Swiss training for Industrial Energy Optimization

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Abstract

Audits in 25 Swiss factories analyzing 4142 motor systems have shown that many motor systems are old, inefficient, oversized and need to be optimized systematically. This has been hampered by different barriers, including a lack of know-how, competence and capacities of in-house technical staff. A new Swiss training program for industrial energy optimization (IEO) aims to close this gap through building a pool of skilled professionals to implement motor systems optimization projects.

IEO is supported by the Swiss Federal Office of Energy, local governments, utilitites and other organizations and is managed by Impact Energy.

The primary target group of the training is factory engineers working in industrial plants, the secondary target group is energy consultants, representatives of utilities and government authorities, etc. IEO is the first unique training program combining both technical knowledge and management skills.

IEO is six days long and consists of the following main parts:

1. Introduction
2. General energy management
3. Specific technology focus including laboratory or facility demonstration for the following modules: motors and converters, pumps, fans, compressors. Examples of realized optimizations and group work also play an important element within the program.
4. Final exam, including presentation of individual optimization assignments.

The goal of IEO is on the one hand, to teach the technical fundamentals of electric motors, applications (pumps, fans, compressors, etc.) and system optimization including the audit methodology Motor-Systems-Check (www.topmotors.ch). On the other hand, to train technical staff how to sell an investment project to company management.

A feasibility study was conducted in 2014 including all relevant educational institutions preceding the choice of training sites, supporting national organizations and teachers in 2015. Courses are held both in the German and French part of Switzerland, in both languages. The first German course was held in 2016. The feedback of the first participants was collected and carefully evaluated, based on which an update of the program was elaborated. The first French and second German courses were held in 2017, the next course dates for 2018 are already published. After the first trainings, possibilities for a longer training duration and introduction in other countries will also be investigated.

Introduction

Electric motor systems are responsible for more than 50% of Swiss electric energy consumption. The analysis in 25 Swiss industrial and infrastructure plants has shown that motor systems are responsible for more than 80% of electric energy consumption in these companies, with savings potentials between 20% to 30%.

Switzerland has a long tradition of over two decades with target agreements. Companies commit to reducing their CO_2-relevant energy consumption and in turn get the tax they pay on their CO_2 emissions reimbursed. As in Switzerland electric energy is generated almost CO_2-neutral, there has been little incentive in the past for companies to improve their electric energy efficiency. Although new policy instruments (e.g. public tenders with financial incentives [6], financial benefits for energy-intensive users, etc.) gave a new impetus in this field during the past few years, motor systems so far have been a neglected area of action for many companies in the industrial and services sectors. [3] [7]

In order to tackle this issue, the Topmotors program (www.topmotors.ch), managed by Impact Energy and supported by the Swiss Federal Office of Energy, has been running in Switzerland since 2007. The goal of the program is to raise awareness of industrial end-users, manufacturers of motors and machines and other relevant stakeholders on the potential of efficient electric motor systems used in industrial and infrastructure facilities and large buildings and to show ways to exploit these.

Topmotors has since 2007:

- Developed the four-step Motor-Systems-Check methodology with software tools for each step, designed to find the 20% of motors within a factory which bring 80% of the potential savings of electric motors;
- Developed a number of fact sheets on the efficient design of motor systems, i.e. pumps, fans, the use of Variable Frequency Drives (VFD), compressors for air and cold, etc.;
- Organized a number of workshops on specific topics related to motor systems, such as pumps, fans, compressors, measurements on site, specific applications (escalators, elevators, hydraulic machines, machine tools), the use of VFDs, etc.
- Organized the international Motor Summit conference (www.motorsummit.ch) in Zurich six times, bringing together policy and technology experts across the globe to debate the latest developments on efficient electric motor systems.

