

On the road to green machines... How OEMs can improve the energy efficiency of machines

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by the OEM Solutions/ Energy Efficiency Team

Make the most of your energy



Summary

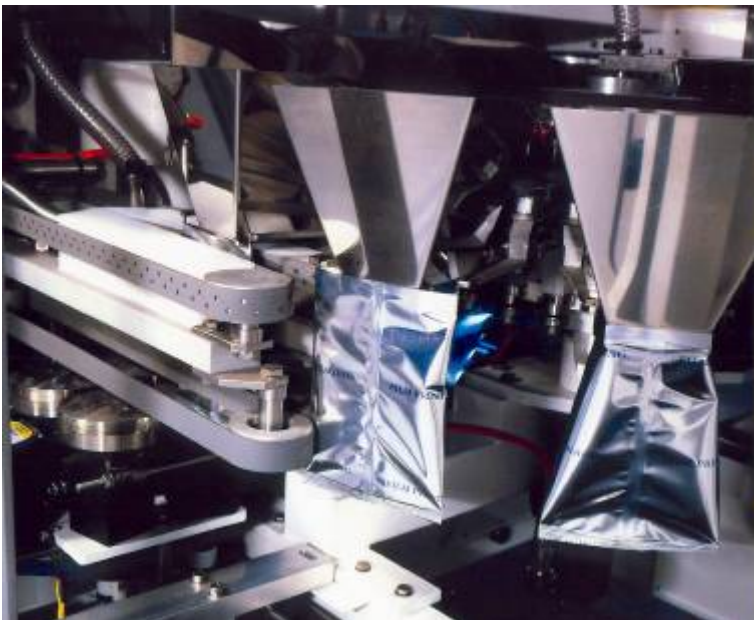
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Executive summary

The State of the Machine Builder industry: Recent studies show that OEMs are well-aware of the available energy efficiency technologies for improving the efficiency of their equipment and machines. But while many OEMs are conscious of the growing pressure and demands coming from the market, they are reluctant to make changes due to the perception that new technologies will make their machines more expensive to sell.

In fact, companies that endorse energy efficiency and sustainability in their thinking experience stronger loyalty from their customers, produce better quality machines with improved machine performance, and find more opportunities for new business even in a tough economic environment.

This document will discuss how adopting an energy efficiency strategy concerning automation and control systems can help OEMs develop more sustainable and energy efficient machines, as well as how these new technologies bring benefits and new values to end users that OEMs can use to differentiate their offer.



Permanent savings through active energy efficiency

Introduction

The manufacturing industry (consumer goods and life sciences) tries to manage production through a key methodology: OEE (Overall Equipment Effectiveness), and the key principal is tracking metrics from machines/ lines between:

- **Availability:** measures productivity losses from downtime - events which entirely stop production,
- **Performance:** measures losses from slow production cycles - processes not working at maximum speed, and
- **Quality:** measures losses from production not achieving established quality levels.

The OEE score measures manufacturing efficiency and effectiveness and is closely linked to sustainability: **Better quality means less waste, greater availability means better energy efficiency.**

The constraints of cost reduction, usage of resources and energy reduction are becoming key drivers in the industry as consumers require manufacturers to be more “green”. End users understand the new challenges **and have developed strategies to reduce the energy for their production and to become sustainable companies.**

Machine builders are now in the front line to design, provide and innovate for this new demanding market. Some solutions already have proven their effectiveness and benefits. They bring new added value to their equipment and a truly competitive advantage through this new differentiation. The End-Users choosing these new benefits, in regard of their strategies.

It is at the design level that all the benefits of an energy efficiency approach can be implemented. The following is a review of key highlights that can benefit the energy efficiency objectives of your customers and offer an advantage for your machines/equipment, depending on their applications.

“The benefits mentioned are specified for each point and not cumulative. Application examples have been measured in real cases.”

**OEE Range is usually
from 40% to 80%
World Class in Manufacturing
reaches 85%**





On the Road to Green Machines...

