EASY- Lessons learned from four years of the Swiss EASY audit and incentive program

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Abstract

Between 2010 and 2014 the Swiss financial incentive program EASY encouraged Swiss industrial factories to implement electric energy efficiency improvements of electric motor systems. During the EASY program period, 4142 motors have been analysed regarding their age, operating hours, size and the use of a variable frequency drive (VFD). 104 motor systems have been measured on site and analysed in detail. Based on these results, new knowledge about the current state of electric motors in Switzerland has been gained. The optimisation of all motor systems led to a total energy saving of 73.7 GWh calculated for the lifetime of the newly installed equipment (10-20 years, depending on their size, based on [1]).

Background

In 2010, the audit and financial incentive program EASY (Efficiency for motor systems, www.topmotors.ch/easy) was started, led by the Swiss Agency for Efficient Energy Use (S.A.F.E.). EASY supported companies with an annual electric energy consumption of more than 10 GWh, aiming to improve the efficiency of their electric motor systems. The program was financed with 1 million CHF for four years through public funds, from a surcharge on the electricity tariff. The target was to improve electric motor systems in industry and save a total of 69.2 GWh over the lifetime of the newly installed equipment. During the EASY program, the Motor-Systems-Check methodology, developed by Topmotors in 2010, was applied and refined. The Motor-Systems-Check [2] is a 4-step audit method for analysing and optimising motor driven processes in industry (see Figure 1). The focus of this method is always on the motor system and not only on the motor itself.

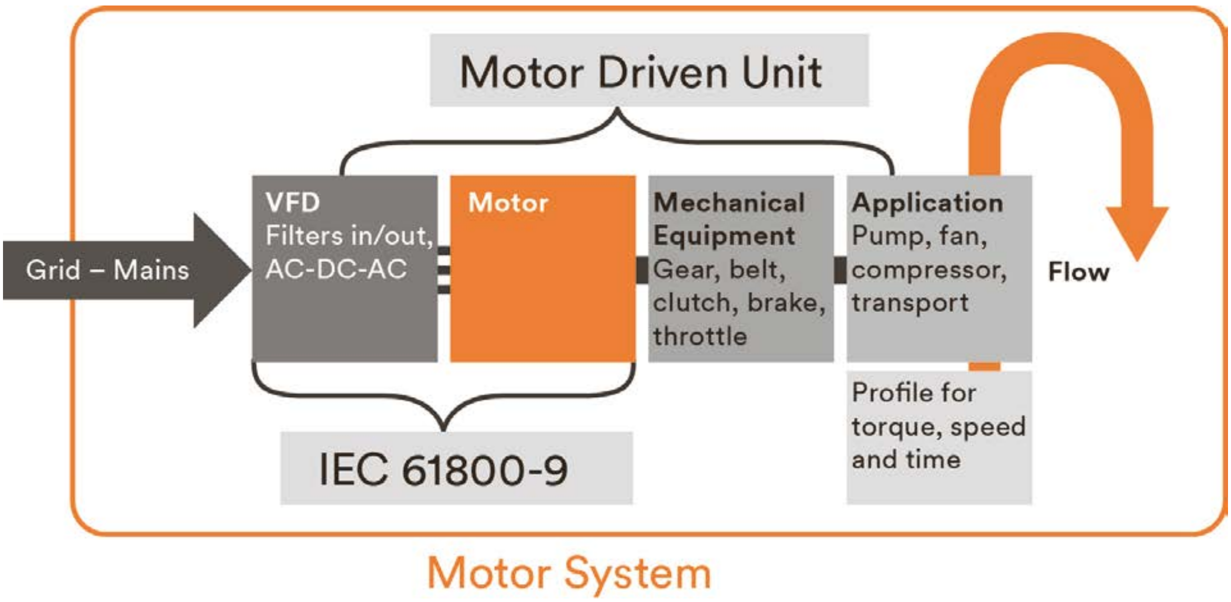

Figure 1 **Definition of Motor System. Source: EMSA, 2014.**

A motor system means the whole chain of components from power supply to the output of the application. The Motor-Systems-Check regards the efficiency of every single element and delivers not a single replacement with more efficient identical products; it resizes the components, application and the output flow if possible. The system integration of modern and properly-sized elements enables much higher savings compared a one-to-one replacement of components with more efficient products.

