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Application Guideline for Implementing Switch-off Concepts with PROFIenergy

http://support.automation.siemens.com/WW/view/en/96837137

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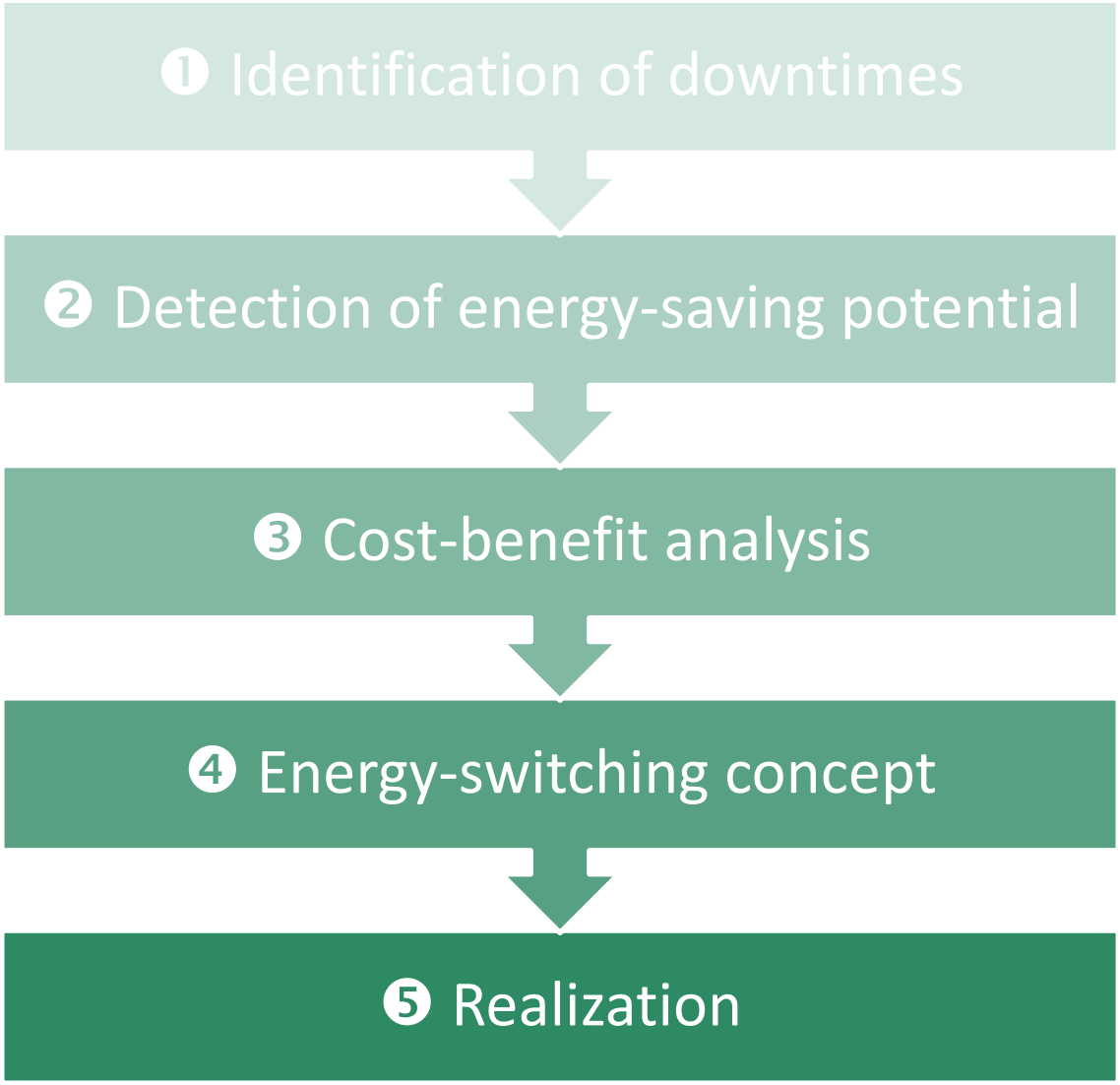
Five Steps for Saving Energy with PROFIenergy



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1 Basics of PROFIenergy

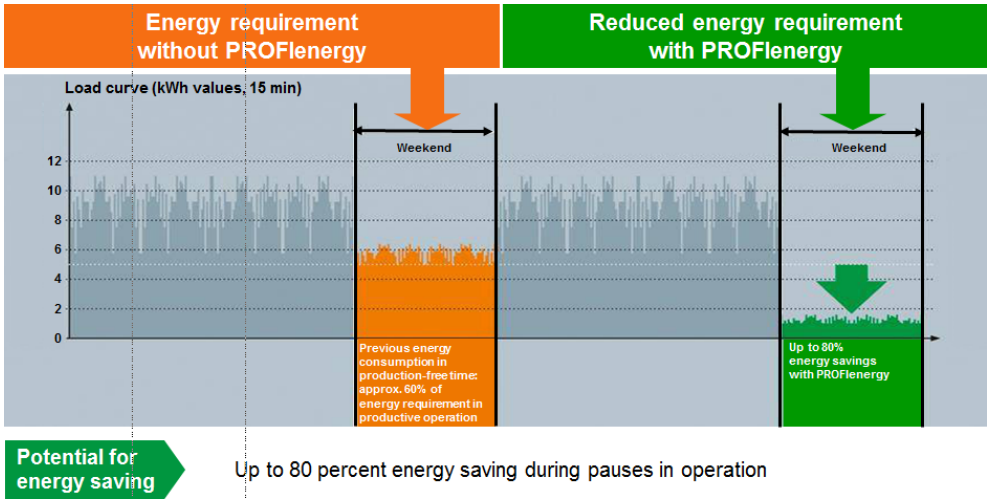
1.1 Energy-saving potentials

Preconditions

In order to use the energy-saving potential of systems,

- the energy flows in systems and system parts have to be measured
- and systems, system parts or equipment must be switched off when not in use.

Figure 1-1 Typical energy consumption in an industrial production plant



→ PROFIenergy provides a uniformly defined interface for this.

The contribution of PROFIenergy

The PROFIenergy interface makes an important contribution towards reducing the expenditure for measuring energy consumption and energy savings by switching the system off during pauses.

- Saving costs since no external hardware and wiring is needed.
- Saving energy even during short pauses by selective switching.
- High level of system reliability by coordinated switching procedures.
- Protection of investment thanks to a simple, non-reactive integration into existing standards and well-known product families.
- Free selection of devices due to a standard which is independent from the manufacturer.
- Competitive advantage by implementing energy-efficient machines and systems.

Current solutions to make plants, systems and system parts switchable

- Manual switching (time-consuming, unreliable restart).
- Usually, there are only the states “on” and “off” (usually, there is only a main switch).

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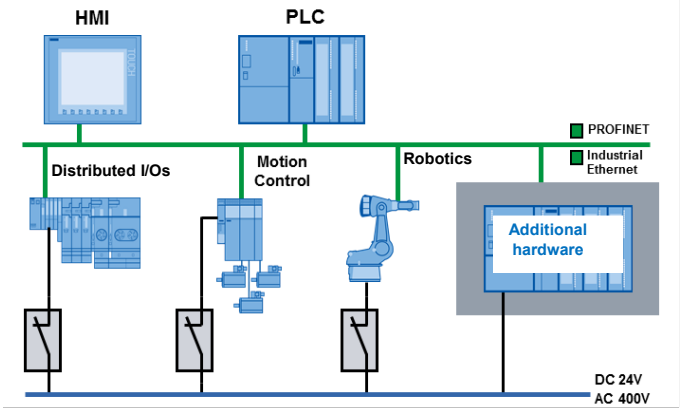
- Automated switching by means of external hardware.
  - These solutions need space and cost money.
  - Engineering and maintenance required.
  - System-specific programming.

→ Unfavorable ratio of expenditure and energy-saving potential

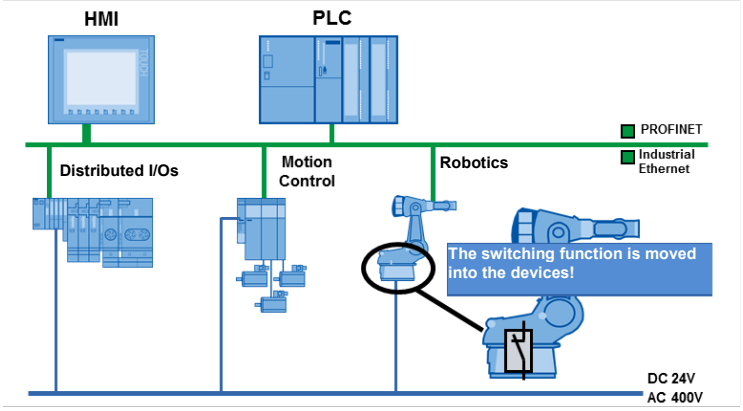
Figure 1-2 Realization of switch-off without PROFIenergy



Solutions with PROFIenergy

- Switching function is moved into the devices.
- Uniform, cross-vendor interface on the basis of PROFINET.
- No additional hardware needed.
- New energy-saving states possible.

Figure 1-3 Implementation of PROFIenergy



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1.2 PROFIenergy definition

Introduction

PROFIenergy is a profile standardized by PROFIBUS & PROFINET International (PI), which uses proven PROFINET mechanisms. By means of PROFIenergy commands it is possible to shut down consumers independent of the device or the manufacturer centrally and in a coordinated fashion during production-free times. Individual components, system parts or whole plants can be switched off and switched on again automatically at the end of the production-free time.

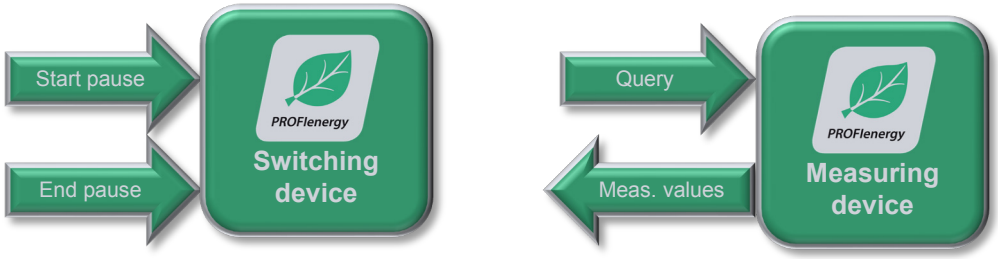
PROFIenergy-capable devices can change into a more favorable energy state during downtimes to be able to provide the process with the minimum amount of energy required.

During the energy-saving states, the full PROFINET communication is ensured.

Additionally, PROFIenergy makes it possible to read out measuring values if devices support this functionality.

Field devices with and without PROFIenergy functionality can be used together at the same PROFINET line. Their integration into existing systems is simple and reaction-free.

Figure 1-4 Overview PROFIenergy function principle



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Basic information

PROFINET devices are switched off via special commands in the user program of the PROFINET I/O controller. No additional hardware is needed, the PROFIenergy commands are directly interpreted by the PROFINET devices.

Function principle

At the beginning and at the end of the pauses, the system supervisor or a higher-lever system activates/deactivates the pause function of the system. Then, the I/O controller sends the PROFIenergy command “Start_Pause” / “End_Pause” to the PROFINET devices. The device then interprets the content of the PROFIenergy command and switches off / back on.

PROFIenergy has other functions to retrieve device information during the pauses. This information can be used to transmit the “Start_Pause” / “End_Pause” in good time by the user.

