Energy efficiency in SMEs – key research findings from the IETS TCP

Executive summary

Around the world, extensive attempts are taken to improve energy efficiency for various sectors of the Economy, and industrial SMEs (Small and Medium-sized Enterprises) are no exception to that. Industrial SMEs are in various forms provided with funding opportunities, policy programs such as low-cost or free-of-charge energy audits are being offered etc. Despite so, many industrial SMEs still does not maintain their in-house energy management beyond the minimum law requirements, if any such national legislation exists. Further, the sector as such, industrial SMEs, is a way too broad definition to really, be able to make some major conclusions ranging from medium sized very energy intensive pulp mills with continuous production to small non-energy-intensive companies with production weekdays, 8am to 5 pm.

In an attempt to further explore research in the area of industrial SMEs, the IETS TCP initiated research in the area. Two different research programs were carried out within the IETS, entitled Annex XVI, one between 2011-2015 consisting of the following researchers:

Rogelio Zubizarreta Jiménez, Inés Morales, Osamu Kimura, Erwin Cornelis, Magnus Karlsson, Mats Söderström, Sandra Backlund, Svetlana Paramonova, Christine Weibøl Bertelsen and Patrik Thollander

In 2018-2020 an additional attempt was initiated consisting of the following researchers:

Clemens Rohde, Osamu Kimura, Simone Maggiore, Hans Even Helgerud John Cosgrove, Ida Johansson, Anna Realini and Patrik Thollander.

This report is a condensate of this IETS TCP research aiming to provide a brief, easily understandable presentation of the key findings.

This report is a result of the below reports and papers:

Patrik Thollander, Rogelio Zubizarreta Jiménez, Inés Morales, Osamu Kimura, Erwin Cornelis, Magnus Karlsson Mats Söderström, Sandra Backlund, 2014. Energy end-use policies and programs towards industrial SMEs – the case of Japan, Belgium, Spain and Sweden. Download at: https://iea-industry.org/app/uploads/annex-xvi-task_1.pdf (2020-11-25)

Thollander, P., Cornelis, E., Kimura, O., Morales, I., Zubizarreta Jiménez, R., Backlund, S., Karlsson, M., Söderström, M., 2014. The design and structure of effective energy end-use policies and programs towards industrial SMEs. In proceedings of ECEEE Industry Summer Study, Arnhem, 2-5th of June.

Thollander, P., Paramonova, S., Cornelis, E., Kimura, O., Trianni, A., Karlsson, M., Cagno, E., Morales, I., Jiménez Navarro, J.P., 2015. International study on energy end-use data among industrial SMEs and energy end-use efficiency improvement opportunities. Journal of Cleaner Production 104: 282–296.Thollander et al., 2014. Download at: https://www.sciencedirect.com/science/article/abs/pii/S0959652615004485 (2020-11-25)

Erwin Cornelis, Osamu Kimura, Magnus Karlsson, Svetlana Paramonova, Patrik Thollander, Juan Pablo Jiménez Navarro, Inés Morales, Christine Weibøl Bertelsen. Energy services and business models for industrial SMEs. Download at: https://iea-industry.org/app/uploads/annex-xvi-task_4.pdf (2020-11-25)

Osamu Kimura, Magnus Karlsson, Erwin Cornelis, Svetlana Paramonova, Patrik Thollander, Inés Morales, Juan Pablo Jiménez Navarro, Christine Weibøl Bertelsen. Methods and tools to achieve energy efficiency in industrial SMEs. Download at: https://iea-industry.org/app/uploads/annex-xvi-task_3.pdf (2020-11-25)

Johansson, I., Mardan, N., Cornelis, E., Kimura, O., Thollander, P., 2019. Designing Policies and Programmes for Improved Energy Efficiency in Industrial SMEs. Energies, 12(7), 1338; https://doi.org/10.3390/en12071338

Thollander, P., Rohde, C., Kimura, O., Helgerud, H., Realini, A., Maggiore, S., Cosgrove, J. & Johansson, I. (2019). A review of energy efficiency policies for small and medium-sized manufacturing enterprises from around the world. 2019 ACEEE Summer Study on Energy Efficiency in Industry, Portland, August 12-14, 2019.

