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PANEL 1

Policies and programmes to drive transformation

History and prospect of voluntary agreements on industrial energy efficiency in Europe 1-001-18

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Keywords
voluntary agreements, energy efficiency policy

Many European countries have implemented voluntary agreements or long-term agreements to stimulate energy efficiency in the industry. This paper analyses the history of voluntary agreements on industrial energy efficiency in Europe and reflects on its future. This history reveals some factors influencing the deployment of such agreements in Europe. A first factor is the demonstration of good practice examples of a successful implementation of voluntary agreements, which seems to be instrumental in building enough confidence in this novel policy instrument. Second, EU legislation both has had a stimulating and inhibiting effect. Third, national circumstances have triggered the implementation of voluntary agreements in some cases. In contrast, the Global Financial Crisis did not substantially impact the deployment of voluntary agreements in Europe.

The analysis of the design of the different European voluntary agreements on industrial energy efficiency revealed a huge variety. No tendency to harmonize the design can be observed, apart from a gradual introduction of the implementation of energy management schemes as an obligation in most voluntary agreements.

The comparison of policy instruments implemented by countries with or without voluntary agreements has not led to the identification of some policy instruments that compete with voluntary agreements.

This analysis concludes that voluntary agreements still can have a future in Europe on the condition that there is still room to stimulate an efficient energy consumption practice in industry compared to a continuously more stringent baseline in a way that is both cost-efficient for the government and attractive for the industry.

Principles of successful non-residential energy efficiency policy 1-003-18

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Keywords
energy efficiency policy, market implementation, investment decision-making, business strategy

Most organisations do not invest in energy efficiency even when it makes sense to do so. This is the "energy efficiency gap" that policymakers have struggled with for over 40 years. Current policy is based on overcoming the range of technical, economic and organisational barriers to energy efficiency that exist. However, governments are finding that energy efficiency policies are still not delivering their full potential.

Researchers now consider that policy should focus not simply on finding and overcoming barriers, but on how energy efficiency fits with the organisation's wider investment decision-making processes. The evidence is that energy efficiency happens when it is strategically important, or "salient", and that salience is strongly influenced by external drivers such as reputation and risk and also by the way different part of the organisation are connected and resourced.

These salience drivers are complex, but vary in a predictable way between organisations and sectors. This patterning could be used to open up new intervention points and approaches for policy to influence investment behaviours in businesses and the public sector. The experience of successful energy efficiency policies overseas supports this conclusion with case studies presented from Australia and Germany.

The overall message for policymakers is that effective policy depends not just on which policies are used, but how they are used together:

- Connecting policies together, for example by both exploiting reputational drivers and providing incentives to enable the organisation to respond.
- Deploying policies in the right order, for example by engaging with trade bodies to build confidence and capacity before regulating.
- Devolving policy towards regional and local agents and support networks that have better access to and understanding of the organisation's needs.

Market-based instruments for energy efficiency – can they support the energy efficiency industry? 1-004-18

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Keywords
ESCO market development, energy efficiency obligation, tender, competitions, energy efficiency policy

There is a growing interest in so-called market-based instruments (MBIs) for energy efficiency, such as auctions, energy efficiency obligations on utilities and white certificate programmes. In this paper, we assess how important MBIs are globally as a driver of the energy efficiency industry and particularly the ESCo market. Our research found that the number of MBIs has quadrupled over the last ten years, while investment stimulated by them has risen six-fold, to USD 26 billion in 2015. What distinguishes MBIs from other policy instruments is that, by giving market actors the freedom to choose the measures and delivery routes that work best for them, the market as a whole is able to discover the most cost-effective way to achieve the outcomes set out by policy makers. That freedom puts a premium on good policy design and implementation, including strong monitoring, verification and evaluation. And as this paper shows, sharing knowledge across jurisdictions will be central to the success of the next wave of policy making in this area.

Towards zero carbon emissions – climate policy instruments for energy intensive industries, materials and products 1-014-18

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Keywords
climate policy, energy-intensive industry, industrial processes

Energy intensive industries (EIIs), producing the basic materials and products needed in society, contribute significantly to global emissions of greenhouse gases (GHGs). Motivated by the fear of carbon leakage, climate policy has so far treated the EIIs leniently with e.g. low carbon prices and/or free allocation of emission allowances. This has not resulted in more than marginal emission abatement. However, the emissions from EIIs have to approach zero by 2050 to 2070, following the overall target of the Paris Agreement. It is therefore urgent to develop policy strategies for a deep decarbonisation of EIIs.

In this study, we explore the role of various policy instruments in the transformation of EIIs to zero emissions and how they can be combined. In our analysis, we acknowledge the specificities of the various EII sectors with regard to mitigation options (e.g. available technologies and potential for recycling), market situation, and feedstock substitutability. The feasibility of specific policy instruments depends on these specificities and might therefore differ between subsectors of the EII.

The analysis of instruments is structured through an extended typology that takes its starting point in the economic impact the instruments have on the actors. The types of instruments include the commonly used sticks, carrots and sermons, as well as an additional type that we call "cushions" (Sticks, carrots and sermons are often assumed to be equal to regulation, economic instruments and information but we have slightly adapted the concepts to fit our "resource" perspective). These cushions can be flanking policies, that soften the negative effects on competitiveness that follow from implementing policy instruments, while climate policies between countries are not in pace. We also differentiate between instruments according to where along the value chain they are applied. How different instruments affect the competitiveness of industry is a key consideration.

We conclude that both energy and material efficiency, emissions-free processes and clean energy are needed to transform the EIIs. For this purpose, a range of in-

struments can be used in different parts of the value chain and the mix can change over time as technologies, markets and institutions change. New approaches to policy evaluation are needed to assess the combined and long term effects of such policy strategies.

White certificates as a tool to promote energy efficiency in industry 1-017-18

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Keywords
tradable white certificates, white certificates, energy efficiency obligation, Energy Efficiency Directive (EED), incentive mechanisms, industrial energy saving, baseline, additionality

Energy efficiency obligation schemes (EEOs) are used in many EU countries as a policy measure to reach energy efficiency targets. Some of the first EEOs (UK, Italy, France, Denmark) have been capable to reach positive results over the years, as clearly demonstrated by the ENSPOL project. The Italian mechanism, in particular, is an interesting example of white certificate scheme (WhC), since it is one of the most long-lasting schemes (operatively started in 2005), has ambitious targets, covers all sectors and energy efficiency solutions, and has many flexibility options in place (e.g. non-obliged parties, tradable market, bankability, etc.).

Another point of interest is Italian WhC development over the years. In the first phase, most of the projects were related to buildings with deemed savings as energy savings assessment method. Then the industrial sector rose constantly, till covering 80 % of the savings in 2014, mostly assessed through metered savings procedures. In the last three years, the buildings sector has started to recover, while metered savings have remained the most used energy savings evaluation procedure. This last development is mainly due to some regulatory decision and to the modification of the assessment of additionality for many industrial projects categories.

The paper will illustrate the reasons behind these developments, the issues that have arisen over the recent years, and the decisions taken to address them through a major redesign of the Italian scheme that has been introduced with new ministerial guidelines in 2017: many aspects – such as targets, baseline and additionality, saving assessment, and measurement, verification and control procedures – has been deeply affected. The paper will cover such themes, focusing in particular on the industrial side and highlighting themes like cost effectiveness, energy savings assessment, and how baseline and additionality have been dealt with over the years.

Feedback on white certificate on an industrial process: all-electric injection moulding machines 1-025-18

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Keywords
white certificates, industrial processes, energy saving assessment, injection moulding machines

The French White Certificate (WC) program, whose goal is to increase energy efficiency in France, launched its fourth period of three years on January 1st, 2018 with a new target of energy efficiency savings of 1,600 TWhc (TWhc counts the final energy savings over the life span solution actualized at 4 %). During the first three periods, the majority of the WC energy efficiency operations in the French industrial sector focused mainly on energy utilities with the exception of one process, the all-electric injection moulding machine. Our paper aims to analyse the impact of the WC program action since its approval in 2013. This energy efficiency operation replaces a hydraulic injection moulding machine with a completely electrified machine that produces electric savings of up to 50 %.

This article will first describe the new and the existing technologies, then analyze the number of WC obtained from this action and the WC market impact. Finally, it will evaluate the size of the operations and the percentage of CAPEX, capital expenditure), covered by the commercial incentives emanating from the WCs obtained via this action. The data used for this study comes from the national WC register, EDF (French Electricity Company), and from a survey conducted by EDF in concert with ADEME (French environmental agency) in 2017.

Between 2013 and 2017 the substitution of hydraulic machines for electric equivalents saved more than 4.7 TWhc of electricity. During this same period sales of the injection moulding machines increased by 50 %, more than half of which were all electric or hybrid models. The newer models tend to run between €50 k and €400 k while on average the WC commercial incentive provides around 5 % of the machine total cost (the purchase of the machine itself). The survey results predict a slight growth in the market over the next WC period (2018 to 2020).

Industrial operations such as the injection moulding machine represent more than 20 % of WC savings accomplished to date. The wide range of innovations in the industrial sector are an essential and rich field for new WC process operations which must be exploited in order for France to achieve the ambitious energy efficiency targets set for the WC's fourth period.

Further development of policies to enhance energy efficiency in the EU industry sector 1-027-18

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Keywords
energy efficiency policy, EU policy, energy efficiency market

Energy efficiency is a key building block in the transformation process to a decarbonised and sustainable way of doing business. While the main EU instrument for energy and climate policy in the industry sector is the EU Emission Trading Scheme, it only has secondary effects on energy efficiency. Additionally, the Energy Efficiency Directive (2012/27/EU) only regulates partial aspects, such as energy audits, yet a comprehensive EU strategy enhancing energy efficiency policies in the industry sector is absent. Nevertheless, energy efficiency potentials of up to 192 Mtoe final energy until 2050 remain untapped in the EU (Fraunhofer ISI, 2012). Due to the heterogeneous nature of the industry sector, policies cannot follow a generalist approach. Therefore, certain aspects of industry policy will need to be regulated by member states. This paper discusses incentives for the energy efficiency market and the design of policy instruments to enhance energy efficiency in the industry sector. It thereby differentiates which policies will be developed at EU level, and which aspects have to be addressed by member states. The paper builds on a report for the German government, which analysed the effectiveness and consistency of existing policies in the industry sector and made recommendations for the further development until 2050 in the EU. Furthermore, insights from the Energy Efficiency Watch 3 project are being used. Key aspects include defining a strategy for the industry sector towards a climate-neutral economic system, including the promotion of key technologies with transformation pathways for 2030 and 2050 as well as policy instruments such as further developing the requirement and implementation of energy audits and developing benchmarks. Furthermore, strengthening a harmonised energy efficiency market and providing new business models will support this development.

Less hot air for a less hot climate: evaluating the German waste heat reduction programme 1-035-18

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Keywords
waste heat, impact evaluation, evaluation, evaluation methods, free riders, spillover, policy evaluation, energy efficiency policy, CO_2 emissions, avoided emissions

The German industry sector amounts to almost one third of final energy consumption and shows large potentials for energy efficiency. Research has shown that waste heat reduction and utilisation bears great savings potential. Hence, one of the more large-scale programmes is the waste heat programme for subsidised credit financed by the German Federal Ministry of Economic Affairs and Energy (BMWi) and administered by the development bank KfW. It is open for companies of any size with a special support scheme for SMEs.

To successfully adapt the programme to changing conditions, thorough evaluation is imperative. This paper draws on primary data from the evaluation of the programme. It gives insight both into individual waste heat concepts, as well as into the impact on macro-level emissions reduction targets. The methodology for the impact evaluation is thoroughly described and applied on evaluation results.

Policies are structured according to a line of priorities starting with waste heat avoidance. The remaining waste heat should then be used according to the waste heat cascade: 1. direct integration of waste heat into processes 2. integration of waste heat into other operating processes 3. external utilisation, and 4. generation of electricity from waste heat. The effectiveness of waste heat utilisation depends on numerous influencing factors such as the quantity of waste heat, temperature level and time availability.

In the evaluation, waste heat concepts showed to be very heterogeneous in structure and quality. Surveyed administrative staff stated that stricter requirements for the structure standardisation of the presented concepts would help to streamline

the application process, which would reduce waiting times and reduce barriers for companies to participate. Target achievement analysis concludes that with a constant number and structure of participant companies, the target of yearly savings of 1 million tonnes of CO_2-eq. until 2020 can be achieved with an exceedance of 90 %.

While free-rider effects are an issue in such a large-scale programme, survey results show an increased awareness for energy efficiency pointing towards the existence of positive spill-over effects into further investments inside or outside of the company.

Simplifying funding conditions for competitive tenders: more energy savings with less paperwork 1-036-18

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Keywords
funding, targeted approach, administrative burden

Programs aimed incentivising energy efficiency face the challenge of precisely assessing the energy savings realised in order to give efficiency measures a fair and just value. Funding agencies therefore typically demand extensive documentation to justify the costs and reasoning of efficiency measures as well as information on how the assumed energy savings are calculated or estimated. The documentation for the funding application, of course, represents transaction costs for the participating industry. It also produces additional costs at the funding agency, as the agency has to analyse and evaluate the documentation provided by the applicant. Therefore, both the participating industry and the funding agency should be interested in low transaction costs and in using the funds for investing in energy efficiency rather than in administrative overheads.

This paper analyses over eight years of experiences from ProKilowatt, a Swiss policy program (www.prokilowatt.ch), which provides funds for energy efficiency measures through a competitive application process. The Swiss Federal Office of Energy (SFOE) defines and modifies the rules of ProKilowatt on a yearly basis, taking into account technological developments and lessons learnt from previous tenders. In recent years, the SFOE simplified the conditions imposed on industry, thus simplifying the application for financial support.

This paper explains the simplifications and analyses their impacts through a number of simulations as well as through actual experience. The results show that from the perspective of a funding agency, a simple funding scheme can be as precise as a more complicated one. It is possible to lower transaction costs for participating industry significantly without the loss of quality. For example, it is not necessary to force applicants to describe a base scenario, a condition still imposed in numerous funding schemes.

RDI roadmaps on industrial decarbonization 1-055-18

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Keywords
roadmaps, energy-intensive industry, primary energy

Industry is responsible for a significant share of energy consumption in Austria. It can be derived from the Austrian energy balance that the producing sector is responsible for 29 % of the national final energy consumption. The energy-intensive industries of Austria are to be found in the fields Iron and Steel, Non-ferrous metals, Pulp and paper, Chemical and petrochemical industries, Stones/Soils/Glass industries (including cement). This listing is coherent with the list of the unification of the German energy-intensive industry. The energy balance shows that these energy-intensive industries account for about two-thirds of the energy demand of the production sector and one-fifth of the total national energy demand.

The Austrian energy-intensive industry is one of the most energy-efficient in the world and has already invested in a variety of mitigating measures in the past. This is probably true for many other European industries. Further efficiency measures are a major challenge for companies, requiring high investments facing low payback times.

However, the current framework and policy conditions clearly require an ambitious increase in energy efficiency in the long term (2050). Thus, a rapidly advancing research and technology development is to be supported in order to generate economically justifiable energy efficiency potential. The questions raised by the conducted R&D roadmaps are: What are the – from the perspective of industry – pending/expected research needs for the increase in energy efficiency industry? And what are the pending/expected research needs for the integration of industrial processes with energy supply from fluctuating renewables?

In order to find out, we develop an R&D roadmap indicating the most promising fields of research for energy efficiency. In the workshops conducted, industry representatives define an ambitious vision for industries in 2050: Subject to the provision that "the framework conditions are right", their common vision foresees a high-efficient use of energy taking a holistic perspective. Given an attractiveness of the location for research and technological innovation, Austria (Europe) is a long-term secured industrial location. Based on a backcasting process, industrial stakeholders then defined necessary technologies and policies to reach this vision. Being very industry-specific, these generally include holistic approaches, e.g. exergetic, regional or life cycle issues.

Supplementary results: In the R&D roadmap on renewables in industry, we find similar optimism concerning the vision (subject to the provision that "the framework conditions are right") on the use of renewables in industrial processes (up to 100 %). However, we also find that there are not enough electricity potentials in Austria to electrify the whole industry and supply the rest of the economy. Austria does not have enough electricity storage potentials to supply its own demand. The Austrian energy system needs synthetic gases for storage and back-up capacities. Concerning overlaps with the efficiency roadmap, we find that the ability of buildings to use low-temperature excess heat is more important than their efficiency (primary energy efficiency) (this does not imply that building end-use efficiency should not be increased!).

The Swedish National Energy Efficiency Network Program for SMEs – a review of methodology and early experiences 1-072-18

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Keywords
SME, methodology, energy efficiency measures, energy efficiency networks, early experiences

Since 2015 the Swedish Energy Agency operates a national energy efficiency network program for small and medium sized enterprises (SMEs). The program will continue until 2020 and is a part of the Swedish Energy Agency's initiative to increase energy efficiency in SMEs.

Each network consists of 6 to 16 companies led by a network coordinator. The network is assigned an energy expert, which provides the companies with both individual counselling and group consultancy within energy efficiency issues. The networks operate on a common methodology based on energy management and theory behind learning networks. Energy efficiency networks in Switzerland, Germany and Sweden have served as inspiration when the methodology of the program was developed.

The aim of the program is to increase the participating company's knowledge regarding energy efficiency. After completing the project, the companies are expected to work with energy efficiency in a systematic and structured manner. Some may have chosen to implement energy management systems according to ISO 50001. The project goal is to decrease the energy consumption of companies with 15 % by 2020.

At the time of writing, 38 networks for SMEs have been established and so far, 320 companies have joined the program. The majority of the companies have conducted an energy audit and at the end of November, the companies are expected to present an action plan for their energy efficiency measures until 2020.

The aim of this abstract is to present early experiences regarding the network program and it's methodology. Among other things, these experiences include the process of recruiting companies as well as the process of the companies conducting their energy audits and action plans. Finally, a summary of the potential for energy efficiency and identified energy efficiency measures among the participating companies will be presented.