To be able to use the PROFIenergy functionality, the controller existing in the network must be upgraded to a so-called “PROFIenergy controller” by means of a function block, and there must be at least one PROFIenergy-capable I/O device. The PROFIenergy commands (e.g. for starting and ending a pause) are sent to the individual PROFIenergy devices by the “PROFIenergy controller”. Every PE device

decides individually how it is going to react to the PE command (the reaction is device and manufacturer-specific).

Note PROFIenergy can be used for any media in the industrial environment, **not** only for electric energy.

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1.3 Four use cases for PROFIenergy

Use case 1: Saving energy during short pauses

Short pauses can be coffee or lunch breaks. They are from a few minutes up to one hour long. The aim is to save energy during the production-free time without jeopardizing system availability. It is also possible to switch off only some of the consumers during short pauses. If the complete production power is needed at the end of the pause, it is supplied without delay.

Therefore, the amount of energy saved is less than in use case 2.

Use case 2: Saving energy during longer pauses

Typical pauses of this kind are nights and weekends. Since these pauses are considerably longer, additional consumers can be shut down into energy-saving mode. Even processes with longer start-up phases such as heating processes can be addressed. Since the duration is longer, a maximum amount of energy can be saved during these pauses. It is also possible to switch complete units into energy-saving mode.

Use case 3: Saving energy during unscheduled downtimes

Typically, this type of pause (downtime) has not been planned or scheduled. The point in time and the duration of such an interruption cannot be foreseen. Nevertheless, we also want to save energy in this case. Such interruptions occur, for example, if the flow of material falters. Since PROFIenergy can also coordinate complex correlations between units, it is also possible to save energy optimally in such situations.

Since in such a case, the duration of the downtime cannot be foreseen, it is first classified as the shorter use case 1 for not to affect a quick change-over to the production phase. Should it turn out that the downtime will take longer, it is possible to change to use case 2.

Use case 4: Measuring and visualizing the energy flow

PROFIenergy also allows for reading out consumption data such as the electric power from the devices in a uniform format. During operation, these data are collected and can be displayed on an operator panel for example. This ensures that the measured variables as they are nowadays available in frequency converters or motor starters, for example, are available to the user for further processing in a uniform format and structure. These PROFIenergy functions thus form the basis for an active load and energy management during operation.

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1.4 PROFIenergy components

PROFIenergy I/O controller

The controller sends the respective PROFIenergy commands to the subordinate devices, but it is also possible that the complete PE intelligence (state model) is represented in it. The production process can be controlled by this controller, too, but this is not mandatory.

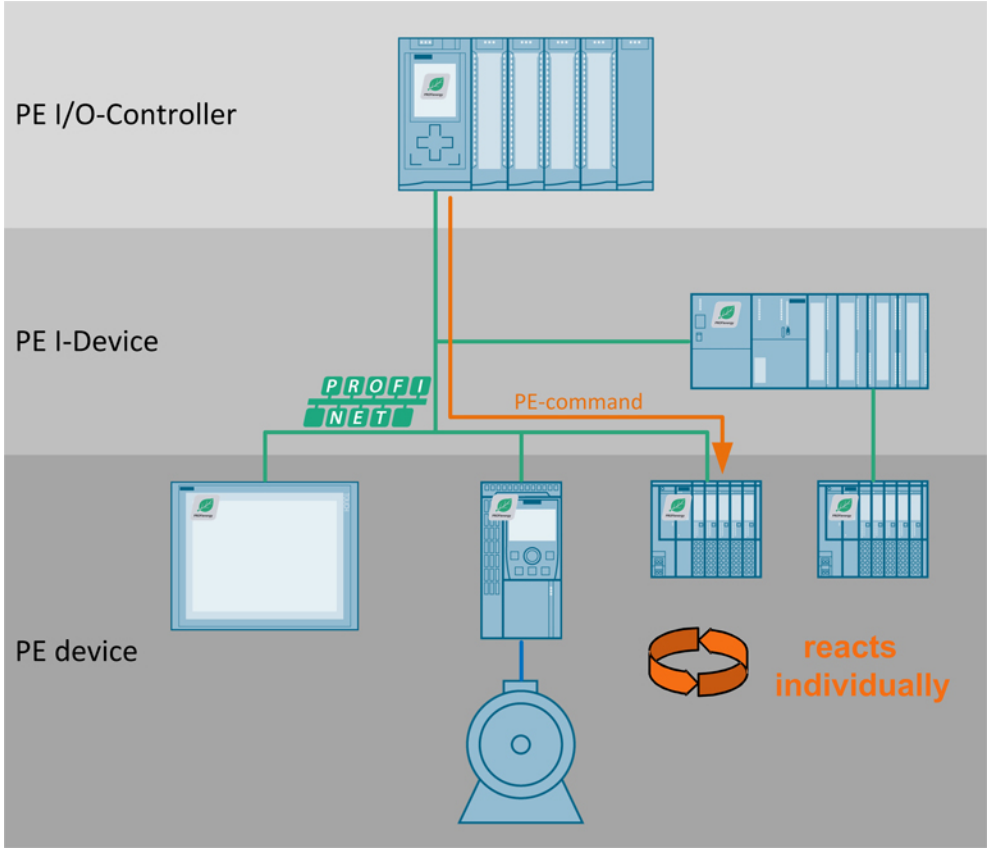
PROFIenergy device

The device can be a simple PROFINET I/O device or a drive, but it can also be a more complex device such as a machine tool or a welding robot.

PROFIenergy I-Device

The functionality “I-Device” (Intelligent I/O device) of a CPU makes it possible to exchange data with an I/O controller, thus using the CPU for example as an intelligent unit for preprocessing partial processes. In its role as an I/O device, the I-Device is connected to a “higher-level” I/O controller. The preprocessing is ensured by the application program in the CPU by the functionality “I-Device”. This is a special PROFINET functionality which can also be used with PROFIenergy.

Figure 1-5 Overview of PROFIenergy components



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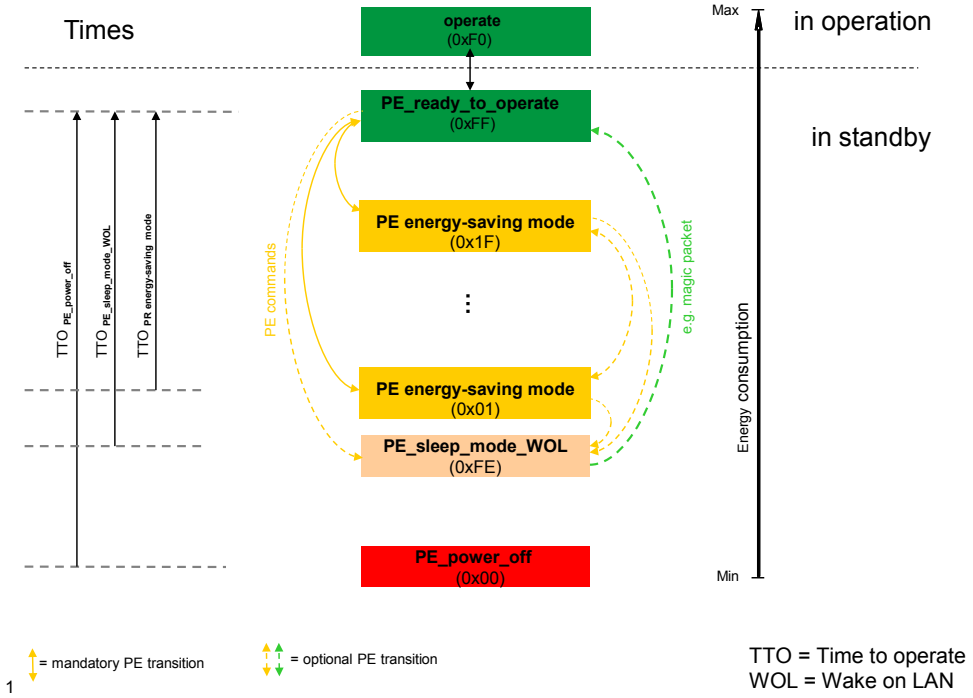
1.5 The PROFIenergy state model

Every machine or system basically has two states: “ON” or “OFF”. These states also represent the productivity of the system. As far as energy is concerned, the “ON” state represents the highest power consumption, and the “OFF” state represents the state of least power consumption. Ideally, the power consumption in the “OFF” state is zero.

With PROFIenergy you can define energy-saving states in between these two natural states, which make it possible to bring the system into a more “favorable” energy state during unproductive times. These energy-saving states are defined on the basis of the duration of the pauses and each consumes specific amounts of energy.

The following figure illustrates the correlations between the different states, pause times and energy consumption.

Figure 1-6 PROFIenergy state model



The different states in the figure are briefly explained on the next page.

[1] Source: Technical Specification_PNO_PE___PE_3802_V11_Aug12_lastPGreview.doc

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PE_power_off

In “PE_power_off”, the device is de-energized and represents the “OFF” state. This mode is one of the two natural states present in every device. In this mode no communication with PROFINET is possible. The consequence is that the respective device cannot be switched on again with PROFIenergy commands. In this mode the device must be switched on manually.

operate

“OPERATE” is the other natural state representing the “ON” state. The device is in productive operation. PROFIenergy does not consider any dependencies caused by production procedures (such as waiting for material to be fed). Various operating modes that are irrelevant for PROFIenergy are not differentiated, they are combined.

PE_ready_to_operate

In the “PE_ready_to_operate” state, the device is ready to operate, but is not in productive operation. In this state, the transition into an energy-saving state can be triggered.

The complete PROFINET I/O communication is active in this state.

PE energy-saving mode

A device supporting the energy-saving functionality of PROFIenergy provides a definite number (at least one) of PROFIenergy energy-saving states defined by the manufacturer.

As far as energy is concerned, all the PROFIenergy energy-saving states lie between the “PE_power_off” and “PE_ready_to_operate” modes; in the model they are sorted according to the duration of the time each energy-saving state needs to change back to the “ready-to-operate” mode.

These states represent the energy-saving states of a machine. They are not considered productive states, but can be reached any time by PROFINET communication.

PE_sleep_mode_WOL

“PE_sleep_mode_WOL” is a special energy-saving state developed for industrial PCs. In this mode, there is no PROFINET I/O communication, therefore the device cannot be switched on/off via PROFIenergy.

With special data packs (e.g. with the “Magic Packet Technology” by AMD), the device can be “woken up” and set into the “PE_ready_to_operate” mode.

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1.6 Application example for PROFIenergy

The following example illustrates how a controller can switch system parts on and off in a coordinated way by means of PROFIenergy.

