|---|---|---|
| Filling line 01 | Soft drink2 | 200503 | 01.09.2020 00:00 | 01.09.2020 03:30 | 3:30:0 | 146,96 | 28 095,00 |
| Filling line 01 | Soft drink3 | 300503 | 01.09.2020 03:30 | 01.09.2020 08:00 | 4:30:0 | 141,96 | 27 084,00 |
| Filling line 01 | Soft drink1 | 100504 | 01.09.2020 08:00 | 01.09.2020 10:15 | 2:15:0 | 116,92 | 22 435,00 |
| Filling line 01 | No material | 0 | 01.09.2020 10:15 | 01.09.2020 11:15 | 1:0:0 | 0,24 | 0,00 |
| Filling line 01 | Soft drink2 | 200504 | 01.09.2020 11:15 | 01.09.2020 14:15 | 3:0:0 | 124,79 | 23 899,00 |
| Filling line 01 | No material | 0 | 01.09.2020 14:15 | 01.09.2020 15:15 | 1:0:0 | 0,23 | 0,00 |
| Filling line 01 | Soft drink3 | 300504 | 01.09.2020 15:15 | 01.09.2020 18:45 | 3:30:0 | 110,32 | 20 973,00 |
| Filling line 01 | No material | 0 | 01.09.2020 18:45 | 01.09.2020 19:45 | 1:0:0 | 0,24 | 0,00 |
| Filling line 01 | Soft drink1 | 100505 | 01.09.2020 19:45 | 01.09.2020 22:00 | 2:15:0 | 118,43 | 22 540,00 |
| Filling line 01 | No material | 0 | 01.09.2020 22:00 | 01.09.2020 23:00 | 1:0:0 | 0,25 | 0,00 |
| Filling line 01 | Soft drink2 | 200505 | 01.09.2020 23:00 | 02.09.2020 02:00 | 3:0:0 | 125,52 | 23 833,00 |
| Filling line 01 | No material | 0 | 02.09.2020 02:00 | 02.09.2020 03:00 | 1:0:0 | 0,25 | 0,00 |
| Filling line 01 | Soft drink3 | 300505 | 02.09.2020 03:00 | 02.09.2020 06:30 | 3:30:0 | 109,95 | 21 031,00 |
| Filling line 01 | No material | 0 | 02.09.2020 06:30 | 02.09.2020 07:30 | 1:0:0 | 0,25 | 0,00 |
| Filling line 01 | Soft drink1 | 100506 | 02.09.2020 07:30 | 02.09.2020 09:45 | 2:15:0 | 118,38 | 22 407,00 |
| Filling line 01 | No material | 0 | 02.09.2020 09:45 | 02.09.2020 10:45 | 1:0:0 | 0,24 | 0,00 |
| Filling line 01 | Soft drink2 | 200506 | 02.09.2020 10:45 | 02.09.2020 13:45 | 3:0:0 | 127,03 | 24 045,00 |
| Filling line 01 | No material | 0 | 02.09.2020 13:45 | 02.09.2020 14:45 | 1:0:0 | 0,24 | 0,00 |
| Filling line 01 | Soft drink3 | 300506 | 02.09.2020 14:45 | 02.09.2020 18:15 | 3:30:0 | 111,88 | 21 065,00 |
| Filling line 01 | No material | 0 | 02.09.2020 18:15 | 02.09.2020 19:15 | 1:0:0 | 0,24 | 0,00 |
| Filling line 01 | Soft drink1 | 100507 | 02.09.2020 19:15 | 02.09.2020 21:30 | 2:15:0 | 118,74 | 22 787,00 |
| Filling line 01 | No material | 0 | 02.09.2020 21:30 | 02.09.2020 22:30 | 1:0:0 | 0,24 | 0,00 |