Energy efficiency networks – first results from the monitoring process 1-075-18

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Keywords
energy management

Energy efficiency networks are a main pillar of the German industrial energy efficiency policy mix. Within the initiative to establish 500 energy efficiency networks in Germany until 2020 a continuous monitoring process has been established to show the effectiveness and efficiency of the instrument.

The first monitoring cycle is scheduled for the end of the year 2017. About 30–40 networks have reached the end of their first operational cycle by then. Within the monitoring process, all implemented measures in these networks will be collected in a standardized process. For all measures, the classification and the savings are mandatory parameters, the provision of economic data such as related investments is voluntary. The achieved savings will be aggregated to show the achieved impact of the networks and their contribution to the overall savings target of the 500 networks initiative.

We will also compare these results to evaluations of the pilot project for the implementation of energy efficiency networks in Germany as well as comparable initiatives such as existing funding schemes or international approaches. So far other initiatives with energy efficiency networks in Europe have not been monitored in a comparable way.

Energy efficiency regulations for cement and paper industries based on maximum allowed specific energy consumption 1-085-18

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Keywords
energy efficiency regulation, specific energy consumption

In Taiwan, the industrial sector is the largest energy consumption sector and responsible for approximately 37 % of the country's total energy consumption. To improve the energy efficiency of the industrial sector, the Bureau of Energy in Taiwan issued energy efficiency regulations for six energy intensive industries. The energy efficiency regulations set the maximum allowed specific energy consumption (SEC), i.e., the total energy consumption per unit of product produced for cement and paper industries and stipulate the operating conditions of utility facilities for the other four energy intensive industries. The SEC for three systems of cement plants (raw material and clinker system, rotary kiln system, and grinding system) and for seven products of paper industries, including liner board and toilet tissue paper, are limited by the regulations. The value of the maximum allowed SEC is set equal to the upper 70th percentile of SEC in the same product category to compel the low energy efficiency plants to raise their performance.

The energy efficiency regulations for cement and paper industries came into force in 2015. From 2015 to 2016, the regulations for cement and paper industries controlled 20 cement plants and 27 paper plants and contributed toward the energy saving of 1,359 TJ, which was approximately 1.1 % of the total energy consumption of the cement and paper industries. According to a survey conducted in this study, 6 % of respondents from the cement plants and 54 % of respondents from the paper plants agreed that the energy efficiency regulation is an important impetus for improving plant energy efficiency. Furthermore, 77 % of the cement plants and 86 % of the paper plants thought the SEC of their products has been improved in the past three years.

Machine tools: 12 points – catching complexity in ecodesign 1-088-18

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Keywords
ecodesign, case studies, assessments, machine tools, points system

The saving potentials from the adoption of appropriate Ecodesign technologies have been shown to be significant; however, due to the increasing share of complex products or product systems in the Ecodesign work plan, the process of deriving prospective Ecodesign and Energy Labelling requirements is becoming progressively more challenging. Such complex products, as for example machine tools, are characterized by a high degree of heterogeneity and multiple functional units. A machine tool can thereby be defined as a fixed powered tool for cutting or shaping metal, wood, or other material. This could be for example a simple and small lathe or drilling machine as well as a large-scale and highly automated multi-spindle machine, which combines various technologies in one. In order to assess these complex products with regard to their potential benefits from Ecodesign and Energy Labelling requirements, this paper proposes a "points-system" based methodology that could be applied to the development of Ecodesign requirements for complex products and/or product systems. This approach has been elaborated for the European Commission within a technical assistance study. The starting point was a review and assessment of existing methods (for example LCA ISO 14040 and 14044, STRES, BREEAM, LEED, …) and their potential applicability for adaptation and use in the appraisal of Ecodesign requirements for complex products. Based on the findings a generic method consisting of 9 steps was developed. After defining a generic Ecodesign points-system approach for complex products the methodology was applied to the specific case of machine tools. This case is especially challenging, not only because of the complexity of the products but also because of the problem of defining a suitable reference system as benchmark. So far, some attempts have already been made without fully meeting

the requirements for a reference system. This paper demonstrates a methodological approach which enables this basic problem to be solved and a reference system defined regardless of the complexity of the specific machine tool being addressed. The methodology is applied to hypothetical machine in order to illustrate it. The main insights from this evaluation process and shared before the paper closes with a discussion of the benefits and boundaries of a "points system" approach for machine tools.

Energy efficiency networks: lessons learned from Germany 1-100-18

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Keywords
monitoring, assessments, evaluation, energy saving technologies, multiple benefits, energy management system, energy efficiency networks (EEN)

The energy efficiency network (EEN) concept was first developed in Switzerland in the late 1980s and was adopted in Germany in 2002. During a long pilot phase between 2002 and 2013, the lessons from 40 Learning EENs (LEENs) in Germany led to a certain format for regional EENs for SMEs and larger companies. By the end of 2014, the Energy Efficiency Network Initiative (IEEN) was launched as a voluntary agreement between the German government and currently 22 industrial and economic associations, to support the creation of 500 new EENs until the end of 2020. This paper reports on two aspects of EENs of companies in Germany:

1. The results of ongoing evaluations regarding German EENs following different operational formats in terms of duration, number of participants, network energy saving target, etc. The evaluations regard challenges and means to improve EEN-related work as well as first results of a rough assessment of the IEEN impacts regarding energy savings and emission reductions.
2. The long-term impacts on energy use, innovative activities and changed decision routines in participating companies of regional LEENs. This evaluation gives deep insights into achieved energy cost savings within an investment period, into the diffusion of efficiency-related knowledge into subsidiary companies within groups and into the reaction of machinery manufacturers and plant planners to the demand of more efficient solutions by network participants.

Finally, this paper concludes with an analysis of the lessons learned from German EENs including barriers and challenges to initiate EENs as well as suggestions to

improve EENs' promotion. The main finding is that EENs are not only a successful concept in terms of energy efficiency but it also offers multiple benefits to the participants such as innovative ideas for energy efficient solutions. However, a major challenge is to convince companies to join EENs.

Bridging the valley of death: A multi-staged multi-criteria decision support system for evaluating proposals for large-scale energy demonstration projects as public funding opportunities 1-111-18

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Keywords
multi-criteria decision support, demonstration projects, governmental support, funding

There is an increasing pressure that enhanced and novel energy technologies are swiftly adopted by the market to ensure meeting the energy and climate targets. An important issue with such novel developments is their risk to be stuck in the 'valley of death', i.e. that their transition to the market is delayed or unsuccessful. Publicly supported demonstration projects could help to bridge the valley of death by reducing barriers to the adoption caused by missing information and perceived risks. A challenge for technology demonstrations in the industrial context is their often high investments that are required to prove their real-world benefits. Given the magnitude of such investments, it becomes crucial that public funding focuses on the most promising demonstration proposals. Structured evaluation processes can help to facilitate the identification of promising proposals and to improve the quality and transparency of decisions. This paper deals with a corresponding multi-staged multi-criteria decision support system (DSS) suggested to the German Federal Ministry for Economic Affairs and Energy. It deals with the evaluation of demonstration proposals across three stages: The first stage represents a filtering stage to identify those proposals relevant for further considerations. The second stage comprises a multi-criteria scoring method drawing on an evaluation against nineteen criteria. The final third stage serves to critically review the need for public funding of well-scored proposals. This contribution outlines the development of the DSS and its design and thus provides insights on proposal evaluating in energy research.

EU member states energy efficiency policies for the industrial sector based on the NEEAPs analysis 1-113-18

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Keywords
EEES Directive (ESD), national energy efficiency action plans (NEEAPs), voluntary agreements, energy efficiency action plans

The EU has been promoting energy efficiency through a number of policies. However, only a few EU policies have been targeting the industrial sector, in particular the Ecodesign and the Energy Efficiency Directive (EED), mainly with Articles 7 and 8. In addition, EU climate policies (specifically the EU Emission Trading scheme (ETS)) have also contributed to improving energy efficiency in industry. EU Member States (MSs) have since a long time introduced policies at national level to promote energy efficiency in industry, in particular voluntary agreements (Sweden, Finland, The Netherlands, etc.) and energy audits.

Under the Energy Service Directive (ESD) initially and then under the EED, MSs have been required to submit National Energy Efficiency Plans (NEEAPs) to the European Commission every three years since 2008. The NEEAPs describe the present and planned policies in the different sectors, including industry, in order to reach the 2020 energy efficiency targets. Under the EED the NEEAPs also contain an evaluation of the energy savings achieved.

There are several national policies in the industrial sector described in the NEEAPs. The paper analyses energy consumption trends in industry, the major national energy efficiency policies in MSs (classified under different categories, e.g.: voluntary agreements, training, audits, financial incentives, energy company obligations, etc.) based on the most recent NEEAPs of 2017.

EU 28 industry policies – the EED three years later 1-116-18

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Keywords
Energy Efficiency Directive (EED), national energy efficiency action plans (NEEAPs), energy audit, energy management system

Accounting for more than 25 % of the whole EU-28 final energy consumption in 2015 and coming in second place right after the transport sector as one of the most energy consuming sectors, industry has come a long way in the past years in terms of reducing its environmental impact, with a decrease of 17.6 % on energy consumption in the 2000–2015 period. Although some of this decrease may be associated to economic factors, there is a great part of this effort that is due to both the push being done by the private sector in order to stay competitive and from the policy measures being implemented by the Member States in which the industry operates.

The Energy Efficiency Directive (EED) has now been published since 2012, with its majority fully transposed into national legislation, in all EU-28, since 2014, which represented also the timing of the first National Energy Efficiency Action Plans (NEEAPs) under the EED. Three years after, the European Union Member States have produced its second NEEAPs under the EED. This paper focuses on the industry measures being proposed by the EU-28, evaluating the changes between the action plans, what type of measures are being proposed and analyzing its potential impact in different scenarios. An overview of the status of the transposition of Article 8 of the EED will also be presented.

French SMEs: towards carbon neutrality 1-117-18

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Keywords
small and medium-sized enterprises, framework, domestic policies and measures, carbon neutral

The world economy has to become neutral in carbon emissions around the middle of the century. This is what IPCC demands in order to respect the goal of limiting global warming "well under 2 °C". For the target of 1.5 °C the ambition is even more stringent. This means carbon neutrality for all firms in a short time.

Present policies concentrate mainly on larger firms. Such firms are already involved in complex precedures such as EU quotas, with in-house specialized staff. This makes sense for policymakers, because these firms represent over 80 % of emissions. But carbon neutral means not only removing tons from the country balance, it leads also to stopping emissions of any firm.

Small firms represent 99.8 % of the total, with about 50 % of employment. It is thus essential that SMEs become involved by the carbon regime, beyond goodwill and green labels. New instruments have to be implemented so that carbon neutrality become a winning strategy.

How to adapt existing policies such as research, subsidies and fiscal policy? What carbon accounting will be adapted to SMEs and how will it be reported? What is the role of sectors and professions and what responsibility can be devolved directly to the small firm? Can small firms become early adopters of carbon free technology and practice? Finally, what perimeter should be considered when dealing with small firms? In particular, should the downstream productions be considered including emissions incurred by the consumer of the service or the product? Is the aim of de-carbonization an enabler of larger change such as the circular economy or de-materialization?

The presentation will build on the debates held in the French Social, Economic and Environmental Council (CESE), an advisory body of Professionals, Unions and NGOs. The CESE constitutes the third assembly of the French Republic.

Effects of the energy audit obligation for large companies in Germany 1-121-18

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Keywords
energy audit, energy management system, energy management, energy efficiency action plans, evaluation

In February 2015 the German Government enacted a law which targets non-SMEs in order to implement the EU Energy Efficiency Directive of 2012. According to the EU definition non-SMEs are companies or institutions with more than 250 employees or 50 million Euro turnover. They were obliged either to complete an energy audit by the end of 2015 or to introduce a certified energy management system by the end of 2016.

A very early evaluation of the measure was commissioned in autumn 2016. Its aim was to determine energy savings, reduction of emissions, investment and administrative expenses for the companies as well as effects on the German energy service market. An online survey has been carried out with 462 companies which have completed an energy audit and 403 which have introduced a certified energy or environmental management system. The quantitative impact of the law was extrapolated to Germany. The questionnaire covered the quantitative data mentioned but also aspects such as quality of the audits and reports, involvement of external or internal experts, management elements implemented, qualitative impacts and side effects.

Most of the companies surveyed would not have completed an energy audit without the law. About half of the companies, which had introduced a management system, did it before the Act came into force, in order to benefit from the exemption of eco taxes for energy-intensive enterprises. With regard to the audit performance not all quality criteria were met and the audit reports often covered only part of the elements specified in the EN 16247-1 standard. However most of the respondents were very or quite satisfied with the audits including the reports.

The extrapolation to the whole country resulted in energy savings between 14 PJ and 30 PJ by 2020 which amounts to 1 to 2 % of the final energy consumed by non-SMEs. Insofar the expectations of 50.5 PJ by the German Government were only partially fulfilled.

Non-energy benefits of Swedish energy efficiency policy instruments – a three-levelled perspective 1-132-18

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Keywords
non-energy benefits (NEBs), policy instruments, energy audit

Industrial energy efficiency (EE) is widely recognised to be one of the most important means for achieving environmental sustainability. However, a large share – up to 50 % – of the potential for EE in industry is still untapped. Previous studies have shown that there are potential additional effects beyond energy savings, referred to as non-energy benefits (NEBs), such as improvements in relation to production, operation and maintenance, the work environment or the external environment. Nevertheless, there is a need to fill a knowledge gap about how NEBs can be communicated to industries and how they are linked to policy instruments (PIs) for improving industrial EE. In Sweden, several PIs have been launched with the aim of improving EE. The Swedish Environmental Code (MB), the Act on Energy Audits (EKL), the Swedish Energy Audit Programme (EKS) and Industrial Energy Efficiency Networks (networks) are examples of PIs that are in use in Swedish businesses, and they are the focus of this paper. The aim of this study was to map the NEBs arising as a result of Swedish PIs for EE measures in the industrial sector. In-depth interviews were held with administrators, energy auditors and companies about the four PIs to investigate how NEBs are perceived by actors at these levels. Results showed a variety of NEBs identified for the various PIs and revealed that NEBs were generally perceived positively by the interviewees. Moreover, the results also revealed that it is difficult to directly link one NEB to a specific PI. Administrators tend to be those who are most aware of NEBs and work actively with the concept, while energy auditors and companies were somewhat less aware.

PANEL 2

Sustainable production towards a circular economy

Excess heat recovery potentials in Swiss industrial systems 2-006-18

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Keywords
heat recovery, industrial processes, energy savings potential, energy and exergy efficiency, heat maps

The share of energy demand for process heat is typically 70 % of the total final energy demand in industry. A significant amount of heat leaves process heating systems through the walls of heat generation and transfer devices and via exhausts and effluents, all termed excess heat. There is a large potential for excess heat recovery in industry worldwide that could be used to substitute part of the process heat demand but there is limited understanding of the size of this potential heat source and on the recovery potential. This study aims to identify excess heat recovery potentials in Swiss industrial process heating systems through exergy and energy analyses. The overall mean energy and exergy efficiencies of the Swiss industrial sector were estimated at 61 % and 28 % respectively. The gap between the high quality energy input and the comparatively low temperature process heat requirement explains the destruction of exergy. The total amount of excess heat that can potentially be recovered is estimated at 15 PJ p.a. This amount corresponds to 12 % and 24 %, respectively, of the total final energy and total process heat demand of Swiss industry in 2015. This study also aims to provide an overview of the spatial distribution of the process heat demand by energy carrier and the excess heat recovery potential by temperature level in Swiss industry. These maps highlight different areas of the country with high levels of excess heat and can serve as basis for analyzing potential district heating networks.

Transforming energy productivity in value chains 2-011-18

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Keywords
value chain, innovation, business models, energy productivity, transforming markets

This presentation will provide a review of the work A2EP is leading, using an innovative value chain methodology to define the major opportunities for transforming energy use. This promises to provide a major change in the way we look at energy through the lens of the effectiveness of energy application to deliver the end services required. By systematically examining the end service and how it is best delivered along the supply chain from end user back to initiation, integrating examination of energy and material flows, we have been able to define the key opportunities to improve energy productivity. We then group these opportunities into transformative themes and define a path to implementation and then facilitate that change.

The presentation will show the principles of this methodology, and then demonstrate how we are implementing our approach in the food value chain to accelerate the introduction of these new business models and technologies. We are carrying the process through from concept to demonstration and/or handover to accelerators to further commercialise the IP and take it to market. An example is our work on real time tracking of food through the cold chain from farm to supermarket, and how this will enable reductions in food waste and significant improvements in energy use across the chain. Another example is our work to replace steam in industry with point of end use electro-technologies (which we call 'moving from industry 1.0 to 4.0'.)

Energy efficiency for a sustainable industry: energy saving potential for Italian manufacturing sectors and impact of energy efficiency measures on economic performance and competitiveness of enterprises 2-024-18

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Keywords
energy-intensive industry, sustainability, competitiveness, pulp and paper industry, energy savings potential, glass industry, sustainability

Italian industry is responsible for nearly one third of domestic final energy consumption and therefore it has a fundamental role in achieving the compelling EU 2030 targets for greenhouse emissions and energy efficiency. Moreover, Italian industry is facing the increasing competitiveness of emerging economies. Since energy and environmental externalities can affect even 50 % of production costs, the carbon leakage risk is more real than ever and it threatens the ability of enterprises to survive in international markets.

In this challenging context, RSE is carrying out the project InduCO (Industry – energy Consumption – Optimization), which aims at investigating how energy efficiency can help industries to address virtuously energy performance, competitiveness and environmental impact. The study is based on the analysis of over 2,500 energy efficiency measures implemented in Italian industries in the last 10 years. The purpose is to identify the best practices and estimate the energy saving potential achievable by each industrial sector, according to technical feasibility and economic sustainability criteria. Finally, the study investigates the impact of energy efficiency on economic performance and competitiveness of enterprises.

In this paper methodology and results of the study are presented for two energy intensive manufacturing sectors: paper and glass.