Machine Design and Energy Efficiency

Optimisation of Machine Design

“Machine engineering can be a key source of improvement in the energy consumption of machines.”

Sizing of Motors

All too often machine actuators are over-sized (electrical motors, pneumatic actuators...). This leads to machines that consume more energy than necessary, something which can easily be avoided through proper design. Applications need to be carefully evaluated to consider how robust and reliable a machine must be, as well as what future evolutions of the machine might be needed.

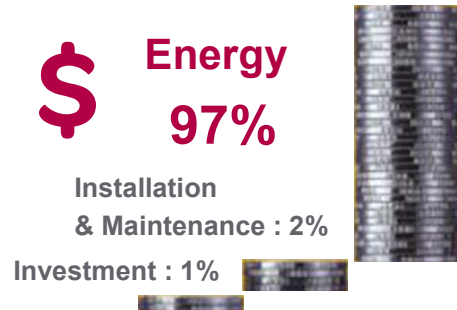
Small, simple motors are better than bigger.

Experience shows that from an energy efficiency perspective, using motors that are precisely matched to an application rather than simply using motors with “more than enough” power optimises energy consumption. This basic recommendation can lead to an **average savings of 3-4%**. At the same time, it can impact in reduction/ sizing of the power control system!

Better sizing brings cost reduction in the run-time with some impact in lowering machine costs. (See example on cost of motor energy bill next column)

Motor’s energy bill = motor cost x 100

Global cost during motor life (average 15 years)



Beyond the **investment**, the key point is to secure an **efficient** motor control



Usage of high-efficiency motors

High-efficiency motors have proven their effectiveness and typically have a **pay-back period of only (1-2) years**. The new standard IEC classification for high efficiency motors specifies 4 categories (see below). The additional benefit is that the longer machine life of high-efficiency motors contributes to sustainability – and a benefit of about **10% energy savings** can be expected.

Design your machines with optimized motor control

Smaller motors in cascading



Use smaller motors in cascading when possible (pumps, compressors, ventilation...) and adapt according to the needs

► **Up to 30% of saving using synchronous motors**

Higher efficient technology

① Use a motor with higher efficiency

► **Up to 10% of saving**

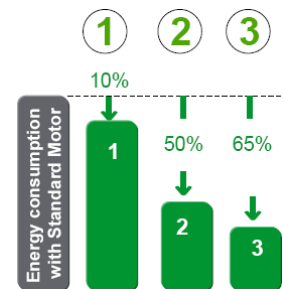
② Use a variable speed drive to control your motor

► **Up to 50% of saving**

③ Use a Servo drive and Synchronous motor

► **Up to additional 30% of saving***

* compared to speed drives in positioning applications



New international efficiency classes of motors

The new EN 60034-30:2009 defines worldwide the following efficiency classes of low-voltage three-phase asynchronous motors in the power range from 0.75 kW to 375 kW. (IE = International Efficiency)

- IE1 = Standard Efficiency (comparable to EFF2)
- IE2 = High Efficiency (comparable to EFF1)
- IE3 = Premium Efficiency
- IE4 = Super-Premium-Efficiency

Thinking about motor starters: variable speed drives are a must

For applications with variable loads, the use of speed drives can bring immediate benefits and **up to 50% in energy savings** (pumps, ventilation fans, and compressors are obvious applications).

At the same time, any application which requires repetitive starting, the choice of speed drives over conventional contactors limits starting current and therefore reduces losses and load peaks.

The instant benefits for end users such as cost savings in their electrical bill can be highlighted by a pay-back in less than 1 or 2 years.

Some applications, such as hoisting and lifts can benefit from regenerative devices like regenerative drives.

Introducing Mechatronics

Motion solutions enable the mastering of movement. Every time there is a transfer or a movement, motion technologies (servo motors, motion controllers) bring incredible advantages. When associated with synchronous motors, they bring significant energy advantages.

Besides the key advantage of improved performance of **up to 60% in energy savings**, faster machine cycles increase output and their more precise positioning means fewer defects.

The technology of synchronous motors (yield of 95%) outperforms asynchronous motors. The calibres of motors are smaller as well.