# SIMATIC Energy Manager PRO
# Batch and material analysis - Evaluation

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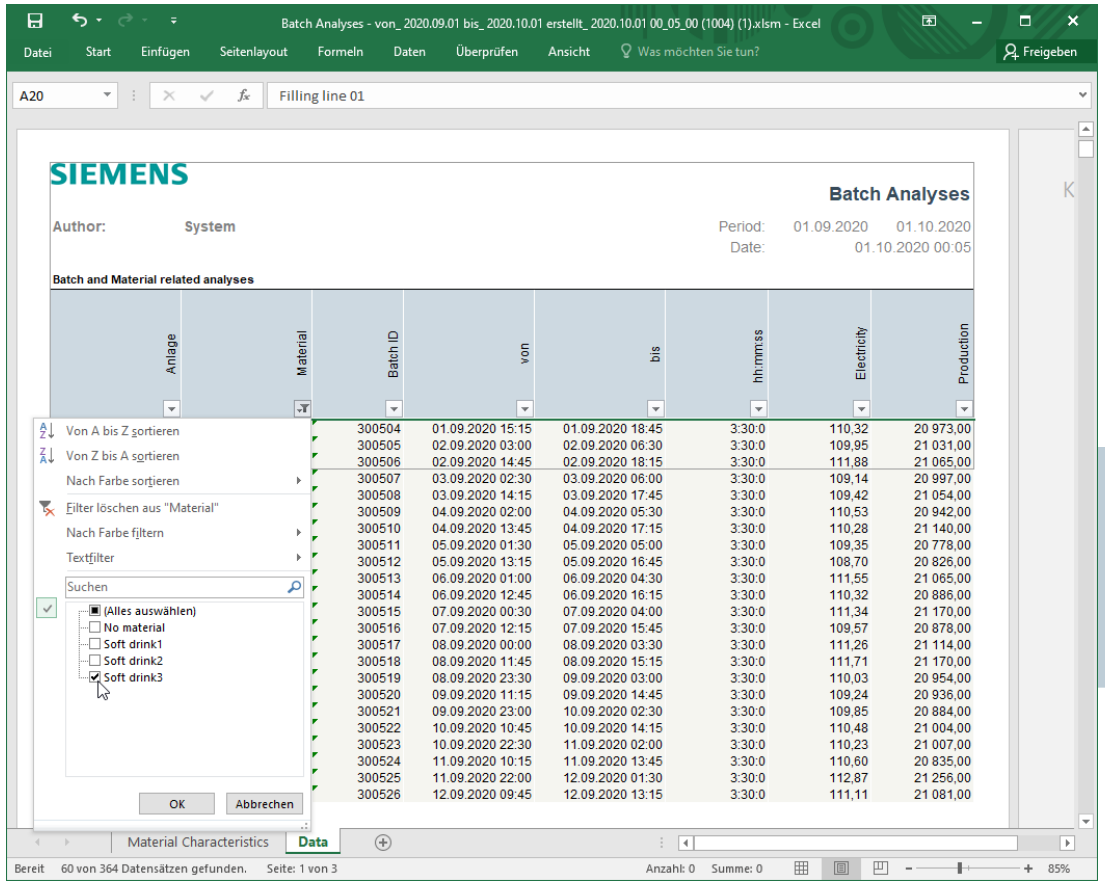
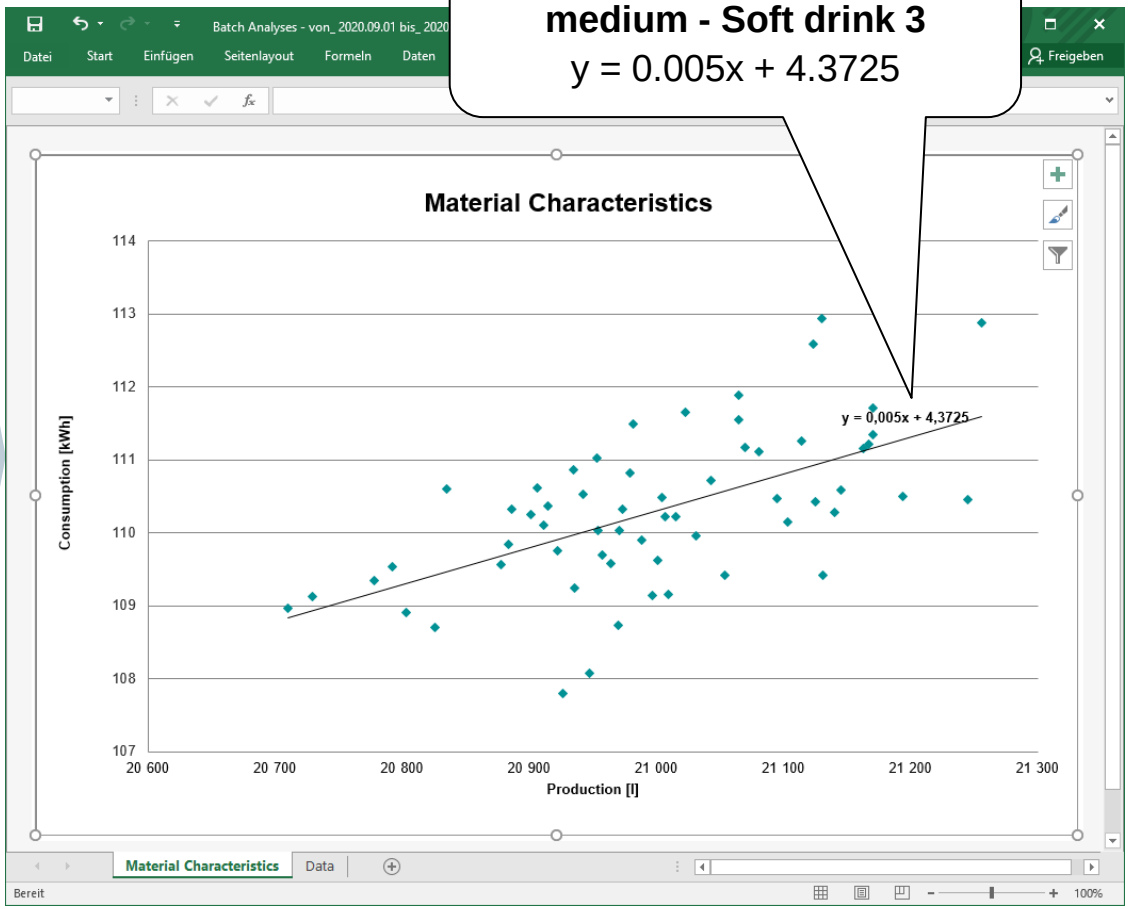
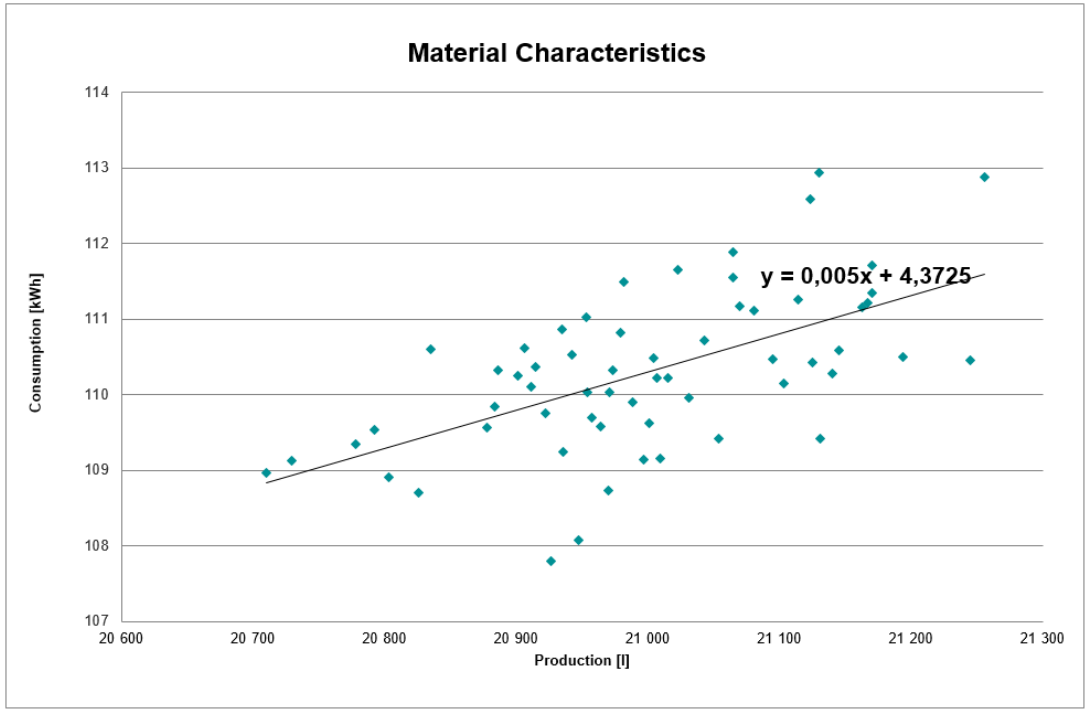