Assessing the heat pump market in the industry 2-026-18

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Keywords
heat pump, waste heat

In the French Industry, the energy lost through waste heat accounts for roughly 25 % of its total energy consumption. Though recognized as of significant potential for recovery, heat wastes are at 50 % concentrated in low level temperature wastes, below 100 °C, too cold to be directly used through a heat exchanger for most industrial processes. Hence, EDF contributed to the development of heat pumps that were segmented in this study in three levels of maximum condensing temperature: 70 °C (HP 1), 100 °C (HP 2) and 150 °C (HP 3).

This paper proposes a three steps method to evaluate the potential of heat recovery with HPs in France for each industry sector and under consideration of technological and economic constraints.

In the first step, we build an indicator to show the statistical potential of each HP by cross referencing a heat waste with a heat consumption database taking into account the relevance of the HP compared to a heat exchanger, and the HP coverable share of the needs. In the second step, heat wastes and industrial processes are identified and matched to validate the technical feasibility of an HP. The third step consolidates the results by confronting them to the field: industrial references, energy audits and on-site visits.

This paper presents the results for HP1. The potential for this HP in the Malting sector (NACE 11.06Z) particularly stands out. Most of the heat needs come from drying: the malt's humidity is reduced from 45 % down to 5 % at a temperature range from 60 to 85 °C, generating heat wastes. The HP is integrated into the drying process recovering the hot exhausted vapour and using its remaining heat to fuel back the dryer. The malting industry counts at least two important references in France in Strasbourg and Vitry le François. For each 100 tons of product, the HP can roughly save 60 MWh of gas and consumes an additional 12.5 MWh of electricity preventing 2 tons of CO_2 emissions.

Compressed air systems: factors affecting the adoption of measures for improved efficiency 2-040-18

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Keywords
energy efficiency measures, compressed air, manufacturing, industrial energy saving, decision-making process

The sustainability and competitiveness of industrial activities may strongly rely on increased energy efficiency. In that, compressed air could be one of the most expensive forms of energy in industry because of its low efficiency. Nonetheless, compressed air is widely used, and is considered as relevant in many facilities, accounting for even more than ten per cent of industrial electricity consumption in the EU, in US and in China. Moreover, it should be noted that the life-cycle cost of a compressed air system is mostly covered by the operating costs, so that most of the measures to lower energy consumption pay for themselves almost immediately, producing relevant monetary savings. Nevertheless, several studies show that the adoption rate of such Energy Efficiency Measures (EEMs) is still low. For this reason, we have carefully reviewed scientific and industrial literature over EEMs for Compressed Air Systems (CAS), so to get useful insights into the main factors leading to their adoption. Our study lays a good foundation for a novel framework aimed at describing and characterising EEMs in CAS, revealing that, so far scientific and industrial literature has mostly presented energy and economic factors, thus giving little room to other factors that still could be quite relevant for an effective EEM adoption, such as compatibility of the measure within the production system (e.g., adaptability to different conditions, presence of different pressure loads), complexity of the production system (e.g., accessibility for operational activities, expertise required for implementation), observability of the performance (e.g., impact on air quality and/or safety). The framework could result in a valuable tool offering different perspectives in the decision-making of industrial managers and technology suppliers, as well as industrial policy-makers.

A supply chain model with integrated thermal recovery and electricity generation from industrial waste heat 2-045-18

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Keywords
supply chains, industrial symbiosis, waste heat recovery, sustainable production

The industrial sector is the most energy-demanding activity in modern societies, consuming about 54 % of the world's total delivered energy. The largest amount of waste heat in the industry sector is generated by energy-intensive processes, such as the manufacturing of food, paper, basic metals (e.g. iron and steel), chemicals, and non-metallic minerals. Among these, the metal industry, which includes iron and steel manufacturing, aluminium production, and metal casting, covers a great share of the overall energy consumption, and present large energy efficiency potentials. In these processes, the opportunity to recover waste heat represent an effective way to reduce both energy costs and greenhouse gas emissions. Recent research streams focused on the potential of supply chain management, and of integrated network in enhancing the outcomes of energy efficiency measures. A few works analysed the opportunity to recover energy from excess heat in integrated systems, mainly focusing on active applications for the generation of electricity. In this study, this approach is extended by formulating a supply chain inventory model with integrated waste heat recovery from the exhaust gases generated by energy intensive processes. The decision-making process is firstly modelled as a decentralized policy in which the two actors aim to minimize their own total costs, and then as a centralized policy in which the actors cooperate in order to optimize the economic performance of the supply chain. The decision variables of the model are the lot size, the number of shipment from the vendor to the buyer, and the amount and use of recovered energy.

Increasing the value stream mapping potential in an industrial process, with a dynamic model, based on data from an industrial ethernet bus 2-059-18

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Keywords
energy-intensive industry, lean manufacturing, internet of things (IoT), robotics, industrial internet of things (IIoT), value stream map (VSM), Industry 4.0

The paper focuses on one of the main tools of Lean Manufacturing implementation, and namely the method called Value Stream Mapping (VSM), which aims at describing the factory as a Value streaming throughout the sequential process phases from raw material to the packaged final product. The case here referenced to is concerned with a roof tiles factory, and the goal is mostly towards identifying any waste in the production operation and improving energy efficiency.

The VSM is a visual tool intended to give a vivid representation of the real process, therefore making it easy to identify possible bottlenecks or waste. It takes advantage from a comparison in a unique map of three lines representing the flux of material, the flux of information and the time line. It is considered as an excellent starting point to exploit the process evolution. Nonetheless, the modern technology in industrial automation makes it available a quantity of digital information in real time, so that a VSM could be significantly enriched and become a more powerful tool that can be used even in further phases of the industrial operation, including diagnostics and energy efficiency improvement. The paper presents a VSM companion, in form of an Excel based dynamic model, which is able to collect, organize and process the main data related to the process. The data are collected from a standard communication Ethernet bus, running throughout the plant, with a time interval as low as order of minutes or even seconds, so that only a proper and ordered storage can make them useful. Characteristics of such model are modularity and expandability. Examples of its use are therefore reported, such as calculation of the best distribution of industrial cycles during the year, or minimization of the energy expenses at a given production rate.

The result is a VSM that keeps the advantages of its qualitative representation of a process, while allowing, when necessary, a quite simple implementation of a quantitative and dynamical simulation.

Rethinking steelmaking: zero-emissions and flexibility with hydrogen direct reduction 2-064-18

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Keywords
steel, energy-intensive industry, hydrogen, decarbonisation, zero-carbon technologies

The steel industry faces the big challenge of reducing its CO_2 emissions to zero and breakthrough technologies are needed alongside efficiency and demand reduction measures in order to meet decarbonisation goals (Lechtenböhmer et al (2016), Worrell and Carreon (2017), Fischedick et al (2014)). Several European R&D projects are now looking into the possibility of using hydrogen for steel production. In Sweden the HYBRIT initiative aims at developing an entire fossil-free value chain for steel on the basis of hydrogen direct reduction (H-DR) and electrolysis.

Hydrogen direct reduction is a relatively unexplored process. The principle behind H-DR is to operate a natural gas based direct reduction with hydrogen from electrolysis instead, a changeover which has not been demonstrated industrially up to now. We analyse the energy efficiency and energy demand of the H-DR process and discuss the consequences for business opportunities and energy system integration. We use a previously developed chemical process model to evaluate different operational strategies.

We show that hydrogen-based steelmaking requires less energy than the incumbent blast furnace route, but instead of coal, oil and natural gas the process is based on electricity and renewable heat. The electrolyser is the largest energy consumer in the process, which makes its efficiency a crucial parameter for both energy efficiency and production cost. In addition we highlight several parts of the process which require high-temperature heat, which should be supplied from renewable sources to be in line with the Paris accord.

Our results show that H-DR can be competitive with the blast furnace at today's electricity prices plus a carbon price of €50/tCO_2. The main driver of production cost is electricity cost. The H-DR process is highly flexible because it bridges ore-based and scrap-based steelmaking. Furthermore, the storage of hydrogen and hot-briquetted iron enables a continuous steel output while reducing the load in parts of the process. The high degree of flexibility can be used by steelmakers to adapt to developments in the markets for electricity, scrap and iron ore by engaging in grid balancing services and active participation in electricity markets. Thus, hydrogen steelmaking opens doors to new business areas and intensified integration of the steel industry into the energy system.

What about heat integration? Quantifying energy saving potentials for Germany 2-066-18

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Kewords
waste heat recovery, energy savings potential, industrial symbiosis

Industry accounts for approximately 30 % of the final energy demand in Germany. 75 % of this is used to provide heat. A quite substantial fraction of this heat leaves processes and factories unused. Current bottom-up estimations indicate that the available excess heat potential in Germany equals up to 13 % of industrials fuel consumption. The most common approach to utilize excess heat is to recover it for heating up other processes, also known as heat integration. However, heat integration within a company requires the presence of heat demands with lower temperatures than the temperature of the excess heat currently unused. If this is not given, inter-company heat integration offers an alternative. Nevertheless, up to now there is no quantification of energy saving potentials for heat integration at all, or inter-company heat integration in particular. Thus, we make a start by applying a top-down cascade approach for Germany.

First, we estimate excess heat potentials differentiated by industry sectors and temperature intervals for Germany using a top-down approach. Therefore, we use energy balances for Germany differentiating heat demand by industry sector and temperature intervals.

Second, we calculate which fraction of the excess heat is usable within the industry sector it comes from. Therefore, we balance cascade like excess heat and heat demand at lower temperature levels in the same sector, which results in the energy saving by intra-company heat integration.

The previous step leads to the conclusion that some industry sectors have still excess heat after the cascade balancing and some don't. Consequently, we calculate how much of this excess heat can still be used to heat up demands at lower temperatures in other industry sectors as a third step.

Adding up energy saving potentials by intra- and inter-company heat integration, the final results indicate energy saving potentials of roughly 11 % referred to industrials final energy demand in Germany.

Integrated energy management in digital enterprise 2-073-18

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Keywords
industrial energy saving, energy management system, energy management, analytics, VDMA standard, SIMATIC energy management

Digitalization enables companies to transform their enterprise and to optimize their value chain in regard to shorter time-to-market, higher flexibility, better quality and increased efficiency. Energy efficiency is one additional optimization criterion in this value chain – from product design and production planning up to engineering and production phase.

The digital twin of a plant can be used in many ways to simulate and optimize all aspects of plant operation, including in regard to energy efficiency. In engineering- and operation phase, integrated energy management from machine up to enterprise level is an important leaver to achieve higher energy efficiency in a digitalized production environment. Important enablers are integrated metering hardware and integrated engineering – one standard engineering software for automation as well as energy management.

Based on that and by means of seamless vertical integration a transparent operation is possible for immediate reaction and continuous optimization. A very concrete example is the Siemens S7 Energy Efficiency-Monitor for machines: This software monitors the efficiency of production machines in discrete manufacturing. An easy-to-use solution which offers an intelligent, vendor-independent energy evaluation of machines during operation on shop floor including easy-to-use energy acceptance test, which makes it also attractive for machine builders.

Digitalization is the enabler for integrated energy management in the digital enterprise, energy efficiency as new DNA in each step of the value chain.

Towards zero-CO_2 production and practices in the supply chains for buildings and infrastructure – first experiences from a Swedish case study 2-082-18

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Keywords
construction industry, supply chains, climate change mitigation, buildings, infrastructure, greenhouse gas emission reduction, policies and measures, cement, steel

This paper reports from initial case study work, with the aim to analyse transformative roadmaps for the supply chains for buildings and transportation infrastructure. The work is part of the Mistra Carbon Exit research programme, which addresses and identifies the technical, economic and political challenges for Sweden to reach the target of net zero greenhouse-gas emissions by 2045. The case study work gathers some 30 stakeholders, along the supply chain from building materials to end products in the form of buildings and infrastructure. The work is structured as a participatory integrated assessment and this paper provides an analysis based on the first stages of the assessment process. The aim of the first participatory workshop and case study meetings was to capture a wide range of perspectives with regards means available to tackle the challenge of radically reducing the climate impact from the building and infrastructure sector. This includes exploring:

1. Measures/tools to realise the potential of a 50 % reduction in the climate impacts from building and infrastructure construction processes that have been shown to exist already today, and,
2. Measures/tools to accelerate the transition towards zero-emission production and practices in the supply chains from raw materials to completed buildings and infrastructure.

The outcomes from the first stages of the case study work show the importance of:

- Increasing coordination and collaboration along the supply chains, so as to facilitate collective action among stakeholders in the supply chain from basic materials to buildings and infrastructure. This will include developing a common understanding, language and framework among the stakeholders.

- Public actors taking the lead in the transformation, for example by means of innovative procurement practices
- Establishing markets for zero-CO_2 products and services, both for tapping the potential for early mitigation and for developing and deploying transformative shifts in production and practices, including: i) financing and de-risking investment in transformative technologies, ii) pricing emissions and de-meriting use/production of CO_2-intensive products, and iii) incentivizing demand reduction and substitution of materials.

What to do with industrial waste heat considering a water-energy nexus perspective 2-083-18

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Keywords
district heating, waste heat recovery, water energy nexus, water footprint

It is generally accepted that waste heat recovery from industrial processes is an enabler of energy efficiency and CO_2 emission reduction. Options for industrial waste heat recovery include power generation, heat upgrading, and distribution through district energy networks to meet a remote heating demand. Particularly in presence of subsidies, even technologies with relatively low conversion efficiencies may become feasible. In the last few years, however, novel concerns arose as to the links between primary energy consumption, carbon equivalent emissions and blue water consumption. The water-energy nexus concept is well known in energy planning and in water infrastructure planning, has been however hardly examined in the industrial sector. In a recent work, the impact of an industrial absorption cooling project based on waste heat recovery on both energy and bluewater consumption has been evaluated for the EU-15. It was found that, depending on the national energy mix and market situation, alternatives with higher energy savings but increased water consumption compared with baseline operation were preferred in some countries. Building upon that study, in this paper the water footprint of district heating options for recovering low grade industrial waste heat is investigated. The sum of direct and indirect bluewater consumption, carbon emissions and primary energy demand are evaluated. A parametric study of economic feasibility is performed in order to evaluate under which circumstances the additional water and carbon footprint, produced by district energy systems construction and operation, is offset by the reduction in fossil fuel consumption, caused by the substitution of remote boilers. Switching values and trade off curves are presented and a comparison is drawn between district heating technologies, and energy conversion via Organic Rankine Cycles, so as to answer the research question posed in the title.

A case study on the analysis of an injection moulding machine energy data sets for improving energy and production management 2-097-18

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Keywords
data, industry 4.0, injection moulding, industrial energy saving, industrial SME

Energy consumption is a concern worldwide, and energy efficiency approaches are among the pillars of Sustainable Manufacturing nowadays. Additionally, the industrial sector accounts for the largest share of energy use, being responsible for roughly 30 % of all energy consumption worldwide. Due to developing and more restrict regulations towards energy efficiency, investing in this area presents big opportunities for industry such as reducing costs, increasing productivity and a significant reduction in environmental impact. Unfortunately, this engagement is still far from the desired level of development in many companies, especially small to medium enterprises (SMEs), who usually do not have the in-house expertise or the correct resources for applying such techniques.

However, with the developing technologies in industrial sector and the growth in the processing and storage capacity of IT equipment, industry has entered the age of "Big Data", where data collection and analysis play a major role in this scenario to acquire further knowledges towards energy efficiency and a better understanding of the production processes.

A study was carried out on a Thermoplastic Injection Moulding company, which segment is known for having an intense electrical energy usage given the nature of its production stages. In order to determine the productive and non-productive electrical energy embodied in manufacturing operations and get a better understanding of the production processes, an analysis based on the Machines' time series data streams and some extra information about the processes was made. The outputs result in a better understanding of the machine's electrical consumption, and provide insights regarding potential saving strategies and improvements on the production side such as better scheduling, improved production tracking, operator engagement and equipment efficiency.

Developing a georeferenced database of energy-intensive industry plants for estimation of excess heat potentials 2-098-18

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Keywords
database, excess heat, industrial processes, waste heat recovery, spatial analysis

Industrial excess heat may be one of the pillars needed to transform the energy system. Integrating excess heat in district heating networks can reduce the primary energy demand of the heating sector. Thus, industrial sites need to be analysed in high spatial resolution with regard to heating demand and excess heat potentials. This paper presents a methodology to estimate site-specific excess heat potentials for industrial plants in Europe. Different data sources are matched and analysed to collect information about CO_2 emissions, subsector (NACE and ETS activity), process and production capacity per site in the EU28, Switzerland and Norway. From this dataset of energy-intensive industries (steel, paper, cement and glass), the fuel demand is calculated for each site and process. Two different approaches are used to calculate the fuel demand: first, based on the CO_2 emissions, and second, the production capacity in tonnes per year of each site. These two approaches are compared and their accuracy is analysed. In this paper, the excess heat potentials for the most important industrial sectors in Europe are estimated based on process-specific fuel demand for different temperature levels.

Measuring multiple benefits for energy efficiency in the industrial sector 2-112-18

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Keywords
multiple benefits, energy efficiency policy, energy efficiency indicator, top-down evaluation methods, bottom-up analysis

In previous work we developed a comprehensive indicator set for measuring multiple benefits of energy efficiency (MB-EE). The aim is to complement the harmonised approach to energy efficiency indicators and policies which is realised through the ODYSSEE-MURE project (www.odyssee-mure.eu) with an indicator set measuring Multiple Benefits.

We focus in this paper on indicators to characterise MB which are relevant for the energy efficiency industry at the macro-level and, hence, also the whole economy:

- MB indicators describing innovation and competitiveness triggered by EE (e.g. impacts related to innovative EE technologies and foreign trade with EE technologies)
- Turnover achieved through energy savings, which makes relevant contributions to the economic development of a country.
- Macro-economic impacts from EE, in particular impacts on economic growth and employment

We discuss the methodological approach to the indicator set, the underlying data sources and limitations. This indicator set is applied for EU28 countries or a subset of countries. Knowledge made available in new tools and projects, such as the ODYSSEE-MURE facility on multiple benefits should therefore be made easily accessible for the policy level and be used by policy makers when evaluating the impacts of energy efficiency policies.