Synchronous motors provide energy efficiency benefits of **up to 10%** compared to asynchronous motors, thanks simply to the technology (no losses in rotor).

Motion solutions substitute as well other technologies and are bringing significant advantages in terms of energy efficiency:

- Mechanical for synchronisation of movement (cams, gears, etc.)
- Pneumatics and hydraulics; eg pneumatic substitution reduces energy use, as losses and leakage are significant and seldom avoidable; it finally costs to the Users.

“Mechatronic machine designs offer the lowest TCO* as they are the most energy-efficient and most reliable machinery on the market.”

* Total Cost of Ownership

Benefits for end users:

- More productive machines
- Less waste
- More flexible production
- More compact machines
- Less energy used

Benefits OEMs as well:

- Fewer mechanical,
- Fewer components,
- Optimised power and smaller control panel.

Clearly, motion control is a field of innovation that benefits the industry and brings new machine value to machine builders.

Application engineering can bring strong Energy Efficiency benefits

Automation is a key opportunity for achieving energy efficiency; the capabilities available through programming provide many new possibilities. New algorithms, for example, have already proven themselves and can be found in application libraries.

Predictive Control Loop: a new source of energy efficiency

The classical PID can be out-performed by a Predictive Control Loop when algorithms are integrated into the programming system, with potential savings of **more than 10%**.

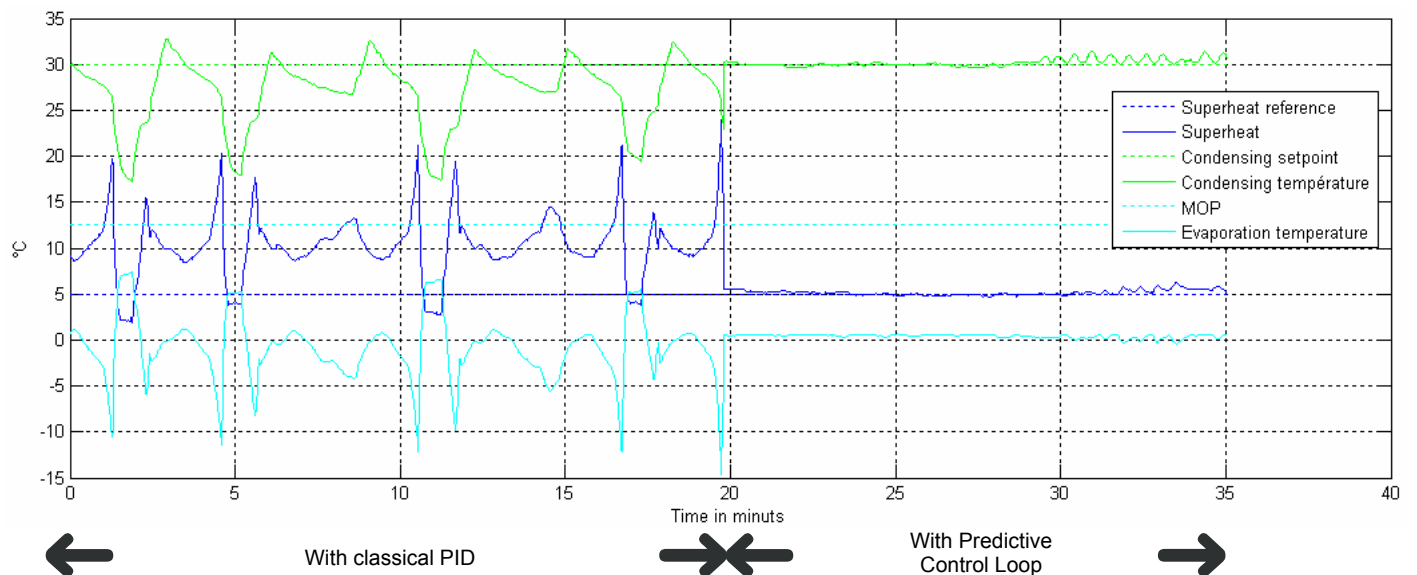


Figure above: Advanced control functions in HVAC applications have been measured recently bringing more than 10% in energy efficiency compared to PID regulation.

