

# Final report

## 1. Project details

<b>Project title</b>	Danish Participation in International Energy Agency (IEA) Technology Collaboration Programme on Industrial Technologies and Systems IEA IETS
<b>File no.</b>	64017-05136
<b>Name of the funding scheme</b>	EUDP
<b>Project managing company / institution</b>	DTU Mechanical Engineering
<b>CVR number</b> (central business register)	30060946
<b>Project partners</b>	Weel & Sandvig, DTU Compute
<b>Submission date</b>	20 January 2021

## 2. Summary

### *English Summary*

The project has focused on the continued Danish participation in the International Energy Agency's (IEA) technological collaboration programme (TCP) on industrial energy-related technology and systems (IETS). Denmark has a historical position as leading in industrial energy efficiency, and has numerous companies, which supply excellent energy technology. This position has been reached through close collaboration between research and industrial development as well as close contact to the international environment, among others through IEA. In the project, we have contributed to several parts of the work in the IEA program. This includes participation in executive committee work, in Annex XV on excess heat utilization, in Annex XVIII on Digitalization, Artificial Intelligence and Related Technologies for Energy Efficiency and GHG Emissions Reduction in Industry as well as the development of new annexes on electrification, industrial decarbonisation and roadmaps in industry. Denmark is furthermore represented in Annex XVII Membrane Processes in Biorefineries without support from the EUDP grant. The work has involved organization of international workshops and meetings for the Danish National Support Group. The results of the work have been communicated to Danish stakeholders, while the dissemination of Danish results are done by work several annexes. This will result in increased industrial energy efficiency as well as further options for Danish impact internationally. Further development of the National Support Group and contribution to annexes are also expected as future outcomes of the work.

### *Dansk Resumé*

Projektet har fokuseret på den fortsatte danske deltagelse i Det Internationale Energiagenturs (IEA) teknologisamarbejdsprogram (TCP) om industrielle energirelaterede teknologier og systemer (IETS). Danmark har en position som førende inden for industriel energieffektivitet og har adskillige virksomheder, der leverer energiteknologi i verdensklasse. Denne position er nået gennem tæt samarbejde mellem forskning og industriel udvikling samt tæt kontakt til det internationale miljø, blandt andet gennem IEA. I projektet har vi bidraget til flere dele af arbejdet i IEA-programmet. Dette inkluderer deltagelse i bestyrelsesudvalgets arbejde, i annekse XV om overskudsvarmeudnyttelse, i annekse XVIII om digitalisering, kunstig intelligens og relaterede teknologier til energieffektivitet og reduktion af drivhusgasemissioner i industri samt udvikling af nye annekser om elektrificering, industriel dekarbonisering og roadmaps i industrien. Danmark er desuden repræsenteret i annekse XVII membranprocesser i bioraffinaderier uden støtte fra EUDP. Arbejdet har indeholdt organisering af internationale workshops og møder for den Nationale Støttegruppe. Resultaterne af arbejdet er formidlet til danske interessenter, og kommunikation af danske resultater er sket ved arbejdet i annekser. Dette vil bidrage til øget effektivitet i dansk industri og giver mulighed for at danske løsninger anvendes yderligere internationalt. Videre udvikling af den nationale støttegruppe og bidrag til annekser forventes også som fremtidige resultater af arbejdet.

## Project objectives

The project had four primary goals:

1. To support Danish industry in meeting the future energy-economic and energy policy changes that will come in connection with the transition of the energy system towards independence from fossil fuels
2. To contribute to disseminating Danish knowledge and technology to international stakeholders through the IEA's effective dissemination system and presentations at international workshops
3. To take advantage of the rapid development of digital solutions to improve the energy efficiency of the industry, including meeting the need for greater electrification of the industry's energy use in connection with the conversion to renewable energy
4. To strengthen energy research among Danish knowledge institutions through participation in the IEA's expert network and projects

## 3. Project implementation

The work in the project has been divided into five work packages. The work in these were done in agreement with the definitions in the projects application – with a few exceptions related to developments in the IEA program during the period. These changes in the program were agreed upon in the Executive committee:

### *WP1. Participation in the IEA-IETS Executive Committee*

The participation in the ExCo work has been done by Delegate Brian Elmegaard, DTU Mechanical Engineering, and Alternate Delegate Jan Sandvig Nielsen, Weel & Sandvig. This has involved two annual meetings of two days duration. The meetings have been hosted by members of the TCP – except for the meetings in 2020, which have been held online.