Energy end-use policies and programs towards industrial SMEs – the case of Japan, Belgium, Spain and Sweden[1]

Key findings regarding studies on energy efficiency policy programs are that the overall energy use among industrial SMEs in the studied countries are lower than larger and energy-intensive industry. Focusing on energy end-use efficiency, it may thus be questioned why industrial SMEs should be top priority. On the contrary, the economic impact from industrial SMEs is of great relevance for a nation providing numerous employment opportunities.

Moreover, the cost-effectiveness, i.e. how energy that is improved compared with the cost of the program, of energy-end-use policy measures among industrial SMEs has been found to often be high, compared with larger firms, reason be that may have already exploited some of the low-cost potentials. Larger and energy-intensive companies have higher energy efficiency potentials in absolute terms, but many of these have implemented low hanging fruit measures because they have sufficient management capability etc. to do so. So, if one just sees the availability of low-cost potentials of energy efficiency measures in the market, share of SMEs might in fact be high.

Moreover, the goal with energy end-use policies towards industrial SMEs, may be seen as not only an attempt to improve energy end-use efficiency, but equally or perhaps more importantly support these firms in their long-term survival and success. In these regards, energy end-use efficiency in the longer run is of great importance as firms otherwise may face competitive disadvantageous in comparison with competitors from outside the country.

Table 1. Some characteristics for industrial SMEs.

	Medium-sized SMEs and energy-intensive industrial SMEs	Small-sized SMEs and non-energy-intensive industrial SMEs
Amount of energy used	**Medium**	**Small**
Human resource for energy management	Limited, but they usually have a couple of responsible engineers	Very limited, often without responsible personnel
Where major energy efficiency improvement lies	Production and support processes	Mainly support processes

An attempt was made to try categorizing successful SME energy efficiency. The presented list is by no means conclusive but may rather be seen as an attempt to try to categorize and structure various policies directed towards industrial SMEs.

[1] Thollander et al., 2014. Download at: https://iea-industry.org/app/uploads/annex-xvi-task_1.pdf (2020-11-25)

Industrial SMEs have a large diversity in energy end-use and energy management and can be categorized into many segments by size and type of business etc. Among these, the following categorization was suggested: i) Medium-sized and energy-intensive industrial SMEs, and ii) Small-sized and non-energy-intensive industrial SMEs. The difference of the two segments are described in table 1. Because the characteristics of in the two SME segments are different, different approaches are suggested for improving energy efficiency among industrial SMEs.

Medium-sized and energy-intensive industrial SMEs

They have in general a modest capacity to work on energy efficiency, so giving economic and/or regulatory incentives is important. This underscores for example regulation (like the Energy Conservation Law in Japan), or LTA/VA (like in Sweden) as effective policy measures. Yet another reason for those types of support is that these companies also have significant energy use for the production processes and for those measures, more support may be needed, e.g. energy audit programs, networks, investment subsidies etc.

Small-sized and non-energy-intensive industrial SMEs

They do not in general have enough capacity to work with energy efficiency improvements, and are thus in need of a more supportive approach, e.g. assistance from external experts. Energy audit programs are effective, but is suggested to be complemented with networks where an experienced engineer supports the companies within the network.

The report ends with a list of suggested relevant polices for industrial SMEs to be considered among policy-makers:

Company size	Suggested energy policy program design
Medium-sized and energy-intensive industrial SMEs	1. Energy Conservation Law/LTA/VA 2. Energy audit programs for industrial SMEs, preferably but not necessarily located regionally or locally 3. Energy networks (preferably locally or regionally anchored) 4. Investment subsidies mainly for investments in production-related technologies 5. Benchmarking 6. Sector guidelines
Small-sized and non-energy-intensive industrial SMEs	1. Energy audit program (preferably locally or regionally anchored) 2. Energy networks (preferably locally or regionally anchored) 3. Investment subsidy 4. Benchmarking 5. Sector guidelines

International study on energy end-use data among industrial SMEs and energy end-use efficiency improvement opportunities[2]