Figure 1-7 Application example for the implementation of PROFIenergy

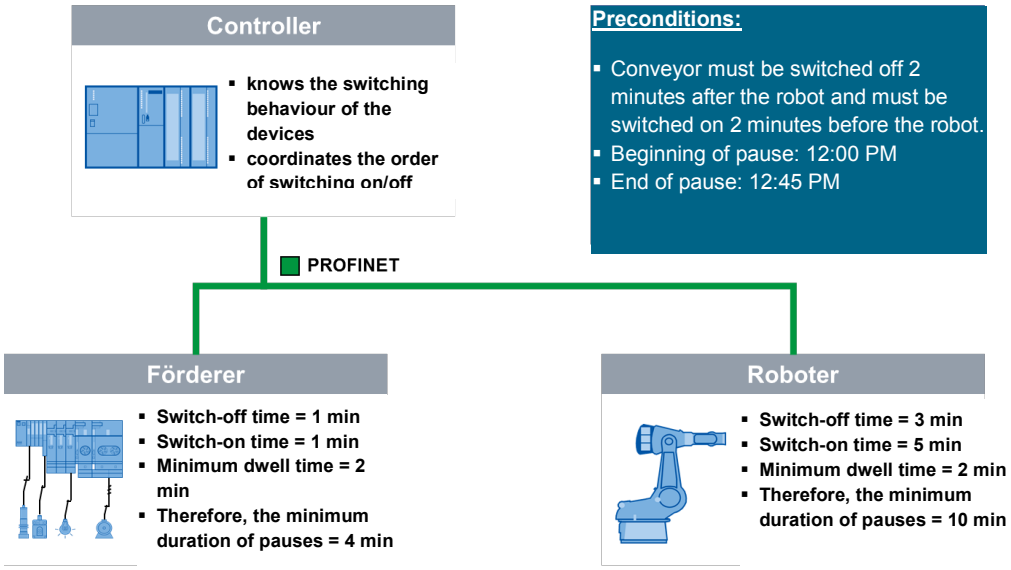
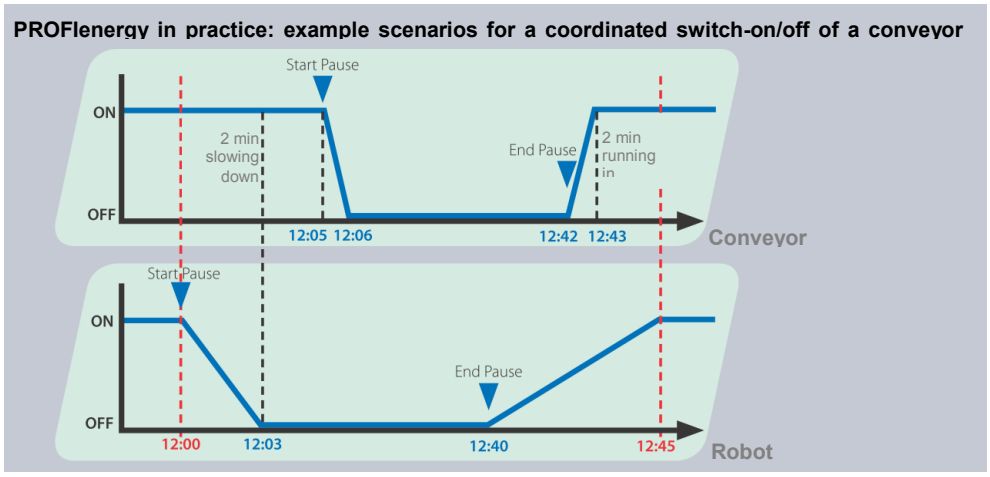


Figure 1-8 Switch on/off scenario



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1.7 PROFIenergy-capable devices (extract from the Siemens portfolio)

Examples of PE devices:

	PROFIenergy functionalities	
	Standby management	Measuring functionality
I/O		
• SIMATIC ET 200S	☑	
• SIMATIC ET 200SP	☑	
• SIMATIC/SIRIUS motor starter	☑	☑
Measuring devices		
• SENTRON PAC		☑
Panels		
• SIMATIC HMI Comfort Panel	☑	
Drives		
• SINAMICS	☑	☑
SIRIUS switching devices		
• SIMOCODE pro V	☑	☑
• SOFT STARTER 3W44	☑	☑

Examples of PE controllers:

- SIMATIC ET 200 CPU
- SIMATIC S7-300 CPUs
- SIMATIC S7-400 CPUs
- SIMATIC S7-1500 CPUs

CPs

- PC CPs (CP1604, CP1616)
- Industrial Ethernet CPs (CP343-1)

PROFIenergy matrix

All modules of the Siemens portfolio that support PROFIenergy functions are listed under the following link.

http://support.automation.siemens.com/WW/view/en/95848378

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1.8 Examples of PROFIenergy in the Siemens Industry Online Support

By means of the application examples, the PROFIenergy functionality is illustrated in the correlation with various Siemens products.

Table 1-1 Application examples in the Siemens Industry Online Support

Title of the PROFIenergy example	Link
Saving Energy with SIMATIC S7 and SIMATIC HMI (TIA Portal)	http://support.automation.siemens.com/WW/view/en/58235225
Saving Energy with SIMATIC S7 (STEP 7 V5.5)	http://support.automation.siemens.com/WW/view/en/41986454
Saving Energy with SIMOTION and SIMATIC ET 200S	http://support.automation.siemens.com/WW/view/en/58386840
PROFIenergy – Easy Configuration with PE_CTRL	http://support.automation.siemens.com/WW/view/en/93906424

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2 User Guide PROFIenergy “Brownfield”

2.1 General Procedure

The following five steps illustrate the procedure, if you wish to integrate PROFIenergy in your system:

1. First of all, you have to answer the question whether the system has any downtimes or pause times. Those can be longer pauses such as the weekend, but also shorter pauses like lunch or coffee breaks - and even very short, cyclically occurring downtimes.
2. In a second step, it has to be assessed whether parts of the system can be shut down during these times. If yes, you have to examine in detail which parts of the system and which components can be switched off.
3. Then you have to determine which components (PROFINET I/O devices) can support PROFIenergy and what potential for energy-saving the individual components have. A cost-benefit analysis is also very important. Especially the replacement of components in existing systems, possible mechanical modifications that become necessary and the engineering expenditure need to be considered.
4. If the cost-benefit analysis is positive, the planning phase of the energy-switching concept can be initiated. It can be broken down into the software implementation of PROFIenergy and the hardware concept. Another important aspect is to find out what issues have to be considered when individual devices are switched off. Do any mechanical aspects such as braking or holding functions (which are still needed when power is shut down) have to be considered? Are safety functions still ensured, and do any release signals have to be called up?
5. The last step would be the implementation itself, such as an exchange of the appropriate components and the necessary engineering for the configuration/adaptation of programs, taking the order of components to be switched on/off into account.

In order to keep this application guideline simple and understandable, the expression “system” shall be used for every kind of space under consideration. Where the expression “system” is used in the following, it shall also include individual machines (such as milling centers), parts of the plant, units and also individual lines.

Note

Where PROFIenergy is to be integrated into existing systems, a PROFINET infrastructure must already exist. Otherwise the expenditure for the implementation would increase considerably, and a cost-benefit analysis would hardly ever be positive.

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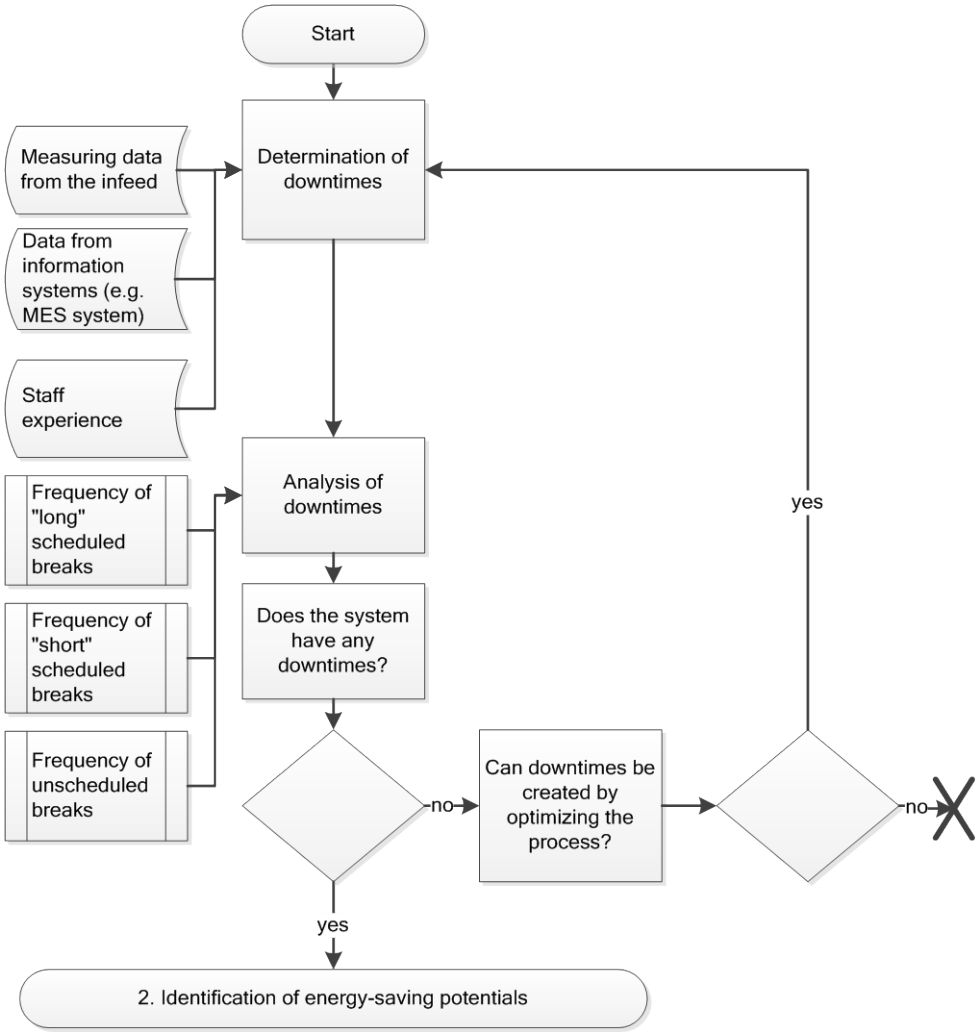
2.2 Identification of downtimes

First of all, you have to answer the question whether the system has any downtimes or pauses.

Those can be longer pauses such as the weekend, but also shorter pauses like lunch or coffee breaks - and even very short, cyclically occurring downtimes.

Figure 2-1 Flowchart about the “identification of downtimes”



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2.2.1 Determination of downtimes

Procedure

In order to determine downtimes, various sources of information must be used. They are different depending on the sector of industry and the components to be considered (machines, systems, lines).

Staff experience

Asking your staff operating the system is often one of the most important sources of information.

The following questions should facilitate the analysis of downtimes. The answers should be entered in the respective tables in 2.2.2 Analysis of downtimes.

Table 2-1 Questions for the determination of downtimes

No.	Question
1.	Is there a shift plan? If yes, what does it look like?
2.	How many breaks are there and how long are they?
3.	Is there a break for change of shifts?
4.	Are there any cyclic downtimes (e.g. change of tool, setup and changeover times, waiting times in the process, regular staff meetings, ...)?
5.	Are there any acyclic downtimes (e.g. maintenance, ...); do you have more specific information (frequency, duration)?
6.	Are there any disruptions of the flow of material; do you have more specific information (frequency, duration)?

Data from information systems (e.g. MES system)

If the site has an MES system, usually a lot of information about downtimes can be identified there.

The information gathered can be entered in the respective tables in Chapter 2.2.2 Analysis of downtimes.

Measuring data from the infeed

An evaluation of the data from the infeed counter can help to identify downtimes from the considerably reduced power consumption. If the direct access to the power consumption is not possible at the infeed level, and if it cannot be determined in any other way, a temporary measurement at infeed level is recommended. Since the focus is on the identification of downtimes in this context, the accuracy of the measuring system is not so important.

The information gathered should be entered in the respective tables in Chapter 2.2.2 Analysis of downtimes.