Motor-Systems-Check

The Motor-Systems-Check is composed of 4 steps to detect and harness the efficiency potential of electric motor systems:

Step 1 Determines the total efficiency potential of a company by improving all electric motors.

Step 2 Indicates the motor systems with the biggest savings potential of all motors included in the analysis, depending on their age, size, operating hours, etc.

Step 3 Creates a standard test report based on the on-site measurement with load factor, savings, costs, payback, etc.

Step 4 Implementation.

Every step is supported by software tools which help to calculate the single saving potentials on the basis of the current state or by default values based on Topmotors' estimates and experience. Every step was subsidised with an incentive between 10% and 100% (see Figure 2).

Sequence	Measures	Subsidy	**Software tool**
Step 1	Efficiency potential	100%	SOTEA
Step 2	Motor list	75%*	ILI^{+}
Step 3	On-site test	50%	Standard Test Report (STR)
Step 4	Implementation	10%	Motor Systems Tool

Figure 2 **The four steps of the Motor-Systems-Check and associated subsidies. Source: S.A.F.E., 2011.**

Results

Step 1: Efficiency potential

In the framework of Topmotors and EASY, 25 companies did the "efficiency potential" check using the software tool SOTEA[1]. The evaluation of these 25 SOTEA results was used to estimate the share of electric motors within the total electric energy consumption of these companies. The share was with 87.8% even higher than expected (see Figure 3). This is another proof of the importance of efficient electric motor systems.

Some of the companies left the program after each step either because of a small potential or because of technical, political or economic reasons.

[1] Available for download at www.topmotors.ch/Download/

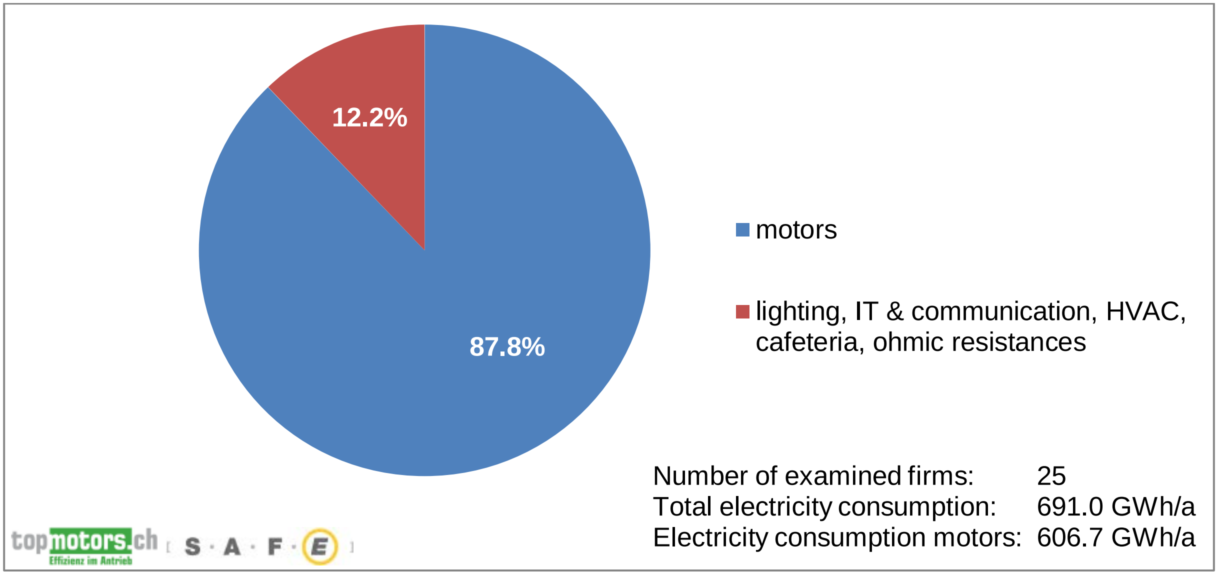

Figure 3: **Share of motors' electricity consumption in industry. Source: S.A.F.E., 2013.**