Results from this research can be read in a full paper by Thollander et al. 2015[2]. The energy end-use (EEU) in the industrial sector is complex in general as processes are intertwined and interrelated. Moreover, bottom-up data of EEU on an aggregated level is scarce. Data for total energy supply like electricity, oil, coal, and natural gas exists but bottom-up data of what processes these energy carriers are used in, and moreover, where the major potential for implementation of energy efficiency measures (EEMs) exists, is less prevalent. This holds in particular for industrial small and medium-sized enterprises (SMEs). This makes in turn policy formulation and design for industry a great challenge. Knowledge on where and how energy is used, as well as where opportunities for improvement exist, may provide good support for developing the most effective policies. Therefore, the aim of this research was to present and compare available bottom-up energy data for industrial SMEs in four countries, namely Belgium, Italy, Japan and Sweden. Results showed that the existence and quality of bottom-up EEU data differs largely between the countries and the development of a general taxonomy of structuring EEU data as well as EEMs is needed. Without the development of such a general taxonomy, the deployment level of EEMs and carbon dioxide emission reductions is unlikely to ever reach its full potential as knowledge is missing on how large the potential is, in which processes the major potential is found, how far industry has reached in terms of deployment levels, and in which areas future energy policies are needed. In conclusion, this paper of EEU and EEM in industrial SMEs addresses the high importance of future research in creating a harmonized data categorization, as this will greatly support the transition towards sustainable industrial energy systems.

[2] Thollander, P., Paramonova, S., Cornelis, E., Kimura, O., Trianni, A., Karlsson, M., Cagno, E., Morales, I., Jiménez Navarro, J.P., 2015. International study on energy end-use data among industrial SMEs and energy end-use efficiency improvement opportunities. Journal of Cleaner Production 104: 282–296.Thollander et al., 2014. Download at: https://www.sciencedirect.com/science/article/abs/pii/S0959652615004485 (2020-11-25)

Methods and tools to achieve energy efficiency in industrial SMEs [3]

Tools for energy audits, energy management and benchmarking directed towards industrial SMEs seems scarce, and not widely adopted by the SMEs where available. This was clearly shown by the fact that many of the tools for benchmarking, auditing, and supporting Energy Management Systems (EnMS) adoption that are practiced in the studied countries were all developed by public funding. This would be partly because of the difficulty of establishing appropriate management/benchmarking methods and of bringing such efforts into viable business due to the existence of various market barriers to energy efficiency, e.g. high transaction costs or hidden costs for energy audits experienced by the audited companies.

As regards benchmarking, the intricate matter of relevant indexes for industrial SMEs makes the use of benchmarking a challenge, yet an important challenge to overcome. While finding an appropriate index is crucial to maintain credibility from SMEs, it is very difficult when there is a high degree of variety in processes, products, and activities. One way to tackle this challenge is to use several kinds of benchmarking indexes. This makes benchmark more reliable by providing several perspectives that compensate each other weaknesses. For example, a energy end-use database in Sweden used several metrics, including energy use per product, per square meters, per capita. Another way is benchmarking individual process or facility, instead of benchmarking whole site or whole company. This approach is based on an understanding that benchmarking figures are less relevant on a company level and more relevant for a process or installation level, e.g. compressed air etc. The fact that results from two project, BESS (Benchmarking and Energy Management Schemes in SMEs) and ex-BESS (Benchmarking and Energy management Schemes in SMEs) are not used operatively today after these projects was ended, seems to be an indication that tools as such are of lower value for industrial SMEs. Rather, SMEs may instead require a simple message based on a simple index. To attract SMEs it might also be important to stick to an aggregated index.

The need of simplification when trying to enhance adoption of EnMS in industrial SMEs is also stressed to be of importance. SMEs often need more simple system descriptions and less documents because they do not have sufficient human resources compared to larger enterprises. Examples include EnMS Light for SMEs in Sweden and a similar EnMS Standard in Japan, “How to implement energy management in small and medium-sized enterprises - A guide with supporting tools”, developed in a joint Nordic project. The same holds for Spain and a developed lighter EnMS for SMEs.