Monitoring operating modes and status through automation

End users do not always use the full capacity of their machines and equipment, depending on their production objectives. Some key areas are frequently stopped intentionally in order to activate only the needed resources. These techniques can be efficiently applied in conveying such as becoming active only when the load arrives rather than running continuously.

Stopping or idling or on-hold functions are deactivating the actuators, and should be integrated in the programming to generate further energy efficiency for the benefit of end users.

Studies have demonstrated that machines are rarely in production 100% of the time, and it is estimated that consumption could be reduced nearly 37% if machines were properly managed during these idle periods, for example by simply powering them off.

Safe stopping and safe restarting conditions should also be considered as a source of energy efficiency, such as avoiding keeping the control system and communications bus under power when switching off the machine. This is possible when parameters are saved upon stopping and re-enabled upon restarting under the previous state. Sometimes the solution is not completely obvious, such as for constraints on safety or quick restarting of the line; end users preferably choose to maintain the control system under power.

Some optimisation and benefit can be reached as well in managing the starting of machines. By using sequential starting you are able to minimize the starting current and avoid peaks that generate penalties by the power utilities in some countries.

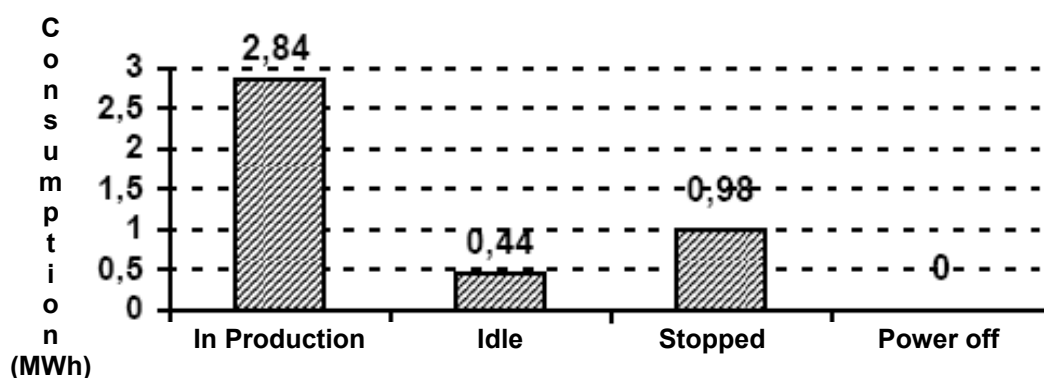


Figure at left
Active energy management through automation
 Up to 37% in savings realized in an automotive production line through the proper management of control systems when machines are idle or stopped.

Application Engineering can bring significant advantages

Implementing the right automation architecture & Control & Power system

The automation control system also consumes power (not at the level of actuators), but optimisation can be implemented by picking the right offer and taking the right decision

Automation architectures

Depending on the application, the right automation architecture can have a favourable impact on energy consumption of the overall control system. For example, a decentralized architecture can double the consumption of a centralized architecture.

Of course, depending on the size of the application, as well as safety and performance criteria, the choice of a decentralized architecture is sometimes necessary.

Also, optimising the number of 24V power supplies can induce energy saving up to 25% by avoiding numerous power supplies and their associated losses.

Choice of contactors

When using contactors, some simple choices can significantly reduce power consumption.

Today the use of low consumption contactors or contactors for specific functions (ex: Latching Relays), in a combination of properly selected contactors (such as Tesys U motor starter) can reduce power consumption up to 4x thanks to the lower energy loss attributed to fewer connections.

