ARC WHITE PAPER

By ARC Advisory Group

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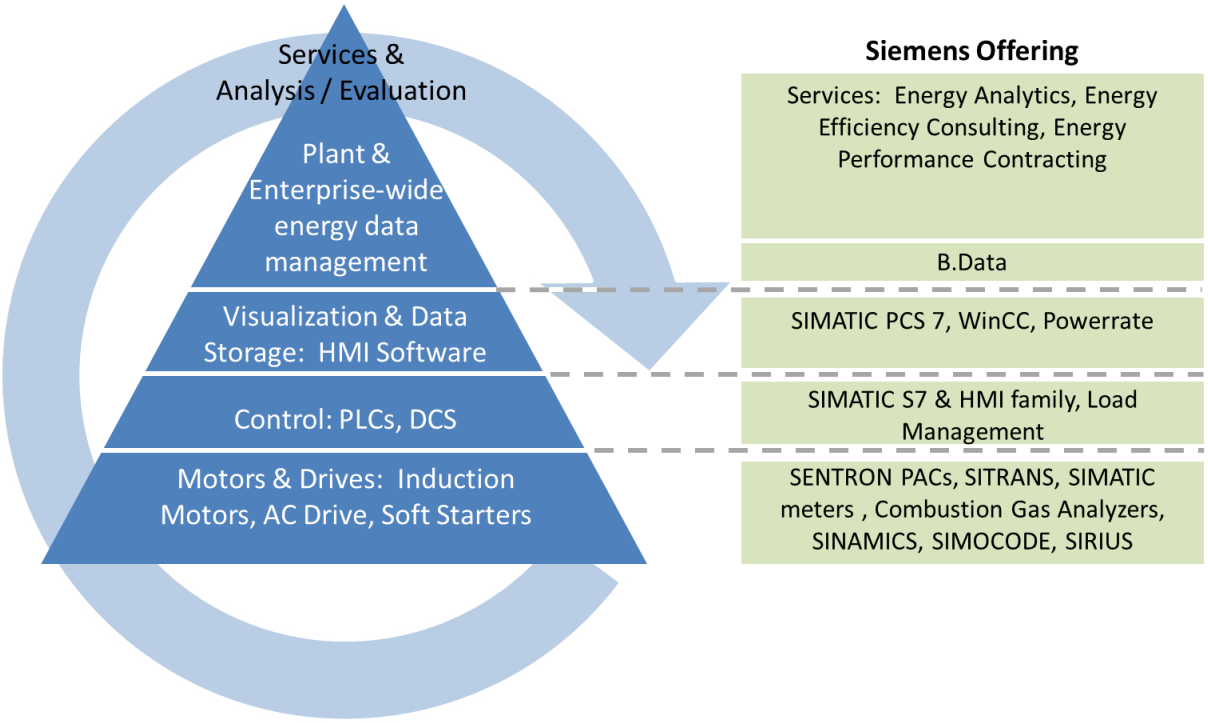
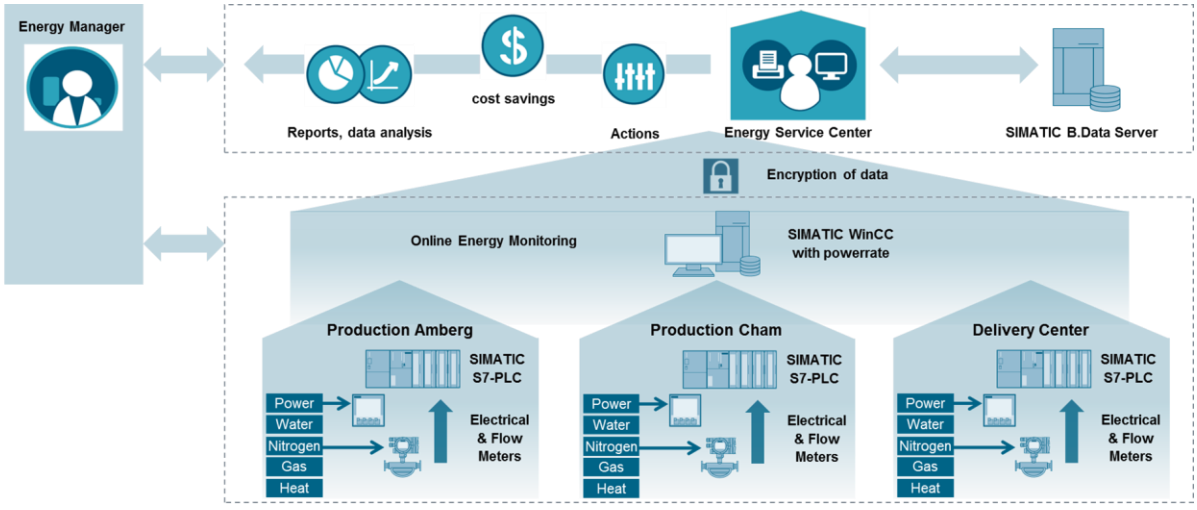
Managing Energy with Siemens: The Case of the Amberg Factory



Siemens Product Offering for Energy Management



Architecture for Energy Management in Siemens' Amberg Plant

Executive Overview

Energy management is currently a hot topic as more industries and more applications are optimized not only for throughput and quality, but also to reduce energy consumption. While energy intensive industries have long applied measures to reduce energy costs, industries that are less energy intensive aren't convinced yet that energy management pays off.

Energy Management is just starting to become a topic in less energy intensive industries. This whitepaper describes the installation and achievements at the Siemens plant in Amberg.

This situation is about to change due to higher prices, stricter regulations on emissions, and generous tax incentives. The Siemens plant in Amberg, Germany, is a good example of how energy management can contribute quickly and sustainably to the bottom line of an electronics and electrical manufacturer. Siemens implemented an energy management system from measuring to the MES layer using its own products and services.

Energy efficiency has been a major topic in Amberg since 2005 and the project to implement a plant-wide energy management system kicked off in 2012. This pilot project provided Siemens with valuable experiences that are now being fed back into its offering of hardware, software and services. The key learnings from implementing a holistic energy management system in this factory were:

- Take enough time at the beginning to develop the right concept
- Create clear responsibilities
- Use a scalable architecture
- Secure the buy-in of people on the plant floor
- Start with a top down approach
- Begin to push energy management not just after installation but during the purchasing process
- Implement an energy management system

As Siemens has the advantage of having most products in-house, the system installed was primarily based on these products. Key products used were SIMATIC AI Energy Meter, SIMOCODE, Sentron PACs, or SIRIUS switchgear for metering power consumption, Simatic S7 controller, B.Data as energy management software, and Energy Analytics as a managed service.

