Introduction to Panel 4 Technology, processes and systems

Panel leader: **Simon Harvey**
Chalmers University of Technology
Sweden
simon.harvey@chalmers.se

Panel leader: **Anna Realini**
Ricerca sul Sistema Energetico
RSE S.p.A.
Italy
anna.realini@rse-web.it

Introduction

Improved technologies can play a major role in achieving the energy saving targets set by international bodies to tackle climate change. Energy efficiency improvements can be achieved by both process optimization as well as implementation of cross-cutting technologies that have the potential to unlock large energy savings due to their wide application base. Both policy and innovative business models can contribute to accelerating the market uptake of energy efficient technologies. When investigating opportunities for implementing energy and resource efficiency measures, it is important to adopt a holistic view of systems and processes, instead of focusing on individual components, since this often leads to the most significant efficiency improvements. This approach leads to the minimisation of waste, energy savings, enhanced productivity and to an overall resource efficiency improvement.

Panel 4 has received contributions highlighting the impacts of improved technologies, processes and systems and the presentations are organized in four themes:

i. Advanced heat pumps

ii. Optimal use of excess process heat

iii. Development of new technologies and process improvements

iv. Scenarios, roadmaps and policies for decarbonisation

Industrial heat pumps

Heat pumps have been implemented widely in the residential heating sector, but their application in industry has spread only recently, due both to the drive to reduce the environmental impact of industrial processes and the trend to electrify energy systems as a replacement for the use of traditional fuels. The introduction of heat pumps in industry has been enabled by the development of new technologies that can achieve the high temperature lifts required to deliver process heat at high temperatures. However, industrial heat pumps operate under conditions that are very different from those of traditional domestic heat pumps and it is therefore difficult to assess their efficiency and capacity to decrease GHG emissions, compared to other technologies.

Jutsen & Leak (extended abstract 4-003-20) introduce the topic of industrial heat pumps by presenting the results of a feasibility study for applying high temperature heat pumps in the manufacturing industry. The scope is to identify a number of opportunities for cost-effective implementation of this technology. The study is focused on the assessment of the pros and cons related to the installation of flexible, modular and responsive distributed heat pumps as a replacement for central boilers and steam systems.

With the aim of assessing efficiency and effectiveness in GHG emissions cut, Tveit et al. (peer-reviewed paper 4-001-20) apply advanced thermodynamic analysis methods (e.g. exergy and pinch analysis) to identify the conditions where a heat pump installation will be beneficial in tackling global warming. The methodology is illustrated using data from European energy systems as practical examples.

A real case-study is presented by Wilk et al. (peer-reviewed paper 4-132-20). It reports the results of the first operation period of a high temperature heat pump, delivering heat up to 160 °C to supply hot air for brick drying. This work was performed under the H2020 DryFiciency project, in which two high temperature heat pump demonstrators were developed and operated in drying processes in a real industrial environment. The paper presents the results of a techno-economic assessment, taking into account energy consumption, CO_2 emissions mitigations as well cost reductions compared to a conventional natural gas burner.

Considering heat pumps application for drying purposes, Kaida et al. (peer reviewed paper 4-156-20) investigated how COP decreases will increasing temperature lift. Using a simple thermodynamic model of heat pump integration into drying process, they identified the appropriate heat pump supply temperature that maximizes performances, in terms of decarbonisation, energy savings and energy cost reduction, for three different case studies.

Optimal use of excess process heat

Many industrial plants currently discharge their excess heat since they are not able to recover it in a way that can enhance their own energy efficiency. However, considering also a circular economy perspective in which the waste from one plant can be re-used by another, it is important to investigate opportunities to harness excess process heat and export it for re-use at other potential off-site locations. Among these, district heating plays an important role, as some of the presentations will highlight.

Bokinge et al. (peer reviewed paper 4-008-20) investigate how future process development can impact excess heat potentials of a plant, due to different decarbonisation options that might be implemented, e.g. transition to bio-based and/or recycled feedstocks and fuels, carbon capture and re-use or storage (CCUS), and electrification. They present a systematic approach to estimate the evolution of excess heat potentials, supported by two industrial case-studies, selected from a portfolio including a wide range of Swedish industrial process sites.

Strictly related to the availability of excess heat related to different decarbonisation options, Biermann et al. (extended abstract 4-053-20) assess the use of excess heat for CCS as a competitor to other applications, e.g. municipal district heating (MDH). The work considers the concept of partial capture at sites that have access to low-value excess heat, that could be used to satisfy the heat requirements of the capture process. The main focus is on investigating how seasonal variations in the availability of excess heat, as well as the demand for district heating, impact cost-efficient design and operation of partial capture at industrial sites.

Aydemir et al. (peer-reviewed paper 4-073-20) present a methodology for estimating the costs of supplying industrial excess heat to district heating areas, considering the availability from supplying factories, the seasonal profiles and the distances (heat transport costs). This is performed by mapping demand and offer of excess heat in the EU-28 and by designing the heat transport network, taking into account investments and operating costs for pipelines and heat exchangers and heat losses. This allows for generation of cost-potential curves that are useful to identify future district heating development areas.

Development of new technologies and process improvements

This topic deals with energy efficient technologies, their integration into processes and their contribution to the reduction of industrial energy demand.

One of the main transformative pathways for industrial decarbonisation is process electrification. Rightor et al. (extended abstract 4-126-20) discuss opportunities and challenges for significantly increasing industrial electrification, including ways to overcome hurdles, pathways to accelerate the growth of niche applications, and policy approaches to enable more rapid adoption of current, emerging, and future electro-technologies.