**Energy model for electricity medium - Soft drink 3**

$y = 0.005x + 4.3725$



# SIMATIC Energy Manager PRO
# Forecast based on production plan




$$y = kx + d = 0,005x + 4,3725$$

- When forecasting based on a production plan, the characteristic (energy model) of a produced material/product is the basis of the forecast
- It is important that this characteristic has a linear behavior. If this is the case, it is formed via the **regression line** in the form $y = k * x + d$
- $x$ reflects the future produced quantity of the product and $y$ the resulting future energy consumption
  $d$ represents the share of the basic consumption of the plant without production.
  The coefficients k and d of the formula are stored for each determined product in a material object.

# SIMATIC Energy Manager PRO
# Forecast based on production plan

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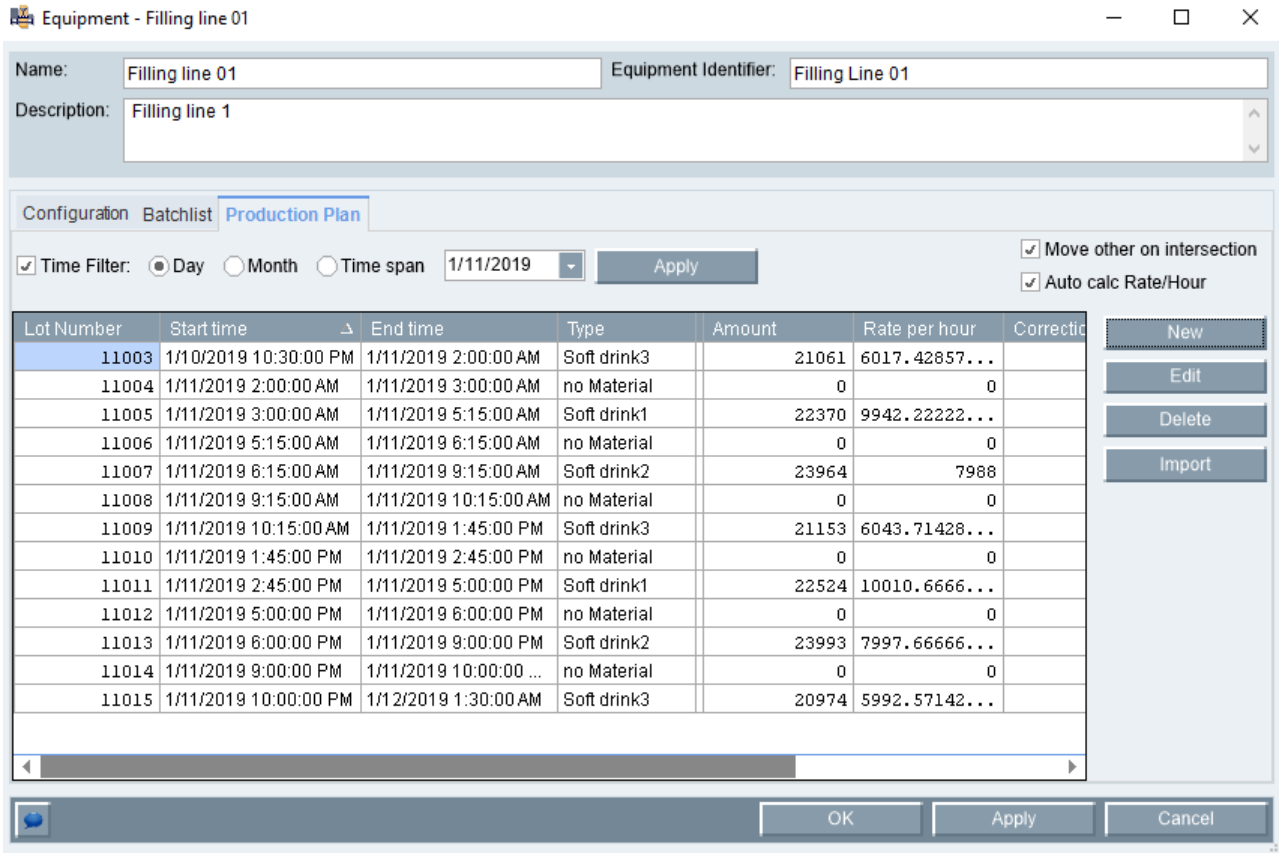