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2.2.2 Analysis of downtimes

Frequency of short scheduled pauses

Short scheduled pauses mean interruptions during the production process, for which it is clear, even before the event occurs, when and how long the event will take (e.g. coffee or lunch breaks). This kind of interruption takes a few minutes up to one hour.

Table 2-2 List of scheduled short pauses

Pause	Start	End	Dura-tion	Mon	Tue	Wed	Thu	Fri	Sat	Sun

Example:

Figure 2-2 Example: Short time analysis for short pauses

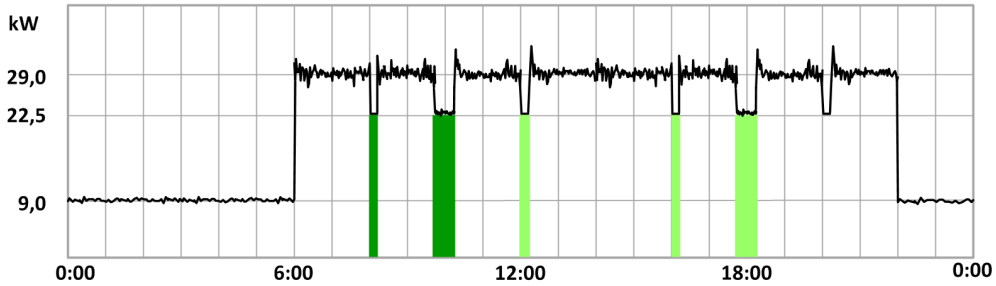

Table 2-3 Example: Identified scheduled short pauses

Pause	Start	End	Dura-tion	Mon	Tue	Wed	Thu	Fri	Sat	Sun
kP1	8:03 AM	8:15 AM	12 min	X	X	X	X	X		
kP2	9:45 AM	10:15 AM	30 min	X	X	X	X	X		
…										

Frequency of long scheduled pauses

The primary difference between scheduled long and short pauses is the duration of the pause. This interruption takes several hours (e.g. overnight) or even several days (e.g. on weekends, annual closure).

Table 2-4 List of scheduled long pauses

Pause	Start	End	Dura-tion	Mon	Tue	Wed	Thu	Fri	Sat	Sun

Example:

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Figure 2-3 Example: Long time analysis for long pauses

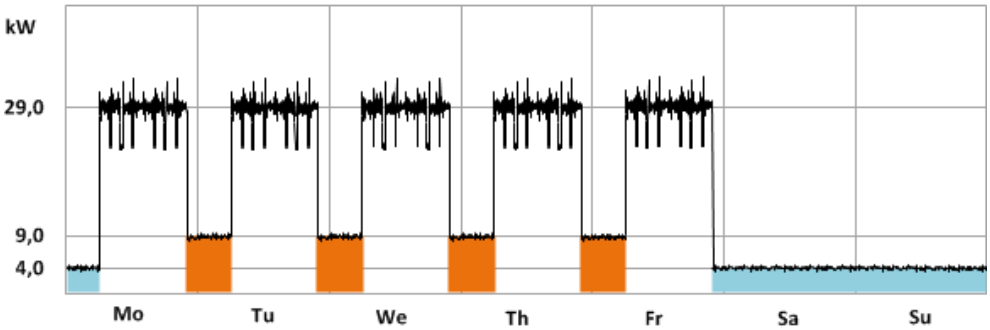

Table 2-5 Example: Identified scheduled long breaks

Pause	Start	End	Dura-tion	Mon	Tue	Wed	Thu	Fri	Sat	Sun
IP1	10:15 PM	6:15 AM	8 h	X	X	X	X			
IP2	10:15 PM	6:15 AM	56 h					X		

Frequency of unscheduled breaks

What is characteristic for this scenario is that the downtime has not been planned or scheduled. The time and the duration of such an interruption cannot be foreseen. Such interruptions occur, for example, if the flow of material falters.

Table 2-6 List of unscheduled downtimes

Pause	Reason for the downtime	Frequency (how often?)	Min. du-ration	Max. du-ration

Example:

The copper caps of welding tongs must be replaced after 5,000 to 10,000 welding points. The replacement takes about 15 minutes.

Table 2-7 Example: Identified unscheduled downtimes

Pause	Reason for the downtime	Frequency (how often?)	Min. du-ration	Max. du-ration
uP1	Flow of material falters System 1→2	about 3 times a day	10 min	2 h
uP2	Replacing copper caps of welding tongs	about 2 times a day	15 min	30min
uP3	Filter change Machine 12	every 2 weeks	1 h	1 h

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2.2.3 Evaluation of the analyzed downtimes

If downtimes occur in the system under consideration, the observed downtimes are entered in Table 2-8 according to the type of interruption and in chronological order of its duration.

If no downtimes could be identified, it should be assessed whether it is possible to create downtimes in the system, for example by an optimization of the process, in the following Chapter 2.2.4 Process optimization.

Table 2-8 Evaluation of the analyzed downtimes

	Pause	Duration	
Short pauses			This section will be used in chapter 2.3.4!
Long pauses			
Unscheduled pauses			

Example:

In this table, all the downtimes identified in the examples in Chapter 1.2 Analysis of downtimes are entered.

Table 2-9 Evaluation of the analyzed downtimes from the examples.

	Pause	Duration	
Short pauses	kP1	12 min	This section will be used in chapter 2.3.4!
	kP2	30min	
Long pauses	lP1	8 h	
	lP2	56 h	
Unscheduled pauses	uP1	10 min 2 h	
	uP2	15 min 30 min	
	uP3	1 h	

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2.2.4 Process optimization

Is it possible to adapt the production process adequately in such a way that downtimes are created by a clever optimization of the individual methods without significantly affecting the productivity?

If no such potentials can be identified, the last step might be to carry out an audit evaluating the efficiency of all production processes and ancillary systems.

Example:

For discrete production systems:

- Handling robots (hold the position by means of mechanical brakes instead of position control).
- Adapt the material flow control in such a way that a few long pauses are created rather than many short ones (buffers, bunching).

2.3 Detection of energy-saving potential

Procedure

After the various pauses have been identified, the power consumers that are not switched off, thus generating “standby consumption” even in production-free times, must be identified.

It must also be determined whether they can be switched off at all.

Note

When the expression “active power” or “consumption” is used in this chapter, the active power or the consumption during the downtimes is meant, and a stationary steady state is assumed.

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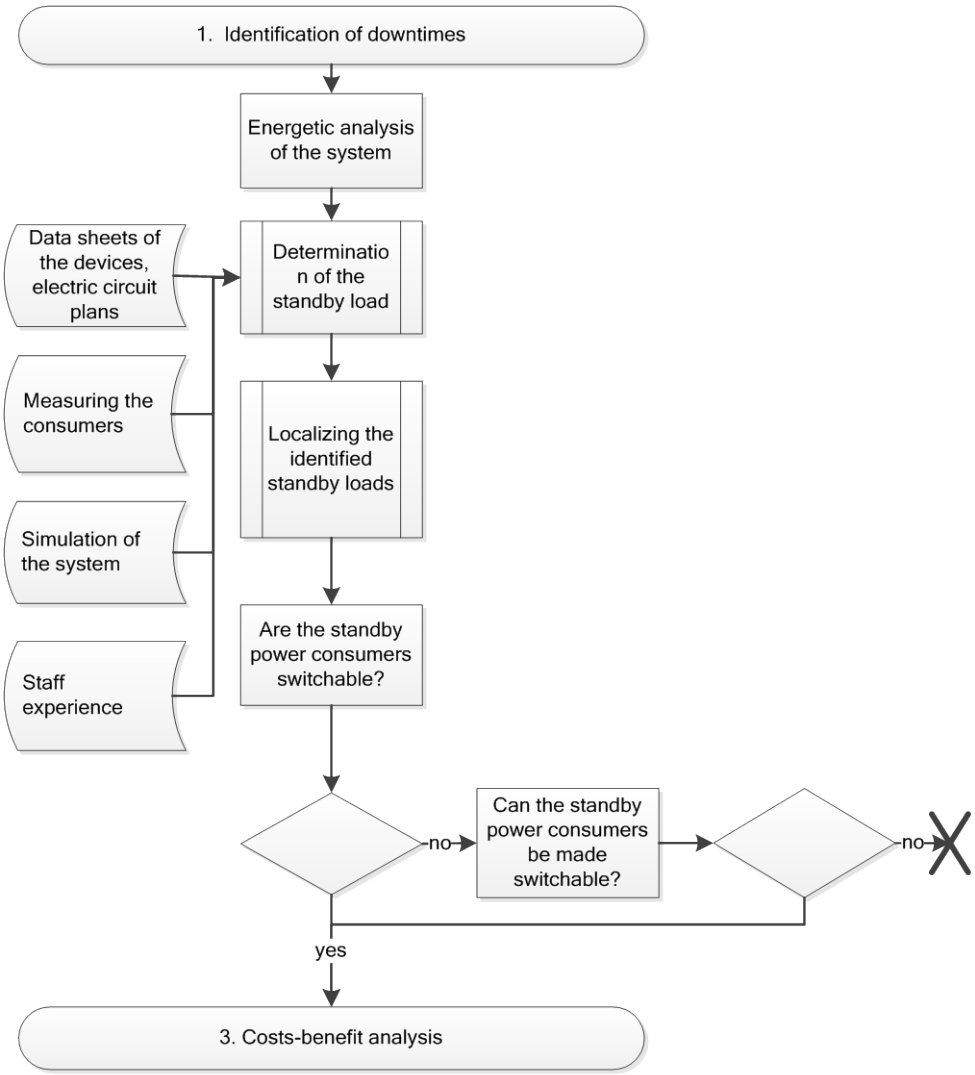
Figure 2-4 Flowchart “Detection of energy-saving potential”



NOTICE	For the detection of switchable loads, it has to be made sure that they are integrated into the safety concept of the system. Should switching processes affect the safety concept, the safety of the system must still be guaranteed. The updated safety concept must be approved again.

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2.3.1 Energetic analysis of the system

Procedure

For the energetic analysis of the system, it must be assessed in a first step what the energy consumption of the system is and whether there are already any differences between short, long and unscheduled downtimes. Then the consumers that remain energized even during production-free times must be identified.

Just like for the determination of downtimes, the energetic analysis of the system also uses various sources of information. In the following, the most important sources and a procedure of how to obtain the required information are described. Of course, other sources might also be relevant.

Staff experience

Experience from operating staff is also an important source of information as to which consumers run constantly. However, these answers are not sufficient for a comprehensive energetic analysis, but they can be an important element for facilitating the analysis.

The following questions are supposed to facilitate the energetic analysis for the system. The answers should be entered in the respective tables in the Section “Determination of the standby load

Table 2-10 Questions for the analysis

No.	Question
1.	Have any energetic analyses been conducted before? Can their results be used?
2.	Are any consumers known to be constantly in operation?
3.	Are there any consumers that are only switched off on the weekends or during longer pauses, and if yes: why?
4.	Have any counters or even a measuring system been installed before?

Data sheets of the devices, electric circuit plans, planning documents

Another important source of information for the electric power is the data sheets of the manufacturers for the individual devices.

Electric circuit plans often indicate the power consumption. Even if no information as to the consumption of the components can be obtained, electric circuit plans must be used to understand the correlations and for marking the system.

If the operator of a system still has the planning documents concerning the system, they should also be reviewed for relevant information.