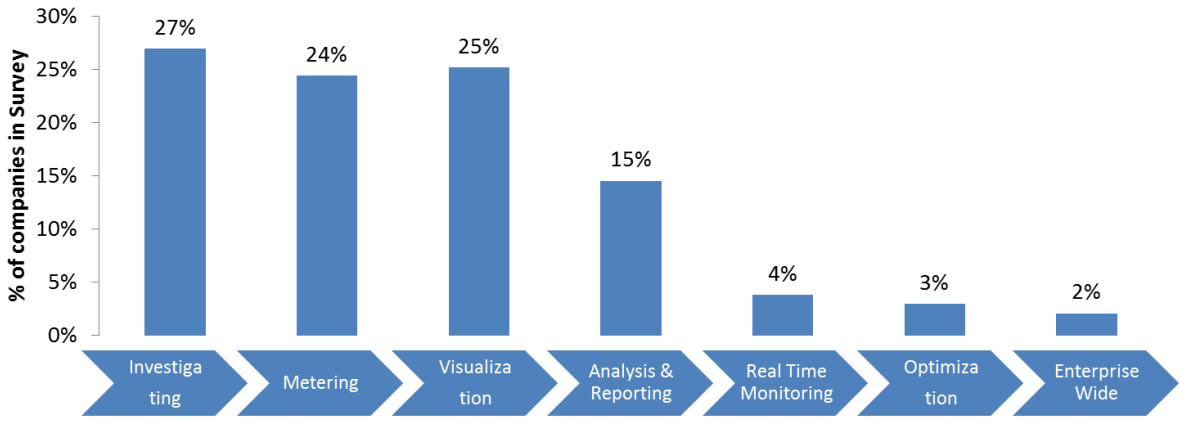
The State of Energy Management

How Mature is Energy Management?

Energy management is a comparably new issue in industrial plants. While some industries such as chemical, refining, pulp & paper, or parts of metals have already implemented highly sophisticated measures to manage energy consumption, other users do not consider energy management at all.

An efficient energy management system needs to take in account every aspect of the collaborative manufacturing model (CMM). The CMM describes manufacturing along three axis: **operations** (from automation to business), **lifecycle** (from design to retirement), and **supply chain** (suppliers and customers).

This includes the value chain axis, mainly in the form of purchasing energy, the lifecycle axis, along which product design is optimized, and the business and production axis, which we will focus on in this report.



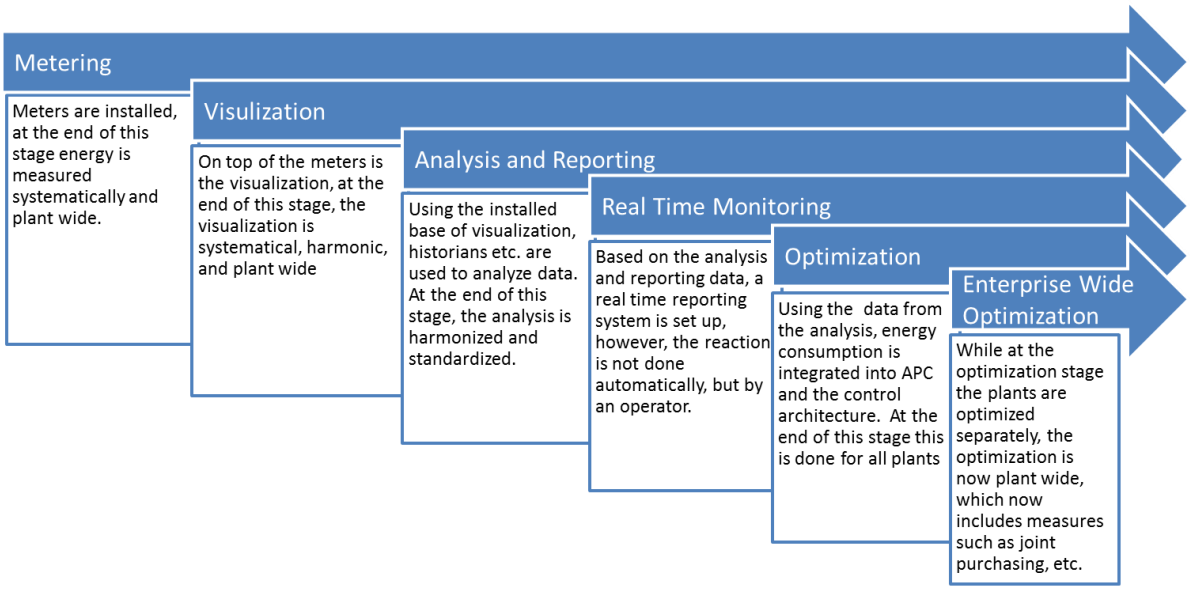
ARC's Energy Management Maturity Axis

The production aspect of energy management has two sides: active and passive. Passive energy management is best described as energy efficiency measures with which energy consumption is lowered, but the production process itself is not changed. Examples for passive energy management are the use of AC drives and more efficient motors, and better isolation of pipes and tanks. Active energy management in contrast means that the production process itself takes energy consumption into account and affects areas ranging from plant design, to model-based optimization during operation, to services based on big data.

The ARC Maturity Axis

ARC has developed a maturity axis for energy management that describes the current state of the market. A survey conducted by ARC produced results spanning from "still investigating" to enterprise-wide implementation of an energy management system.

In ARC's point of view, the largest group represents not those companies investigating, but rather those that are not investigating energy management. Looking at our survey, the majority of companies (just over half) is at the stage of investigating and metering. Investigating ranges mainly describes a status, where users start to measure energy consumption to get a first overview of their energy intensive applications.



Energy Management Maturity

Around 30 percent of the companies have an analysis and reporting system in place, or moved on along the maturity axis.

Small Steps, Big Impact

Up to now, mainly industries with either high total energy costs or with a high share of energy in variable costs have looked into energy management. For these industries, energy costs can make up as high as 40 percent of their variable costs. Many discrete industries have not started to look into energy management, though this may change soon.

Cost pressure and pressure from financial markets looking at earnings and shareholder value also force companies to optimize every part of production. Looking at energy cost in relation to EBIT, it is obvious that this can be a real threat to the bottom line. Industries where this becomes apparent are cement & glass, automotive, food & beverage, plastics & rubber, or textiles, though the latter has not made great steps towards energy management yet. Currently, Germany car companies in particular are putting pressure on their tier-one suppliers to become ISO 50.001 certified.

Even though today's impact on costs by saving energy may be low in some discrete industries, many companies see the long lasting positive effects from investments in energy management and are starting to invest. A good reason for this is the fact that investments in energy management have a direct and long lasting impact on the bottom line, while other cost reducing investments typically wear out quicker.