Step 2: Motor list

The next step was to create a database of all relevant motors of a company with the tool "Intelligent Motor List" (ILI+). Ten companies used the tool to list between 40 and 650 motors each and to identify the motor systems with the biggest efficiency potential. The "Decision Maker" of ILI+ helps to select these motors and gives an indication where to start. The criteria for the selection of motors can be set manually for several input values like age, operating hours, size or VFD existing (yes/no). It also allows the use of the “20-80-rule”, which means that by optimizing only 20% of all installed motors 80% of the total potential savings can be realized.

Age

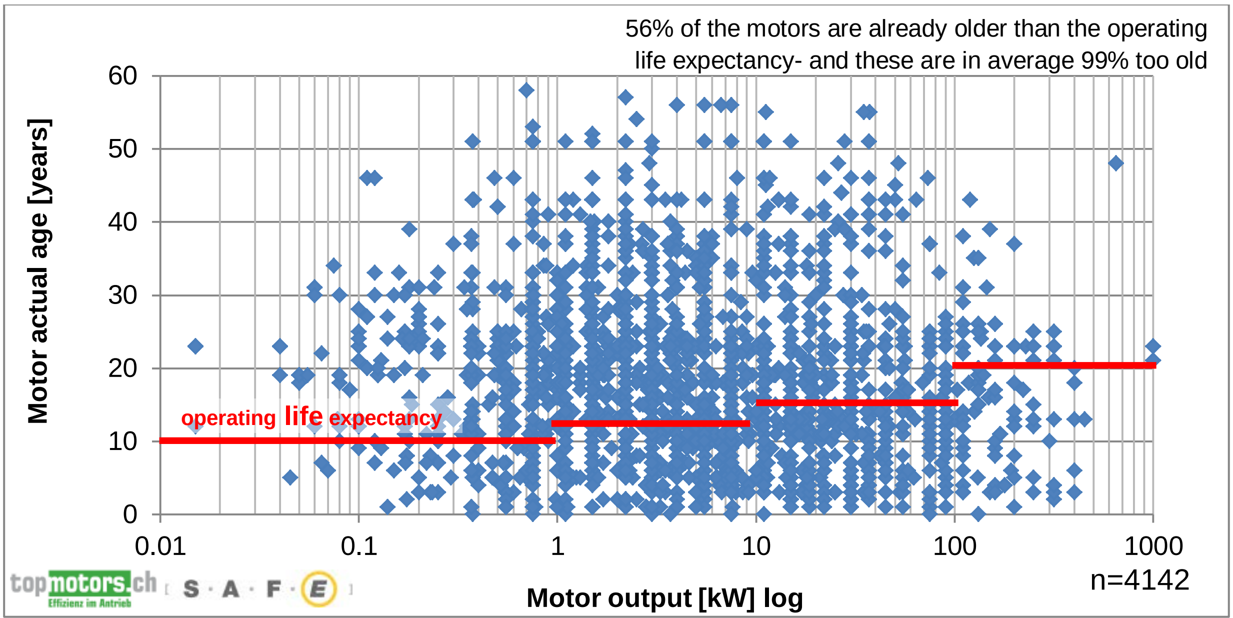

Figure 4 **Motors are too old (and still running). Source: S.A.F.E., 2013.**

The analysis of 4142 motors revealed that 56% of these are already running almost twice as long as their operating life expectancy. This suggests there is barely any continuous improvement process for replacing old, mostly oversized and inefficient motor systems. In many cases, the needs of the process have changed over the years but the single applications like fans and pumps have not been adapted accordingly. That is why the motor and operating point of the driven application has often shifted to an inferior point with lower efficiency. Forty year old motors have missed a large technological evolution and may have also lost some efficiency by rewinding and wear. This is why the age is one important selection criterion in the "Decision Maker".