- The quantity to be produced of each planned material/product is imported into the system via a production plan (direct input or predefined Excel file) for a certain production time range
- The production speed (quantity/h) is then automatically calculated in the plant object
- Additional consumption correction factors can still be added individually
- The forecast consumption of this plant calculated from this can then be added to the overall forecast.

**Calculation of the expected consumption based on the entered production plan**

# SIMATIC Energy Manager PRO
# Forecast with comparison principle

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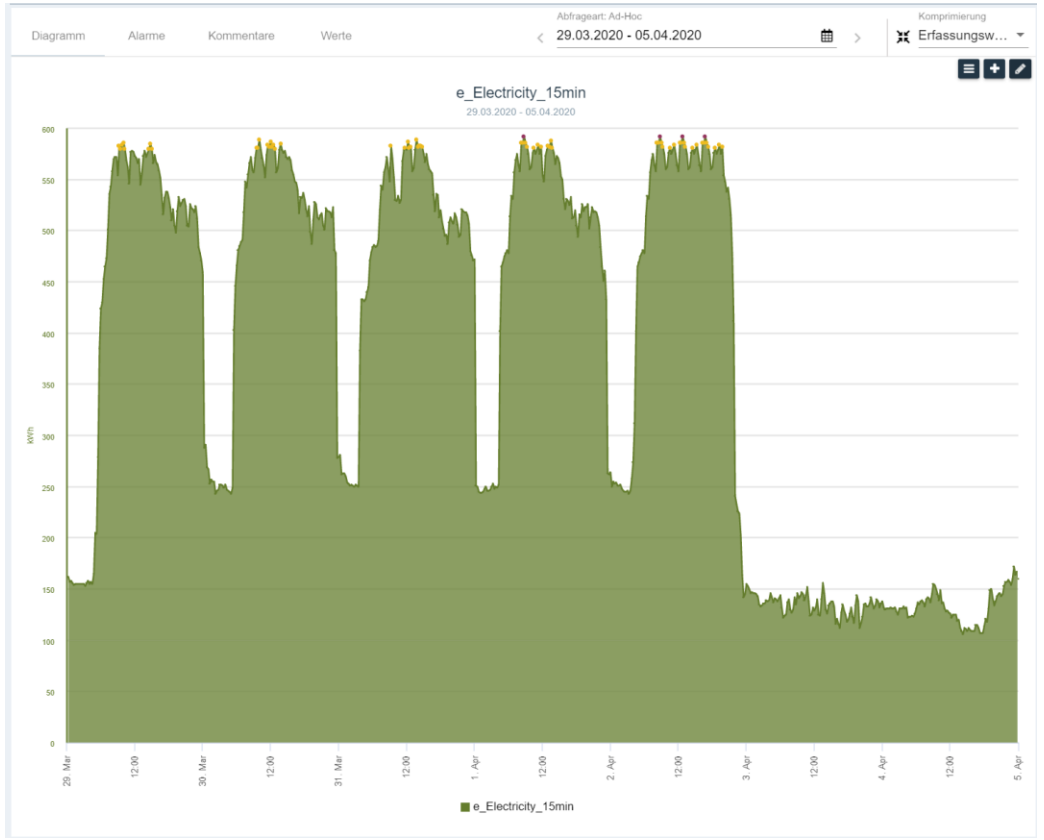
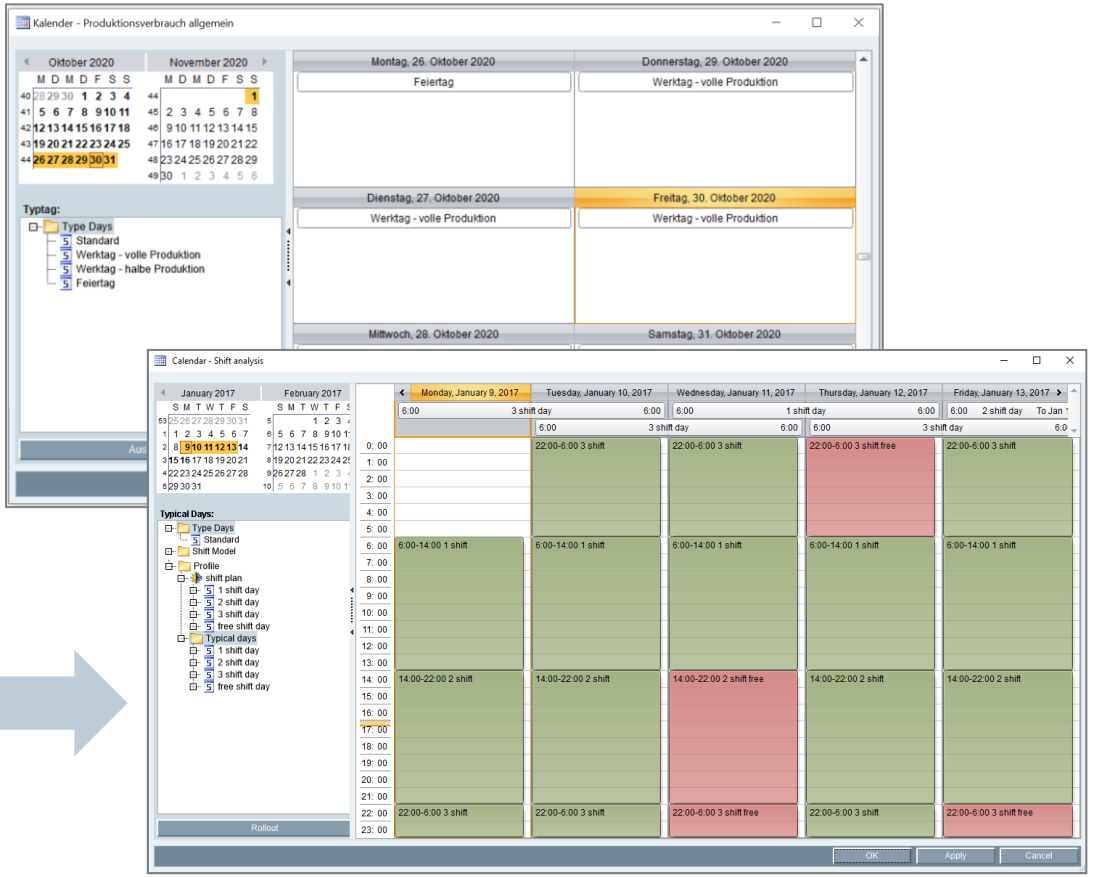
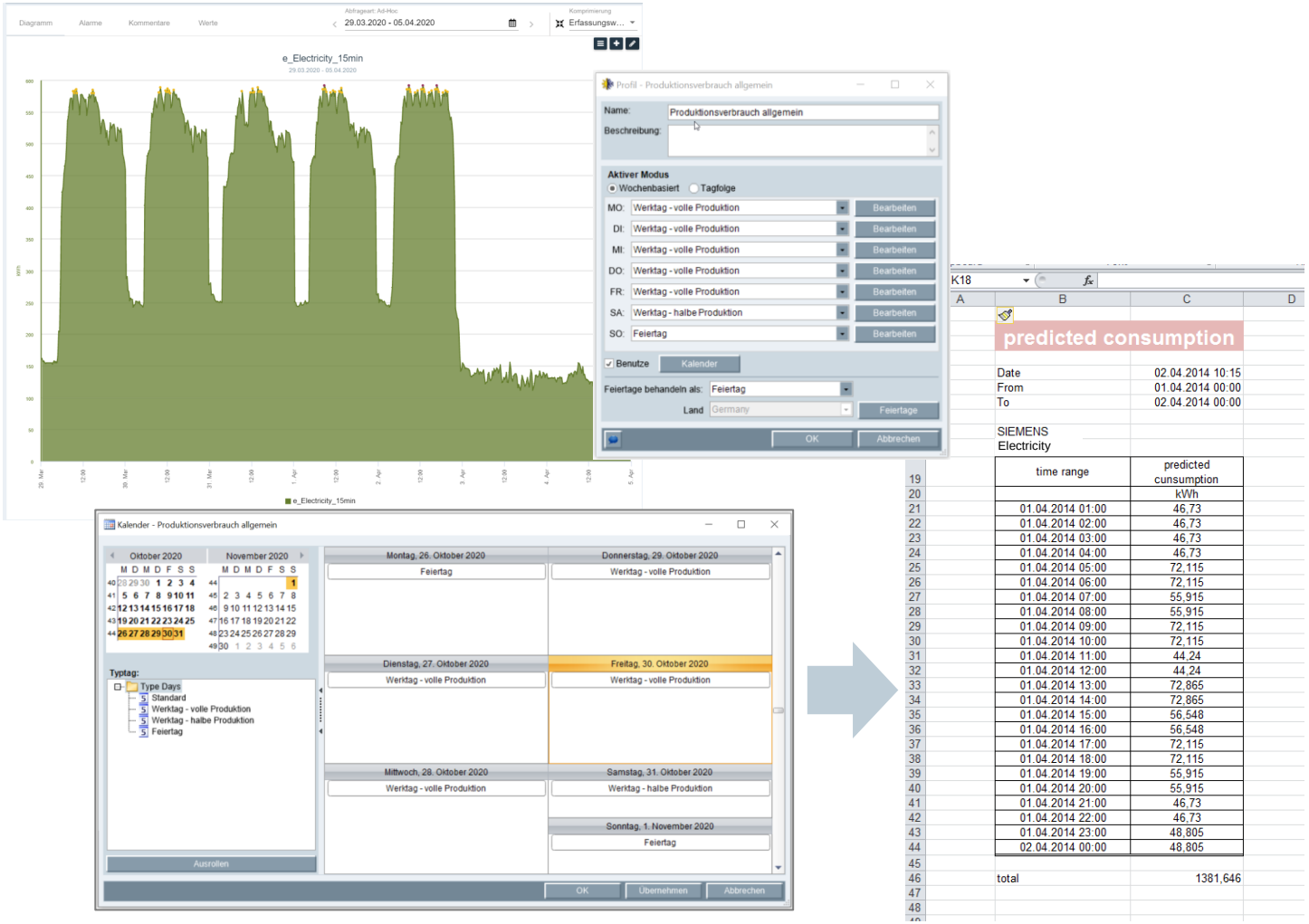