	Energy Costs as share of Variable Costs wto Labor						Energy as % of EBIT
	W	A	G	E	S	Total	
Aerospace & Defense	0%	0%	0%	1%	0%	2%	13%
Automotive	0%	0%	0%	1%	0%	1%	16%
Electronics & Electrical	0%	0%	0%	1%	0%	2%	12%
Fabricated Metals	0%	0%	1%	2%	0%	4%	28%
Machinery	0%	0%	0%	1%	0%	2%	12%
Semiconductor	2%	0%	0%	1%	0%	4%	10%
Textiles	4%	0%	2%	4%	1%	11%	101%
Food & Beverage	2%	0%	1%	1%	1%	4%	19%
Pharmaceutical	1%	0%	1%	1%	0%	4%	11%
Cement & Glass	2%	0%	17%	27%	2%	48%	159%
Chemical	1%	0%	9%	3%	2%	16%	79%
Electric Power Generation	1%	0%	0%	1%	1%	4%	20%
Metals	5%	0%	6%	9%	0%	20%	97%
Oil & Gas	1%	0%	13%	25%	3%	43%	263%
Plastics & Rubber	1%	1%	1%	3%	0%	5%	239%
Pulp & Paper	3%	0%	2%	4%	5%	15%	78%
Refining	0%	0%	1%	1%	0%	3%	62%
Water & Wastewater	4%	2%	5%	82%	1%	95%	182%
Other	1%	0%	1%	2%	1%	5%	15%
Total	1%	0%	3%	4%	1%	9%	44%

Energy as Percent of Variable Cost and EBIT

Next to the direct financial impact, energy management also has some harder to measure value to users. As energy is a highly volatile cost factor and the development is beyond the influence of companies, reduction in energy consumption also increases the predictability of future cost and increases planning accuracy. Furthermore, investment in energy management may pay off in future when companies need to apply load shedding due to electricity shortages.

Recent ARC research also shows that targets are quickly adjusted. Once companies look into energy management, more opportunities are found

than previously considered. As a result, targets for energy reduction remain constant and savings decrease exponentially over time.

	Past Savings	Future Targets	ARC Recommendation
Aerospace & Defense	8%	8%	8 – 9 %
Automotive	13%	17%	15 %
Electronics & Electrical	N/A		5 – 8 %
Semiconductor	N/A		8 – 10 %
Food & Beverage	11%	16%	15 %
Pharmaceutical	N/A		10 %
Cement & Glass	8%	8%	8 – 10 %
Chemical	10%	11%	10 – 12 %
Metals	N/A		10 – 15 %
Mining	8%	8%	8 – 10 %
Oil & Gas	N/A		15 %
Refining	10%	11%	12 %
Pulp & Paper	15%	15%	15 %
Utilities	13%	18%	15%
N/A: Our Sample did not incorporate enough companies from this industry			

Past & Future Targets plus ARC Recommendations
Source: ARC Online Survey and Analysis

Discrete Industries

Energy management plays an especially important role in industries with an investment cycle of two (semiconductor) to three (automotive) years. For this reason, some companies have already lowered the requirement for justifying investments in energy management. While traditional investments need to be justified with a return on invest (ROI) of e.g. three years or less, investments in energy management can be justified with longer ROI.

Next to fast financial pay-off, investments in energy management also enable planning reliability - a hard-to-measure factor. Energy costs and volatility will increase. Both are beyond the control of most businesses. These include infrastructure costs to transmit and distribute energy, commodity prices, exchange rates, and geopolitical factors.

A number of initiatives in the discrete industries have recently started to look into the energy management. Most of the initiatives come out of Europe. Siemens plays an active role in all of the following examples.

PROFIenergy in particular is currently getting more traction in the market. This initiative enables users to switch off energy consumers during times of none-operation. The technology was developed by Profibus & Profinet In-

ternational, a network consortium, in which Siemens plays a lead role, and is also being driven by a consortium of Germany automakers. Acceptance has risen quickly because the technology helps to solve the problem that discrete industries need to face: the involvement of OEMs.

Initiative	Initiative Description	Siemens Involvement
PROFIEnergy:	Driven by PI, protocol to switch of consumers in down-times (Link)	Strong involvement in PI and driving force behind ProfiEnergy
Innovation Alliance "Green Carbody Technologies"	Driven by German Federal Ministry for Education and Research (BMBF) with coordination by Volkswagen AG and Fraunhofer Institute for Machine Tools and Forming Technology IWU (Link)	Siemens partner in major projects
Green Factory Bavaria	Driven by universities with partners (Link)	Gold Sponsorship; partner is FAPS University in Erlangen
SimEM	Simulation-based development and validation of energy management concepts in machine-building and plant engineering. Link to Green Factory Bavaria.	Project in application phase
Blue Competence	Blue Competence Sustainability initiative of German VDMA (Link)	Membership
Future Energy Systems	Joint research alliance for energy systems of the future with FAU University Erlangen and Siemens (Link)	Future Energy Systems campus established
„Effizienzfabrik"	A joint initiative from VDMA and German Federal Ministry for Education and Research (BMBF) as part of "Effizienzfabrik"-Initiative. (Link)	
	e-SimPro: Energy efficient production machines through simulation in product design. (Link)	Involvement of Siemens Drive Technologies
	EWOTeK: Increased efficiency of machine tools through technology optimization for component operation(Link)	Project partner Siemens Drive Technologies
ETA Factory	Energy efficient model factory. (Link)	Siemens Drive Technologies as associated partner
Maxiem	Maximize energy efficiency of machine tools	

Selected Projects on Energy Management with Siemens Involvement

While machine builders can significantly support energy savings, they do not always benefit from the savings themselves. Therefore, as long as there is no pressure from end users, OEMs have only limited to no interest in developing more energy efficient machinery.

Siemens also participates in numerous initiatives for standardization and has initiated an energy efficiency program for its clients.

Siemens Solution for Energy Management

In a recent ARC market study, the offerings of more than 50 automation companies were compared. Among the handful of companies that serve every aspect of energy management, Siemens has the most comprehensive portfolio. Energy management is a key topic for Siemens, which was an early mover in this area.

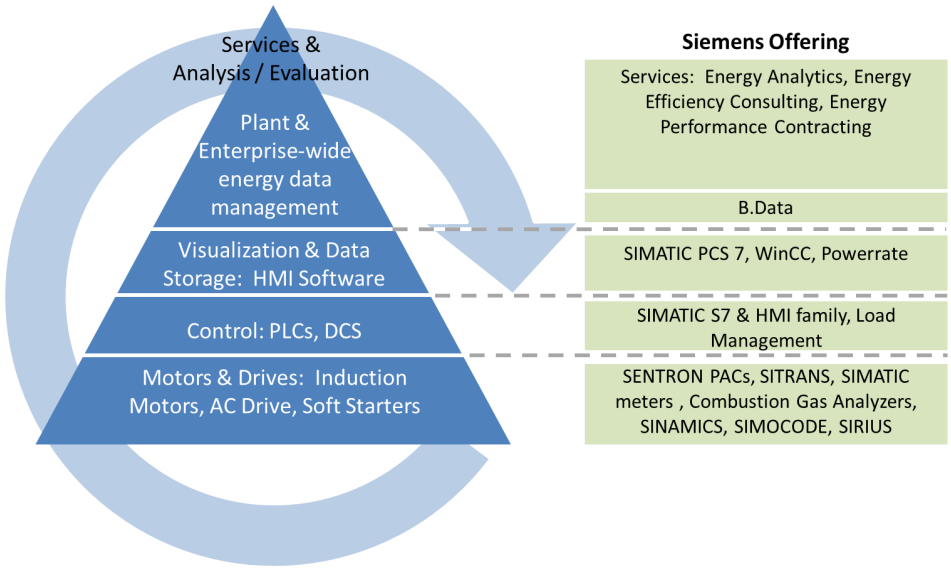
Note: this case study covers only the Siemens offerings for industrial sides in factory and process automation. The product and service offering for buildings and infrastructure are not included.