Operating hours

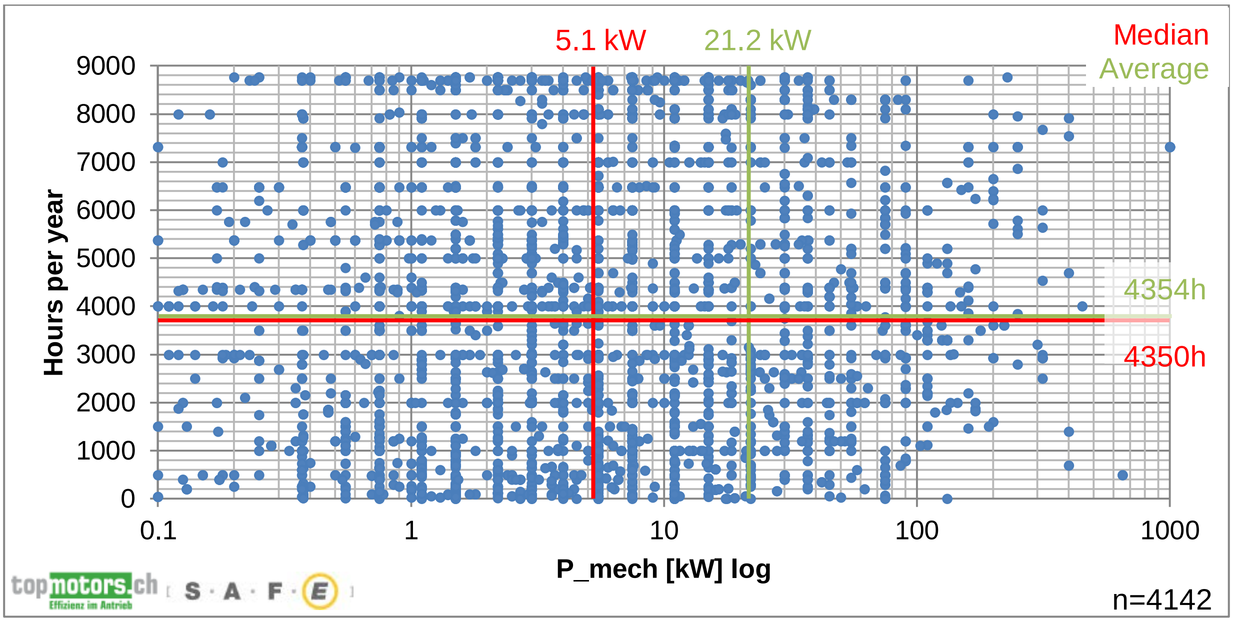

Figure 5 **Operating Hours. Source: S.A.F.E., 2015.**

The operating hours also have been analyzed (see Figure 5). No relationship between output power and operating hours per year has been found. The average output power of all motors is 21.2 kW. The median size of all motors 5.1 kW. This means 50% of all motors listed are smaller and 50% bigger than 5.1 kW output power.