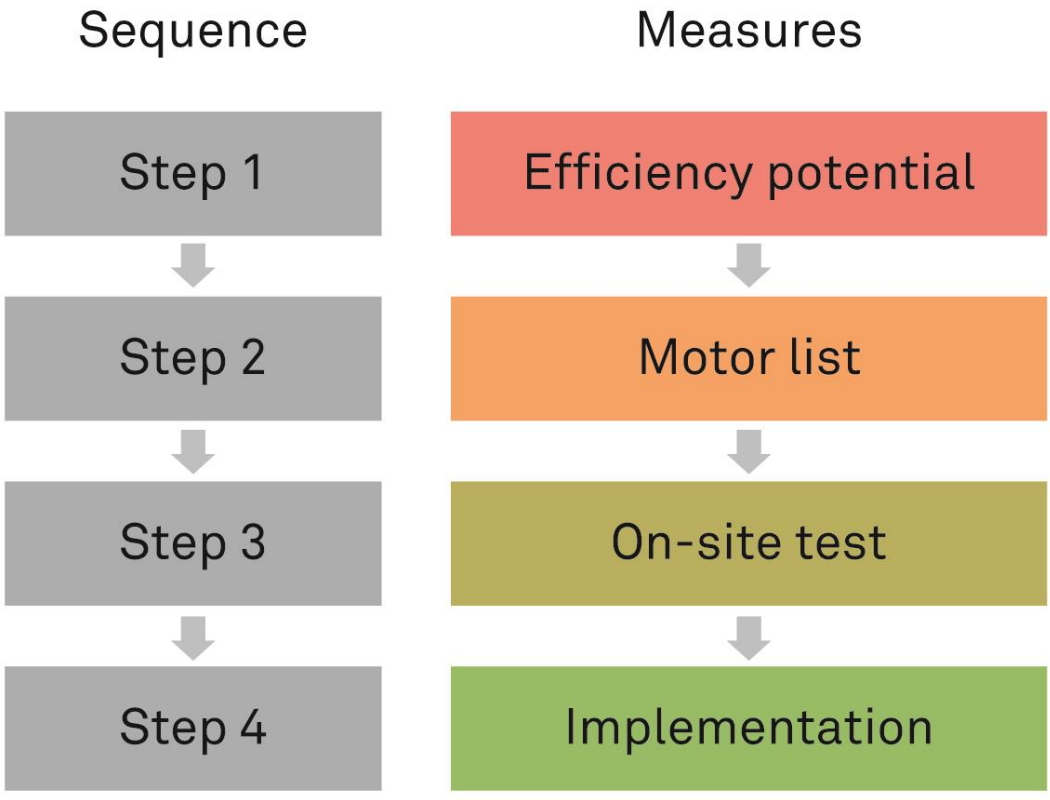

Figure 1 **The four steps of the Motor-Systems-Check**

Between 2010 and 2014, Topmotors ran the financial incentive program EASY (Efficiency for motor systems, www.topmotors.ch/easy) [3][4]. The goal of EASY was to help factories with financial incentives and know-how to improve their existing motor systems. The program aimed at overcoming the barriers preventing companies from efficiency improvements in terms of necessary resources (time, know-how, financial resources). Within four years, 25 companies started the four-step Motor-Systems-Check audit, a method to make a systematic approach to check and optimize the electric energy consumption of the motor systems. During this period, 4142 motor systems have been analyzed in detail. Results have shown that many motor systems are old, inefficient, oversized and

need to be optimized systematically. Within the framework of the EASY program, measures with an overall saving of 74 GWh (over the lifetime[1] of the improved motors) have been implemented.

Almost all companies participating in EASY have one thing in common. They are specialists in producing high-quality products but they all have a lack of knowledge concerning electric energy efficiency and in particular, motor systems efficiency. Technical staff is well trained in maintenance work and their main goal is to keep the system running. Saving energy has a much lower or even no priority, also due to the fact that for most companies, energy costs represent only a minor fraction within total costs (except for energy-intensive companies).

During the course of the program, the need for a dedicated training of technical factory staff became evident.