Products

Energy management addresses the complete automation hierarchy, from measurement up to the ERP functions. Siemens' offering includes products and solutions from metering devices to management functionality for CPM/MES layer. Moreover, the company also acts as a main automation contractor. In energy and mining & metals, Siemens is also a system integrator. The company's financial strength and banking license enables Siemens to offer performance-based energy management contracts to reduce entry costs as a barrier to entry.

For electricity metering, Siemens offers dedicated metering products such as SIMATIC ET200SP AI energy meter, SENTRON 7KM PAC power monitoring devices and SIRIUS switchgear for starting, protecting and switching off motors and loads with integrated electricity metering. These are also designed for integration into the SIMATIC family of PLCs and DCS.

For non-electrical media metering (thermal energy, compressed air, steam etc.), Siemens offers SITRANS flow, pressure, and temperature measurement devices. In addition, the company's field instruments incorporate technology to lower energy consumption like algorithms for pump-control in ultrasonic level controller SITRANS LUT400, or energy efficient valve positioners SIPART PS2.



Siemens Offering and ARC Concept of Energy Management

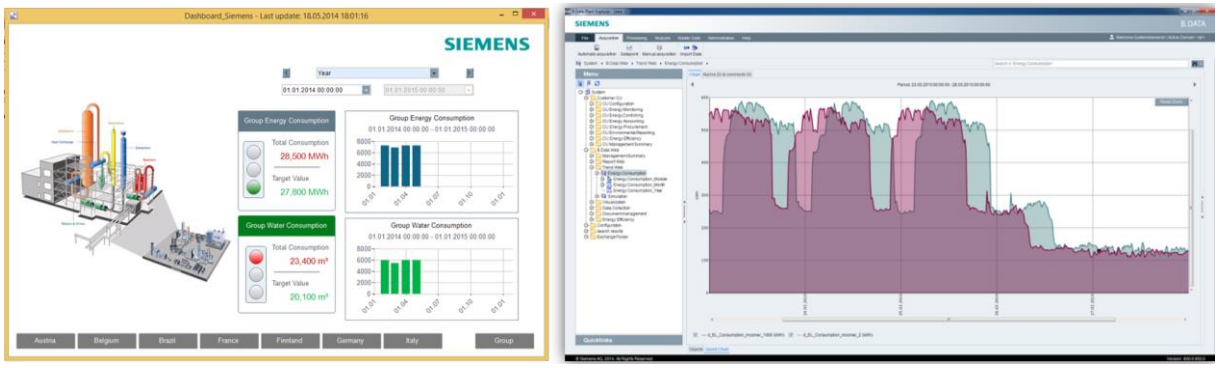
Siemens provides a full process analytical portfolio, including oxygen, CO, CO2 analyzers that enable energy-efficient combustion processes through optimized fuel and air supplies. In process industries like chemical and cement & glass, the chemical analysis of the process gas provides essential information to optimize combustion and reduce fuel consumption. Beyond oxygen, CO, CO2 measurements, high precision natural gas metering analyzers (SITRANS CV) provide calorific value, Wobbe-index and other quality parameters of natural gas.

Based on Siemens' concept of Totally Integrated Automation, all standard SIMATIC HMI products can be used to monitor energy data and visualize energy KPIs.

SIMATIC B.Data is Siemens' ISO 50.001 energy management system. It fulfills the TÜVs requirements for a "certified energy data management". B.Data is scalable from plant to enterprise and is the basis for controlling energy consumption. It provides energy dashboards and flexible reporting, as well as energy purchasing support and support for managing energy efficiency measures. In combination with SIMATIC S7 and WinCC peak load management for immediate energy cost reduction can be realized.

Siemens has a comprehensive PROFIenergy compliant product portfolio to reduce standby-power consumption.

Energy management is also important in the area of motors and AC drives. Here, Siemens offers a comprehensive range of AC drives (SINAMICS) for applications such as material handling, pumps, fans, and compressors.



B.Data Screenshots

Siemens can also support its customers by simulating energy consumption, a capability embedded e.g. in Tecnomatix Plant Simulation. Further, plant data required for energy consumption calculations can be provided by the COMOS engineering environment. The company often uses improved energy management to build an ROI case for its HMI, DCS and other offerings.

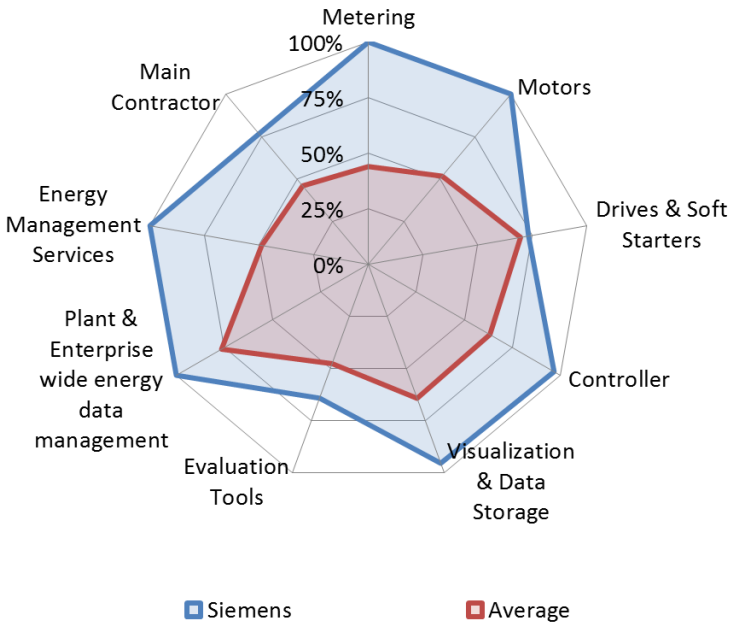
Services

While B.Data is the energy management software installed at the client sites, Siemens also offer energy management as a service. This managed service is called Energy Analytics and also leverages B.Data, but it runs at a Siemens service center. Siemens' energy & environmental services are data-driven and designed to continuously improve cost of energy and resources. In this service, Siemens combines data collection, analytics, and expert consulting to continuously reveal saving opportunities. The support starts with the design and installation of meters to collect data. The data is then collected and transferred via a secure connection to Siemens for further analysis. The customized reports are distributed via a personalized web portal, simplifying Energy Analytics to users.

While Siemens uses B.Data as a the main software to offer Energy Analytics, it also uses a series of additional analysis tools such as data mining, statistical computing, and benchmarks from previous projects in the background. As energy efficiency is not always the highest priority, the services can be tailored in scale and cost.

For improving plant energy efficiency, Siemens offers Energy Efficiency Consulting and Energy Performance Contracting. These services combine the data-driven approach with performance based contracting and financing.

Siemens in Comparison with the Overall Market



Siemens Offering and the Market Average

As noted earlier, Siemens is one of the few companies in the market offering products for nearly all areas of energy management. Special competence centers complement the product offering with relevant know-how. As a result, Siemens performs well in most categories of ARC's.