Measuring the consumers (modular measuring)

If the data sheets and electric circuit plans to not provide sufficient information on the power consumption of the devices and system parts, it often makes sense to carry out a single temporary measurement during a downtime, as the exact consumption can be determined this way.

Simulation of the system

If there already is a model of the system or if part of the system exists virtually (e.g. for a virtual commissioning), information for the energetic analysis can be obtained from this simulation.

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Determination of the standby load

First, it must be assessed what the active power during the production-free times is. For more complex systems, the total standby load and the consumptions of the units could be captured.

Table 2-11 List of standby loads in the production-free times

	System part	Value	Unit kW
Active power during the production-free time			

Should there be differences in the active power according to the downtimes, they are to be entered here.

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Table 2-12 List of standby loads according to the downtime

	Pause	System part	Value	Unit kW
Active power during short pauses				
Active power during long pauses				
Active power during “unscheduled” pauses				

Example 1:

This example illustrates the “simple” scenario: There are two system parts (production line, packing line) that are not switched off during downtimes.

Table 2-13 Standby loads in production-free times, simple example

	System part	Value	Unit kW
Active power during the production-free time	Total	22.50	kW
	Production	20.00	kW
	Packing	2.50	kW

Example 2:

The second example illustrates the more “complex” case: There are differences according to the duration of the pause. We want to consider the same system parts (production line, packing line) as in example 1.

Figure 2-5 Example: Energetic analysis for short and unscheduled pauses

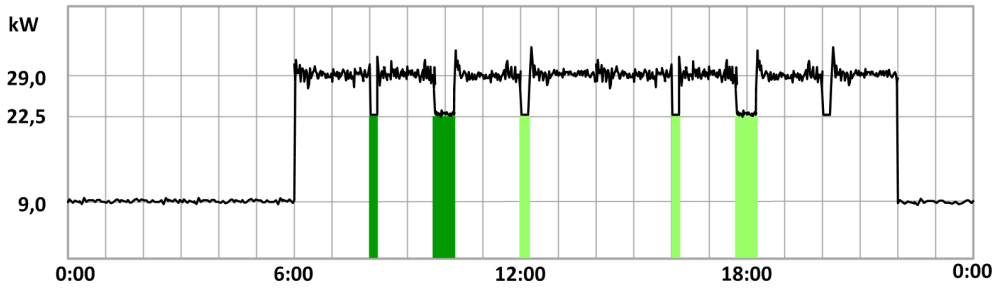

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Figure 2-6 Example: Energetic analysis for long pauses

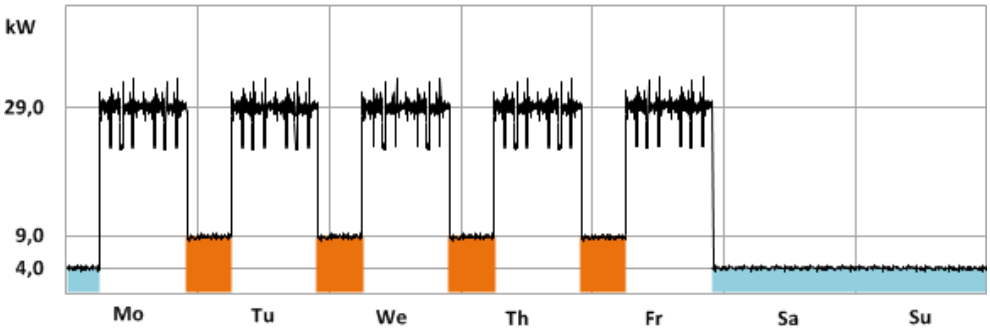

Table 2-14 Standby loads in production-free times, complex example

	Pause	System part	Value	Unit kW
Active power during short pause	kP1 = kP2	Total	22.50	kW
		Production	20.00	kW
		Packing	2.50	kW
Active power during long pause	IP1	Total	9.00	kW
		Production	8.00	kW
		Packing	1.00	kW
Active power during long pause	IP2	Total	4.00	kW
		Production	3.00	kW
		Packing	1.00	kW
Active power during “unscheduled” pause	uP1	Total	25.00	kW
		Production	22.50	kW
		Packing	2.50	kW

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Localizing the standby loads

This section wants to determine which consumers use how much energy during downtimes. With the resulting list, devices can be localized and identified more easily.

Table 2-15 Standby consumers

Type of load	Power in kW	Item desig-nation	System part	Device designation (e.g. article number)

If the standby loads differ depending on the downtime, a separate list of standby loads must be drawn for every downtime.

Example:

To keep the examples simple, we will only consider the whole system. In case of more complex systems it makes sense, however, to break the system down into different sections for a better overview. Since the procedure for the “simple” and the “complex” example are the same, we only explain the “simple” example here.

Table 2-16 Standby consumers

Type of load	Power in kW	Item desig-nation	System part	Device designation (e.g. article number)
Robot 1	0.20	-A01_KU2	Production	KUKA KRC2
Fan 1	0.15	-A01_M12	Production	
Fan 2	1.00	-A01_M24	Production	
Heater 1	2.00	-A02_H12	Packing	
Controller 1	0.40	-A02_Q01	Packing	

2.3.2 Determination of the switchable standby loads

Procedure

Are the identified standby power consumers switchable?

If yes, what do they consume in energy-saving mode?

A load is considered switchable if it can be switched on and off without affecting the process during downtimes. In addition, it must be assessed whether the safety concept is affected when the device is switched on or off. If this is the case and the device is to participate in the PROFIenergy implementation, an alternative solution for the safety concept must be found for which this specific device is not relevant, yet functionality is still ensured.

These considerations must be made for **every pause**.

Table 2-17 Switchable standby loads

Type of load	Item desig-nation	Consump-tion in kW	Standby consump-tion in kW	Switch-able	Safety-relevant

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Example:

Assessing the standby loads in kP1 (short pause 1.55 min). Robot 1 is integrated into the safety concept, but can be “switched off” during the pauses by updating the firmware update and adapting the safety concept. Fan 1 can be made switchable by an additional contactor.

Table 2-18 Switchable standby loads in short pause 1

Type of load	Item designation	Consumption in kW	Standby consumption in kW	Switchable	Safety-relevant
Robot 1	-A01_KU2	2.00	0.50	yes	yes
Fan 1	-A01_M12	1.50	1.50 / (0)	no	no
Heater 1	-A02_H12	2.00	0.05	yes	no

Switchable without restrictions

Not switchable (or only with restrictions)

2.3.3 Extending the switchability

Procedure

During the assessment, consumers that are not switchable are identified. This can be for various reasons. It must be determined whether there is a possibility of making these consumers switchable and of integrating them into the concept.

For example, if a consumer does not have a main switch, a contactor which can be switched via a controller or an external I/O can be retrofitted. Or, if the safety concept does not allow that this specific controlling system is switched off during downtimes, for example, a modified safety concept can be adapted to cover this problem. For example, it would be possible to realize all the safety functions via one - or for redundancy via two - controlling systems. Then all the other controlling systems can be switched off during downtimes.

2.3.4 Determined switchable loads

Procedure

The identified consumers which have a significant consumption during production-free times and can be switched on/off, are the devices which need to be considered for a PROFIenergy implementation. They are stored in chronological order and according to type for further consideration.

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Table 2-19 Evaluation of the analyzed downtimes

	Pause	Dura-tion	Type of load	Item designation	Power in kW
Short pauses					
Long pauses					
Unscheduled pauses					

Example:

In this table, all the downtimes identified in the examples in Chapter 2.2.2 Analysis of downtimes are entered.

Table 2-20 Evaluation of the analyzed downtimes in the examples

	Pause	Dura-tion	Type of load	Item designation	Power in kW
Short pauses	kP1	55 min	Robot 1	-A01_KU2	0.50
			Fan 2	-A01_M24	0
	kP2	60 min	Robot 1	-A01_KU2	0.50
			Fan 2	-A01_M24	0
			Fan 1	-A01_M24	0
Long pauses	lP1	8 h	Robot 1	-A01_KU2	0.50
			Fan 2	-A01_M24	0
			Fan 1	-A01_M24	0
	lP2	56 h	Robot 1	-A01_KU2	0.50
			Fan 2	-A01_M24	0
			Fan 1	-A01_M12	0
			Heater 1	-A02_H12	0.05
			Controller 1	-A02_Q01	0
Unscheduled pauses	uP1	10 min	Robot 1	-A01_KU2	0.50
		2 h	Fan 2	-A01_M24	0
	uP2	15 min	…	…	…
		30 min	…	…	…
	uP3	1 h	…	…	…
		5 h	…	…	…

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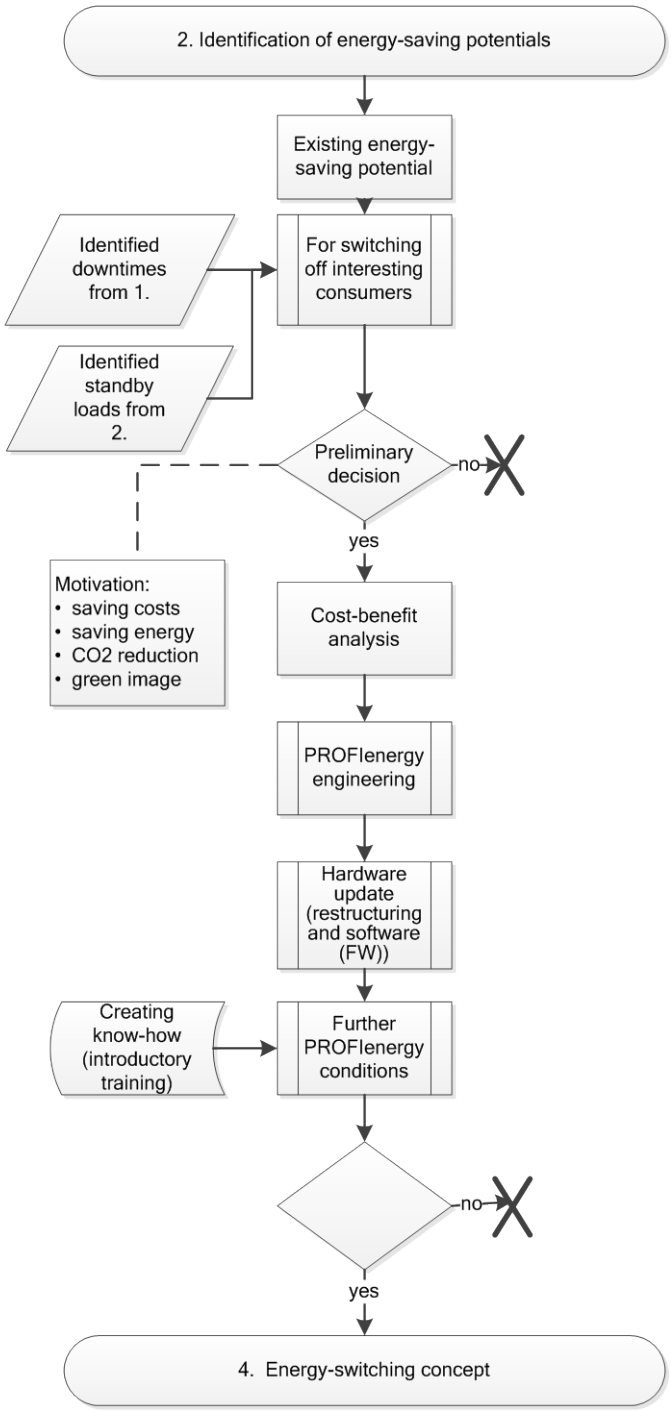
2.4 Cost-benefit analysis

Procedure

Figure 2-7 Flowchart “Cost-benefit analysis”



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2.4.1 Existing energy-saving potential

Procedure

The maximum potential for savings results from the combination of the identified downtimes (see procedure in chapter 1) with the switchable loads from chapter 2.