Variable Frequency Drives

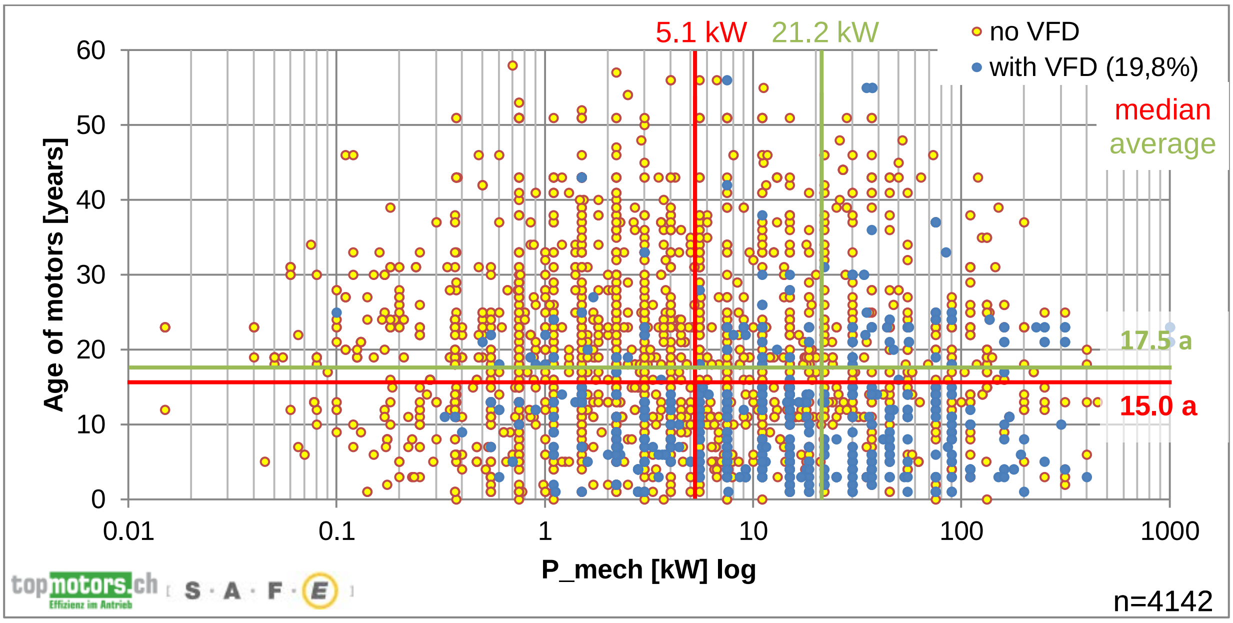

Figure 6 Use of variable frequency drives. Source: S.A.F.E., 2015.

The analysis of the VFD revealed the share of motor systems already powered by a variable frequency drive. In total, 19.8% of all motors already have a VFD. The majority of the motors that are equipped with a VFD is younger than 15 years with an output power between 1 and 100 kW. The authors believe a VFD would be useful for up to 50% of all drives. Smart controls of motor systems by reducing the speed enables huge efficiency potentials.

Step 3: On-site test and Standard Test Report (STR)

After the on-site measurement, a Standard Test Report (STR) is created for every single motor system. All improvement proposals were aimed at optimizing the whole motor system and not exchanging individual components.

Typical improvements include:

- Resizing motors and applications, adjust to the real needs of the process, based on on-site measurements and observations.
- Optimized flow rate, pressure, temperature and time of operation according to the real process requirements.
- Upgrading the motor system with VFD, especially pumps (closed loops) or fan systems with square torque.
- Installing and optimizing higher level controls for complex motor systems (factory automation systems) to coordinate and optimize the operation time and load to the real needs.
- Replacing old components by highly efficient equipment, avoid transmission belts and gears (if possible), choose flat- or synchronous instead of V- belts.
- Installing electric motors of higher efficiency levels (IE3 or IE4).