In a recent survey among users, Siemens also ranks top when it comes to suppliers and their energy management solutions.

Case Study: The Amberg Plant

To improve plant performance in the Amberg plant and to make it a pilot factory, Siemens set up a complete energy management system based on its own products and services. This case study focuses on the Siemens offerings for factory and process automation. Products and services for buildings and infrastructure are excluded.

Introduction: The Amberg Plant

Siemens has produced mechanical and electronic products, such as PLCs, IO modules, low voltage switchgear, protection devices, and other automa-

tion equipment in its plant in Amberg Germany since 1948. As the production is historically grown, it mirrors the organizational development of Siemens over time. Mechanical products are manufactured in the GWA (Gerätewerk Amberg) and electronic products in the EWA (Elektronikwerk Amberg), both located at the same site. For energy management, both plants work together to optimize consumption.

Amberg received several awards over the years, including the "best factory in Europe" in 2007 and 2011. Siemens employs around 5,000 people in plants in Amberg and nearby Cham. Together, the sites produce 55,000 product variations. Standard products include around 4,000 variations with a 24-hour delivery service. This adds up to around 5.2 million orders per year at the rate of about one product per second.

Products Produced in Amberg
Source: Siemens

Amberg has long served as an internal benchmark against which Siemens tests its own products and concepts and from which other factories around the world benefit. For this reason, the plant was also chosen for the energy management related initiatives.

The Amberg plant has a high degree of automation. Around 75 percent of processes are automated, including more than 1000 SIMATIC applications.

Looking at energy, the main sources are compressed air, electricity, nitrogen, and natural gas for heating. The plant has a centralized combined heat and power plant. The locally produced heat and electricity are consumed directly but are not enough to satisfy demand, so additional power is purchased. Compressed air is also centrally produced.

Challenges

Most of the challenges are not technical. Most technologies exist as out of the box solution, which often require only limited adjustment to fit customers' needs. While there can be technical hurdles, the main challenges for energy management are organizational, and managerial, with additional challenges during implementation.

The challenges in Amberg involved:

- **Getting people on board**
  This involves the management as well as plant workers. Without management backing and involvement of workers, energy management will not be able to show its full potential or might even fail completely.
- **Factory already optimized to large extent**
  When a factory is already optimized to a large extent, additional savings from energy management can be low.
- **Data generated**
  The data generated are already a challenge for the people. The challenge is how to handle data, how to interpret them, and how to provide them to whom at the right time. In Amberg the data generated have already increased by a factor of 2000 over the last 13 years. This is the main focus of Siemens' Energy Analytics.
- **Optimize the unknown**
  To justify investment a first step is needed to estimate the potential savings. In many cases, the actual consumption of single applications is unknown.
- **Costs of measuring**
  Energy measurement costs money, without actually having an ROI. The first step needs to be justified and initial hurdles need to be low.
- **Product variety**
  The higher the product variety the more challenging is the optimization process. Also, with high product variety, historical data is often of limited use, as products produced change from month to month.
- **Large variety of applications**
  The larger the production depth, the higher is also the variety in applications. This requires know-how to identify the main consumers of energy.
- **Small share of energy**
  In electronics manufacturing, energy represents only a small share of variable costs (see above). This can harden the bargain for investment budgets.

- **Implement Energy Management from the start**
  When new equipment is purchased, energy efficiency needs to be taken into account. Also energy management needs to be taken into considerations when designing new products.

Solutions

The Framework: Create Clear Responsibilities

To bundle responsibilities there is now one dedicated full-time employee solely responsible for energy management. This person coordinates the team and contacts partners from the business units where selected co-workers are also responsible for energy management.

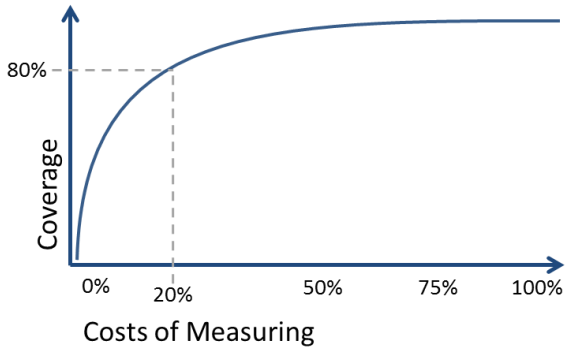
The energy efficiency team is responsible for:

- **Energy transparency**
  This includes systematic monitoring of energy usage and reporting to the relevant stakeholder within the company in a clear manner (meaningful KPIs)
- **Energy efficiency**
  Coordination and controlling of optimization measures. This goes beyond automation and energy management software, but also includes avoidance of losses or the recovery of waste heat.
- **Awareness**
  Continuous communication to employees to raise awareness. This includes all levels from management to plant workers.
- **Contact to development**
  It was important to develop a network around the persons responsible for energy management. This included colleagues from within Siemens (product designers, plant operators, production planning) and also from outside, mainly the machine builders.
- **Implementation of the energy management system**
  This includes the ISO 50.001, which describes energy management as a continuous process.

Clear responsibilities, transparency and continuous communication to all employees helped to convince employees to pull together in this joint effort, mastering one of the key challenges.

Data, Data, Everywhere Data – Energy Data Management

As already described, energy management generates a large amount of data in addition to other data generated. Over the last years, the amount of data generated in Amberg has grown by 80 percent per year, creating 10 million data points per day in 2012. The architecture to collect and analyze energy data in Amberg was installed in parallel to the control layer.



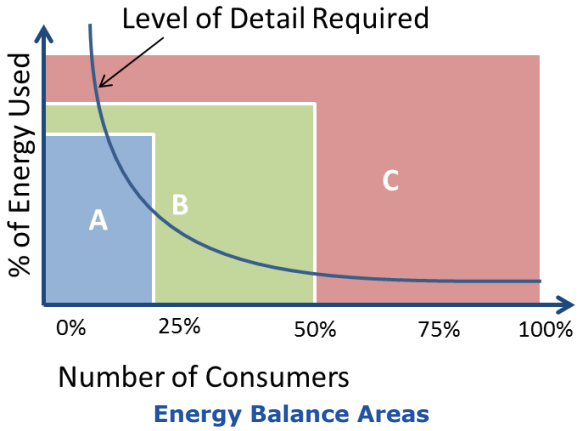
Cost and Coverage of Energy Measurement

Two different time layers were realized: 1) a monitoring level based on Siemens' HMI software WinCC to allow detailed analysis (e.g. minutes; counters, power, or voltage seconds) and 2) a management level based on 15 minute intervals. The visualization was realized in a web client based on either WinCC or Siemens Energy Analytics, which itself is based on B.Data. WinCC passes the data on to Energy Analytics, and while WinCC is used during operations, Energy Analytics is used mainly for identifying saving potentials and energy management. Energy Analytics is located at the MES layer for planning and optimization and management reporting. All layers use web-based technologies, so it is possible to access the relevant information from everywhere.

Through the Energy Analytics hosted service additional consultative support is provided for the energy manager onsite.