In fact, TeSys U motor starters **dissipate 75% less energy** compared to traditional motor starters. This is achieved by the reduced number of power contacts and by the very low energy consumption of the control circuit.



up to **30%** energy saving

Already tested, validated, documented architecture **to quickly build an automation solution**. Ready to use for optimum result

- Predefined architectures and bill of materials
Open and flexible
- Flexible machine control:
embedded intelligence in devices with a new software
- Evolution of cabling connectivity (hardwire or network)
- Your know-how preserved (other products...) Ready to be customized
- Customized tests to validate your own configuration by experts

Choice of HMI (graphic terminals & panels)

The management of backlights in HMI panels can save 65% of the power they consume, for example by powering off the display when the machine is in idle mode (ex. Magelis XBTGT).

Use of LEDs

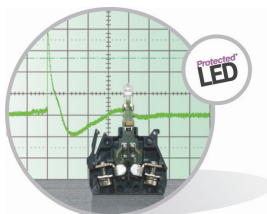
LED technology offers a low-consumption alternative to incandescent lights in push buttons and indicator lights, and should be applied systematically.

Controller sizing

Controllers that are properly sized to the application at hand will also help reduce energy consumption.

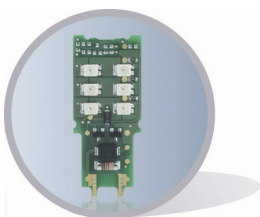
Power Factor Correction

In order to compensate the reactive power, eventually eliminate it, the best is to be positioned closer to the source. This will optimise the energy usage of machine and benefit End Users to avoid penalties and pollution in its Electrical network.



Patented « protected LED » technology

- 100,000 hours of luminosity with no maintenance
- Fuse protected against short-circuits



Low consumption

- Five times less than incandescent



High resistance

- Of LEDs to mechanical shock & vibration

Measuring the energy consumption of a machine brings immediate benefits

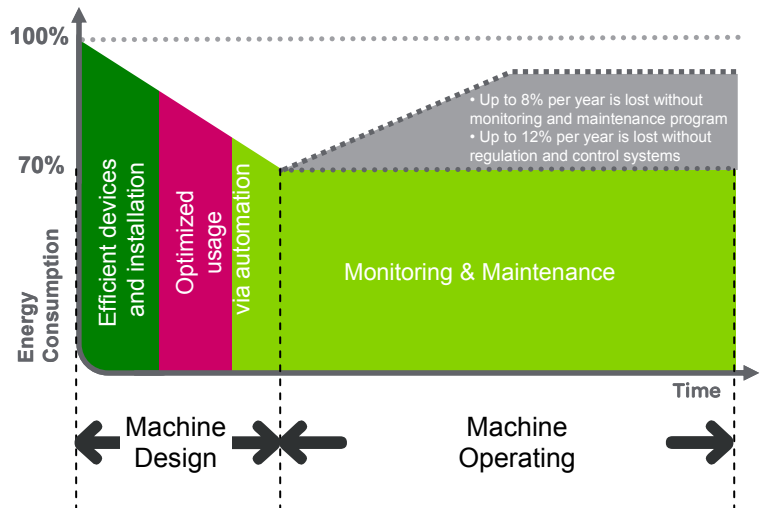
Monitor and control during Lifetime

Experience shows that simply an active approach to energy efficiency will help bring an additional 8% of savings by detecting early on any discrepancies in the operation or ongoing life-cycle of a machine. Operators, maintenance personnel, and production management teams can all take quick action to alleviate any conditions that might be negating the machine's energy efficiency.

Electrical signature of machine: Measurement

This basic measurement can be considered as the "Electrical Signature" of a machine and it can become the benchmark for future improvements and improved machine efficiency. In addition, it is a strong benefit for the End-Users strategy.

This can be achieved quite simply today, such as with the Compact NSX Micrologic, which has the capability to measure incoming of power, or by the monitoring of power through a separate power meter such as the PM800.



Immediate advantage to users, awareness and improvement are the key benefits: Using a power measurement devices and treatment of the machine consumption.