[3] Osamu Kimura, Magnus Karlsson, Erwin Cornelis, Svetlana Paramonova, Patrik Thollander, Inés Morales, Juan Pablo Jiménez Navarro, Christine Weibøl Bertelsen. Methods and tools to achieve energy efficiency in industrial SMEs. Download at: https://iea-industry.org/app/uploads/annex-xvi-task_3.pdf (2020-11-25)

Energy services towards industrial SMEs [4]

Energy services has been an often-stated promising means to deliver high energy efficiency improvement impacts. Energy services has predominantly been targeted towards the building sector where often measures are similar across a large number of buildings in a building stock, minimizing transaction costs in the procurement phase of an energy service contract. Less attention has been paid towards energy services in the industrial sector and even more so, for industrial SMEs. This part of the IETS TCP research involving five countries, Denmark, Belgium, Japan, Spain and Sweden, have made national reviews about the current status of energy services among industrial SMEs in their respective country.

Some notable remarks from the results of this was that the creation by the federal government of Belgium of the public ESCO Fedesco proved to have had a catalytic effect on the development of the ESCO market in Belgium. Despite so, the energy service market in Belgium seems to be declining. The same holds for Japan. The major reason for the decline in Japan was due to a variety of barriers to wider penetration of ESCO projects in Japan. Among them, high transaction costs in the contractual process seem to be the major barrier.

Some general findings from this study were that the market for energy services seems to have started in 1990 and the major focus has been towards buildings, but a growing interest towards industrial SMEs has been seen. Major barriers to the adoption of energy services are distrust at demand side, e.g. Belgium, Japan and Sweden, together with high transaction costs. Successful policies towards an emerging energy service market could be the creation of competence centers, e.g. Belgium and Denmark, or the creation of associations for knowledge exchange as found in Belgium, Japan and Spain. Also establishing a public ESCO has a catalytic effect (as observed in Belgium and Tokyo and Aomori prefectures in Japan).

[4] Erwin Cornelis, Osamu Kimura, Magnus Karlsson, Svetlana Paramonova, Patrik Thollander, Juan Pablo Jiménez Navarro, Inés Morales, Christine Weibøl Bertelsen. Energy services and business models for industrial SMEs.
Download at: https://iea-industry.org/app/uploads/annex-xvi-task_4.pdf (2020-11-25)

Designing Policies and Programs for Improved Energy Efficiency in Industrial SMEs[5]

Results from this research can be read in full in a paper by Johansson et al., 2019[5]. The major method of the study was a literature review of scientific journal publications in the Web of Science database. Also, in some cases conference papers and policy reports from international bodies were also included in the analysis, however not in the presentation of the review. (Johansson et al., 2019).

Results showed that the scientific publications in the field of industrial SMEs and energy policy differed in scope and origin, and a major emphasis of the scientific papers has been on barriers to and drivers for energy efficiency. Scientific contributions from studies of energy policy programs primarily cover energy audit programs and show that the major energy efficiency measures from industrial SMEs are found in support processes. The review further reveals an imbalance in geographic scope of the papers within the field, where a vast majority of the papers emanate from Europe, calling for scientific publications from other parts of the world. The study synthesized the findings into a general method on how to design efficiency programs for the sector, se table 1 below. (Johansson et al., 2019).

[5] Johansson, I., Mardan, N., Cornelis, E., Kimura, O., Thollander, P., 2019. Designing Policies and Programmes for Improved Energy Efficiency in Industrial SMEs. Energies, 12(7), 1338; https://doi.org/10.3390/en12071338

Table 2: Major steps when designing energy efficiency policies and programmes for small and medium-sized industries (Johansson et al., 2019).

Design steps	Comment
Decide primary target sector group	The primary target sector group should be decided and, preferably, should be as homogenous as possible, both in terms of sector(s) and company size.
Mapping of annual energy use	The annual energy demand and end-use is important to consider and mapping the energy use and major technologies and processes are key steps. The share of energy use in support and production processes varies between sectors.
Review the current energy policies	For the major energy end-using technologies and processes in the former step, it is important to analyse which existing public policy programs are in place and thus already provide support for deployment.
Make an energy efficiency potential estimation	By using available policy documents and scientific papers, an estimation should be made of the energy efficiency potential for the policy program in regard. If no documents and studies are available, one can undertake a pilot ex-ante study where companies are asked about this.
Review the barriers and drivers for energy efficiency	A review of the scientific publications regarding barriers and drivers for the specific sector group targeted should be done. If the information regarding barriers and/or drivers for the targeted sector group is scarce, this could be supplemented with interviews or questionnaires in a pre-phase study.
Suggest appropriate policy	Consider the most appropriate policy or policy mix in relation to the findings in the previous steps.
Evaluate the impact of the policy programme	Make an evaluation of the policy programme to evaluate the achieved energy efficiency and cost-effectiveness of the programme. Include the expected implementation rate in the potential estimation. Anderson and Newell (2004) found that approximately half of the energy efficiency measures in the American IAC were implemented and evaluation of the Swedish Project Highland showed an implementation rate of above 40% (Thollander et al., 2007). A common estimation of the implementation rate can be 50%. Further, aim to include quantified non-energy-benefits (NEBs) in the assessment of energy efficiency measures which could cut the payback time of measures Finman, and Laitner (2001).