Meters and Virtual Meters – Lowering the Costs of Measuring Energy

The costs of measuring can be quite high when it comes to energy management. In addition, measuring alone will not bring any savings, so these costs are often a hurdle at the beginning.



Energy Balance Areas

Energy measurement needs a measuring strategy to be effective. In Amberg, the KPI workshop helped to formulate the necessary KPIs.

An energy management strategy also needs to look at granularity and level of detail to be achieved. While this target could easily be set by budget restraints, it is often more meaningful to couple target savings and required measurement points. In Amberg the accuracy was determined

by the ABC analysis (see chart) and the "other" represents the threshold, where additional granularity was no longer economically reasonable.

Energy management is typically an ongoing process and this means that the amount of measurement will need to grow over time. The scalability of the energy measurement system is therefore a key to sustainable success. The Amberg plant used SIMATIC S7 300 as standard automation hardware.

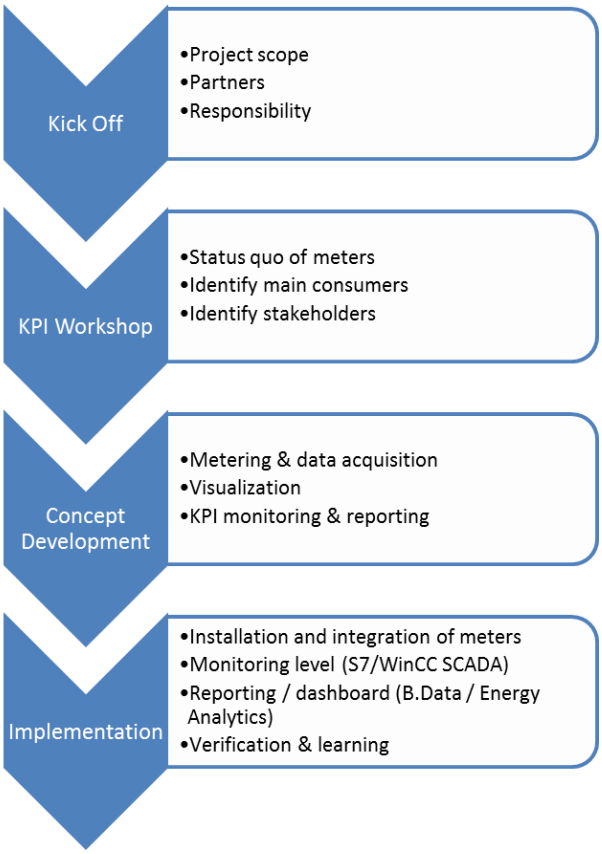
At the Amberg plant some simple steps were taken to lower the initial investment costs:

- **Leverage experienced employees**
  Workers typically know their systems and their electrical characteristics. Their experience should be the first step to identify the large consumers of energy.
- **Use Energy Analytics Experts as external consultants to identify the large consumers**
  Some of the consumers are hidden. Especially auxiliary systems that run 24/7 can consume of energy, but go unnoticed by operators. Siemens experts from Energy Analytics supported the local staff to identify these hidden consumers
- **Leverage meters already in place**
  This can be instrumentation used for process control (in this case nitrogen) or meters embedded in AC drives and existing meters in buildings main supply.
- **Use virtual meters**
  A virtual meter is not an actual meter but a calculation. A pump that runs 100 hours constantly at full load and consumes 5kW consumes 500kWh. Another virtual meter is to measure energy input and then split it to more than two consumers by technical characteristics. Virtual meters can be useful but also add uncertainty and errors to the overall equation. They are useful in applications such as ventilation, lightning, and other auxiliaries. In Amberg 300 virtual meters are in place.

Tackling the Unknown – Siemens as a Consultant

Siemens Energy Analytics Service acted as an integrator and consultant. Especially during the conceptualization phase strong support is needed from solution experts.

At the Amberg project, Siemens acted as its customer and offered the services form Energy Analytics, which experts are based in Erlangen, Dublin, and in multiple smaller centers around the globe. The services are offered



Process of Implementing the Energy Management System in Amberg

from bronze to platinum, whereby the platinum service enables the transparency necessary to be ISO 50.001 certified and recommendations based on the collected data to improve efficiency.

Implementing Energy Management

The process of implementing energy management should always be a joint effort across the different stakeholders in the plant. Without motivation and engagement of employees, energy management projects are doomed to fail.

Project Kick Off

The kick off meeting was used to collect the needs of Amberg and define the project scope and goals. The persons involved were local stakeholders from energy management, the local IT department, people from the production lines, and experts from Siemens' service department (Energy Analytics), acting as outside consultants.

The project kick off lasted around 2 days.

KPI Workshop

One key step in the process was the KPI workshop, which included employees from Amberg and Siemens energy management specialists. The workshop took two days and covered the basic concepts of energy management.

The level of detail is not only relevant to create transparency, but also to assign energy cost to their source and to enable comparability between plants and equipment.

The first step was to scope out the project and identify levels of detail. In Amberg, this started with the basic analysis of energy flows and a top down approach – the top level is the monthly bill received from utilities and other providers. From the top level, further layers are identified, where measurement of energy consumption is required. As the level of detail and the costs are directly connected, Siemens used a standard ABC approach to satisfy the demand for transparency and keep the budget at a reasonable level.

The core goal of the workshop was to define the KPIs needed on which the measurement strategy and other the future energy management concept rely. In practice, different target groups need different KPIs. Not only by the level of detail, but the KPI itself. Examples from the Amberg plant are:

- Energy per part produced: kWh / Unit
- Energy per output: kWh / €
  Gas and other energy is converted into kWh.
- Energy per year: kWh / a
  This indicator is determined by Siemens corporate, which pushes energy efficiency across the company.
- Nitrogen per part produced: N_2 / Unit

Looking at KPIs, all energy sources – secondary and primary – need to be taken into account. In Amberg it includes:

Primary Energy	Secondary Energy
Water	Electricity – Lightning
Gas	Electricity – HVAC
Wastewater	Electricity – Other Usage
Heating Oil	Heat & Cold
Nitrogen	Compressed Air

Energy Sources Identified

The workshop also needs to define the baseline scenario. This is created by the current know-how and represents a starting point for further action. While some industries and processes have benchmarks available, this was not possible in Siemens' Amberg plant. Factors such as different production depth in electronic manufacturing, the batch size, or the product produced are too diverse to compare plants meaningfully.

One of the results from the KPI Workshop is not only the measurement concept, but also the requirement meters and the associated costs.

Concept Development

A key concept in Siemens' energy management approach is the energy balance areas. An energy balance area is equivalent to a certain level of aggregation, where energy input and output are evaluated. Examples of this are the plant, the hall, the line, the machine, the applications, et cetera.