Feasibility (2014)

In 2014, Topmotors made a feasibility study for the training program "Industrial Energy Optimization" (IEO) dedicated to motor systems in Switzerland [2]. In the framework of this feasibility study, a survey was conducted with 34 participants, including 17 potential training sites and a number of other stakeholders: utilities, industry associations, manufacturers, planning engineers, representatives of cantons (public authorities) and industrial end-users. The results of the feasibility study can be summarized as follow:

- There is no training program available in Switzerland specifically focusing on motor systems only. Some trainings briefly treat this topic, while the majority of trainings focuses on buildings, renewable energy and a few trainings dealing with the industrial sector on thermal energy. Despite some earlier training programs that focused on some specific technologies (compressed air, cooling, etc.) there has never been a universal efficiency training program for all important types of motor driven systems. In conclusion: the topic is relevant and not sufficiently present within the continuous education landscape.

- The training is fitting into continued education, i.e. it will be addressing professionals in a working environment with some years of work experience, not students within their tertiary education programs (bachelor, master).

- The primary target group of the training should be technical staff working in industrial factories. The secondary target group: energy consultants, people working for utilities, industry associations, energy agencies, public authorities, etc. Addressing (non-technical) managers was investigated but decided against.

- The training duration was fixed for 6 days, always two consecutive days (Friday and Saturday) on three different occasions. A longer training duration was investigated but decided against. The reason for this was to accommodate for the limited availability of the target group. It also seemed important to split the training time between work time (three Fridays) and free time (three Saturdays) equally.

- The unique selling proposition of the training program is that it combines technical knowledge and management skills. Technical knowledge is being built up in the part of the program with the specific technology focus and management skills in the part concerning general energy management.

The feasibility study gave a good opportunity to engage with relevant stakeholders in the field, as a first step towards building up a national organization behind the training program.

Build-up (2015)

In 2015 work began to elaborate the content of the IEO training program, to choose the training sites, the teachers and to build up the organization.

[1] The assumed lifetime of newly installed equipment is between 10 to 20 years, depending on the size of the motors (for motors below 1 kW 10 years, for motors above 100 kW 20 years).

Training sites

Topmotors established a collaboration with two universities of applied sciences as training sites:

- Lucerne University of Applied Sciences and Arts (Hochschule Luzern HSLU) at Horw in the German-speaking part of Switzerland
- Haute École d'Ingénierie et de Gestion du Canton de Vaud (HEIG-VD) at Yverdon-les-Bains in the French-speaking part of Switzerland.

Both universities have a very-well equipped laboratory for motor systems. At HEIG-VD a pump demonstrator machine is available to showcase the difference in the electric input power of pumps when used with or without a VFD. A similar machine is currently being built for fans at the HSLU.