Perspectives for digitising energy-intensive industries – findings from the European iron and steel industry 2-118-18

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Keywords
digital, energy efficiency improvements, steel, energy-intensive industry, industry 4.0

Industry has to contribute substantially to the low-carbon transformation if carbon dioxide reduction targets of 80 % to 95 % are to be met. Energy-intensive industries like the steel industry play a major role in this transformation since energy-intensive industries account for about 75 % of total industrial carbon dioxide emissions (e.g. IEA, 2009). Digitalisation or Industry 4.0 might substantially affect the way the steel industry operates. Digitalisation could strongly affect production processes, it might lead to fundamental changes in the use of labour and it might turn upside down the structure of entire companies. Visions for factories of the future include concepts such as *one site – one tablet – one worker*, *zero-waste-production* and *complete recycling*. Such major changes are likely to affect energy efficiency, as well. Studies on the current state and future implications of digitalisation in the steel industry are scarce. This contribution reviews policy activities, R&D projects and activities as well as patents in the field of digitalising the European steel industry. The contribution concludes with a qualitative impact assessment of digitalisation's impact on energy efficiency.

Industry 4.0 – can we get from a big buzzword and play for the big ones to a big market? 2-131-18

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Keywords
sustainable production, early markets, connected factory

Industry 4.0 is a big buzzword and a promise. But what is behind, currently and in the future? How can it boost efficiency and zero carbon performance? And how can we get it from a play for the big ones (only?) to a truly big market?

When we looked at the four principles of Industry 4.0 – interoperability, information transparency, technical assistance and decentralized decisions – we asked customers if they truly thought they needed all of these areas to be covered. Most of the mid-market/SME customers do not have large budgets to spend on the transition to a full Industry 4.0 world today, but they still want to participate in the digital world and benefit from both, operational excellence and improved environmental performance. What if they could benefit from e.g. 80 % of the functionality of the digitisation of their manufacturing processes but at only 20 % of the cost? And this market and its impact on the EUs energy use and carbon emissions is truly big, with SMEs representing 99 % of European businesses.

In the presentation we will share E.ON's current view and beliefs on this topic and describe research we are doing with industry and scientific partners and projects we do with our clients.

PANEL 3

Energy management: the nuts and bolts

The evolution of energy managers in the last 25 years: the Italian experience 3-019-18

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Keywords
energy management, energy management system, ISO 50001, non-energy benefits (NEBs), certification, energy manager, supply chain

Since 1991 in Italy it is mandatory to appoint an energy manager for every industrial organization with an annual consumption of more than 10,000 toe (ton of oil equivalent) and for organizations from other sectors over 1,000 toe (listed as one of the 10 EU best practices by the EE Watch project).

In almost 25 years the energy market and the awareness about energy efficiency have dramatically changed. Environmental concerns, strong policies to promote energy efficiency, and transformations such as the liberalization of the energy markets, the high-energy prices in the period 2005–2014, and the effects of the global crisis, are the main reasons behind the gain in importance of energy management among enterprises and public bodies.

In Italy, this leaded to the recognition of the importance of qualified energy managers within the organizations. The energy management expert, a skilled and certified professional according to the Italian standard UNI CEI 11339, was thus introduced in 2009 and many energy managers opted for the certification. Around two thousand energy management experts were certified by the end of 2017.

The introduction of energy management systems (EMS) through the EN 16001 and the ISO 50001 standards started a deeper change in the role of energy managers. By the end of 2017 there were almost 1,500 ISO 50001 certified sites in Italy. EMSs both improve the role of energy managers and start a change management process: such organizations are more like to recognize the importance of resource efficiency all over the value chain and in connection with the value proposition.

This paper is based on four surveys conducted in 2016 and 2017 and a study focusing on non-energy effects, resource efficiency, supply chain transformation, and industry 4.0. The outcomes show how companies are facing the challenges posed by the Paris Agreement on climate change.

Towards a sustainable agro-food INDUstry: Capacity building programmes in energy Efficiency 3-031-18

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Keywords
capacity building, behavioural change, organisation behaviour, food and drink, design

The presentation will address proceedings from the H2020 project INDUCE, that will start early 2018. INDUCE will develop an open access platform (INDUCE toolkit) where training material, online lessons, guidelines and tools will be available for companies aiming to increase their energy efficiency. INDUCE methodology will be integrated in the platform, with the objective to design a specific capacity building programme for every company accessing INDUCE toolkit, resulting in ad-hoc training adapted to the company's needs and opportunities.

INDUCE methodology will link knowledge transfer on energy efficiency with behavioural and organizational change models in order to help companies establish an energy efficient culture, in which employees are motivated and enabled to contribute to sustainability. The methodology will follow a Human-Centred Design approach, in which every phase will be conducted in close cooperation with the end users of the capacity building programme. This will enable INDUCE to interact and test together with the companies the best interventions, measures, and instruments.

INDUCE methodology and toolkit will be tested and validated in 15 pilot companies from the food and beverage sector, in four countries that represent over 45 % of the EU companies in this sector: Spain, France, the Netherlands and Germany. Next, a community of trainers will be established by certifying 60 INDUCE trainers. They will be in charge of implementing INDUCE methodology in another 300 companies, hence increasing INDUCE impact up to 106 GWh/year of energy savings.

INDUCE consortium includes three well-known research centres with expertise in energy efficiency, behavioural science, and decision-making processes. In addition, a partner in charge of training at national level and an association as multiplier organization are involved in every pilot country. The consortium is completed by a research oriented SME focussed on exploitation and dissemination.

EnPI-Connect: monitoring energy performance across the supply chain 3-034-18

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Keywords
ISO 50001, energy performance

We are presenting the Project ''EnPI-Connect'', that we carry out on behalf of the German Federal Ministry for the Environment (BMUB) in collaboration with the companies Mercedes-Benz Berlin, Stockmeyer and City Clean. EnPI-Connect aims at sharpening the monitoring process within energy management. It takes ISO 50006 and principles of IPMVP into account. EnPI-Connect demonstrates how:

- Energy Performance can be effectively monitored. Instead of monitoring the impact of energy performance, companies usually monitor the change of energy efficiency. But Energy efficiency is not only influenced by energy performance (the actions we take to improve efficiency). External influences (e. g. climate conditions, resource quality) can have a huge impact, too. EnPI-Connect demonstrates how to establish useful EnPIs and monitoring mechanisms that allow distinguishing the impacts of measures a company took from the impact of external influences.
- Unsuspected declines in energy efficiency can be detected at once. Realization of measures is no guarantee that energy efficiency improvements are preserved in the long run. Most companies don't have mechanisms that allow early detection of unsuspected efficiency declines. As a result, efficiency declines often remain unnoticed. EnPI-Connect helps implementing early detection mechanisms that allow companies to take early action as soon as a system falls back behind its efficiency potential.
- EnPIs for supply chains can be aggregated from Indicators on system level. Usually EnPIs and energy targets for supply chains and for systems of that supply chain are defined unconnected from each other. It is unclear how improvements on system level affect the supply chain. This leads to inconsistency in targeting and monitoring. EnPI-Connect shows how EnPIs on system level can be aggregated to EnPIs for a supply chain. This allows consistency in planning energy saving targets and monitoring on system level and for the supply chain.

Energy value stream methods with auxiliary systems 3-043-18

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Keywords
energy saving methodology, value stream mapping, auxiliary systems

The energy and costs reduction are crucial in industries, especially in energy-intensive firms, due to the increase of the competitive pressure and environmental awareness. Moreover, in the recent years many researchers and practitioners have strived to implement Lean Production methods in order to reduce wastes and improve the production performances of industrial systems. This research is focused on the application of Value Stream Mapping (VSM) method to energy consumption, named Energy Value Stream Mapping (EVSM).

This research begins with a literature review on the EVSM methods, in order to identify the common and different characteristics and to evaluate the applicability of these methods in the real industrial context. The analysis of these characteristics reveals few attentions to auxiliary systems, even if often they play a significant role from the energy point of view for several energy-intensive firms.

In order to fill this gap, we introduce a new method, which permits to identify corrective actions from the current state map observation including the energy consumption of the auxiliary systems. In particular, we draw a new energy line, named auxiliary energy line, which shows explicitly the energy consumption of the auxiliary systems. The overlapping of the process energy line and auxiliary energy line permits to identify immediately corrective actions (e.g. better synchronisation between manufacturing processes and auxiliary systems). In order to explain the proposed method, we show its application to an energy intensive process.

Energy-efficient business programme klimaaktiv supports Austrian industrial SMEs 3-047-18

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Keywords
energy management, energy audit, system optimisation, training, audit guidelines, cross-sectoral technologies, employee engagement

klimaaktiv is the Austrian climate protection initiative launched by the Federal Ministry of Agriculture, Forestry, Environment and Water Management (renamed Federal Ministry of Sustainability and Tourism since January 2018). klimaaktiv is embedded in the Austrian federal climate strategy. The primary objective of klimaaktiv is to introduce and promote climate-friendly technologies and services, thereby changing both Austria's economy and the everyday life of Austrian people.

The klimaaktiv energy-efficient business programme, managed by the Austrian Energy Agency (AEA), provides comprehensive professional support to companies, ranging from initial analysis to implementation of the efficiency measures. Many companies continue to cooperate successfully with klimaaktiv afterwards as can be seen from numerous award-winning projects across Austria. These companies commit to implement economic energy efficiency measures which entitle them to use the klimaaktiv project partner logo. So far, more than 300 best practice examples of implemented energy efficiency measures have been collected and published. With these measures energy savings of 890 GWh and CO_2 savings of 284,000 tonnes could be achieved.

An important part of the programme is to offer guidelines and trainings to optimise technologies which are frequently used in operations, especially, cross-sectoral technologies like compressed air systems, pump systems, steam systems, etc. More than 2,000 energy managers and consultants have participated in the klimaaktiv trainings since 2008.

Non-energy benefits of heat integration retrofits – case study at a large oil refinery in Sweden 3-063-18

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Keywords
non-energy benefits (NEBs), pinch analysis, case studies, interviews, chemical industry, industrial processes

Heat recovery through heat integration is one important option for increased energy efficiency in chemical process industry. In this type of industry, there are usually large potentials to reduce heat consumption by better utilizing heat excess at high temperatures to cover heat demands at lower temperatures. Techno-economic evaluation of heat recovery projects based on estimated energy cost savings and investment costs for standard heat exchanger equipment often shows that a large share of the potential is economically viable. However, evaluation of the potential for cost-effective implementation of heat integration retrofits requires a wider perspective.

The techno-economic heat-savings potential can be limited by practical implementation and operability issues, sometimes significantly more important for the decision than the fuel cost savings and the cost of the standard heat exchanger equipment for the suggested heat recovery. However, the techno-economic potential can also be enhanced by non-energy benefits.

To investigate how different factors affect the techno-economic potential for implementation of heat integration projects, an interview study has been conducted at a large oil refinery in Sweden. For the refinery, nine heat exchanger network retrofits were designed for different production units of the refinery. These retrofit proposals were discussed in interviews with operations, process, energy and control engineers responsible for the respective unit. The interviews revealed several non-energy benefits to be of great importance when the different retrofit proposals were evaluated.

The presentation will show the non-energy benefits of the heat integration retrofits identified in the interview study and discuss their potential influence for decisions about energy efficiency investment in chemical processing companies. Examples of non-energy benefits that were stated as important were de-bottlenecking, decreased pressure drop and decreased fouling.

Establishing a platform to harmonize ISO 50001 energy performance improvement measurement and verification protocols 3-067-18

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Keywords
ISO 50001, measurement and verification, energy savings, certification

ISO 50001:2011 requires that organizations demonstrate verifiable improvements in energy performance. To encourage organizations of all levels of complexity and resources to take up the standard, ISO 50001 is flexible and does not specify the method by which an organization must conduct the measurement and verification (M&V) of energy performance improvement and if energy performance improvement must be demonstrated for the facility boundaries or for part of the organization within. This flexibility allows for the valid use of any number of M&V methods. As guidance, ISO 50015 and ISO 50047 together outline a process of measuring and verifying energy performance improvement in the form of normalized energy savings based on a "top down" facility-wide approach. However, these standards are not intended to be used for certification as they do not include specific requirements.

While flexibility in how energy performance improvement is measured and verified is advantageous for individual organizations, the ability to define energy performance improvement in any number of ways is problematic for the purposes of comparing energy savings between organizations, particularly as part of national ISO 50001 based programs. To ensure credibility in reported energy performance improvement, harmonization between M&V protocols used to determine facility wide energy savings for the purpose of demonstrating ISO 50001 energy performance improvement should be based upon ISO 50015 and ISO 50047.

To encourage a dialogue for harmonization of M&V practices, this paper identifies eight key elements for the M&V of energy performance improvement based upon ISO 50015 and ISO 50047 and presents an "ISO 50001 M&V Harmonization Matrix."

This matrix expands the eight key elements allowing M&V protocols to specify how to calculate facility-wide energy savings as a metric of energy performance improvement in a harmonized way. The US Department of Energy's Superior Energy Performance Protocol is applied to the matrix as a test case and invitation is made for inclusion of other M&V protocols. By doing so, the process of harmonizing M&V protocols used to determine energy savings as a metric of energy performance improvement resulting from ISO 50001 will move forward, ultimately establishing confidence in reported values.

Working with energy audits in the ROCKWOOL Group 3-068-18

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Keywords
energy audit, sustainable development goals

Melting stone and waste into high quality products is an energy intensive process. The melting and spinning process is our core technology and optimizing capacity and flexibility of those processes with a minimum of waste and energy use has been a key focus for our factories for decades. Energy consumption has been reported since 2012 and optimized as part of the general process optimization but has not been a separate strategic focus area.

Since 2016 ROCKWOOL has used the Sustainable Development Goals (SDG) as a strategic tool to guide and prioritise development in our operation. 10 SDGs have been selected as strategic priorities where we contribute by minimising our operational footprint. Progress is measured against selected targets within each SDG – here energy efficiency is a key focus. A Global Sustainability Function has been created in the organisation which has aligned KPIs and is overall responsible for achieving the targets. Investments which are contributing to the SDGs are now evaluated outside the normal investment procedure using other criteria.

Companies with a unique core technology are likely to concentrate all their focus on optimising the core technology in terms of performance and energy consumption and pay less attention to the side processes which are often standard equipment. Core technology typically accounts for less than half the total energy consumption in the production.

Prioritising energy efficiency investments in industry is a complex matter – which it should actually not be especially not for measures with an extremely short payback time. Our internal work with Energy Audits as part of our strategic work with the SDGs has clearly showed that Energy Audits is only one part of the puzzle which cannot stand alone but needs to be part of a longer dialogue and linked to key "anchor points" in the organisation.

Energy use behavioural change for business & industry: identification, development and enhancement 3-076-18

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Keywords
behavioural change, energy use, energy management system

Europe needs to increase its productivity and competitiveness. The application of energy efficiency in a more widespread and thoughtful manner is a key component of this. Business & industry needs to invest not only in more efficient technologies, but also in the way it operates at a behavioural level. There are challenges though: Europe's business and industrial environment is notably rather conservative in relation to energy use and employee behaviour, in that it generally only focusses on technical solutions.

Previous studies have shown that energy savings potential linked to an Energy Management System (EMS) can in some cases be up to 30 % (average 12 %). And that a significant part of this can be achieved by behavioural change. With an effective system in place, organizations can better integrate energy management into their overall activities and be guided in changing their employee behaviour to make the most out of opportunities available to them. However, while many organisations have implemented an EMS they have often not delivered on expectations. This has been due to them often being aimed only at technical staff. In addition to this, an employee in a technical function within an organization is often the 'ambassador' for the EMS, which is often sub-optimal given that its 'success' is all about timely and dynamic organization-wide employee engagement. Engaging and motivating an organization's technical staff and enabling them to enhance their soft skills is then a key factor in the successful implementation of an EMS across an organization. However, effective communication is often a forgotten factor. If engagement with employees is more personal and specific then an EMS and the realisation of energy savings can be made significantly more effective.

A case study of a company operating in the healthcare sector will be presented to show how the above concept has recently been applied in relation to an EMS and soft skills for behavioural change.

Energy management in Swedish pulp and paper industry – benchmarking and non-energy benefits 3-093-18

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Keywords
energy management, non-energy benefits (NEBs), benchmarking, pulp and paper industry, energy performance benchmarking

Manufacturing industry has a large energy efficiency potential, yet to be utilized, known as the energy efficiency gap. This gap exists due to barriers that hinder industrial companies from making energy efficiency investments. Research also shows that the gap is even larger if energy management practices are included as well. One type of energy management practice for industrial companies is energy performance benchmarking, which deals with several organisational applications. For example, energy performance benchmarking can be used to compare a company's degree of energy efficiency to its peers. A benchmarking approach can also be adopted on different levels of aggregation, including sector, site, and process level. Furthermore, continuous work with energy management also entails additional benefits beyond the energy effects, known as non-energy benefits. In an energy management context, these benefits might for instance be organisational or informational in nature. The aim of this paper is to study these aspects of energy management – benchmarking and non-energy benefits – within the Swedish pulp and paper industry.

These aspects of energy management have not, to the authors' knowledge, been extensively investigated. The adopted method for data collection is a mixed method approach, where a questionnaire was sent to all operating pulp and paper mills in Sweden, and semi-structured interviews were carried out at six mills. The findings in this study show that the most common benchmarking method in the Swedish pulp and paper mills is external benchmarking within a company group. The benchmarking method with the highest perceived value for a mill's energy management, however, is historical benchmarking of energy use. Furthermore, the pulp and paper mills have perceived a number of non-energy benefits from energy management practices, where top management's interest in energy efficiency issues increasing more than expected was perceived as the most substantial.

Moving the masses to ISO 50001 with 50001 Ready 3-094-18

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Keywords
ISO 50001, energy management system, energy management, adoption, software, energy efficiency programmes, market transformation, continual improvement

For over a decade, the U.S. Department of Energy (DOE) has engaged in the development, uptake, and study of the ISO 50001 Energy Management standard, to advance the energy performance and competitiveness of U.S. manufacturing. While U.S. industry has responded with general support for establishing a standard practice for managing energy, the process and cost of certification have frequently been cited as obstacles to widespread uptake.