A review of energy efficiency policies for industrial small and medium-sized enterprises from around the world[6]

Results from this research part can read in full in a paper by Thollander et al., 2019[6]. In a final attempt, beyond the initial research on energy efficiency policies for SMEs[1] and the scientific review paper on SMEs[5], energy efficiency policy design was explored. The various policy initiatives for the studied countries Japan, Germany, Italy, Sweden, Norway and Ireland, in terms of energy policy programs for industrial SMEs were shown to differ in design and operationalization.

The energy efficiency policy programs within the studied countries thus differed but also show some similarities. Apart from energy audit policy programs that was shown to be a common policy approach, policy programs including energy management certification has also started to emanate. Energy management in its various forms is a key driver for improving energy efficiency. Whereas the term "energy management" is often associated with the energy management system ISO 50001 standard, there is a vast array of policy programs and schemes in place involving energy management, which however do not strictly adhere to a framework or international standard. Especially for SMEs, the standardized protocols of ISO 50001 seem often too be a bit too burdensome for a cost-efficient implementation.

All studied countries applied various form of investment subsidies to promote deployment of industrial energy efficiency measures. One studied country, Italy, also relied upon a white certificate scheme and Japan relied upon both the Energy Conservation Law as well as well as the Voluntary Agreement Program Keidanren. All countries applied stand-alone energy audit policy schemes for industrial SMEs in some form, and two countries, Germany and Sweden, also applied energy efficiency implementation networks as key policy programs for the sector. Notably, energy efficiency networks as a form of energy management support for industrial SMEs seems to only be present on a national level for two of the studied countries, Germany and Sweden. If results of the energy efficient network programs are as good as the current research states, i.e. about twice as high degree of improved energy efficiency compared with a stand-alone energy audit program, such policy initiative is suggested to also be used as an argument for undertaking pilot studies in other parts of the world as well.

[6] Thollander, P., Rohde, C., Kimura, O., Helgerud, H., Realini, A., Maggiore, S., Cosgrove, J. & Johansson, I. (2019). A review of energy efficiency policies for small and medium-sized manufacturing enterprises from around the world. 2019 ACEEE Summer Study on Energy Efficiency in Industry, Portland, August 12-14, 2019.

Appendix: Case studies

World-leading company improved energy efficiency with 50 % thanks to University knowledge sharing[7]

Bumax is a world-leading manufacturer of premium stainless-steel fasteners and one of the largest export companies in Gästrikland. They deliver stainless steel fasteners for submarines, oil rigs, cancer care, space research and much more.

The plant with its head office in Åshammar, Gästrikland, Sweden, has managed to halve their energy and electricity use.

"This is a major achievement for a manufacturing company with a large factory, and it's good both for the environment and for our competitiveness," says Managing Director Patrik Lundström Törnquist.

[7] For more information, please see: https://www.hig.se/Ext/Sv/Arkiv/Externa-nyheter/2020-05-11-Doktorand-halverade-energianvandningen-hos-varldsledande-foretag.html (in Swedish)

Energy efficiency networks, the University shares their knowledge to industrial SMEs

For this project, the University of Gävle gathered around 50 small and middle-sized companies from Gävleborg; for three years these were given access to researchers and experienced energy experts from the University. The first step was to carry out energy audits to calculate the current energy end-use and then to suggest cost-efficient measures. Later, the companies, mostly industrial SMEs, meet in energy efficient networks, about 4 times per year.

Preliminary results indicate that energy end-use in the companies, mostly industrial SMEs, in the regional energy efficiency network, has been improved by 16 percent on average.