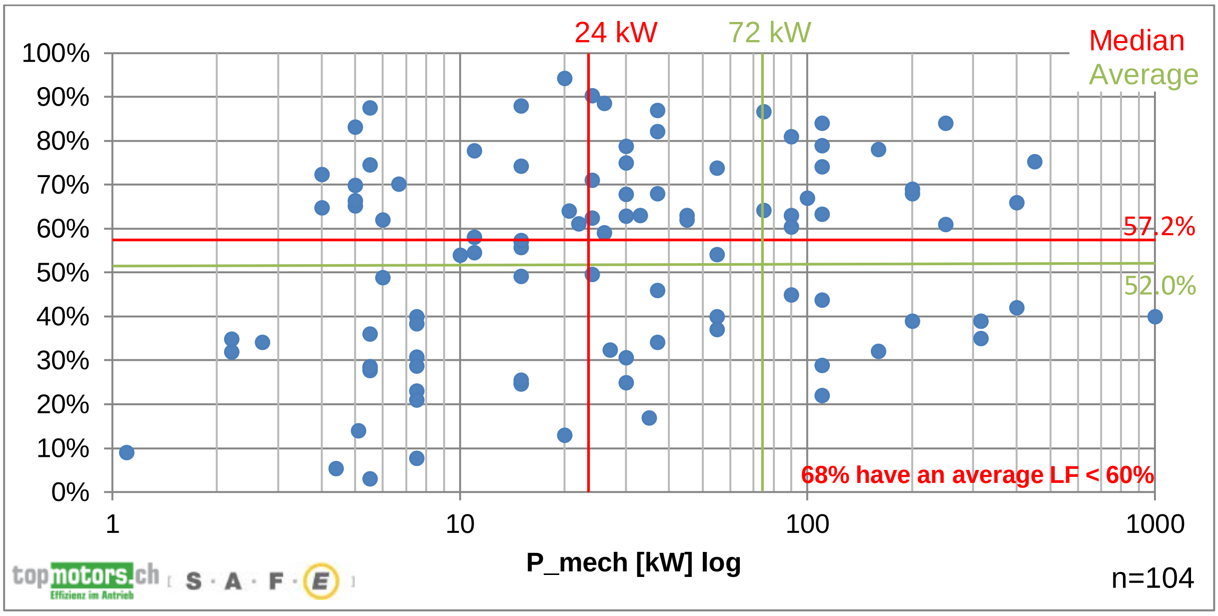

Figure 7: **Average load factor. Source: S.A.F.E., 2013.**

Based on the results of the on-site measurement, the STR has been structured and filled with data. The STR contains the best recommendation for an energetic improvement with all proposed measures and associated costs, life-cycle savings and payback. Figure 7 shows the average load factor of all measured motors. The average load factor is only 52% of the output power. A motor with an average load factor of less than 60% is oversized. So this means, 68% of all tested motors are oversized.

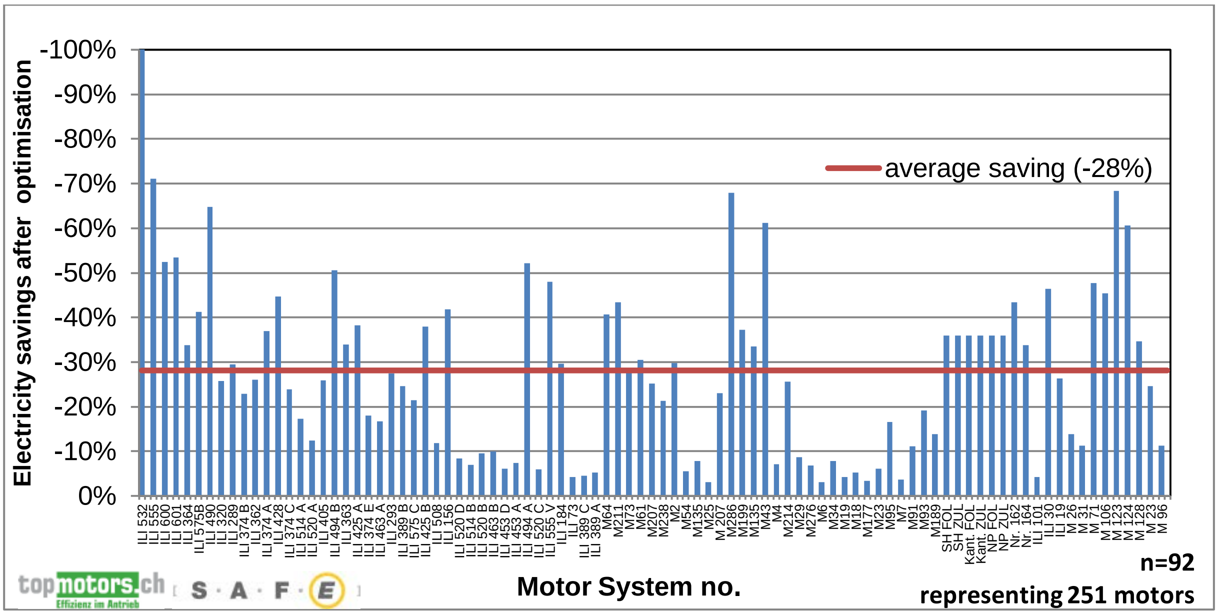

Figure 8: **Relative electricity savings after optimisation. Source: S.A.F.E., 2014.**

For 92 of 104 tested motor systems, it was useful to use the structured analysis of the STR (see Figure 8). Some of these 92 STR represent several similar motor systems. All STR are representing 251 motor systems in total with a saving potential between 3% and 71% respectively. One motor even had a savings potential of 100% because it was running in the basement without any use, the machine it drove was already retired. The efficiency potential of all motor systems show on average 28% lower electric energy input after the implementation.