This paper explores the approach taken by DOE and Lawrence Berkeley National Laboratory (LBNL) to break down this barrier. 50001 Ready is a self-guided recognition program developed by DOE and LBNL to support facility-level adoption of the business practices of ISO 50001, by providing national recognition for self-driven uptake of energy management principles without the need for any third-party audits or verification.

Also developed by DOE and LBNL, the 50001 Ready Navigator is a self-guided online tool and resource database for step-by-step implementation of an ISO 50001-based energy management system, designed to build capacity at all organizational levels. Facilities seeking 50001 Ready recognition complete 25 tasks in the Navigator, self-report their energy performance, and provide executive-level attestation of implementation. The Navigator facilitates collaboration; users can track their progress, share notes with team members, receive expert assistance, and request DOE recognition directly through the Navigator. Since the launch of 50001 Ready in early 2017 there has been widespread interest from both the industrial and commercial sectors, and the number of facilities using the Navigator is growing rapidly. This paper includes reflections from a diverse range of early adopters on the value of open knowledge-building resources and federal recognition, outlines how 50001 Ready can be leveraged and adapted to proliferate energy management best practices around the globe, and offers recommendations for future program strategies based on new research on barriers to ISO 50001 adoption.

Using industry's own words to quantify the benefits and challenges of ISO 50001 3-096-18

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Keywords
ISO 50001, energy management system, implementation, barriers, multiple benefits, drivers, Energy Management Leadership Awards, content analysis

A growing body of research is beginning to collect and analyze data to understand drivers, benefits, and challenges of implementing an ISO 50001 energy management system. One new data source is the annual Clean Energy Ministerial's Energy Management Leadership Awards program. Launched in 2016, this international effort requires ISO 50001-certified organizations to develop a case study of their implementation experience, using a uniform template. Case studies also include quotes from employees, along with energy and cost savings calculations and information on facility locations and industry sectors. Case studies typically range from 5 to 9 pages in length; 35 case studies were tendered in 2016, and 37 in 2017. To analyze these data, researchers at Lawrence Berkeley National Laboratory employed the method of content analysis, a well-established practice widely used in the social sciences to make sense of qualitative information. This analysis occurs via close reading of each case study and transcription of relevant phrases from the following categories: motivations and goals; role of management and the organization; benefits achieved; keys to success; and challenges. Phrases are then assigned carefully defined "codes" that capture their meaning in order to enable quantitative analysis.

This paper presents results from the content analysis of Energy Management Leadership Awards case studies. While organizations undertook ISO 50001 adoption based on a range of motivations and experienced myriad benefits, commonalities exist. The biggest drivers for ISO 50001 certification are existing values and goals, cost savings, environmental sustainability concerns, government incentives or regulations, and gaining competitive advantage via visibility. This analysis of case studies also reveals that top management engagement can play an important role in successful ISO 50001 implementation, cost saving is the most frequently mentioned benefit achieved, availability of disaggregated and transparent energy data is the number one challenge faced, and obtaining top management support is a critical key to success. Policymakers and others looking to promote ISO 50001 uptake can use these results to highlight benefits and incentives that will resonate well when communicating with industrial facilities.

How executive engagement can make (or break) industrial energy management programs 3-102-18

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Keywords
energy management, energy management system, ISO 50001, strategic energy management (SEM), executive engagement

Ask any energy professional the number one driver of successful energy management in a business, and they'll say executive buy-in. Executives can authorize budget resources and worker time. They can remove organizational barriers. They can gain buy-in from reluctant department heads. They can set a clear and visible tone in the organization. But not all executive engagements are created equally; indeed, a poorly engaged sponsor can significantly reduce the success of energy management efforts.

So, what is the answer for how to effectively engage executives? This presentation will answer that question by tracking the experiences of 7–10 executive sponsors from across North America, and add additional color from the author's former role as an energy executive sponsor. Participants will learn how executives are brought in and bought in, to create high impact organizational efforts that are success stories for industrial energy management programs. Participants will also learn practical tips for getting – and keeping – executives engaged; defining clear roles and responsibilities; and effectively managing accountability and program oversight.

Benchmarking of space heating demand for a sample of foundries in Nordic climate 3-103-18

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Keywords
space heating, benchmarking, foundry, waste heat recovery, pump manufacturer

Improved energy efficiency is a cornerstone in climate change mitigation and for individual companies to reduce energy costs and remain competitive. Research over the years has had a strong focus on individual energy efficiency measures as well as processes, e.g. process integration, as well as various barriers to energy efficiency that inhibits the potential measures and process improvements to be implemented. Due to the inhomogeneity of the industrial sector, it remains a challenge to state general key performance indicators (KPIs) from a bottom-up level. This challenge is further complicated by industrial companies' unwillingness to share data regarding, for example, energy end-use. This makes publications where energy-KPIs are reported important.

In this study, purchased energy for space heating and actions undertaken to decrease purchased energy for space heating was compared for a sample of ten Swedish foundries. As hourly heating degree data between company locations differs at most by 7 % for a balance temperature of 20 °C, no adjustments were made to compensate for this difference. The sample spread in terms of energy performance for space heating was noted to be large. The five best performing companies showed values below 100 kWh/(m^2, year), and the two worst-performing companies showed values above 300 kWh/(m^2, year). The companies with less than 100 kWh/(m^2, year) have all worked with process integration and have a high degree of heat recovery, using their excess heat from production efficiently. However, it is important to note that these companies do not necessarily have a more efficient building envelope (U_{tot}). The high energy end-use for companies in this sector makes process integration and heat recovery from processes important. This, among other reasons, as heat removal is needed in order to avoid too high indoor temperatures. If this excess heat is used efficiently, a space heating demand well below 100 kWh/(m^2, year) is possible. In practice, however, there may be technical and economic factors hindering heat recovery from being implemented to this extent.

From audit to actions: How to overcome barriers to implement energy efficiency actions and investments 3-106-18

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Keywords
thermal energy, energy audit, ISO 50001, energy saving potential, CO_2 emissions, energy management, energy-intensive industry, industrial insulation

Practical experiences and lessons learned from a heat loss reduction program with a large manufacturer of insulation material.

Once an energy audit has been performed, the implementation of corrective actions – starting with those offering fast payback – seems to be self-evident. However by implementing the TIP-4-BEST thermal energy saving program inside our group we found several obstacles: from technical difficulties, to financial issues but most of all organizational constraints. Discussing with energy managers, auditors and ESCO's it seems that the implementation of actions and investments in energy efficiency often face similar organizational challenges. Our experience and lessons learned follow a combined bottom-up and top-down process to "crack the hard nut" realizing the EE potential.

It usually starts with the dilemma between "Bottom-up" split of decision making power and "Top-down" low level of awareness, scope and interest. In many industries the 'a priori' way to follow implementation of energy efficiency actions, from top-to down, is difficult. Single EE actions simply lack total cost and business impact. Therefore, we are faced with low availability, interest and focus of top management. Instead we must convince and work with functions such as Energy, Maintenance, Engineering or Production Managers by following a bottom-up approach. However, they usually don't have decision making power themselves, do not have the right tools/information and/or are bound by having to focus on day-to-day problem solving. Consequently, even with short payback solutions, EE actions are left aside.

With our internal experience inside our group's program, we can showcase a successful example on how to find the right way through a complex organization by identifying and pushing all key actors and combining efforts in both directions. Understanding the organization, speaking the right language, creating visibility and adapting to existing processes and programs are keys to success. Finally, the pressure has had the final desired effect and implementation came as a water fall: TIP-4-BEST audits and corrective actions have started to be widely and continuously applied.

Why energy management is taking off in the US and Canada: a look inside the programs and the infrastructure 3-107-18

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Keywords
energy management system, energy management, energy efficiency policy, collaboration, infrastructure, industrial energy saving, energy-intensive industry, ISO 50001, utilities

Energy management programmes, offered by energy utilities, have taken off in the US and Canada. To date, approximately 13 utilities have served over 700 facilities. But that doesn't tell the full story. Many utilities, from New York to San Francisco, are making plans to launch new energy management programs. While each of these programs offers industrial customers a somewhat different approach, they all follow some patterns that can help inform policy and program design.

This presentation will explore two related topics. First, we'll look at the similarities and difference in the programs, exploring the factors that have helped these programs succeed as they evolve and defining some of the key elements within the programs. Second, we'll look at some of the factors that have helped bring together the energy management ecosystem (utilities, policy makers, implementation contractors, utility staff, government agencies, etc.) to better understand what energy management is, how to apply it, solve common problems, and reach what some might consider a "tipping point" in the US.

Energy management at industrial sites: a holistic approach 3-109-18

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Keywords
renewable energy, storage, demand response, business strategy, industrial energy management

The industrial and manufacturing sector uses more delivered energy than any other end-use sector, consuming approximately 54 % of the world's total delivered energy. The sector faces a rapidly changing energy and production landscape including (i) energy costs and exposure to energy market volatility (ii) market-driven product and technology-driven production changes, for example increased customisation and electrification (iii) energy management opportunities such as revenues from flexibility (demand side response), improving on-site renewable generation and storage technologies, energy efficiency and improved automation and control. By combining the evaluation of these factors, industrial/manufacturing companies can improve productivity, competitiveness and sustainability performance. The resulting approach, holistic energy management, if properly developed and applied, can support companies operating in industry sectors in meeting these challenges and opportunities. While recent EU and UK policy supports renewables, flexibility and energy efficiency, there is clearly scope for a more proactive and holistic approach to industrial energy management.

This paper will present a number of industrial case studies that demonstrate the potential of holistic energy management. Each case study will include analysis of a portfolio of sites and a range of opportunities including energy efficiency, on-site renewable energy generation, flexibility and storage. The benefits will be presented in terms of energy, cost and carbon savings and revenue opportunities.

The role and implementation models of diverse market actors (utilities, aggregators, financiers, developers, OEMs and ESCOs) will be summarised to highlight the range of implementation options open to industrial companies.

Cost-benefit analysis of energy management systems implementation at enterprise and programme level 3-110-18

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Keywords
cost benefit, no-cost measures, training and competencies

Improving energy efficiency of the industrial sector is fundamental to decouple economic growth from the negative environmental and climate impacts of industrial development and increased energy consumption.

Energy management systems (EnMS) and standards represent a proven technical-management tool and policy instrument to advance sustainable energy efficiency in industry as well as other economic sectors. EnMS in line with ISO 50001 offer industrial enterprises a systematic approach to identify and tackle opportunities for energy savings and sustain energy performance improvement over time.

Despite a substantial and growing evidence of the operational, economic and environmental benefits of EnMS in industry and other sectors, there are very limited methodological approaches to the analysis of costs and benefits of EnMS implementation. Building on existing literature as well as on the experience of the UNIDO's EnMS Capacity Building and Implementation (CBI) Programme, this paper presents methodological approaches to perform comprehensive cost-benefit analysis (CBA) of EnMS implementation at enterprise and programmatic level, to help build a stronger business case for EnMS implementation vis-à-vis industrial enterprises as well as policy makers.

Costs categories considered include cost of staff time for training and EnMS implementation activities, cost of external expert assistance, cost of additional energy performance monitoring equipment, and expenditures for no- and low-cost energy efficiency projects.

Benefits considered include energy related savings deriving from no-cost and low-cost energy management/efficiency measures, as well as non-energy benefits. Costs and benefits are compared through a payback time function and selected cost-effectiveness indicators.

The methodologies developed are intended to be generally applicable to the CBA of EnMS implementation in organizations and of technical assistance programmes like the UNIDO EnMS CBI Programme. However, the value of many parameters considered (i.e. fees of EnMS consultants, energy prices, number of staff working days dedicated to EnMS training and implementation, salaries of industry staff, energy savings made, etc.) are specific to the markets in which UNIDO operates and to the enterprises participating in the UNIDO EnMS CBI Programme, both in middle-income countries and emerging economies.

Two companies and one Programme case studies from UNIDO's project in the FYRO Macedonia are used to illustrate the methodology and results. The results of the Enterprise CBA methodology clearly show the significant energy saving potential that companies could and can capture through well implemented energy management systems and the very-short/short simple payback times of this type of industrial energy efficiency best-available technique (20 days and 61 days respectively for the two company case studies). The results of the CBA methodology for the Programme case study considered show the substantial leverage potential of a programme like the UNIDO EnMS CBI Programme, with 20 Euro worth of direct energy savings generated per 1 Euro of grant funding invested.

How motivation and digitalisation can drive behaviour change in industry 3-129-18

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Keywords
training, reduced pay-back time, workshop, thermal insulation, business opportunity, learning curves, automatic monitoring, automatic control, control and monitoring devices, motivation, TIPCHECK

The presentation of EiiF will show how the combination of motivation programmes with the use of digital reporting tools can help to change the behaviour of workers and asset owners towards energy efficiency.

Following the principle: "You don't know, what you don't know, until you know" and based on the TIPCHECK experiences EiiF is developing a digital tool for asset owners and their employees to inspect their own facilities for energy efficiency potentials like insulation potentials, switch off machine potentials (reporting if and when machines are running without producing), safety issues (e.g. too high surface temperatures, blocked emergency exits, etc.) and general risks and failures (like leakage or corrosion detection).

The programme will be ready to be presented in June 2018:

- The inspection programme (motivation & digital).
- The used technical devices and app(s).
- First case studies.
- Its practical use.

Aligned energy saving targets and indicators in energy and financial department 3-130-18

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Keywords
energy management system, energy performance, energy efficiency indicator, key performance indicators (KPI), financial indicators, saving targets, barriers

Energy department and Finance department are two of the main departments involved in energy management. Ensuring aligned and compatible targets and indicators in these departments within an organization is one of the keys to long-term successful implementation of energy management systems and performance improvement.

This study aims at building knowledge to analyze and address potential barriers between strategies, targets and indicators adopted by Energy and Finance departments for and with an impact on companies' energy performance and productivity, and to identify best practices and opportunities for improvements. The study wants to build on real information collected from organizations in different countries and industrial sectors by engaging with enterprises that partnered with UNIDO in the Energy Management Systems Capacity Building and Implementation Programme, as well as other organizations.

UNIDO has gained vast experience in supporting the implementation and deployment of energy management systems in industries by providing training, on-the-job practice and direct expert implementation support to consultants and industrial enterprises covering a broad range of sectors and sizes. As of 2017, the UNIDO Energy Management Systems (EnMS) Capacity Building and Implementation Programme has worked on EnMS implementation with over 450 companies and 400 national energy efficiency and management systems experts in 17 countries.

The first phase is a survey in companies that have accepted to participate, consisting of two questionnaires to be filled out by the company's Energy Manager (or other manger fulfilling those roles and related functions) and the Financial Manager

respectively. Online webinars will be organized after the Survey to present results, discuss main barriers and enhance an interchange of real experiences and possible solutions between the different companies. The final result is a paper that aims to highlight main findings and conclusions.

PANEL 4

Technology, products and systems

Energy efficient supply chain of an aluminium product in Sweden – what can be done in-house and between the companies? 4-012-18

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Keywords
value chain, supply chains, aluminium industry

According to the Energy Efficiency Directive executed by the European Union, each member state is obliged to set a national target on energy efficiency. This requirement constitutes the basis for governments to formulate policy measures directed towards industrial companies. Such policy measures, along with the demand for cost-effective production to remain competitive on the market, motivates industrial companies to improve their energy efficiency. The aluminium industry is energy intensive and consumes substantial amounts of electricity and fossil fuels, resulting in both direct and indirect greenhouse gas emissions. This paper presents a study of the production of an aluminium product in Sweden in terms of implemented energy efficiency measures in the supply chain and potential areas for further improvement. Most previous studies have focused on energy efficiency measures in individual companies (value chains). However, this paper presents and analyses energy efficiency measures not only in each individual company but also in the entire supply chain of the product. The supply chain studied starts with secondary aluminium production followed by the production of a part of an automobile motor and ends with installing the motor detail in a car. Empirical data were gathered through a questionnaire and a focus group. The study shows the great potential for further energy efficiency improvements in the value chains of each individual company and in the whole supply chain. The work shown here is a part of a larger research project performed in close cooperation with the Swedish aluminium industry.

A review of pasteurisation process monitoring to support energy efficiency in the dairy industry 4-013-18

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Keywords
energy monitoring, dairy processing, pasteurisation

Pasteurisation is used in a number of food and drink industries but in particular in dairy processing. Pasteurisation is typically one of the highest energy consuming sub-processes on site due to the high levels of heating and cooling demand. This study provides results from a survey with eight major dairy processing sites supporting practitioner experience that the energy consumption of pasteurisation units is often not monitored or understood. This is due to a number of factors including poor provision of equipment specification and support from manufacturers, and insufficient temperature monitoring to allow calculation of heat transfers. The sites fall into three broad categories in terms of how they approach process (and specifically pasteurisation) energy optimisation and reduction (those that undertake no monitoring or review of pasteurisation units; those that undertake periodic review and those with regular monitoring and review). On a number of these sites significant energy savings can be found from an investigation of the data available. We conclude that dairy processing sites can benefit from improving the visibility of the available data from SCADA (Site Control And Data Acquisition software used for process control and data management) regarding pasteurisation. The additional monitoring of regeneration temperatures (where missing) would provide an ability to track individual heat exchanger/regenerator effectiveness and take necessary improvement action. Manufacturers and suppliers also have a role to play in improving and promoting the energy efficiency features of their equipment and to provide monitoring that allows the heat consumption to be tracked.

Bottom-up methodology for assessing electrification options for deep decarbonisation of industrial processes 4-021-18

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Keywords
industrial processes, decarbonisation, electrification, process integration

Industrial processes currently account for a significant share (25–35 %) of the world's total energy demand and related emissions. During recent years, the amount of low-carbon electricity from renewable energy sources (such as wind and solar) has increased continuously. There is therefore an increasing interest in electrification of industrial processes in order to achieve long-term decarbonisation goals.