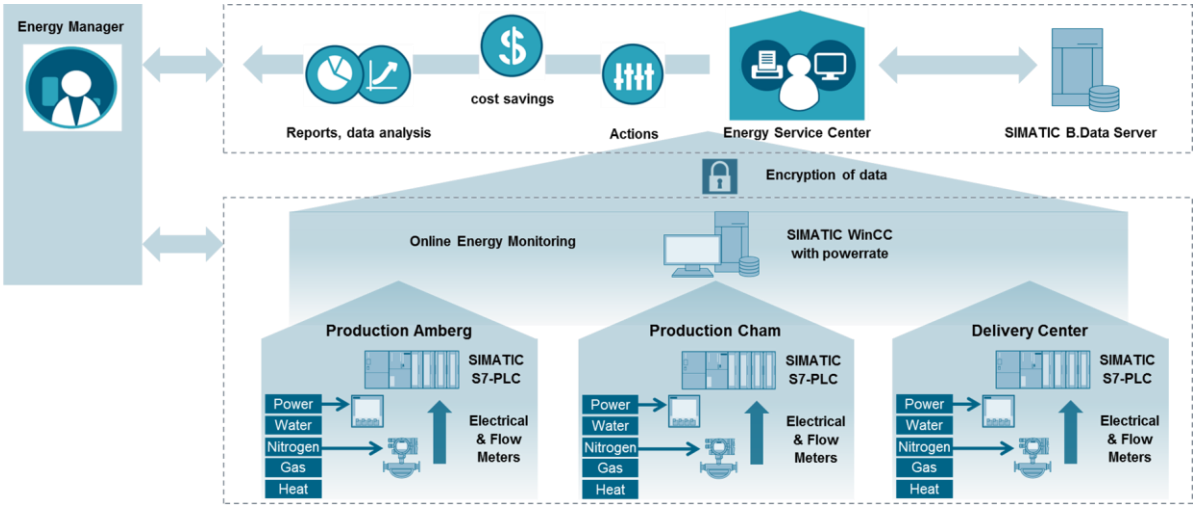
KPIs vary with the level of details required as well as with the application. In Amberg as well as in most industrial facilities, only a handful of A-consumers account for the bulk of the energy consumed. With sufficient pre-measuring effort, cost can be kept down, while results remain the same.

The concept development in Amberg took a top down approach, starting with the monthly bill as a fix point. After the layers were defined, the concept needed to look into more detailed questions, such as where to measure what and how. The standardized measuring is particularly important with hierarchical structure, where the weakest link determines the available granularity of the entire system. At this point meter management has to be discussed as well.

For Siemens it was important that this process was accompanied by people from the plant floor to create a system that is easy applicable.

Implementation

After the workshop, the implementation phase began. 400 physical meters were installed, plus 300 virtual meters. The physical meters include SENTRON PACs, SIMOCODE motor management systems, and SIMATIC ET200SP AI Energy meters, from Siemens and third party devices to measure compressed air consumption.



Architecture used in Amberg Factory

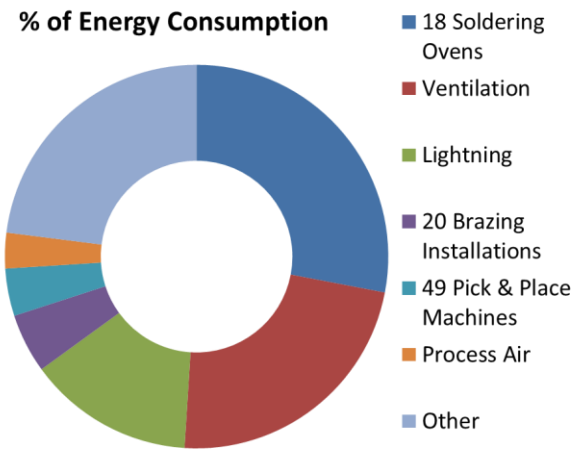
While the A-consumers were already identified during the KPI workshop, after the measuring phase, more accurate data became available. In hall 5, the 18 reflow soldering ovens are the largest consumers of energy. In other halls, mold blowing was another consumer of energy. The second and

third largest consumers are in the area of buildings and include ventilation and lightning.

On top of the 400 meters in Amberg are SIMATIC S7 controllers, which collect the data, provide it to the operator and pass it on to powerrate. After this layer, the data is encrypted and sent to the Energy Analytics. While Energy Analytics works without WinCC and can be implemented as a third party solution, it was a requirement from the Amberg factory to integrate it into WinCC due to the higher data resolution.

The meters were connected to the controllers by PROFInet, the controllers used Ethernet to pass on the data.

Optimization and First Results



Energy Consumption in one of Amberg's Halls

After the kick off meeting in Amberg, it took around six month to achieve first results (three month for installation of meters and three month of measuring). This is a short time considering the pilot – character of the project. Starting measuring the time to first results can be very fast – in this case it took only a few days – usually it is not necessary to wait month for the first regression analysis.

Reflow Soldering Systems

For the soldering systems, the main source of power is electricity and nitrogen. To measure the nitrogen, 18 meters were installed, that measure consumption in volume per time (m^3/h or l/min). Depending on the model the reference value varies from 20 to $55m^3/h$. In addition 18 meters measure electricity consumption, which spans from 60 to 92kW.

Siemens was able to reduce nitrogen consumption during stand-by times in collaboration with its OEMs. The nitrogen consumption in operation was

reduced with four days of effort and without any capital invest. This sums up to around €30,000 of annual savings.

Nitrogen consumption	€30,000 savings p.a.
Additional benefit	Optimization of technology

Energy Savings with Nitrogen supply

Integration of Buildings and HVAC

Building automation was included in Amberg's energy management system. Amberg has a central block heat and power plant with a centralized heating network. For most users the integration of building automation and standard automation is a nightmare, because of the different networks and standards applied. In this case, the buildings were already optimized using SICLIMAT building management system, which enables an easy integration with SIMATIC hardware and PROFIbus networks, this helped reduce integration costs.

Lighting	+ 60% output
Energy consumption	~ -30%
Additional benefit	Increased maintenance intervals

Energy Savings with Lightning

Overall, optimizing lightning included three measures: 1) the installation of latest technology fluorescent tubes with variable light control with 800 Lux, 2) switch-off on weekend was put in place, and 3) a day light control system. In total these savings amounted to €40,000 per year at current electricity prices.

Siemens currently looks into applying LED technology to further lower its electricity consumption. Especially, when it comes to control circuit manufacturing, lightning plays a large role in the total energy costs.

Switching off Consumers – Long Breaks

Automation components and systems have different ramp up and ramp down requirements that need to be identified, so they can be clustered accordingly and switched off, whenever possible. This is a challenging step.

Overall, around 50 percent of electricity consumption is base-load, which means it is consumed during non-productive times. The reason is that

larger consumers (for example reflow soldering ovens, calibrators, or some lasers) cannot be switched off during shorter brakes.

At a first step, Siemens invested around two workdays to switch off consumer during holidays, which added up to nearly €50,000 in savings.

Switching off Consumers – Short Breaks

Next to the slow-reacting consumers, other consumers can be shut down during shorter breaks. On an assembly line for the S7-1200 PLC, Siemens implemented a project to reduce energy consumption in off-times, even when these are short. This means that ramp-up and ramp-down times need to be implemented in the controller and in the machines. The challenge was to not impact production by the installation of the energy management system. The necessary data points include: electricity consumption, compressed air consumption, and units produced.