Table 2-21 Estimation of the maximum power reduction in different pauses

	Pause	Consumption without PE switch-off	Consumption with PE switch-off	Maximum power reduction
Active power during short pause				
Active power during long pause				
Active power during unscheduled pause				

Example:

Analog to the system described in Example 2:

in chapter 2.2.1 Determination of downtimes, the following differences in power consumption result for the individual pauses when the switch-off is implemented by means of PROFIenergy. (The exact values can be determined as described in chapter by analyzing the individual consumers).

Table 2-22 Estimation of the maximum power reduction in different pauses

	Pause	Consumption without PE switch-off	Consumption with PE switch-off	Maximum power reduction
Active power during short pause	kP1 = kP2	22.5 kW	4.5 kW	**18.0 kW**
Active power during long pause (idle shift)	lP1	9.0 kW	1.5 kW	**7.5 kW**
Active power during long pause (weekend)	lP2	4.0 kW	0.1 kW	**3.9 kW**
Active power during unscheduled pause	uP1	25.0 kW	6.0 kW	**19.0 kW**

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In a two-shift operation (5 days a week) and with two short pauses 1 and one short pause 2 per shift, the following pauses per week result:

Table 2-23 Estimation of the maximum power reduction in different pauses

	Pause	Duration of the pause	Number of pauses per week	Time total	Max. energy-saving potential = Time total x power difference
Short pause 1	kP1	12min	20	4 h	4 h x 18.0 kW = **72 kWh**
Short pause 2	kP2	30 min	10	5 h	5 h x 18.0 kW = **90 kWh**
Long pause (idle shift)	IP1	8 h	4	32 h	32 h x 7.5 kW = **240 kWh**
Long pause (weekend)	IP2	56 h	1	56 h	56 h x 3.9 kW = **218.4 kWh**
				Total	**620.4 kWh**

With 46 production weeks per year, the resulting maximum energy-saving potential for the system under consideration (without any unscheduled pauses) is **28.538 kW** per year.

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2.4.2 Preliminary considerations

Depending on the motivation for implementing energy-saving measures, a first estimation can show whether the implementation of a PROFIenergy project makes any sense in order to save energy.

Saving costs

Should the main target be to save costs, the scale of the energy-saving potential of the PROFIenergy switch-off concept that influences costs should be estimated, taking the various contracts with energy suppliers into account.

In the example under consideration, assuming a price of € 0.10 / kWh, this would be a maximum cost reduction of about **€ 2,854** per year thanks to a reduced purchase of energy.

Saving energy

Should saving energy be the direct target, for example to attain a specific absolute or relative energy-saving target, an estimation directly on the basis of the maximum energy-saving potential can be made to assess in how far switching off devices with PROFIenergy could contribute to attaining the target.

If you assume a production power consumption of 29 kW for an example plant, a maximum energy-saving percentage of 22% in a production week results.

CO_2 reduction

For the estimation of the CO_2 reduction, a calculation with the respective fuel mix factor must be made.

$$CO_2\ savings = CO_2\ fuel\ mix\ factor \cdot standby\ savings$$

For the example plant in Germany, the following reduction in CO_2 emissions would result.

$$CO_2\ fuel\ mix\ factor\ for\ Germany = 0.546\ {}^{kg}/_{kWh}$$ [2]

$$\boldsymbol{CO_2\ savings\ per\ year = 15581.7\ kg} = 0.546\ {}^{kg}/_{kWh} \cdot 28538\ kWh$$

This means that over 15 tons of CO_2 less would be emitted every year.

Green image

A “green image” mainly focuses on the public perception; implementation costs usually take a back seat. In this case it is possible that a project is implemented although the use of PROFIenergy does not have any direct financial advantage.

2.4.3 Cost-benefit analysis

Procedure

If these preliminary considerations revealed that - according to the respective motivation - it would basically make sense to implement a switch-off concept by means of PROFIenergy, the next step should be an exact cost-benefit analysis to assess the profitability of the planned measure in greater detail.

Hardware update

Hardware update means all the necessary adaptations and modifications in the hardware environment of the existing system that have been determined so far. They especially include

- firmware updates (e.g. an update of devices to support the PROFIenergy functions)
- hardware expansions (e.g. additional power modules for switch-off or additional I/O modules).
- hardware replacement (especially the replacement of devices that are not PROFIenergy-capable against devices that support the protocol)
- additional hardware (installation of additional switching equipment or HMI for operating and monitoring the system).

[2] Source: http://www.umweltdaten.de/publikationen/fpdf-l/4488.pdf

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PROFIenergy engineering

This means the total expenditure necessary for implementing the planned PROFIenergy solution. Of course the kind of required works largely depends on the conditions of the system, so that not all of the measures listed in the following must be carried out for every system (for further details on hardware and software concepts and their implementations, see chapters 2.5.2 Creating the software concept and 2.5.3 Creating the hardware concept (automation system)).

- Preparing an overall concept for the implementation.
- Configuration and documentation of the required hardware changes.
- Programming the required PROFIenergy controller functionalities (e.g. based on PROFIenergy controller FBs such as FB820).
- Configuration/programming of the PROFIenergy device.
- Configuration/programming of the HMI and/or connection to higher-level systems (SCADA/MES level).
- Test, documentation and approval of the complete system.

Further PROFIenergy boundary conditions

For the implementation and the successful operation of a system with PROFIenergy functionalities, further measures might be necessary. For example the extension of the know-how (introductory training) and the training of the operating staff.

The estimated costs for the necessary measures can be compared with the expected energy savings to calculate the ROI.

$$ROI = \frac{energy\ savings\ per\ year\ in\ €}{project\ costs\ in\ €}$$

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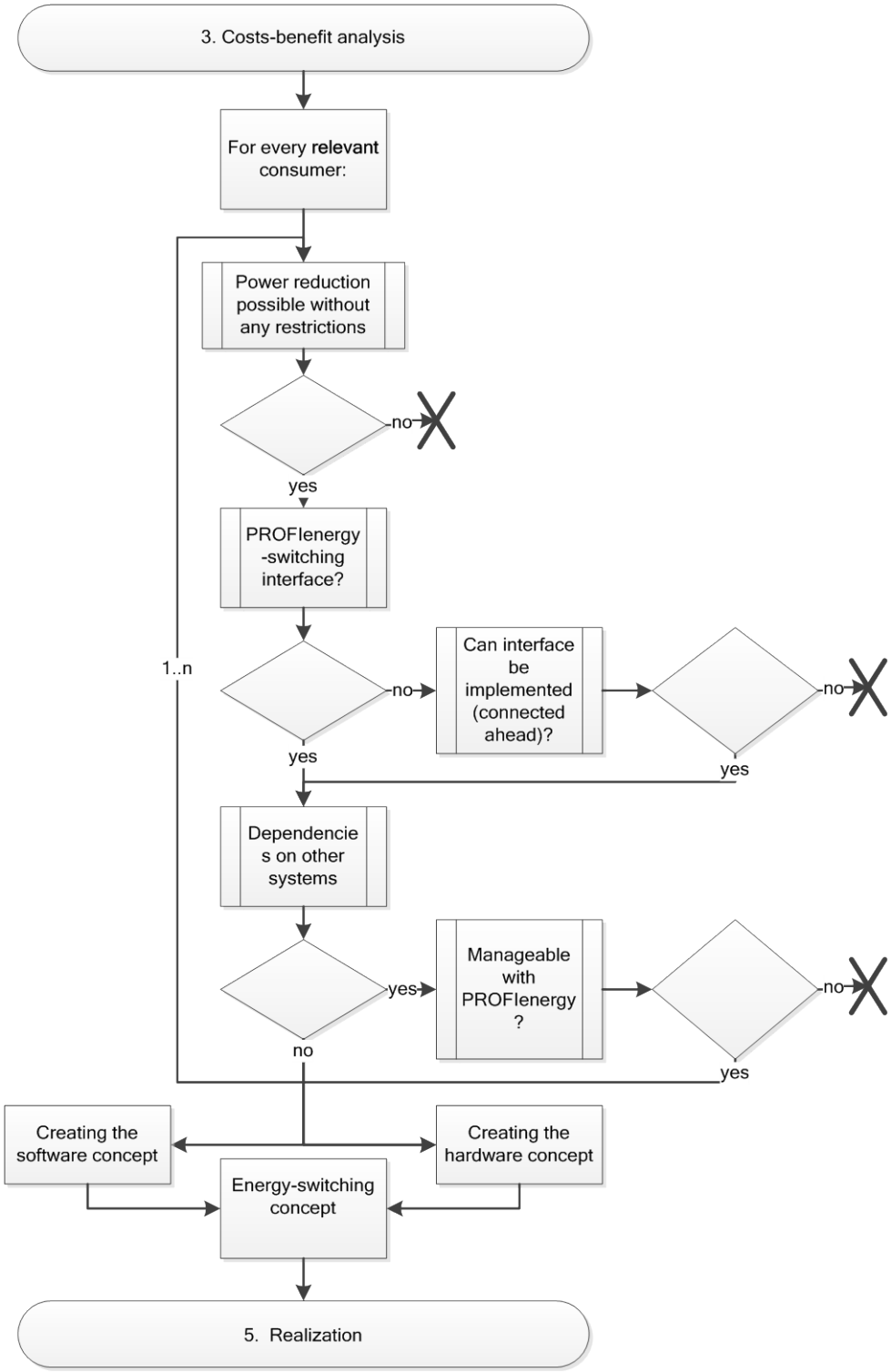
2.5 Energy-switching concept

Procedure

Figure 2-8 Flowchart of the energy-switching concept



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2.5.1 Consumers to be switched with PROFIenergy

Procedure

For every identified consumer which is to be switched with PROFIenergy, the items in this chapter must be carried out to ensure that the required functionality for the further configuration of the system is available.

Afterwards, you can start creating the concept. This application guideline began with the software concept, since the operating concept is also covered in this context. However, in some points it is necessary to switch between the different chapters on the software / hardware concepts.

A power reduction is possible without any restrictions

There are no restrictions for the device, neither from the process point of view nor under safety aspects. There are no dependencies on other systems / no dependencies are created that would prevent switching.

PROFIenergy interface

For the consumers which have been found to be switchable, it has to be assessed whether a **switching PROFIenergy interface** has already been implemented or if it is possible to implement one. If the device is not connected to a bus system (PROFINET, ...), it has to be examined whether it can be integrated into the concept by connecting a PROFIenergy device “ahead”. “Connecting ahead” could mean a 3RW44 soft starter added in front of a motor for example. It has to be determined whether the extension might generate error states.

Dependencies on other systems

If the device that is to be switched has dependencies on other systems, it has to be determined whether there would be any negative reaction on the whole system if the device were switched. In this case it has to be checked whether these influences can be managed by PROFIenergy.