Structural changes in the capital-intensive processing industry take a long time to implement. Furthermore, the number of possible technologies and systems for electrification of industrial processes is high, and different technologies and combinations of technologies will have different performance both in terms of economy and carbon footprint. For industrial decision-makers, it is important both to understand such systemic effects of electrification technologies and to discard low-performing candidates at an early stage. So far, studies on industrial electrification have focused on top-down approaches using explorative scenarios for analysing the consequences of a sector-wide full electrification assuming greenfield investments. There is a lack of studies adopting a bottom-up perspective for investigation of partial electrification options in brownfield investments at existing sites including process integration aspects and system consequences as well as the impacts on overall energy efficiency.

The objective of this paper is to propose a methodology for bottom-up assessments of industrial electrification options and to demonstrate this methodology with a case study. For this purpose, a bottom-up methodology that especially accounts for the systematic effects of increased electrification on a plant level was developed and then applied to the steam system of an oil refinery plant in Sweden. The results show that the energy and carbon footprint consequences of such measures are hard to predict

without detailed modelling studies since industrial process unit operations are highly interlinked. Furthermore, the results from the techno-economic as well as carbon footprint bottom-up assessments can be used to compare electrification with other decarbonisation options and to formulate detailed roadmaps for decarbonization of energy-intensive industrial processes.

Deep decarbonisation pathways for the industrial cluster of the Port of Rotterdam 4-022-18

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Keywords
low carbon industry, decarbonisation, chemical industry, circular economy, energy-intensive processing industries

The Port of Rotterdam is an important industrial cluster mainly comprising of oil refining, chemical manufacturing and power and steam generation. In 2015, the area accounted for 18 % of the Netherlands' total CO_2 emissions. The Port of Rotterdam Authority is aware that the port's economy is heavily exposed to future global and EU decarbonization policies, as the bulk of its activities focuses on trading, handling, converting and using fossil fuels. Based on a study for the Port Authority, our paper explores two possible pathways of how the industrial cluster can keep its strong industrial position and still reduce its CO_2 emissions by 98 % by 2050. The "Biomass and CCS" scenario assumes that large amounts of biomass can be supplied sustainably and will be used in the port for power generation as well as for feedstock for refineries and the chemical industry. Fischer-Tropsch fuel generation plays an important role in this scenario, allowing the port to become a key cluster for the production of synthetic fuels and feedstocks in Western Europe. The "Closed Carbon Cycle" scenario assumes that renewables-based electricity will be used at the port to supply heat and hydrogen for the synthetic generation of feedstock for the chemical industry. The carbon required for the chemicals will stem from recycled waste. Technologies particularly needed in this scenario are water electrolysis and gasification or pyrolysis to capture carbon from waste, as well as technologies for the production of base chemicals from syngas. The paper compares both scenarios with regard to their respective technological choices and infrastructural changes. The scenarios' particular opportunities and challenges are also discussed. Using possible future pathways of a major European petrochemical cluster as an example, the paper illustrates options for deep decarbonisation of energy intensive industries in the EU and beyond.

Small-scale industrial cogeneration with high efficient gas turbine 4-032-18

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Keywords
distributed energy resources (DER), bio fuel, greenhouse gas emission reduction, energy efficient technologies, gas, micro gas turbine, combined heat and power generation

The small-scale process and SME industry uses over 20 % of the total energy consumed in Europe. This sector includes small factories in iron & steel, food, chemical, pharmaceutical, building materials, and other industries. All these factories need Combined Heat and Power (CHP) generated locally, but power only in relatively small amounts, generally less than 2 MW. A majority of these factories are using very inefficient energy systems, that cannot handle the fluctuating power demand and varying ratios of power/heat needs.

The potential of energy savings in industrial processes of the SME sector is vast. According to the German Energy Agency, process heat is the most energy intensive application field by covering 64 % of industrial total final energy consumption. Process steam (between 100 and 500 °C) accounts for 21 % of industrial final energy consumption in EU. A study by IEA shows that the industrial sector can save up to 30 % in process heat costs through energy efficiency measures. According to German CHP association, steam-CHP technology targeted at the small scale and SME industry can reduce fuel consumption up to 40 % by enhancing efficiency and allowing the use of a range of different, also renewable fuels.

In distributed energy generation the power and heat needs can vary significantly depending on the production degree and time of day, week or year. The power and heat demand of a particular time do not necessarily correlate. Major energy savings can be achieved with efficient flexible CHP generation technologies. This presentation shows simulations of power/heat demand and on-site generation of three different small industrial sites in Germany using three different technologies; reciprocating engine, conventional micro gas turbine and a novel, high efficiency micro gas turbine.

Small-sized gas turbines have gained increased attention due to their multiple benefits compared to conventionally used reciprocating engines: lower emissions and lower operating and maintenance costs and wider variety of allowed fuels, in-

cluding biofuels. Additionally, in a novel, innovative two-spool variable speed gas turbine the two spools can be controlled independently of each other, which allows the turbines to be operated with high efficiency in a broader operating range. The operation of this kind of gas turbine can be easily controlled on the basis of the current power/heat ratio demand.

A bottom-up analysis of energy efficiency improvement and CO_2 emission reduction potentials in the Swiss basic metals and fabricated metal products industry 4-042-18

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Keywords
basic metals and fabricated metal products, cost-effectiveness

Manufacturing of basic metals and fabricated metal products (NOGA 24 and 25) in Switzerland is responsible for 20 % of total final energy demand of the Swiss industrial sector. In the time period 2008 to 2016, total final energy consumption of the sector increased by 5 %. In the year 2015, 11.3 PJ of total final energy was consumed by this sector. This study investigates the current potential of energy efficiency improvement and carbon dioxide abatement for manufacturing of basic metals and fabricated metal products in Switzerland by constructing bottom up electricity, fuel and CO_2 cost curves. Based on the values available in literature, the technical energy savings potential for this sector is estimated at 25 % of sector's final energy consumption of the year 2015. The cost-effective energy efficiency potential of this sector is estimated to be 10 % and the corresponding reduction in CO_2 emissions associated with the cost-effective energy savings is 6 %. A sensitivity analysis is carried out to test the sensitivity of cost effectiveness of energy conservation measures to changes in fuel, and electricity prices. The results of this study can help to develop a better understanding of energy efficiency gap in basic metals and fabricated metal products manufacturing sector and to identify cost effective energy efficiency and CO_2 emission reduction technologies in basic metal manufacturing and foundries.

Organic Rankine cycle technology with direct heat exchanger for the waste heat recovery of energy intensive industries 4-046-18

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Keywords
waste heat recovery, organic Rankine cycle (ORC), energy-intensive industry, direct heat exchanger, cement

Industrial plants of Energy Intensive Industries (EII) such as cement, glass, petrochemical and steelmaking, are at present dissipating huge amounts of heat into the atmosphere. Furthermore, these flue gases have to be cooled before being vented either with heat exchangers or by adding external air. Both solutions introduce additional energy consumption. Unfortunately, this waste heat is recovered for internal needs only in few cases.

The ORC technology is considered as a technology with a high real potential for the recovery of these waste heats. The ORCs (Organic Rankine Cycles) typically use a high molecular mass organic working fluid such as butane or pentane that have a lower boiling point, higher vapour pressure, higher molecular mass and higher mass flow compared to water operating in the steam Rankine Cycles. These features enable higher turbine efficiencies than those offered by a steam system. The ORC systems can be utilized for waste heat sources as low as 150 °C, whereas steam systems are limited to heat sources greater than 260 °C.

The ORC systems are typically designed with two heat transfer stages. The first stage transfers heat from the waste gases to an intermediate heat transfer fluid (e.g., thermal transfer oil). The second stage transfers heat from the intermediate heat transfer fluid to the organic working fluid. The work presents the design and development of a new generation of the Organic Rankine Cycle (ORC technology) to generate electricity based on the application of direct heat exchange solution. The main objective is to eliminate the intermediate heat carrier medium circuit that transfers the thermal energy from the first heat exchanger to ORC units in conventional Waste Heat Recovery systems.

Aspects related to the analysis of materials, control and monitoring and modelling of the gas flows within the heat carrier have been approached. Eventually an industrial scale demonstrator with a capacity of generating up to 2 MWe is being built that will be installed in a cement plant for the validation of the process. The design and details of this case study will be shown in detail.

The new ORC developed during the project presents a lot of innovative aspects if compared to a standard configuration with thermal oil. The first worth mentioning aspect is the use of a working fluid that is nor toxic, nor flammable and with low GWP for high temperature applications. Based on the existing literature it is the first time worldwide this specific low GWP refrigerant is used as working fluid for a real scale ORC. Design of heat exchangers and turbine blades have been changed according to thermodynamic properties of the new fluid. The WHRS design is able to efficiently recover heat from gases and maintain organic fluid temperature below decomposition limits. The WHRS materials are able to resist high temperatures and dust, but also cheap enough to be economically feasible. This solution (ORC with Direct Heat Exchange) represents the first worldwide application in the cement sector and is furthermore suitable for cross sectorial applications. It should allow reducing the overall costs while increasing efficiency, considered as the key factors to cut existing barriers for a significant penetration of the ORC technology in the industrial energy efficiency market.

Electrification of industrial process heat: long-term applications, potentials and impacts 4-051-18

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Keywords
electrical heating, industrial steam systems, industrial processes, renewable energy, energy systems, greenhouse gas emission reduction, primary energy, decarbonisation

Converting electricity into heat offers the opportunity to make of use large scales of renewable (surplus) energy in the long run in order to reduce shut-downs of renewable power plants and to substitute fossil fuels. Electrification seems to be also very promising for industrial heat applications, as it enables high process temperatures to be achieved in a tailor-made and efficient way and enables the utilisation of other energy sources like waste heat, geothermal or ambient heat (via heat pumps).

This article analyses theoretical and technical electrification potentials of *Steam Generation* and *Other Process Heat Generation* in the following energy-intensive branches: iron & steel, non-ferrous metal, iron foundries, refineries, base chemicals, glass, cement clinker and paper industry in Germany. Literature research, expert interviews as well as own modelling were conducted to determine potentials and their implementation barriers. Based on these methods, market potential to electrify industrial steam generation was estimated. On the basis of two climate protection scenarios, the effects of both a monovalent and a hybrid industrial power-to-heat strategy were quantified with regard to greenhouse gas reduction and energy efficiency (primary energy saving).

The pathway towards electrification will be reflected by criteria such as path dependency, dependency of infrastructure and system compatibility. Recommendations for research and development as well as policies are derived from the overall analysis.

The article shows that electrification can be an important option to achieving high CO_2-savings in the industrial heating sector in a long-term perspective. However, the scenario calculations show that electrification does not in itself guarantee reduction of greenhouse gases or savings of primary energy. To reach these goals, it is essential to further develop industrial heat pumps and to map electrification and further development of renewable energy (including infrastructure such as power networks and storage facilities) in a concerted strategy.

Reverse electrodialysis heat-engine: Case studies of improving energy efficiency through recovery of low temperature excess heat 4-054-18

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Keywords
waste heat recovery, case studies, emerging technologies, reverse electrodialysis

Reverse Electrodialysis (RED) is a technology for generating electricity from the difference in salinity between two solutions. RED is usually applied to natural water streams with different salinities, like seawater vs. freshwater. In the RED Heat-to-Power project we explore the option of using artificial water solutions operating in a closed loop where the difference in salinity is regenerated in a separation step powered by heat at temperature ranges between 60 and 100 °C. We call this system Reverse Electrodialysis Heat Engine (RED HE).

In this paper, first we summarise the possible system configurations and the overall amount of excess heat available in Europe for powering the RED HE process, as described in our previous publications. Then we take a closer look at specific sites, where a RED HE engine could be potentially applied, assessing the amount of waste heat that can be technically and realistically recovered and sizing the RED HE system for those applications.

The case studies include the excess heat recovery from:

1. a typical large-sized pulp and paper industry based in Sweden
2. a typical medium-sized food industry as described within the IEE project GREENFOODS
3. a relatively large biogas plant in Germany
4. the on-board auxiliary engine of a medium-sized bulk carrier
5. a gas compressor station in Poland.

The results show that the RED HE is suitable to be used by all those sectors. For most cases, the typical heat engines would be of relatively small size, because of the Carnot limits for temperatures at 100 °C or lower: Industry 150–600 kW, Biogas plants 5 to 20 kW, Marine 4 to 17 kW. On the other hand, the gas compressor stations are suitable for larger applications, in the range of 2 to 8 MW.

Energy efficiency and line productivity improvements for a continuous heat treatment process 4-056-18

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Keywords
industrial energy saving, energy management, energy-intensive industry, energy efficiency measures, energy analysis

Industry sector in Europe reaches 35 % of total energy consumption. Energy-intensive industries (as die-casting, refining, concrete) are liable for more than half of that consumption. Commonly, these industries are mainly focused on reaching the desired levels of production without considering the energy efficiency along the process. However, current data acquisition methods are revealing new room for improvement which should be analyzed. Energy efficiency in industry is not as high as it should be. Models, researches and experience, situate the level of the hypothetical energy efficiency in the manufacturing sector many points above the current state. This research explores and analyses a representative heating process in order to improve its productivity and energy consumption. The aim of this paper, which focuses on analyzing energetic and productive variables, is to present energy efficiency and line productivity improvements for a continuous heat treatment process of an aluminium die-casting plant by means of an integral modelling methodology which includes a sensitivity analysis. Solution, quenching and aging processes were represented by productive and energetic time-dependent models combining thermal phenomena with techno-economic considerations that allowed energy consumption, resource utilization and the working way to be evaluated. Simulated theoretical phenomena were compared and validated with real data measurements.

A virtual model of the heat treatment process was applied to search the best work configuration and to identify, quantify and evaluate proposed improvements. Based

on the simulation results, both technical furnace modifications and productive improvement actions were identified; and their viability, impact and resulting energy savings or production increase were quantified. For instance, a waste heat recovery system from solution to aging furnace, by a novel heat exchanger (heat pipes) was analysed, reducing, as consequence, the natural gas consumption from the heat treatment up to 14 %, with approximately 3-years payback period and savings of 512 MWh/year. Besides, other modifications in tactical or operative working way (without investment cost), such as modifying batches entry, were evaluated, with production improvements between 5 % and 10 %.

Concepts and pathways towards a carbon-neutral heavy industry in the German federal state of North Rhine-Westphalia 4-065-18

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Keywords
carbon capture and storage, low carbon technologies, low carbon industry, infrastructure, electrification, industrial symbiosis

The German federal state of North Rhine-Westphalia (NRW) is home to important clusters of energy-intensive basic materials industries. 15 % of the EU's primary steel as well as 15 % of high-value base chemicals are produced here. Together with refinery fuels, cement, lime and paper production (also overrepresented in NRW) these are the most carbon-intensive production processes of the industrial metabolism. To achieve the ambitious regional and national climate goals without relocating these clusters, carbon-neutral production will have to become standard by mid-century.

We develop and evaluate three conceptual long-term scenarios towards carbon-neutral industry systems for NRW for 2050 and beyond:

- a first scenario depending on carbon capture and storage or use for heavy industries (iCCS),
- a second scenario sketching the direct electrification of industrial processes (and transport) and
- a third scenario relying on the import of low carbon energies (e.g. biomass, and synthetic fuels (like methanol) for the use in industries and transport.

All scenarios share the assumption that electricity generation will be CO_2-neutral by 2050.

For all three scenarios energy efficiency, primary energy demand for energy services and feedstock as well as the carbon balance are quantified. We apply a spatial-explicit analysis of production sites to allow for discussion of infrastructure re-use and net investment needs. Possible symbiotic relations between sectors are also included. The robustness of the three conceptualised future carbon-neutral industry systems is then analysed using a multi-criteria approach, including e.g. energy security issues and lock-ins on the way to 2050.

Efficiency analysis and optimisation for small scale data centres 4-074-18

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Keywords
IT equipment, data

In the light of growing computing-demand and significant new build of large data centers, smaller data centres and server rooms still count for a significant energy saving potential based on the number of installations and their low efficiency. For large data centres efficiency optimisation has become more and more common and the energy management is often certified. But for the vast amount of small scale server rooms such optimisation is often considered not to be economical feasible or the technical staff is not aware of these saving potentials. Using a small scale data centre as an example a study was conducted to identify the biggest efficiency potentials in prevalent server rooms and data centres. The dimensions of these data centres make up a huge portion of the current infrastructure and are expected to increase their share due to "Industry 4.0" and autonomous driving in the future.

For this study the temperature, humidity, air pressure and multiple power consumptions were measured in the server room. In addition, a literature review was conducted, focusing on best practices and scientific papers. The findings are weighted with respect to the limited budget and technical capabilities commonly attributed to SMEs. The two most promising optimisations can cut the energy costs for the cooing system by up to 65.3 %. Of which 40.3 % saving were derived from real data simulations and 25 % from literature estimations. These simple measures, consisting of restructuring the server room, can be replicated in other installations. Further system optimisations are possible but the needed higher investments or expertise are commonly not available for most SMEs.

Analysis of different transformation pathways for the energy-intensive industry in Germany on the basis of exergy analysis 4-080-18

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Keywords
energy-intensive industry, exergy analysis

In recent years considerable measures have already been undertaken to increase energy efficiency in the German industry. In an increasingly energetically efficient system, the sole consideration of the energy efficiency as an indicator for further efficiency improvements might be questioned. This is due to the fact that a purely energetic assessment does not include energy quality. In the exergetic evaluation, on the other hand, the quality of energy input and energy service is included in a system to be assessed. The preservation of energy quality is therefore taken into account in the evaluation. Against the background of scarce resources, this is particularly relevant as resources can be more appropriately allocated to a specific usage.

The main objectives of this paper is to examine the decarbonisation pathways of selected main processes of the industry from a holistic perspective with an exergy analysis. The selection of the main processes takes place with regard to their energetic relevance referred to the final energy consumption in the German industry. The exergy analysis is conducted for the current situation and for 2050 based on two decarbonization scenarios for the German's industry. First results on the current situation show that the interpretation of exergetic indicators has to be done very carefully in the context of transition pathways for the industry. This is based in several reasons, such as system boundaries, availability of data and implicit definitions influencing interpretations. We present these issues for exemplary cases.