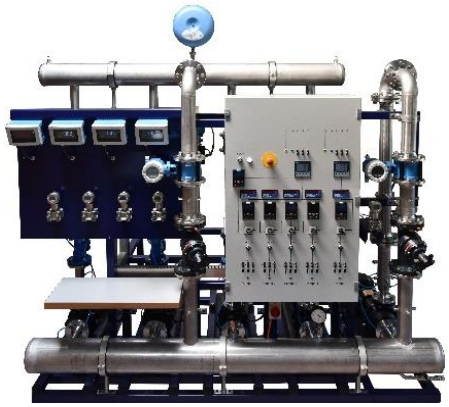

Figure 2 Pump demonstrator at HEIG-VD

Organization

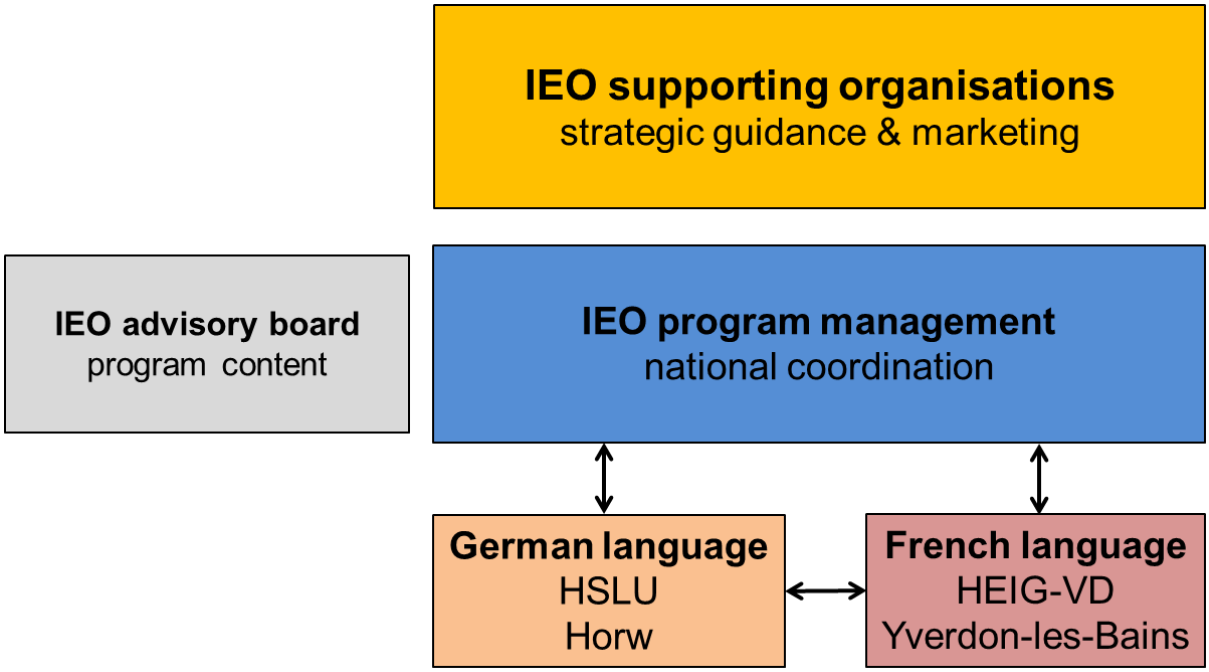

Figure 3 Organizational structure of IEO

Topmotors entered into partnership agreements with a number of organizations supporting the program with financial contributions and/or their marketing channels in an attempt to inform potential participants on IEO. The supporting organizations include energy agencies, an industrial association with a wide network of technical professionals, utilities with industrial customers as well as public authorities, acknowledging the importance of the topic (see Figure 4). Public authorities also gave

financial support in the form of a reduced training fee to participants, to encourage greater participation.

Figure 4 IEO supporting organizations

The IEO advisory board played an important role in the elaboration of the training content.

Goal

The goal of IEO is to empower technical staff in industrial factories to:

- establish a long-term, continuous improvement process for motor systems within the factory,
- lead and implement efficiency optimization projects for motor systems involving external specialists, manufacturers and service providers and
- present the optimization projects and convince upper management to invest into them on a regular basis.

Content

The training consists of the following main parts:

1. Introduction to the Swiss energy efficiency policy background and legal requirements,
2. general energy management, communication, profitability calculations, and suggestions to convince upper management,
3. specific technology focus including laboratory or facility demonstration for motors systems, and
4. a final exam, including a presentation of individual optimization assignments.

There are three crucial aspects of the IEO training: its practical orientation, a systems approach and the combination of technology and energy management topics.

The IEO program recognizes that it is not enough to have a sound technical proposal for optimizing a system, but technical personnel also needs to be able to convince the people within management who have authority over investment decisions. This is the reason for addressing profitability calculations (including life cycle costs) and communication aspects within IEO. Studies have shown that the assessment of life cycle cost or total cost of ownership is not very widespread yet in companies although it clearly increases the implementation of efficiency improvements. [8]

Practical assignment

For a successful completion of IEO, participants have to make an individual practical assignment which means they have to:

- identify a suitable motor system (i.e. a pumping or fan system) within their factory, or any other suitable object,
- describe the system, gather parameters for peak and average load, annual operation characteristics,
- investigate variants for optimizing the energy efficiency of the complete system and quantify the expected savings, and
- present the motor system optimization recommendations to the class.