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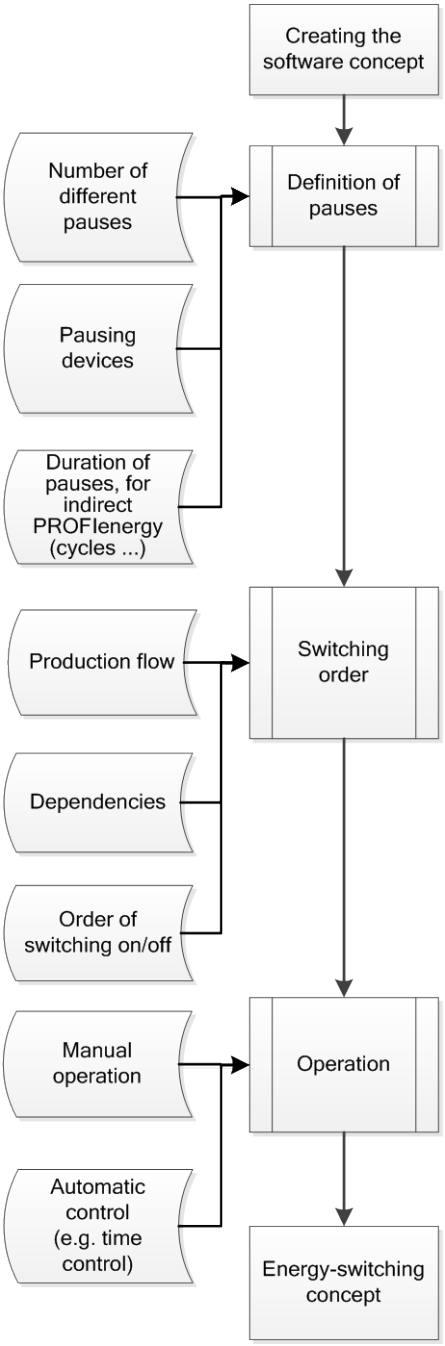
2.5.2 Creating the software concept

Procedure

Starting with the consumers to be switched, a concept for the implementation of the PROFIenergy switching functions must be created. The operation of the overall system and its link to other functions has to be considered.

Figure 2-9 Flowchart of the software energy-switching concept



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PROFIenergy controller

The kind of implementation of the PE controller has not been defined in the standard, and therefore it has to be considered for each system individually, depending on the specific requirements. The necessary scope of functions mainly depends on the following requirements:

1. Number of devices to be addressed
2. Automatic restarting of devices
3. Release/blocking caused by the production process must be considered
4. Controlling/operation by local HMI and/or external systems (e.g. pause management, MES, etc.)
5. Taking dependencies into account that could influence the switching behavior (such as orders of switching on/off, time lags, etc.)

Siemens supplies various function blocks that can be used as a basis for the implementation of a PE controller, including:

1. FB815/816 (implementation of the basic functionalities for starting and ending pauses and for sending and receiving PROFIenergy commands)
2. FB820 (controller function for switching off several devices at a time, supporting WOL mode)

For simple systems with the requirements 1-4, there is an application example with the function block PE_CTRL “PROFIenergy – Easy Configuration with PE_CTRL”, which supports the simple configuration of the system and all the necessary basic functions.

If dependencies (according to requirement no. 5) or interactions with several different external systems are to be implemented, usually a specific applicative solution must be created.

For the implementation of complex behavior it usually makes sense to plan a hierarchic system on the basis of the functionality “I-Device” (see “Saving Energy with SIMATIC S7 (STEP 7 V5.5)“ entry “Saving Energy with SIMATIC S7 - PROFIenergy With an I-Device”). In doing so, the desired behavior of the PE device can be realized in the controller.

The above solutions are also suitable if for indirectly switched consumers, e.g. via distributed I/O “Saving Energy with SIMATIC S7 (STEP 7 V5.5) entry “Project Archive for the application example “PROFIenergy with ET200S”) special features of the consumer, such as the number of allowed switching cycles, are to be taken into consideration.

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Operation

The operation of a PROFIenergy system can be either manually or automatic (e.g. time control) or a combination of both.

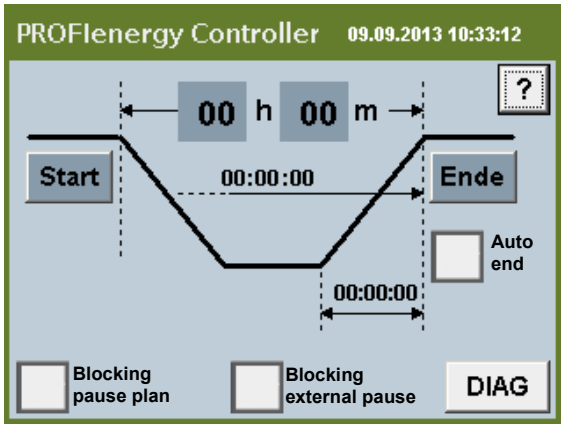
For **manual operation**, a user interface should be designed which at least supports the following functions:

1. Starting/ending pauses
2. Configuration of the duration of the pause and/or selection of predefined pauses
3. Feedback about the status of the controller and the connected PROFIenergy devices

It can make sense to provide for further functions:

1. (De-)selection of additional functions such as waking up devices at the end of the pause
2. Visualization of the (remaining) duration of the pause and maximum required ramp-up time
3. Activation/deactivation of the influence by external systems

Figure 2-10 Example of a faceplate for the operation of a PE controller



An automatic starting and ending of pauses is usually either directly time-controlled (e.g. on the basis of the stored break and shift schedule) or for example controlled by a production control system.

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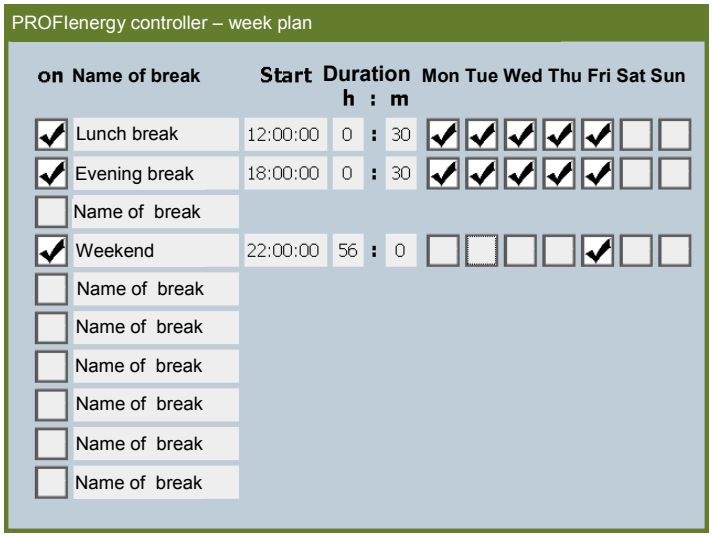
Figure 2-11 Example of the configuration of a break and shift schedule for controlling a PE controller



If a combination of automatic and manual operation is to be used, it is important to implement a clear priority rule to avoid any unclear or undesired behavior of the system. Usually it makes sense that manual operation overrules or deactivates an automatic starting/ending of pauses.

Note

The faceplates from Figure 2-10 and Figure 2-11 are contained in the PROFIenergy example “PROFIenergy – Easy Configuration with PE_CTRL” in the Siemens Industry Online Support.

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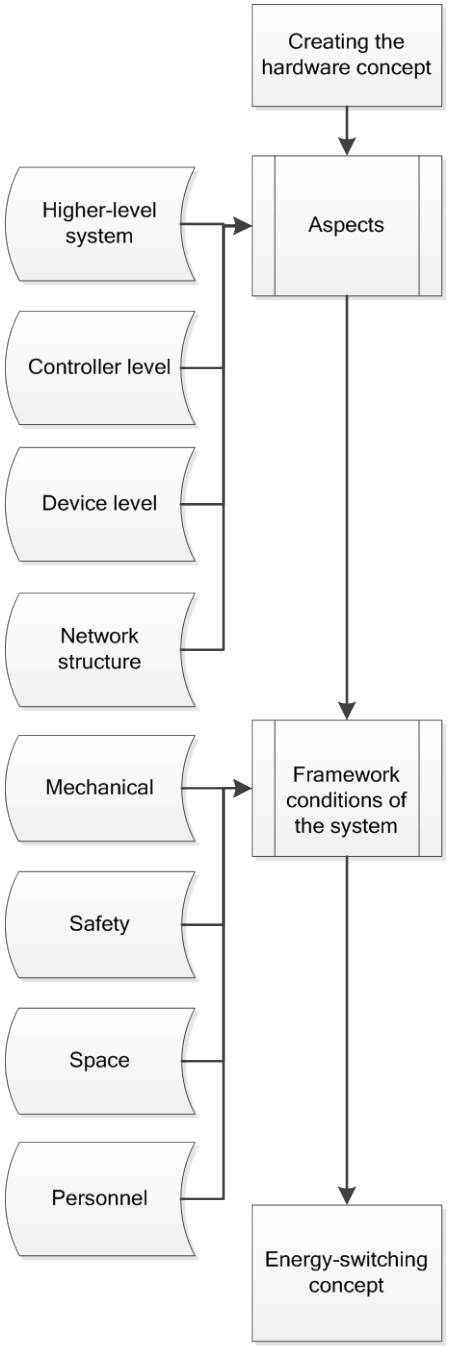
2.5.3 Creating the hardware concept (automation system)

Procedure

When all the nodes that can be switched by PROFIenergy have been identified and the operation concept has been created, the planning of the hardware concept can be started.

Figure 2-12 Flowchart of the hardware energy-switching concept



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Higher-level system / source of the switching commands

A higher-level system must generate the trigger for the beginning of a pause. This can be done manually by an operator or by a higher-level system. In case of a manual trigger by the operator, an HMI must be provided. If the pause command is issued by a higher-level system, the interface must be known and transmit the command to the controller.

Controller level / Who receives the command

Normally it should be aimed at integrating the PROFIenergy application into an existing controller; if this is not possible, a suitable controller (e.g. SIMATIC S7-300 CPU, ...) must be provided for this.

Device level

At the device level all the PROFIenergy devices to be switched are listed (see Table 2-27 Device level hardware structure (automation system)).

By means of the “I-Device” functionality it is possible to create a hierarchy of several controllers; this is not presented in detail here. For further information, please refer to the application example “Saving energy with SIMATIC S7 - PROFIenergy with an I-Device”

Network structure

Please make sure that all the PROFIenergy notes are connected in the PROFINET. Otherwise, additional PROFINET connections have to be created between devices. The network topology is analog to the requirements for the PROFINET network structure.

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Hardware concept device list

Table 2-24 Higher-level system hardware structure (automation system)

	Item designation	Type
Higher-level system (manual)		
Higher-level system (automatic)		

Table 2-25 Controller level hardware structure (automation system)

	Item designation	Type
Controller		
…		

Table 2-26 I-Device level (optional) hardware structure (automation system)

	Item designation	Type	Controller
I-Device			
…			

Table 2-27 Device level hardware structure (automation system)

	Item designation	Type	Controller (I-Device)
Devices			
…			
…			
…			

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Framework conditions of the system

In addition to the PROFIenergy-specific conditions, other influences must also be considered, which might arise from modifications of the energy demand of the system. The following items represent a selection of typical additional influences:

- **Mechanical boundary conditions**

  E.g. a fan is driven by a motor via a belt. As long as the fan runs permanently, there are no problems. If the motor is switched off, the belt slips when it is switched on again and wears much quicker or the fan might not restart at all. In this case, the fan cannot be switched off, or it has to be modified, e.g. converted into a directly-driven fan or equipped with a soft starter.