The study is financed by the German BMUB.

Energy flexibility in industry: evaluating simultaneous battery use cases and identifying generalized electricity profile indicators 4-086-18

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Keywords
electric storage, batteries, electricity bill, indicators, electricity markets, energy flexibility

The application of battery storage systems (BSS) to provide electrical flexibility has attracted increasing interest over recent years. Because of their high energy demand, this is especially interesting for industrial companies. To industry, a BSS provides a pseudo-flexibility: a flexible electricity demand can be offered to grid operators and electricity markets via different use cases while the production remains unaffected. Additionally, a unique attribute of BSSs is the ability to follow different use cases simultaneously (Reid und Julve 2016). In many studies, this possibility is mentioned but the potential has not yet been thoroughly studied (Stephan et al. 2016), especially not with the focus on an industrial application.

This paper evaluates the economic potential of energy flexibility in different German small and medium sized enterprises (SMEs) through the installation of a BSS employing different uses cases simultaneously. The focus is on peak shaving, provision of primary balancing power and energy-arbitrage-trading on the German intraday and day-ahead markets. To evaluate the profitability of the BSS, the energy system of an industrial manufacturing plant is modelled as a mixed integer linear program (MILP) with the objective of minimizing total energy-related system costs. In addition, this paper develops several indicators from the analysis of the load profile, market price profile and battery characteristics. The aim is to extend existing indicators (e.g. McLoughlin et al. 2013) to describe the dynamic characteristics of the industrial load profile in more detail. This allows us to pre-evaluate the suitability of a BSS for industrial companies in future studies.

We observe that employing different use cases simultaneously substantially increases the return on investment compared to a single use case. The magnitude of the revenue depends on the volatility of the load profile and the ratio between the battery capacity and total energy consumption.

Sustainable EU ETS glass industry through carbon management and waste heat recovery 4-090-18

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Keywords
carbon management, sustainable industry, waste heat recovery, glass, low carbon industry, EU Emission Trading Scheme (EU ETS)

The European Emissions Trading Scheme (EU ETS) covers 45 % of European Greenhouse Gases (GHG) and particularly affects the energy intensive industries by imposing the risk of "carbon leakage", i.e. the risk of EU industry departing to countries with weaker restraints on GHG emissions. The current work addresses the EU Glass industry which covers app. 1 % of total EU ETS emissions and 3 % of the total industrial ETS emissions, has a market share close to one third of global production and is capital intensive therefore requiring long investment cycles. The work to be presented makes an assessment of the position of EU ETS glass manufacturing sites in terms of carbon management with different price scenarios in the case of the replication of a successful case of batch/cullet preheating during waste heat recovery (WHR) in a Bulgarian EU ETS glass manufacturing plant. The work addresses EU-ETS glass industrial plants which cover an allocation in the range of 100 million of European Emission Allowances (EUAs) for the third EU ETS trading period 2013–2020. These 299 plants had a cumulative shortfall in emission allowances of 8 $MtCO_2$ for the period 2013–2016. The presented work aims at supporting the EU ETS glass industry in developing a proactive strategy towards a low carbon industrial future.

Energy efficiency good practices in industry: the EIEEP platform 4-099-18

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Keywords
good practice, best practice, best available technologies (BATs), industrial energy saving, energy efficiency measures, Horizon 2020

Since the introduction of the IPPC (International Pollution Prevention and Control) directive and of the BREF documents, BATs (best available techniques) have become a reference both for policies and for companies, to compare performance and to identify investment opportunities. Due to the environmental core of the IPPC first, and of the IED (Industrial Emissions Directive) after, energy efficiency BATs are not always detailed and often lack energy performance indicators.

The H2020 EU-MERCI project, aimed at fostering and facilitating the implementation of energy efficiency projects in the manufacturing industry sectors by selecting and disseminating technological and policy best practices. A set of energy efficiency good practices was developed both considering BREF indications, literature analysis and, as innovative approach, the outcomes of energy efficiency obligation and support measures aimed at the industrial sector. This was implemented through an in-depth analysis of the existing schemes in Austria, Italy, Poland and UK carried on by AEA, RSE, FIRE, KAPE and Carbon Trust. A project that required a thorough activity to normalise and compare the data made available by the different schemes.

The outcome is available through the EIEEP (European Industrial Energy Efficiency good Practices) platform implemented by EU-MERCI Partners. On the web site, a database of energy efficiency projects implemented in industry under the existing schemes is available. The database is searchable by country, sector, supporting scheme, implementation year, and company size. The complete list is also downloadable as Excel file.

Besides, a library divided by sectors is available, in which it is possible to look for the available good practices (both BATs and projects implemented under the national schemes) for each phase of the manufacturing processes. Sectoral and national analysis are finally available.

The paper will illustrate the methodology used for the project and the main outcomes, also by applying the methodology to a sector in Italian industry and comparing the results with EU-MERCI ones.

Scenario analysis of a low-carbon transition of the EU industry by 2050: Extending the scope of mitigation options 4-105-18

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Keywords
mitigation options, industry transition, innovative technologies, carbon capture and storage, fuel switch

Industry accounts for about 25 % of EU final energy demand and uses gas, electricity, coal, and oil as the dominant energy carriers. This makes the sector critical for the achievement of European climate goals. The EU Roadmap for moving to a competitive low carbon economy in 2050 states a potential of 83 to 87 % emission reductions in industry by 2050. Several analyses show that industry is unlikely to meet this target without a major change in the policy frame. Our contribution presents two alternative transition scenarios for the EU28 that achieve a reduction in GHG emissions of more than 85 % by 2050 compared to 1990 for the industrial sector. The scenarios are based on the bottom-up simulation model FORECAST, which allows simulating technological change with a high level of technological detail also considering policy instruments. The transition scenario contains mitigation options including energy efficiency, fuel switch to RES, CCS, power-to-heat, secondary energy carriers based on RES, innovative production technologies and new products, material efficiency, substitution and circular economy elements. Thus, the scope of mitigation options is very broad, particularly compared to the scenario calculations that were conducted to support the EU Low Carbon Roadmap, which is mainly based on CCS for the industrial sector. Results show that RES and energy efficiency have huge potentials towards decarbonisation. But also changes in production structure giving way to new innovative technologies like renewable hydrogen based direct reduction in the steel industry or low carbon cement types are needed. This scenario reflects a radical change to be achieved in less than 35 years. Even if many mitigation options will be rolled out in large quantities only after 2030, policies need to be in place soon to drive this transition. A potential policy mix towards implementation of the modelled transition scenario is discussed at the end and compared to current policies in place in the EU.

Machine level energy data analysis – development and validation of a machine learning based tool 4-114-18

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Keywords
industrial energy saving, data monitoring, machine learning, energy profiles

Industrial energy consumption is known to be significantly high worldwide, reaching up to one half of the total energy in some countries and almost one third of the world's consumed energy. Consequently, the industrial sector is also responsible for a large share of greenhouse gases (GHG) emissions. Many recent manufacturing standards and methodologies have efficiency, environmental and social impacts as key aspects and concerns, in order to meet the demands of international agreements and regulations on these subjects. The ongoing development brought by Industry 4.0 and Smart Factories are the main demonstrations of the growing awareness of the importance of efficient and intelligent production. Data gathering, processing, analysis and benchmarking play a key role in this scenario, enabling a smarter and well informed decision-making process. In this context, energy consumption data extracted directly at machine level inside factories also show a significant potential for being a reliable source of process-related information, such as automatic production counting, consumption analysis, Overall Equipment Effectiveness (OEE) and costs identification. This paper presents a pilot implementation of a machine learning based application for the automatic extraction of useful insights from machine level energy data sets. The developed tool uses a K-means clustering algorithm in order to categorise energy profiles into production or idle periods, from which relevant Key Performance Indicators (KPIs) are calculated. A controlled experiment using Non-Invasive Load Monitoring (NILM) equipment connected to a CNC milling machine was performed in order to validate the approach, and the results are presented in this paper. The method has identified potential savings of up to 30 % in an Injection Moulding machine and up to 25 % in a Precision Engineering company, besides providing deeper understanding of the consumption profiles of machines in these sectors.

Exergy efficiency of ammonia production 4-115-18

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Keywords
chemical industry, industrial energy saving, exergy efficiency

The chemical industry is responsible for roughly 6 % of global primary energy consumption and global greenhouse gas emissions, as well as a key fossil-fuel user (Cullen and Allwood 2010). Material and energy efficiency are the focus of industrial and policy decision-makers but are often pursued as separate strategies. This paper applies exergy analysis to reconcile material and energy flows into a single unit and the separate efficiencies into an integrated metric and take into account the quality of the flows. The analysis was performed on simulated data for an ammonia production site based on Steam Methane Reforming (SMR) to produce syngas from natural gas. The combustion zone of the reformer in the SMR plant is modelled separately from the reaction zone, facilitating the allocation of exergy destruction to the separate sections. Exergy flow maps are constructed using Sankey diagrams to illustrate the resource (material and energy) flows around the site and the principal sources of exergy loss and destruction. Exergy efficiencies and exergy destruction values are calculated for every plant. A more detailed analysis of the SMR plant is conducted that takes into account transit exergy (untransformed exergy). Losses in the SMR plant are finally allocated to the specific mechanism of loss (for instance combustion and heat exchange) to guide future improvements. The analysis yields specific results for the ammonia and syngas case study but the methodology is applicable to any chemical production site with minimal adjustments.

Three electrification scenarios to decarbonise the Dutch heavy industry 4-124-18

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Keywords
energy-intensive industry, decarbonisation, long-term scenarios, electrification pathway, transport fuels

Recently, renewable electrification is mentioned as a promising option to reach deep decarbonisation of industrial production (Energy 115 (2016) 1623–1631). For the Netherlands, these scenarios are merely conceptual ideas. The aim of the present study is to quantitatively assess deep decarbonisation scenarios through electrification of the production of basic materials and transportation fuels in the Netherlands in 2050. This to explore the technical feasibility, required feedstock and energy potentials and pro's and con's of different electrification pathways for the Dutch energy intensive industry.

The study focuses on steel, minerals (cement and glass), basic chemical industry (olefins, chlorine and ammonia), paper & pulp and food industry and in addition to that the refining and transport processes (passenger, freight, navigation and aviation). Next to the current situation, 3 deep decarbonisation pathways have been developed: A. All electric, B. Big on hydrogen and C. Competition; all of these what-if scenario's have equal demand scenario's (from PBL) and their own specific set of technologies to reach near zero CO_2 emissions in 2050. For each scenario, we explore the required renewable (wind) energy potentials. Furthermore, different sources of CO_2 (fossil or bio-based), process emissions, the end-of-life of products (with fixed carbon getting released or recycled) and indirect CO_2 emissions of wind are calculated to assess the total net system CO_2 emissions. About three quarter of the current Dutch CO_2 emissions is covered in this study, including international bunkers and export of oil based products.

In all three pathways, it is technically feasible to reach nearly zero CO_2 emission

levels through electrification of the heavy industrial production and transport, even with maintaining the current Dutch export position in polymers. The scenarios, however, differ with respect to relative stakeholder power, type of technological options and TRL.

PANEL 5

Business models and finance in the age of digitalisation

Increasing the flow of investment into energy efficiency in industry 5-015-18

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Keywords
investment, industrial energy saving, cost efficiency, finance

This presentation examines the current state of the energy efficiency financing market with specific reference to industry. As well as the importance of retrofit projects the paper examines the different types of capital investment that lead to improved efficiency including investment in new production facilities and the need to maximise the opportunities afforded by normal, every day investments that do not have energy efficiency as their prime objective. It examines initiatives in the US and EU market, and discusses the specific barriers to the growth of private capital investment into energy efficiency in industry. These include: lack of standardisation in development and documentation, small project size and the need to develop large pipelines, the need for both development as well as project finance, and the need to build capacity in the demand side, the supply side and the finance industry. It then looks at various examples from around the world that have successfully brought the elements together to increase the flow of capital into energy efficiency in industry. It reviews significant developments including the Investor Confidence Project, the EEFIG Underwriting guide, project performance databases and platforms and their role in the ecosystem of energy efficiency financing. It also looks forward to emerging business models such as metered efficiency and Pay for Performance.

Innovative business model for a standardised evaluation and re-financing of industrial energy efficiency and renewable energy projects 5-020-18

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Keywords
Directive on Energy End-use Efficiency and Energy Services (EEES), renewable energy, business models, energy-intensive industry, web-based digital platform, re-financing

Promising industrial energy efficiency (EE) and renewable energy (RE) projects in Europe lack viable financing due to insufficient performance or credit guarantees, lack of ability/capacity among lenders to assess project risks, or related financing challenges. To overcome these barriers, the H2020 project TrustEE launched in 2016 to accelerate implementation of EE and RE solutions by developing an innovative project financing model and digital platform to standardise project evaluation. The innovative business model, which targets SMEs, combines project evaluation and development, contracting, risk hedging and external financing via a two-pronged approach. First, TrustEE established a securitization vehicle ("Sustainable Future Trustee"), which

purchases receivables from technology supplier's who have successfully installed and commissioned industrial EE and RE projects. These purchases allow industrial SMEs (end users and suppliers) to create flexible project payment plans, and are financed by tradable securities offered to investors on the capital market. Investors are de-coupled from most technical risks as projects are already commissioned. This vehicle is supported and serviced by a semi-automatic project evaluation, using a three-stage, web-based platform. Stages 1 and 2 perform an automated technical and financial evaluation by comparing the project parameters to an automatic background simulation that uses comprehensive models for the envisaged EE and RE technologies. If a project meets the screening criteria, the TrustEE manager initiatives Stage 3, which includes technical optimization and legal and insurance-related preparation for re-financing. In the long term, plant and technology suppliers will be able to qualify and register on the platform, thus building a pool of certified suppliers. The presentation shows real projects initiated by TrustEE and the performance and impacts from the project evaluation platform (TrustEE platform) and re-financing vehicle.

Driving investments in energy efficiency through energy savings insurance 5-030-18

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Keywords
domestic energy efficiency, business models, financing mechanisms

In order to meet emissions reductions, and energy efficiency (EE) targets set out under the Paris Agreement, the Global Sustainable Development Goals, and by governments throughout the world, a significant amount of private sector investment will need to be mobilized – public financing alone is not enough.

For small to medium-sized enterprises (SMEs), investments in EE can generate cash flows that allow them to recover their upfront costs in a short period of time, while also improving productivity, efficiency and reducing emissions. However, this opportunity remains largely untapped. There are barriers that inhibit SMEs from investing in EE – including a lack of trust between the different actors, and high perceived risks associated with EE investments.

The energy savings insurance (ESI) model consists of different mechanisms that aim to drive demand and motivate SMEs to invest in EE, by reducing their perceived risks and creating trust between key actors (technology providers, enterprises, financial institutions). The model consists of four main components 1) a financing structure, 2) a standardised and simplified contract that includes a retention guarantee, 3) an insurance, or risk coverage product that guarantees the energy savings, and 4) an independent (third party) validation procedure. The model also includes a management information system that facilitates simplified reporting processes online.

The ESI model is being planned, developed or rolled out, in various countries across Latin America, Africa and Asia, and is now also being implemented in three countries in Europe – Italy, Portugal and Spain – as part of a Horizon 2020 funded project titled ESI Europe. The model was recognised by the Global Innovation Lab for Climate Finance as one of the most promising instruments to mobilize private investments in EE, and also featured in a G20 Toolkit on financing EE. In Colombia and Mexico alone the model is expected to mobilise USD 50 million in private investments in the first years of operation.

Barriers to and drivers for industrial energy management program investment decision-making 5-038-18

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Keywords
investment decision-making, energy management, drivers, barriers

Global demands are forcing manufacturing industries to develop their energy programs by increasing efficiency and lowering environmental impacts. Energy management has therefore played a key role in industrial energy efficiency in recent years. However, still there are problems at very first step of energy management programs which is decision making. The reason can be explained through market and non-market failures. Another essential reason can be explained through how an energy program is characterized by top managers. Managers are positioned in a place to make strategic decisions. Therefore, any program including energy management programs should have both financial and strategical value for the company. Keeping in mind the adoption of energy investment through conformation with financial analysis and organization's contextual factors together with characteristics of energy management program as two macro perspectives in energy efficiency literature, this paper aims to understand the main driving factors which lead to either positive or negative energy investment decision making for a particular energy management program. The investigation has been conducted as a multiple case study involving 15 manufacturing companies of varying size and in different sectors located in Sweden. Having the results from studied cases, enabled the authors to develop a taxonomy of drivers and barriers for industrial energy management investment decision making. The most relevant and pronounced barriers to and drivers for negative and/or positive investment decision making through the studied cases are: access to capital, time and expertise, awareness and uncertainty, practice characteristics, risk and Industry's complexity. According to the analysis of the results, two of the listed barriers that appeared most prominently were non-core business character of the programs and awareness and uncertainty which cause relatively high perception of risk.

Crowdfunding and crowdinvesting: A financing solution for energy (efficiency) investments in businesses? 5-044-18

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Keywords
business models, crowdfunding, local economy, financing, crowdinvesting

Crowdfunding and crowdinvesting offer the opportunity to finance projects with the help of many small financial contributions by many different people ("the crowd"). In the course of the last few years, there has been a rapid development of online platforms and service providers aiming at facilitating crowdinvesting campaigns.

As banks are subject to an increasingly strict regulatory framework governing the rules for issuing loans, access to finance has become more difficult, especially for small and medium sized enterprises (SMEs). Lack of financial means is often mentioned by SMEs as one of the reasons why energy efficiency measures recommended in energy audits are not implemented.

This presentation shows common types of crowdfunding/crowdinvesting models and examines whether and under which conditions it makes sense for businesses to take these financing methods into consideration when they need funds to finance an investment to improve the energy efficiency of their operations or to use renewable energies. This is illustrated by examples, highlighting the benefits, success factors, and also possible risks.

Preliminary research in this field has been carried out by the author with a focus on Austria, where the "Alternative Financing Act" passed in 2015 has clarified the legal framework, and crowdinvesting platforms have boomed. While at first it was mostly start-ups looking to fund the development of innovative products/services, more recently also established firms, for whom financing is not a major issue, use the opportunity for marketing and community/customer involvement.