Pilot course (2016)

During June/July 2016, the first pilot course was held at the Lucerne University of Applied Sciences and Arts in German. Seven participants were trained in energy efficient motors in industry. Although the primary target group of the program is technical staff in industrial factories, all seven participants were energy consultants belonging to the secondary target group.

All participants were asked for a detailed feedback on the first course, consisting of written feedback to a comprehensive questionnaire and oral feedback within the group in form of a discussion. Their feedback can be summarized as follow:

1. The topic of IEO is good, important and not sufficiently covered in the running continued education programs in Switzerland.
2. The structure, timing and duration of IEO is optimal.
3. Participants wished to include even more practical work and examples in the training course and less theoretical background.
4. They especially valued the exchange among one another which was intensive during the last day of IEO when participants presented their individual practical assignments.
5. While they acknowledged the importance of energy management, they urged to reduce the time spent on it (originally one training day) and make it more focused.
6. As there are many small and middle sized enterprises (SME) in Switzerland there was a wish to dedicate more attention to an SME-approach within IEO.

The program management assessed this feedback, taking into account that the participants were from the secondary target group of the program, and changed the structure of the program for the regular courses accordingly (see Figure 5).

The practical orientation was reinforced through more group work and the fact that Modules 1 to 5 take place in the university laboratory or on site within a factory. The theoretical background for explaining how efficient motor, pump, fan and compressor systems work was reduced, assuming that participants are already familiar with basic concepts. For each participant, detailed information is required on their educational and professional background (work experience) upon their registration for the training. This enables the program management to assess in advance the profile of participants and make adjustments to the program content if deemed necessary.

Day 1	Day 2
Welcome, Introduction	**Module 1: Motors** -typology, -losses, -measurement
Swiss Energy Industry	
Pre-post comparison	
Practical assignment	Motor-Systems-Check: methodology and tools
Questions & Answers	Questions & Answers

On site practical assignment

Day 3	Day 4
Module 2: Variable Frequency Drive (VFD) -typology, -losses, -measurement	Energy management and internal communication
Module 3: Pumps -typology, -losses, -measurement	Practical assignment -current status of the motor system -definition of improvements
	Questions & Answers

On site practical assignment

Day 5	Day 6
Modul 4: Fans -typology, -losses, -measurement	Written exam
	Presentation practical assignment
Modul 5: Compressors -typology -losses, -measurement	Presentation practical assignment
	Feedback
	End

Figure 5 **Updated IEO training content. Training participants are required to work on their practical assignments in between the training days, namely after days 1&2 and days 3&4.**

Regular courses (2017)

The first French course with 13 participants took place between March and April 2017 and the second German course with 8 participants took place between May and June 2017.

In the French course, around half of the participants came from the primary target group (technical persons working in industrial facilities) and the other half of the participants was made up from persons within the secondary target group, i.e. persons working for utilities, public authorities, universities, or as energy consultants. In the German course the audience was mixed as well, with participants from the primary and secondary target groups, i.e. technical persons working in industrial facilities, for utilities and energy consultants.

The feedback of training participants was very positive for both courses, especially for the French edition. Here the training site offered the advantage of using the pump demonstrator plus the factory visit on site was also appreciated. Participants of the German course suggested a more extensive use of the infrastructure provided by the German training site, where currently a fan demonstrator is being built up and to be used in the next training editions.

Other forms of training

Topmotors is launching regular webinars from 2017. These are online seminars that last between 30 and 60 minutes. There is usually a presentation of a topic related to efficient electric motor systems, followed by questions from the audience (questions are usually raised in writing, i.e. chat). The main characteristics of these webinars are:

- Online streaming which makes live participation possible,
- no need to travel and being physically present to attend the webinar and
- recording and publishing the webinar online makes looking at it later possible.