- **Physical boundary conditions**

  E.g. in a thermal bonding process, the bonding control cannot be switched off and on again, or the adhesive material would solidify.

- **Safety requirements**

  Effects on safety circuits, etc.

- **Further specific conditions of the system**

  Could include personal conditions (competence/acceptance) for example.

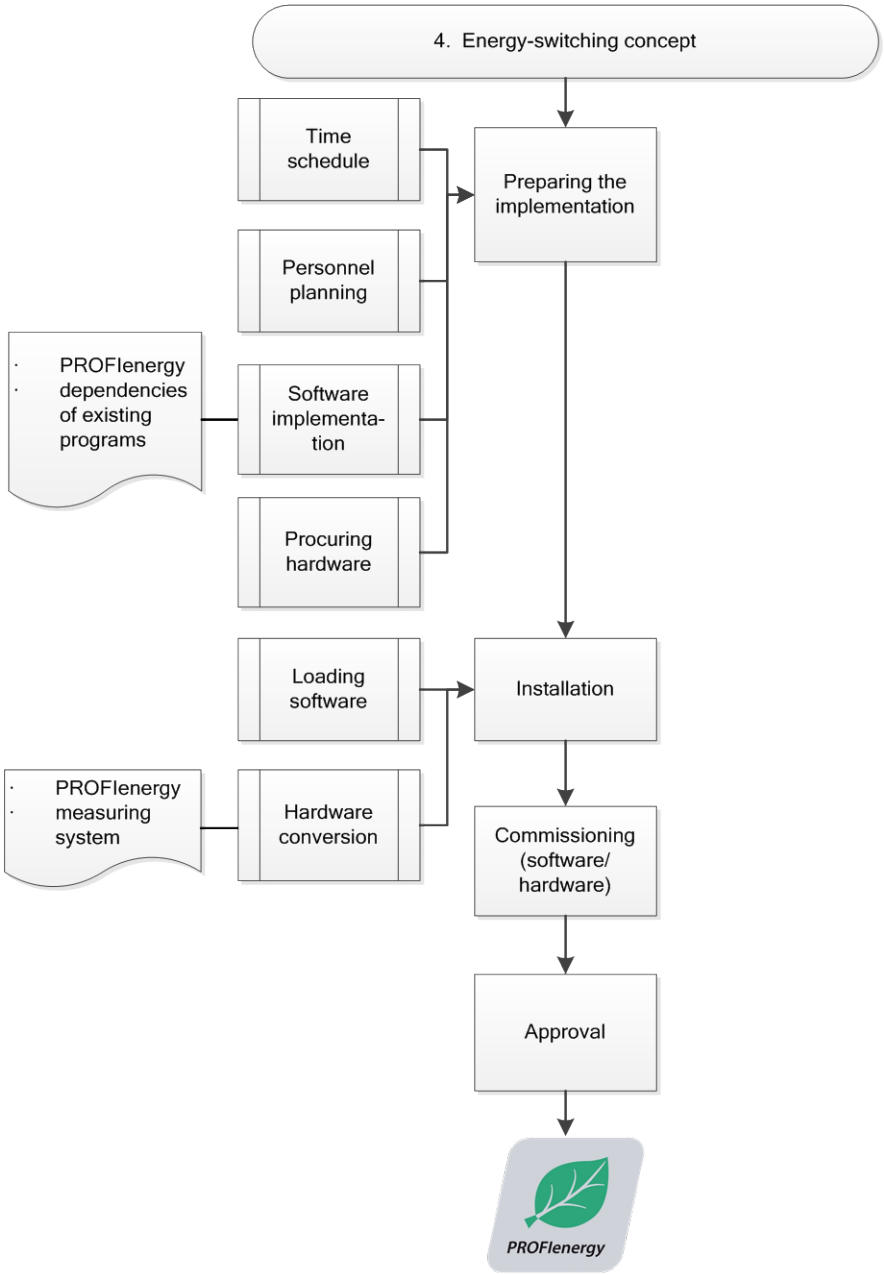
2.6 Realization

Procedure

This chapter shows the general implementation of a PROFIenergy project. It is intentionally brief, since the process is the same as the typical PM process, which should be used for handling the project.

However, the individual steps needed for the realization will be described. These steps should also support the project management, i.e. the subchapters can be defined as milestones (completion of individual phases).

Figure 2-13 Flowchart of the “realization”



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2.6.1 Preparing the implementation

Time schedule planning

- How long does it take to implement the software/procure the hardware? _____
- How long does the hardware/software installation take? _____
- When is the staff available? _____
- When can the installation be carried out? _____
- Until when can/must the commissioning take place? _____
- Until when must the approval take place? _____

Personnel planning

The roles required for the implementation, which have to be taken into account for the personnel planning, are listed here.

- Programming “PROFIenergy”
- Programming “System” (adapting the software of the existing system)
- Software installation
- Hardware installation (conversion, new installation)
- Commissioning the system
- Approval of the system
- New approval of the safety system, if applicable

Software implementation

Implementation of the created software concept “**PROFIenergy**” and implementation of the “**dependencies of existing programs**”

Table 2-28 Software implementation

	PROFIenergy	Dependencies of existing programs
Specification		
Carried out by		
Starting date		
Finish date		
Responsible		
Completed		

Hardware to be procured

The additional hardware and consumables needed for the installation is to be entered in the following list.

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Table 2-29 List of hardware to be procured

Number	Device designation (e.g. article number)	Finish date	Responsible

2.6.2 Installation

Loading software

Loading programs created in the preceding subchapter

Table 2-30 Software installation

	PROFIenergy	Dependencies of existing programs
Specification		
Carried out by		
Starting date		
Finish date		
Responsible		
Completed		

Hardware conversion

Installation and connection of new hardware and/or conversion of existing hardware.

Table 2-31 Hardware installation

	PROFIenergy “switching” system	Measuring system, if required
Specification		
Carried out by		
Starting date		
Finish date		
Responsible		
Completed		

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2.6.3 Commissioning (software/hardware)

A commissioning record has to be prepared for commissioning.

Table 2-32 Commissioning

	Software	Hardware
Wiring check		
Function check		
Starting date		
Finish date		
Responsible		
Completed		

2.6.4 Approval

Procedure

In brownfield systems, the approval will be a so-called “Site Acceptance Test” (SAT). This means the approval of the system directly at the customer's premises, where it is installed.

The SAT is usually carried out together with the customers or their authorized representatives.

The approval comprises the following items:

Testing the components

The following components are tested:

- completeness of the system (hardware/software)
- completeness of the documentation (adaptation of electric circuit plans, manual, operating instructions, spare parts list, CE declaration)

Safety test

Afterwards, the system is submitted to a safety test. If the safety concept was changes by the implementation of PROFIenergy, a new safety approval must be carried out for the system.

If no changes in the safety concept of the system were caused by the implementation of PROFIenergy, a short test should still be conducted, for example by pressing the emergency off button in full run and trying to open the doors.

Function test

Moreover, the system is run without a product, the implemented pause times being addressed.

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Test run with product

In the end a complete test run of the system with the product is carried out. This production run should be carried out under real production conditions with machines connected upstream and downstream.

If the tests carried out did not reveal any deficiencies or only minor ones, the machine can be approved. Should considerable deficiencies be detected, the factory acceptance test has to be carried out again after the supplier has corrected (cured) the deficiencies and it has been determined that the machine is flawless. As an alternative, the customer is free to decide to approve the machine in spite of the deficiencies found. In this case, usually a compensation regulation (e.g. reduced price, longer warranty period, free or reduced spare parts) is agreed upon.

All the steps of the approval must be recorded in a written approval record, which is then signed by the supplier and the customer together.

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3 Related Literature

Bibliography

This list is not complete and only represents a selection of relevant literature.

Table 3-1 Bibliographic references

	Topic	Title
/1/	PROFIenergy profile	Common Application Profile PROFIenergy Technical Specification for PROFINET Version 1.1 August 2012 Order No: 3.802

Internet link specifications

The following list is not complete and only represents a selection of relevant information.

Table 3-2 Link collection

	Topic	Title
\0\	Download page of this entry	http://support.automation.siemens.com/WW/view/en/96837137
\1\	PROFIenergy - Saving Energy with SIMATIC S7 (STEP 7 V5.5)	http://support.automation.siemens.com/WW/view/en/41986454
\2\	PROFIenergy - Saving Energy with SIMATIC S7 and SIMATIC HMI (TIA Portal)	http://support.automation.siemens.com/WW/view/en/58235225
\3\	PROFIenergy: Saving energy with SIMOTION and SIMATIC ET 200S	http://support.automation.siemens.com/WW/view/en/58386840
\4\	Siemens I IA/DT Customer Support	http://support.automation.siemens.com
\5\	PROFIenergy Matrix	http://support.automation.siemens.com/WW/view/en/95848378
\6\	PROFIBUS & PROFINET International	http://www.profibus.com/

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4 Glossary

Brownfield

In this document, brownfield systems mean industrial systems that already exist. In this case the existing infrastructures and production procedures have to be taken into account.

Greenfield

New systems are called greenfield systems. Energy-efficient production steps can already be considered during the planning phase.

Item designation

In industrial plants and systems, electrical equipment is usually designated with the so-called item designation. The current reference designations, formerly called item designations, are to be found in the standard EN 81346-2.

PNO

Profibus Nutzerorganisation e.V., an association of Profibus users

PE

PROFIenergy

HMI

Human-Machine Interface

MES

Manufacturing Execution System. A level of a multi-layer production management system operating close to the process.

WoL

Wake on LAN

FB

Function Block

SAT

Site Acceptance Test is the acceptance of a machine or system directly at the customer's premises, where it is installed.

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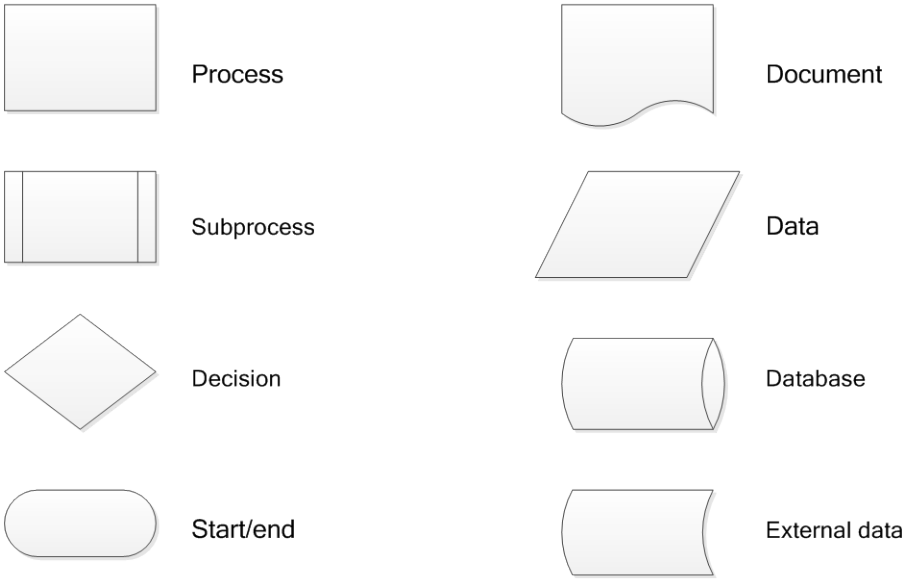
5 Legend flow charts



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6 History

Table 6-1 History

Version	Date	Modifications
V1.0	28.07.2014	First release