So far, projects related to energy efficiency measures have been very scarce, though, compared to e.g. financing the development of energy technologies or smaller RES projects (PV, small hydro). This presentation broadens the perspective and looks also at examples from selected other countries, such as Germany, where this type of project is somewhat more frequent.

From energy audits to action plans for implementation of energy efficiency measures 5-049-18

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Keywords
implementation, energy efficiency action plans, energy efficiency programmes, industrial SME, small and medium-sized enterprises

In order to support energy efficiency implementation in Swedish industry, the Swedish Energy Agency has started a number of national programs that are funded by the European Regional Development Fund and are directed towards SMEs. In one of these, the goal is to better utilize the opportunity provided through the supervision of the Swedish Environmental Code to reach companies with guidance on energy efficiency. On the legal grounds of the code, which requires companies to conserve energy, authorities for environmental inspection and enforcement at county administrative boards and municipalities have unique opportunities for enhancing energy efficiency activities in companies. So far, most of the focus has been on best available techniques in energy-intensive industry. Now, however, activities directed towards industrial SMEs and their energy management efforts are being practiced increasingly. There is, consequently, a need for strengthening the competency in energy issues at the authorities and to provide them with methods, tools and information material that can be used in communication with companies in connection with site visits.

One of the outputs of the project, which aims at meeting this need, is a guide for companies on how to develop an implementation plan for energy efficiency. The guide is targeted towards companies that already have identified possible energy efficiency measures, for example in an energy audit, and needs guidance in how to move on and decide which measures to implement. The guide offers advice for developing a useful and effective plan for implementation of energy efficiency measures. It describes how measures can be prioritized based on profitability as well as business strategies, resources and company goals. Methods for investment evaluation are explained and a tool for life cycle cost calculations is provided. In this presentation, the guide and the suggested work process for setting up the implementation plan will be outlined.

Energy efficiency pays: How to convince your CEO 5-052-18

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Keywords
energy management, business case, stakeholder, corporate investment decisions

Most energy efficiency programs can pay for themselves in just a few years. It's not uncommon for large multi-national companies to realize 20 percent or more in reduction over time. That's just the beginning of the potential energy efficiency savings many companies are missing out on simply because they don't have a shared corporate vision, a clear financial plan or a way to track and verify results.

Launching a successful efficiency program starts with building an effective business case that not only sells the plan internally, but also helps to ensure momentum throughout implementation. Drawing from real-life experience with our clients, we have identified the following key steps to creating an effective business case for energy efficiency.

1. Establish early buy-in starting at the executive level. Aligning corporate goals with energy efficiency goals is a fundamental first step, as is aligning corporate goals with individual facility goals. This means that all stakeholders – from the factory floor to the C-Suite – must be involved in identifying and prioritizing energy efficiency goals and performance expectations.
2. Map current performance baselines. Companies operating multiple sites will benefit from having an enterprise-view into energy data so they can compare like sites. It is important to establish a process for normalizing energy usage with input from key stakeholders involved in operations and facilities.
3. Develop an opportunity profile. Once you have a comprehensive view into your energy consumption data, you can assess and prioritize savings opportunities for planning and budgeting. Forward looking companies are starting to take an integrated approach, pursuing operational and capital opportunities in parallel and using savings to pay for their efficiency initiatives.
4. Confirm support of implementation owners. Once you have the pan and buy-in, remember to stay in touch to ensure consistent implementation and to troubleshoot issues early.

How policies incite investments into energy efficiency 5-053-18

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Keywords
energy management, investment decision-making, energy efficiency policy, energy intensity, energy monitoring, measurement and verification

The research project 'Management as a Key Driver of Energy Performance' (M_Key) investigated the relationship between the level of energy management and investments into energy efficiency improvements. It specifically addressed the factors that influence whether a company perceives investments into energy efficiency as strategic.

M_Key targeted large-scale energy consumer companies in Switzerland (above 0.5 GWh/a electric energy and/or 5 GWh/a thermal energy consumption) in the industrial and services sectors. The research was conducted between 2015 and 2017 in three phases:

1. Online survey among 305 companies
2. Face-to-face interviews at 26 companies from those surveyed
3. Case studies with a "walk-through-audit" on site at five companies from those interviewed.

This methodology with the case studies is unique, as a closer "reality-check" was possible by independent energy efficiency experts, assessing the actual status of energy efficiency investments. The presentation will focus on the findings of the case studies which can be summarized as follows:

1. Several factors determine whether a company perceives energy as a strategic issue. Important factors are in particular energy intensity, public policy and the decision-making power and skills of the person in charge of energy (energy manager).
2. If energy is perceived as strategic, the company has a high(er) level of energy management.
3. Energy management has the function to deliver reliable, fact-based data and information as a basis for investment decisions.

4. In most of the five companies the ceiling of possible, feasible and profitable energy efficiency improvement measures is not reached.
5. Monitoring of energy consumption and especially verification of energy savings within the companies remains a challenge.

M_Key is supported by the Swiss National Science Foundation (SNSF) and is part of the National Research Programme "Managing Energy Consumption" (NRP 71): www.nrp71.ch.

Analysis of a new support scheme for energy efficiency investments for industry in Germany 5-057-18

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Keywords
governmental support, investment, funding

Organizations that individually use significant amounts of energy either because of their size or because they use energy for manufacturing still have ample opportunities to undertake energy efficiency measures.

To support their investment into energy efficiency, originally, various support schemes with very concrete elements (e.g. engines, process innovation, energy management) targeted various defined sub-groups among those organisations (e.g. SMEs, manufacturing industry, certain types of municipal companies) with different support mechanisms (e.g. de-minimis grants or grants in accordance to the EU regulation 651/2014, subsidized loans or competitions with an array of special conditions). The support schemes differed in their incorporation of intermediaries, energy service companies and efficiency services providers, and in the way they are linked to existing support schemes for the range of energy services the German market offers.

Funding authorities noted that the outflow of funds had to be increased through heightened activity in order to reach energy efficiency goals. Market research shows that there was and is a significant need for the funding of investment in energy efficiency measures and of energy efficiency services that support the development and implementation of economically viable energy efficiency projects to fully realize the energy savings potential in the commercial and public sector. Policy evaluations have indicated that the energy efficiency projects that exist in reality rarely fit the boxes that had been created by support schemes over the years.

This paper introduces the new support scheme for investments in energy efficiency for industry, commerce and municipalities and links its development to empirical research. It emphasizes the new approach that integrates energy services and intermediaries into the holistic investment support scheme.

Energy efficiency projects deliver! An analysis of 6,500 industrial energy efficiency projects 5-078-18

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Keywords
energy efficient technologies

The success of energy efficiency projects is often reported on an anecdotal basis relying on successful case studies. That information is important, in particular to show technological progress. Still, those highlight projects do not represent the vast majority of energy efficiency projects implemented by the market.

Within the publicly available database DEEP, technological and economic data from over 10,000 energy efficiency projects has been collected by a project consortium on behalf of the European Commission. Half of them are production related industry projects. The other half comprises building projects of which a third has been implemented in the industry, too. The database covers projects from the European Union as well as the United States.

In our paper, we will present an analysis of the industrial projects in the DEEP database, showing payback, avoidance costs and savings of the implemented energy efficiency measures. We will consider influencing factors such as company size, sector, type of measure and country. With our analysis, we can show in detail that cost-efficient measures exist for a broad technological scope.

Overcoming barriers to investing in industrial energy efficiency 5-081-18

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Keywords
energy efficiency investments, survey, overcoming barriers, multiple benefits, energy efficiency measures

The presentations shows analysis of a survey among energy efficiency practitioners on barriers to investing in energy efficiency and ways to overcome them. Part of the survey specifically addressed issues related to investing in energy efficiency in industry. The main conclusions derived from the responses are as follows. A majority of companies have either internal or compliance driven energy efficiency/energy intensity goal. Energy efficiency decisions in companies are often made by the same people as core business decisions. At the same time, low priority of energy efficiency as it is not part of the core business is one of the main barriers faced by a company when considering investment in industrial energy efficiency. The other two significant barriers are lack or high cost of capital and lack of government incentives. About half of companies have some kind of energy management system (EnMS) but no more than one-fifth has EnMS that is ISO 50001 certified. Almost all companies implement some measures or projects to improve energy efficiency. Most common measures to improve energy efficiency are implemented to enhance energy efficiency of buildings and to improve energy efficiency of plant and equipment. As the main business benefits from implemented energy efficiency measures, companies consider improved production efficiency and quality, followed by general cost control, demonstration of corporate social responsibility, and compliance with legislation. In the general part of the survey, low awareness about the multiple benefits of energy efficiency projects is viewed as the main barrier to increasing investment and financing flows to energy efficiency projects. Next important factors are lack of understanding of energy efficiency financing by banks and other financial institutions; administrative barriers and bureaucracy; and low energy prices. Self-financing remains the most widely used type of financing of energy efficiency projects.

The business case foundation: Overcoming the communication gaps between policy makers, corporate management and engineering 5-091-18

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Keywords
business case, business strategy, communication, energy efficiency policy

Energy efficiency has been shown to be largely cost effective and in line with typical industry investment criteria, however, it is still over-reliant on the climate change topic rather than on the business case as an implementation driver. Consequently, energy efficiency is in most cases treated separately from a company's day-to-day core operations, which in turn reduces its prioritization when competing with other more typical internal investment projects.

Adding to this issue are the communication gaps between the policy makers who develop energy efficiency policies, the corporate management who create a company's energy efficiency strategies and the engineers who have to implement projects driven by these same policies and company strategies.

This presentation will demonstrate how a new and innovative policy approach that moves beyond the more classic mix of incentives and obligations is required to bring about a more acceptable common understanding of the energy efficiency topic, which would improve considerably the ability to achieve tangible results on the ground. Reference will be made to such innovative initiatives as the "Policy Maker Meets the Engineer" project, which brings together policy makers and policy end users (corporate management and engineers) to find common and business orientated solutions to increase energy efficiency uptake.

Rather than just compel or entice industry to implement energy efficiency, there is a need to convince them of the beneficial role energy efficiency can play within their overall business model. Industry is first and foremost about business. Energy efficiency makes financial sense and leads to increased industrial productivity, regardless of its importance to climate change. Convincing industry of this fact is crucial, as is convincing policy makers and supporting organizations to take this fact into account when designing energy efficiency policies and financial mechanisms.

Project Asset Class Energy Efficiency – improving pace and number of energy efficiency investments in industry through standardization of the due diligence-processes and risk analysis 5-104-18

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Keywords
energy efficiency investments, energy efficiency financing, risk assessment, due diligence

To increase energy efficiency investments in industry and building sectors, private investments are needed. According to EFFIG, standardization is essential in order to increase third party financing. Part of the project 'Asset Class Energy Efficiency' (ACE) addresses standardization by setting up a technical and economical due diligence process. ACE is aiming at designing framework conditions which allow investors, financiers and ESCOs to evaluate six cross sectional technologies utilizing technical and economical key performance indicators; on top of this other qualitative empiric performance data allows performing a risk analysis. This paper will summarize the results of the evaluation process in an economic and technical due diligence.

For the investment in energy efficiency measures, the progress is divided into five major activities: a) baseline building, b) modeling & savings calculation as well as planning/design decision making, c) implementation on the construction site, d) operation, maintenance and repair and e) monitoring & verification.

The risk evaluation will be carried out for each of these five fields of activity and consider the evaluated experience resulting from ongoing or concluded projects and from re-calibrated modeling calculations. At the same time different stakeholder per-

spectives are taken into account as for each risk the importance for different stakeholder groups differs. In the following, a de-risking strategy will be developed for each technology based on qualitative and quantitative target values and technical, economic and organizational quality management criteria. The de-risking strategy will be summarized in a due diligence protocol and will allow financiers, investors, ESCOs to evaluate project proposals in each of the five fields of activity. In order to integrate market experience, the work is carried out in close collaboration with stakeholders from industry, auditors, insurance companies, financiers, ESCOs and companies.

Barriers to and decisions for energy efficiency: what do we know so far? A theoretical and empirical overview 5-127-18

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Keywords
awareness, industrial SME, decision-making process, barriers, energy efficiency index, quantitative study, qualitative study, skills, energy advisor

To achieve any of the energy conservation and climate goals on a national, European or global level, much more action is required in the field of energy efficiency (EE). To achieve this, barriers of various types need to be overcome and drivers for the decision to act on energy efficiency need to be identified and broadly applied.

Building on earlier findings, this paper empirically investigates the major barriers for EE and what characteristics may play a role in determining the perceived severity of barriers. Underpinned by data of 1,005 manufacturing companies gathered in context of the Energy Efficiency Index of the German Industry (EEI), the Institute for Energy Efficiency in Production (EEP) at the University of Stuttgart and Reutlingen University's REZ explore the role of company size, energy productivity, and in comparison with qualitative studies also geography (Northern Italy) and type of intervention (market ready innovations) in relation to barriers to energy efficiency measures (EEM). Overcoming these barriers often subsequently requires action by the management.

How to trigger that subsequent action, the decision for energy efficiency and notably raising awareness for it, is being looked at in part two of the paper. As previous work indicates, having the staff's support is beneficial in the context of energy efficiency. Exploring how and by whom awareness is raised in aforementioned companies brings to light that whilst a vast majority of companies do it, there are differences depending on size and energy productivity of a company and quite a clear reasoning is found why the majority of the remaining companies don't raise staff awareness.

Obstacles and suggestions of external waste heat projects 5-133-18

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Keywords
waste heat, primary energy, subsidies, peak load supply and redundancy, obstacles and suggestions

In Germany, there are enormous energy efficiency potentials regarding industrial waste heat use. To reach these potentials, dena is supporting fifteen flagship projects in this field. Four of these projects are using waste heat to heat buildings in an external service area. The experiences of the dena-project show that the following issues can be obstacles to realize external waste heat projects:

1. Several subsidy programmes
2. Case of different primary energy factors
3. Displacement of baseload heat supply

SEVERAL SUBSIDY PROGRAMMES

There are several subsidy programmes supporting external waste heat projects with different conditions and levels of investment grants. This put companies in a complex situation (e.g. analysing whether and how these subsidy programmes can be combined).

Another complicating issue for new heating networks is that not all relevant components (like peak load supply) are included in the KfW waste heat programme, which is on the financial side attractive. Waste heat of industrial processes is not generated in such a way to fit the heat profile of consumers. Moreover, industrial plants regularly shut down processes for maintenance purposes. As a consequence, a redundant heat and peak load supply in the heating network must be constructed. Moreover, further subsidy programmes might be needed for financial feasibility of the project. Such a matter should be discussed in an early planning and negotiation stage of the project with all relevant stakeholders.

CASE OF DIFFERENT PRIMARY ENERGY FACTORS

A low primary energy factor of a heating network is a good selling argument for heat providers, since homeowners purchasing heat with a low primary energy factor can fulfil requirements of the energy saving ordinance. Using waste heat in a heating net-

work leads to a lower primary energy factor, since emissions are attributed to the industrial processes.

However, in some particular cases, companies may fear implementing waste heat projects will lead to a higher primary energy factor. For example, in a city with two separate heating networks, the smaller heating network has the requirement not to exceed a certain low emission factor. The larger heating network uses coal and has a higher primary energy factor. To use waste heat in the larger heating network, a connection of both networks would be necessary (direct connection would lead to higher investment costs).

A simple connection (hydraulic coupling) would lead to a common primary energy factor, whereby the smaller heating network will not fulfil its obligations anymore. A hydraulic separation enables to have two separate energy factors. The above mentioned points lead to the question, whether changes in the existing regulation are needed or whether even a system based on emission intensities is more constructive.

DISPLACEMENT OF BASELOAD HEAT SUPPLY

Generally baseload supply in heating networks is an attractive business. However, even for energy sources with low costs and low emissions like waste heat, it is difficult to gain market shares, since CHP, waste incineration plants or solid fuels (often used to supply baseload) are available at low costs. This competition leads to lower usage possibilities of waste heat. In a flagship project, a CHP plant is used for baseload and has a long term contract for biogas delivery. To realize the external waste heat project, the CHP will be used more flexible in the future (according to market prices), after the end of the long term contract with the biogas supplier. However, solid fuels are cheap and may lead to lower economics of such projects. Additional measures, like a CO_2-price, might be needed to increase attractiveness of external waste heat projects.

CONCLUSION

On the one hand waste heat projects have an enormous potential in terms of energy efficiency, on the other hand there are several obstacles for such projects. Moreover, there are very attractive financial conditions for realizing these projects at the moment.

Lighting as a service: key learnings from implementing 100+ projects in three EU countries for corporate & industrial customers 5-134-18

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According to IEA's "Energy Efficiency 2017" report (www.iea.org/efficiency/), lighting has the highest incremental investment share in total energy efficiency spending, but despite ongoing transition to more efficient LED lighting technology, there are still significant barriers in decision-making for corporate and industrial ("C&I") customers, for instance, lack of financial priority (for example Renault has 1 year payback policy), landlord–tenant dilemma, lack of specific LED knowledge (for example: Carrefour does not have a dedicated LED person). On top of that, there has not been significant progress in terms of Lm/W efficacy (the most important criteria for lighting energy efficiency) in the last 1–2 years and customers often choose less efficient and less qualitative solutions that undermine the full potential of LED lighting technology.

RCG Lighthouse, a pioneer in developing "Lighting as a Service" (LaaS) concept in its true sense (which is not fixed lease payment) and holds a Lm/W record of 180 Lm/W, argues that LaaS approach can facilitate faster and more efficient transition to LED lighting technology if LaaS provider can find the right balance by taking and sharing the risks that customers are not willing or capable to take (financial, technical, operational). RCG Lighthouse has raised over EUR 2 million in funding (equity and commercial debt) and has successfully implemented more than 100 projects in three EU countries for C&I customers (retailers, warehouses, factories and other building types).

The contribution will discuss what are the financing challenges for energy efficiency, what are the most recent trends in LED lighting market and how to exploit the full LED lighting potential at wider scale.