Examples of Implementation

Packaging: “Double savings” with tension control function block

Energy Saving

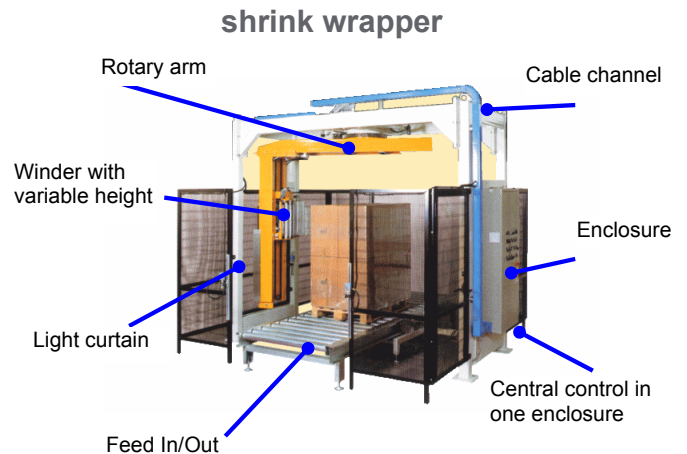
By using Motion drives + Brushless Motors

► **30% less Energy than speed drive + Asynchronous motor**

Raw material Saving

Due to the precision of the motion drive controlled by the motion controller using Schneider Electric function block, “control of film tension”, we can increase the tension of the film by more than 2.

► **50 % less plastic film**



Conveying: replace contactors by variable speed drives

85% of conveyors are started and driven with direct on line starters using mainly contactors. Replacing contactors by drives brings up to **30% Energy Efficiency**



HVAC: save up to 30% on air-cooled chillers with dedicated solutions

Energy savings by adjusting fan speed to changes in external air temperature.

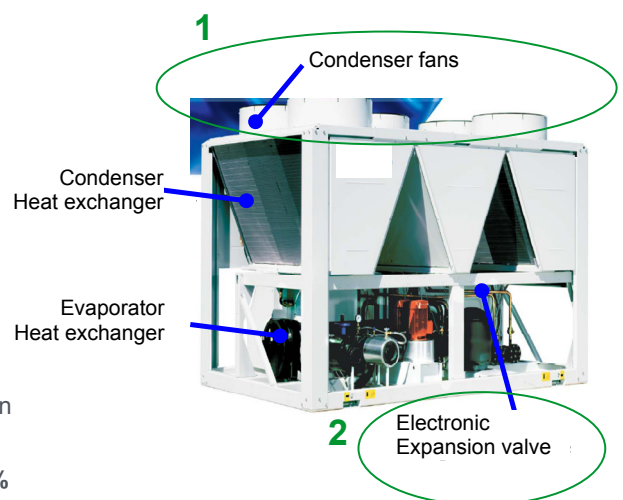
ATV21 drive + Modicon M168 controller using the “Floating high pressure control with VSD” function block

► **Up to 20% less energy than On/Off condenser fan controls**

Energy savings by optimized electronic expansion valve control

Due to the implementation of advanced control “Superheat control” function on Modicon M168 controller for a chiller’s electronic expansion valve control

► **Up to 5°C superheat setpoint reduction equivalent of up to 10% less energy than standard superheat control with higher set point**



Save 60,000 kWh every year in Hoisting: Container crane with regenerative solutions

Example Container crane hoisting application, 250 kW load

- Cycle time: 5 min (1 min lifting, 1 min lowering, 3 min handling)
- Operation time: 8 h/day, 200 days/y
- Energy cost: 0.12 €/kWh
- Drive investment for resistor braking: 23,000 €
- Drive investment for AFE (Active Front End) solution: 34,000 €