Step 4: Implementation

After the implementation of the recommendations from the STR, there have been random tests to verify the expected savings. Many of the measurements have shown better results than expected. In some cases there have been fewer savings than what the STR predicted. In all cases the difference can be explained by deviations between the implementation and the STR or by differences of the process parameters (e.g. more output).

Lessons learnt

To implement energy efficiency improvements in industry takes significantly more time than assumed. A lack of responsibility, internal decision standards and budgeting cycles are causing many delays.

Companies are concerned about external engineers in their factories. It takes time to build up trust (even if confidentiality is warranted).

The main focus of the companies is always on their core business: the production of high-quality goods and minimizing the risks of interruptions. Saving energy has a much lower priority in their daily business- if at all.

The main criterion for investment decisions is still the payback time. In most cases, companies are ignoring the life cycle costs and base purchase decisions on first cost. The technical staff is often not trained or not motivated to convince the decision maker of a more efficient solution.

As shown in Figure 4, motor systems are in operation since 20, 30 or even more than 40 years. Compared to their expected life time between 10 and 20 years, this is way too long and shows a lack of continuous improvement based on a structured and systematic replacement process. The entire technical evolution during the lifetime of the machines has been missed. The needs of the process have changed and thus most of the equipment today is oversized.

Companies depend strongly on their regular suppliers of components and systems who also provide maintenance of machines. Competitive offers were required only in rare cases. The delivery of more efficient components was delayed in many cases as it would have required a change in the business model (regular products on stock) of the supplier.

The effort for the EASY program management has been substantially higher than expected. Companies need continuous support during the whole 4-step audit program. The lack of knowledge generates a need for extensive "guidance support" through all steps.

Conclusions

The main goal of the pilot program EASY was to save energy by improving motor systems in industry and overcome barriers which are preventing the autonomous implementation of efficiency measures in companies. A main goal was also training of staff, reducing the lack of knowledge and encouraging companies to do systematic analyses without external support.

The measurable goal of saving 69.2 GWh over the lifetime of the newly installed equipment was overachieved with 7%, gaining total savings of 73.7 GWh.

The analyses of the database with 4142 motors confirmed several assumptions about the use of VFDs, oversizing, age of the motor stock, etc.

The main goal for a company is to make sure that it produces the planned amount and quality of their products. Factory staff is trained to ensure the undisturbed daily business. Energy saving has a very low priority. There is no, or only a very limited incentive to save energy or to resize an old motor system. Nobody wants to take the risks (e.g. equipment failure, higher costs than anticipated, lower savings than anticipated, etc.) without any personal advantage or reward.

The electricity costs of the factories that participated in Easy were between 1% and 3% in relation to their total turnover. Therefore, the net financial gain through the savings is small.

The software tools help to identify the motors with the biggest potential and an economically attractive payback. The effectiveness of the implementations with short paybacks is proven by random checks.

EASY has also shown that a financial incentive helps to get into the factories and it stimulates activities in industry that were hindered or neglected before.

EASY also caused additional administration work which in some cases led to irritations.

Way forward

Based on the lessons of the EASY program, a training program for factory technical personnel is being built up in Switzerland: energy technology and management in industry, incorporating the Motor-Systems-Check methodology with its software tools.

Based on the research of Cooremans [3] and the lessons learnt from EASY, the Swiss cooperative project "Management as a Key Driver of Energy Performance"[2] is researching between 2015 and 2017 if companies with an energy management system tend to invest more into energy efficiency.

A direct follow-up of the EASY program is the SPEED program (www.speed-program.ch) operated by Planair (www.planair.ch/en), an EASY program partner.

Acknowledgements

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[2] http://www.nfp71.ch/E/projects/module2/Pages/project-iten.aspx