	Time	Duration	Cell 1	Cell 2	Cell 3	Cell 4	Cell 5
Break 1	9:15	15 min.	✓	✗	✗	✗	✓
Break 2	15:15	15 min.	✓	✗	✗	✗	✓
Break 3	18:00	30 min.	✓	✗	✓	✗	✓
Break 4	24:00	6 hours	✓	✓	✓	✗	✓
Break 5	6:00	1 week	✓	✓	✓	✓	✓

Implementation of Breaks in WinCC

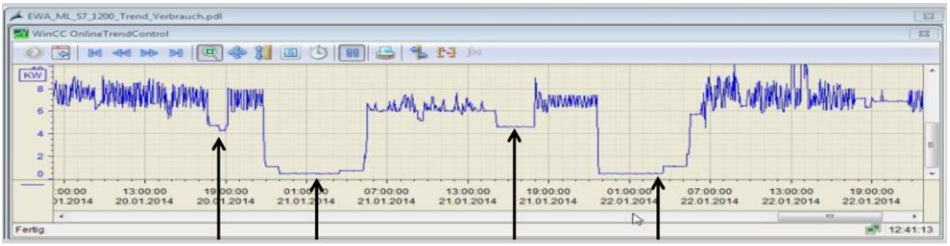
As this project was a pilot project, the architecture for energy management remained partly in parallel to the existing controller to ensure that the actual production was not impacted.

Data was collected with SIMATIC ET200SP energy meters and third party products for compressed air consumption. The data was consolidated by an ET200SP. The data on units came from the S7-300 line controller. An S7-1200 controller was used to for data buffering and pre-processing. Finally, the line where integrated into the site-wide Energy Management project with Energy Analytics/B.Data and WinCC/powerrate.

The planned breaks are entered in the HMI software. A standard template is available and is re-usable in SIMATIC architectures.

As a result of these efforts, energy consumption and deterioration were reduced. Also, the standardized ramp-up and down saves staff and time at

the beginning and end of each shift, and also reduced manual errors. The Operator can visualize the savings in WinCC.



Off-Time Consumption after Optimization

Identifying the ramp up and down curves of machines and equipment also enables Siemens to react to unplanned downtimes and to optimize production along energy cost during low capacity load.

Energy Management and Maintenance

In Amberg, energy management and maintenance are on the same platform, which can leverage two basic synergies:

1) Energy consumption can indicate when machines or parts of a plant need maintenance. Energy consumption often goes up as equipment wears out. For example In Amberg, the monitoring of electricity consumption of ventilators helped to detect failures.
2) Energy meters need to be maintained.

Energy Management Right from the Beginning

One challenge of energy management is that it is not part of most business processes in a company. For example energy management is not part of the purchasing department's targets. This creates a situation, where energy management is implemented on top of an existing production, similar to the way in which machine safeguarding was bolted on to existing systems some years ago.

Energy Management is now a required part of the procurement process. The process and criteria of energy management has been defined and none-conforming machinery is not purchased.

The policy has changed at Siemens in Amberg, enabling sustainable savings in the future. Every new purchase of machinery and equipment needs to be tested for energy efficiency including oversizing, potential to switch off during downtimes, measurement and reporting of consumption, and maintenance. The policy is jointly applied by the facilities for electronics

and electrical manufacturing. A prominent example is the replacement of pneumatics with electrical actuation.

Energy Efficiency at the Siemens plant in Amberg is a binding element during purchasing process for machines and required part of the procurement process for machinery and equipment. A list of detailed elements was defined that need to be taken into account when machinery and other parts are purchased. The concepts include:

1.) **Energy Measurement**
Part of the procurement requirements is that energy measurement is already integrated in the machine, so the consumption of electricity can be added to the energy management system easily.

2.) **Energy consumption during downtimes**
Every new equipment that is added to the Amberg machine park needs to be able to go in an energetically optimized stand-by. This enables the overall plant to reduce energy consumption in long and shorter breaks easily, as the OEM – the expert for the machinery – is defining the ramp-down processes.

3.) **Energy-optimized technologies and parts**
Further, purchased equipment needs to be energy efficient itself. This includes a series of detailed requirements, such as the preference of electric to pneumatic actuation, the usage of high efficiency motors and gearboxes, the usage of DC motors for ventilation, and many more.

In addition products from Siemens are increasingly optimized energetically and power consumption is reduced as well as heat loss, reducing the requirements for cabinet cooling in turn.

Financial Achievements

According to Siemens, this project resulted in savings of more than 10 percent of the plant's annual energy costs. The majority of savings are recurrent, adding to the financial bottom line. Many projects require little or no capital investment and show huge payoff.

Looking at the ARC Advisory Group research in this area, this result is significantly higher than the average savings in electronic manufacturing.

One Step Beyond

For the measures described above, products and solutions for energy management are available from automation suppliers, including product specialists, or solution providers such as Siemens. Most users in discrete manufacturing can leverage these solutions to lower their energy consumption. The main hurdle remains the initial awareness creation and the investment in the first step.

During the time the project ran in Amberg, Siemens recognized three key findings:

1) Transparency leads to quick and long lasting savings, often without capital investments.
2) Energy management solutions are necessary to secure sustainable improvements.
3) OEMs need to be involved for reaching the next step.

Currently, users and integrators are not willing to pay a premium price for more energy efficient machinery. For this reason, OEMs do not have an incentive to develop more efficient machinery, even though the technology is readily available. However, as OEMs do not have a direct incentive to invest in the development of more efficient machinery, this can be driven by end users.

The next challenge is to involve OEMs in energy management to implement ramp up/down processes for certain breaks and off-times (15 minutes, 60 minutes, 1 day, one week …) on their machines. This also requires certain standards for the switch-off management, e.g. PROFIenergy, as well as standardized KPIs for machines to measure and compare their energy consumption.

We are still at the beginning of energy management in manufacturing. The savings potential is huge if today's technology is applied, but we expect even more innovation and saving in future.

While technologies and procedures are necessary, the case study in Amberg shows that successful energy management requires the support and buy-in of the employees.

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Acronym Reference: For a complete list of industry acronyms, please refer to www.arcweb.com/research/pages/industry-terms-and-abbreviations.aspx

API	Application Program Interface
B2B	Business-to-Business
BPM	Business Process Management
CAGR	Compound Annual Growth Rate
CAS	Collaborative Automation System
CMM	Collaborative Management Model
CPG	Consumer Packaged Goods
CPM	Collaborative Production Management
CRM	Customer Relationship Management
DCS	Distributed Control System
EAM	Enterprise Asset Management
ERP	Enterprise Resource Planning
HMI	Human Machine Interface
IOp	Interoperability
IT	Information Technology
MIS	Management Information System
OpX	Operational Excellence
PAS	Process Automation System
PLC	Programmable Logic Controller
PLM	Product Lifecycle Management
RFID	Radio Frequency Identification
ROA	Return on Assets
RPM	Real-time Performance Management
SCM	Supply Chain Management
WMS	Warehouse Management System

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