While nowadays webinars are getting more and more widespread, this form of training is currently not being considered for IEO as not found suitable. Within IEO, the practical hands-on training is a key element, as well as an intensive exchange between teachers and training participants, requiring physical presence throughout the six training days. This is well demonstrated by the fact that throughout the three trainings held so far, only one participant was missing during one training day because of an accident..

www.hslu.ch/w103 www.entrainements-electriques.ch

Figure 6 Flyer images and website links of the German and French IEO courses

Program costs and financing

The IEO program is designed to run for at least five years. The program costs consist of the following three key elements:

1. Basic research:
   feasibility of topic, prerequisites and level of training, identification of target group, training program concept, training sites, etc.

2. Preparation of the training courses:
   preparation of coordinated training material, selection and training of the trainers, coordination

of lessons (terminology, no overlap, few contradictions, same methodology for both German and French courses, etc.), selection and cooperation with training sites, building of an association with industry and utilities to carry the program nationally for the next decade, publicity for students and sponsors.

3. Implementation of the training:
   Classrooms, schedule, laboratory and field studies, monitoring of results, evaluation of participants' feedback.

For the basic research and preparation of the training external funding was needed, to a large extent provided by the Swiss Federal Office of Energy. During the implementation of the training, it is assumed that a minimum number of 12 participants paying the training fee of USD 3 000 should be sufficient to cover the costs.

Financial support by other further sponsors was twofold:

a. Support for the preparation of the training courses
b. Reduction of training fee by 50% for participants.

While the financial support for the basic research and preparation of the training courses was absolutely crucial, the incentive reducing the training fee proved to be very helpful in attracting participants for the training.

The program management continues its efforts for attracting further financial support from local governments, utilities, industry associations and other interested stakeholders.

Conclusions and next steps

After the pilot course and during the preparation and launch of the regular courses the program management faced a number of challenges and learned important lessons which can be summarized as follow.

1. The branding of the program with renowned host universities, the Topmotors program, the Swiss Federal Office of Energy and several well-known national supporting organizations was a key to success. It helps in the program positioning and strengthens credibility.
2. Marketing remains a big challenge. With the Swiss continued education landscape offering roughly 300 different courses it is crucial to get the right information to the right target audience and show the unique selling proposition of the program. The program management puts great effort into an information and marketing campaign through print and online media as well as through the network of the IEO supporting organizations to reach the target groups of the training. As long as the training is not well-known, it is more difficult to attract participants. Participants have a long planning horizon, they need to know several months in advance the training dates to be able to plan their absence from their workplace.
3. The teachers of the training were both university professors (rather strong theoretical knowledge) and external technical practitioners (rather strong practical knowledge). The program management put great emphasis on securing the most knowledgeable experts within their respective fields and on the coordination of the program contents, the use of one common terminology, key messages to be conveyed and reinforced, avoiding overlaps, repetitions or contradictions among multiple teachers. This combination of university professors and external practitioners was seen as valuable, while at the same time it was a challenge to make sure that the whole training material suits the level of the target group and is close enough to their practical field of work.
4. The availability of laboratories was important while at the same time a stronger focus with the use of demonstrators (see Training sites) or work at a factory was desirable. A stronger focus is also given to work in groups, to enhance the exchange among participants. The courses so far have shown that an access to objects suitable for the individual practical assignments did not constitute a hurdle (as originally expected by the program management).
5. The whole IEO project was supported from its outset in 2014 by the Swiss Federal Office of Energy. The program management analyzed the costs of the training program for a period of five years based on a business plan. It was clear from the outset that the operational phase of the training could be covered through the course fees paid by the participants (USD 3 000 for six days), but the build-up of the program needed additional financial support. This was secured through support from the national and local governments as well as other parties.

IEO is planned to continue in the coming years with at least one German and one French course per year. From 2018 two German courses are planned per year and in 2020 two French courses per year. The program management is investigating potentials for exporting the program to other countries. German and French-speaking countries are in favor due to ease of implementation, translation into English and Chinese is also being considered.

Acknowledgements

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