Result

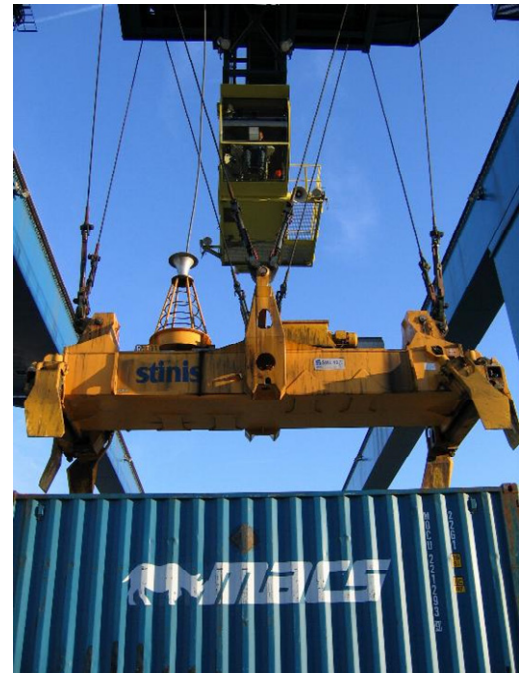
Energy consumption with resistor braking:

- 100,000 kWh/y = 12,000 €

Energy consumption with AFE:

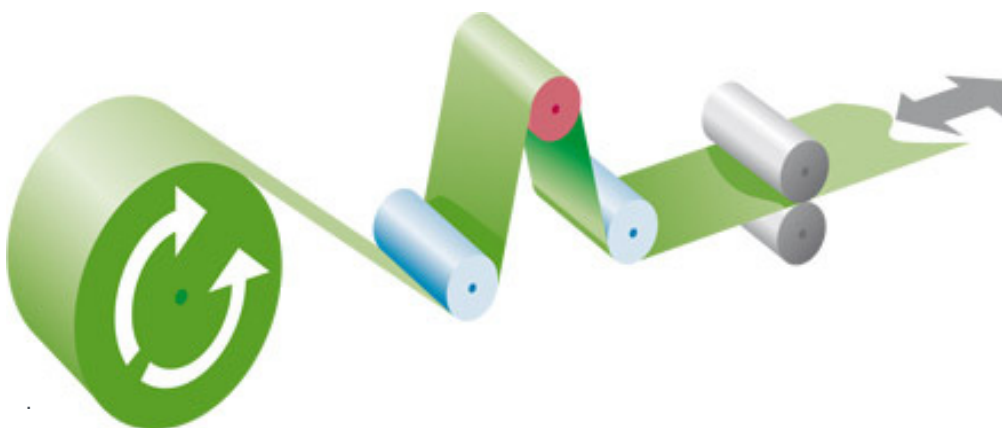
- 40,000kWh/y = 4,800 €

- **Energy and cost savings: 60.000 kWh/y = 7,200 €**
- Payback time: ≈ 1,5 years**



Innovation: the next steps - PacDrive*

PacDrive Packaging Solutions have added a new optional upgrade to its software library for integration of web winding and unwinding mechanisms with a control solution for dancer-less operation. Leveraging servo technology, the new software functionality lets designers reduce the number of wear-prone components in production and packaging machines, including pneumatics. As a result, dancer-less web handling can reduce machine footprint, OEM engineering times and end user maintenance tasks and bring substantial energy efficiency benefits



* PacDrive is a range name launched by Elau, a company today integrated into Schneider Electric.

Conclusion: Improving the energy efficiency of machines creates innovation

As seen by the new design and introducing new technologies OEMs are able to bring new values and contribute strongly to the sustainable approach that End-Users are now implementing. Automation and control functions are bringing a wide range of possibilities to improve energy efficiency and reduce waste, therefore should be considered systematically. The active approach to energy efficiency gives end users the possibility to optimise the energy consumption of their production investments for both immediate and long-term savings.

Schneider Electric is committed to sustainability and helping OEM customers improve the performance and energy efficiency of their machines.

Let's go together on the road to green machines
(application files will be issued following this first document)



An Energy Efficiency approach has naturally a cost for the OEMs: new design and new technologies integration, as presented in this document, would probably **impact the final cost of the machine** which could be estimated in **less than 10%** depending on the application

Today the energy saving has become a key decision factor for the End-Users. This is a **new differentiation opportunity** for OEMs in a very competitive market: to bring new benefits for its customers, less energy consumption by unit produced, less waste, better quality, more performance, with a **return of investment in less than 2 years**.

Robust Automation, Control and Monitoring of Energy Usage can deliver up to 30% Energy Saving

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