**Determining a consumption profile of desired periods from archive values and rolling out for forecast**

# SIMATIC Energy Manager PRO
# Forecast with comparison principle




- With the **comparison principle**, **similar load profiles** (production days, shifts, etc.) can be recorded from the respective media consumption archive and saved as average values of previously defined time periods (for example 1 hour) in a type profile (for example, working day, holiday, shift 1).
- In the internal **calendar tool**, these **type profiles** can then be rolled out for a desired forecast period, taking into account the locally applicable public holidays, and can also be corrected for various time periods if required (such as special days, shift reallocation).
- The resulting forecast load profile of the area/plant can thus **perfectly complement** a more detailed **overall forecast for the entire facility**

# SIMATIC Energy Manager PRO
# Advantages at a glance

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- Using **ISO 50006 as a guideline** of ISO 50001 to get more out of your energy management.
- Using **energy baselines (EnB)** and energy performance indicators (EnPI) helps **to increase** the **energy efficiency** of your plant.
- **Technical calculation models** such as multivariable regression analysis, which also takes into account **diverse influencing factors** of energy consumption, can be used not only to define your **baseline** more precisely but also to provide a **forecast** of the expected energy consumption of your production plant.
- The flexibility of using **different forecasting models** provides you with the desired energy calculation for many applications (energy purchasing, energy schedule,...).
- Declaring the generated **product or material** in future with an **energy consumption label** is just as easy as specifying the **carbon footprint** for it.

# Thank you for your attention!

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**Outlook for the next webinar:**

Global usage option of the calculated energy data and key figures with our cloud/edge platform services.

**Webinar 8**

Energiemanagement based on MindSphere (Cloud) – SIMATIC Energy Manager MindSphere app

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