Zuberi et al. (peer-reviewed paper 4-108-20) explore the techno-economic final energy and CO_2 saving potentials in the Swiss industry in the short-to-medium term at the level of individual sectors and for cross-cutting technologies, by means of process integration and electrification as compared to traditional energy efficiency processes.

One of the most currently discussed topics is digitalization of industrial energy systems. van Werkhoeven et al. (extended abstract 4-014-20) discuss how electric motor driven systems can be digitalized in order to optimize their efficiency in operation (operational cost, flexibility, procurement, footprint), energy, materials (circularity) and emissions. One of the most important questions is whether digitalization leads to an extra energy use and how to avoid it. The presentation focuses on the assessment of the potential efficiency gain in digitalizing electric motor driven systems and how policies can support it.

Amarnath et al. (peer-reviewed paper 4-056-20) present the results of an ongoing experimental activity on ultra-low charge air-cooled ammonia chillers, a new technology that allows both energy efficiency and water saving in industrial applications, compared to conventional ammonia-based chillers and water-cooled chillers. A case-study is presented of a food processing industrial site in the USA.

Laribi et al. (peer-reviewed paper 4-057-20) investigate how the integration of flywheel energy storage systems in industrial processes can reduce the installed power of new machines and increase energy efficiency, by highlighting benefits and drawbacks of this technology. The main focus is the integration and control of the system, in order to identify the design requirements and the crucial system parameters. This is corroborated by the proposal of flywheel energy storage solutions for three industrial applications.

Side-by-side with completely new technologies or new applications of conventional ones, it is important to continue to optimize of traditional and widespread ones. Gryboś & Leszczyński (peer-reviewed paper 4-092-20) introduce the energy efficiency advantages of double transmission double expansion (DTDE) in compressed air systems. This technology is based on the accumulation of air exhausted from the pneumatic machine which can thereafter be used in another pneumatic machine and, for example, converted into electricity. This overcomes the issues of energy losses in compressed air systems and oversizing of pneumatic lines and machines.

Research and development (R&D) plays a crucial role in industrial energy efficiency. Since many countries have set ambitious targets for curbing GHG emissions through reduced energy usage, public funding is widely available to sustain associated R&D. However, the allocation of public R&D funds should be as efficient as possible, which requires a focus on substantial energy efficiency potentials, identifying bottlenecks and detectable risks, and supporting stakeholder dialogue with comprehensive information. Lösch et al. (peer-reviewed paper 4-109-20) propose a methodology that can be applied to research projects, in order to assess the potential of energy efficient technologies in terms of energy savings and economic benefits. The study is supported by the presentation of a case-study on solid oxide high temperature electrolysers.

Pastowski & Kobiela (peer-reviewed paper 4-155-20) approach the issue of energy efficiency in industry from a different perspective. In particular, they evaluate how the use of additive manufacturing can affect potential energy efficiency determinant, such as the use of material per unit, changes in the number and allocation of some stages of the value chain and end-use energy efficiency of the final product. They present the results of the REINVENT project, which focused on the energy efficiency potential of wire arc additive manufacturing.

Scenarios, roadmaps and policies for decarbonisation

Last but not least, energy efficiency requires not only suitable implementation of technologies and process optimisation, but should be sustained by policies, analysed and guided with roadmaps and evaluated in long-term scenarios that take into account the challenging targets for energy saving and GHG emission cuts put in place by the international community.

Future energy market scenarios should be taken into account when evaluating the long-term effects of energy efficiency projects. Wiertzema et al. (peer-reviewed paper 4-018-20) present a linear optimisation model for assessment of annualised costs under current and future energy market conditions. They apply their model to the case of hybrid electric/gas steam generation, evaluating the optimal capacities in terms of total annualised cost of steam production for different energy market conditions, which are used as base for three investment decisions that were further assessed in terms of running costs, impact of on-site CO_2 emissions, and electric grid capacity limitations.

Among the current policies, white certificates are the main tool used in many countries related to the incentivisation of energy efficiency in industry. Berthou et al. (peer-reviewed paper 4-036-20) analyse the white certificate system in France, focusing on its application to electrical motors. In particular, they investigate how the existing framework, in which each part of the motor device is considered separately, can be improved by the introduction of a new global system approach, which considers the efficiency of the motor driven system as a whole. They analyse the energy efficiency benefits by presenting two case studies.

In order for countries to adapt their policies to the already achieved and the future achievable energy consumption cut, it is necessary to have a thorough analysis of the status of each industrial sector and of the technologies that could benefit those sectors in terms of energy efficiency and cost reduction. Bhadbhade & Patel (extended abstract 4-102-20) evaluate the current status of energy efficiency in the Swiss food and beverage industry and investigate the options to realize the energy efficiency and CO_2 abatement targets.

Conclusions – key messages

The panel covers all aspects of industrial efficiency improvements within technologies, processes and systems as well as their combination, with also some suggestions for policy and long-term scenarios. The key messages from the panel contributions are as follows:

- Technology plays a crucial role in tackling global warming and achieving 2050 targets. It is important to consider new advanced technologies as well as new applications of conventional ones.
- High temperature heat pumps are one of the most promising technologies in terms of energy saving and, more importantly, GHG emission cuts.
- Energy efficiency of industrial systems is continuously improving, reflecting the raised awareness of its benefits, in conjunction with implementation of better strategies to improve industrial processes as a whole. Some of these process improvement strategies are now well proven and have high replication potential.
- Integration with regional energy systems, adopting a circular economy perspective, can play a key role in energy efficiency, as demonstrated by the new ways that are emerging for enhancing the re-use of excess process heat in district heating systems.
- Suitable policies are the foundation upon which energy efficiency is built: however they must be continuously adapted to new technologies and process developments, in order to promote and incentivise the most promising applications.