- 26th IETS ExCo Meeting, May 28-29 in Paris France
- 27th IETS ExCo Meeting, November 27-28 in Rome, Italy
- 28th IETS ExCo Meeting, May 14-15 in Paris, France
- 29th IETS ExCo Meeting, November 27-28 in Espoo, Finland
- 30th IETS ExCo Meeting, May 27-28 online via GoToMeeting

- 31st IETS ExCo Meeting, November 24-25 online via GoToMeeting

Most of the meetings have involved a workshop covering aspects of the future development of the TCP. Denmark gave presentations at the workshop on *News and Highlights on Industrial R, D&D in Denmark, Development of National Support Group and available Roadmaps* at the 26<sup>th</sup> meeting and a presentation on *Danish Industrial Roadmaps* at the 28<sup>th</sup> meeting.

The ExCo meetings cover updates from the chair, the IETS secretariat and the IEA central organization, status for reports and dissemination, status for active annexes and discussion, and decisions about new annex proposals. The communication in terms of Topics sheet and participation in international workshops has had significant attention.

Two international workshops have been organized by the TCP. Denmark participated in both, covering Deep decarbonisation of industry in Vienna in October 2019 and Process Integration for the Energy Transition in Industry in collaboration with the energy section of EFCE - European Federation of Chemical Engineering 30 November 2020.

The ExCo has initiated a survey of the options for collaboration with other TCPs. More than ten ideas for mutual interests have been identified and will be pursued further.

#### *WP2. IEA-IETS National Support Group*

The TCP aims at having an active National Support Group in each of the member countries. During the present period, we have developed the Danish group. Initially it consisted of the partners involved in the project grant, but in the latest meeting more than 30 attended. The National Support Group is used for disseminating the work in the annexes and for communicating new options for participating in the IETS work. The latest meeting included presentations of the work in the ExCo by the TCP chair Thore Berntsson and by Brian Elmegaard. The program also included a presentation of the options for funding IEA work from EUDP and four presentations of the work in the current annexes as well as the new annexes to be started in 2021.

#### *WP3. Danish Participation in Annex XV – Industrial Excess Heat Recovery*

Denmark has been part of the longstanding Annex XV on Industrial Excess Heat Recovery since it was initiated. Presently the annex is working in the third task on covering advanced topics related excess heat recovery. This task covers the topics Combination of methods for excess heat identification and quantification, Consequences for excess heat levels of future changes in industrial energy systems, Operational aspects in industrial energy systems, Opportunity and risk assessment for excess heat projects, Compilation of innovative excess heat projects. The annex will be finalized in October 2021. Denmark has contributed in three online workshops about the annex, and we have provided a collection of recent Danish projects related to the annex for the final report.

#### *WP4. New annex on energy-efficient control*

Denmark had proposed a new annex on the topic *Energy-efficient control*. The work was initiated in collaboration with the chair of the TCP and it was discussed in the ExCo. As a consequence of the work in Annex XVIII on Digitalization, Artificial Intelligence and Related Technologies for Energy Efficiency and GHG Emissions Reduction in Industry, it was decided that the Danish proposal should be connected to this annex. This has been taking place in the form of international collaboration, with partners who may be interested in joining IETS as members or sponsors and in communication with Annex Management.

DTU Compute has contributed to the goals by working purposefully with Danish and international companies and research institutions on the development of advanced control and optimization methods for managing

industrial plants with a view to process efficiency, including energy efficiency. We have disseminated the application of advanced process regulation widely and have demonstrated how these technologies can be used to achieve increased energy efficiency in industry and for heating purposes. We have also participated in a number of national and international conferences and workshops with a view to disseminating methods and results related to digitization, management and optimization of energy and production processes. DTU Compute's activities in this area have gained considerable international attention and been recognized as world leading. The work has involved development and dissemination of solutions for streamlining cement production. Danish and international companies have participated in this development and dissemination. These solutions have been commercialized and applied in industry. DTU Compute has also contributed to the dissemination of these methods and their application in the mineral industry, the iron and steel industry, as well as to the rock wool industry. DTU Compute has participated in the development and dissemination of advanced process control and Model Predictive Control (MPC) for the food industry. Furthermore, the control and optimization methods have been demonstrated and disseminated for a number of integrated energy systems based on electricity from renewable energy sources. In these systems, it is shown how heat pumps can be controlled effectively in coordination with the rest of the energy system. The results related to advanced control in industry have been disseminated in two workshops related to the TCP.

#### *WP 5. Danish participation in future IEA-IETS activities*

We have been involved in Annex XV until the end of 2020. The present task of the Annex will continue until October 2021. We have received funding for joining the remaining part of the annex. Viegand Maagøe will enter as a new partner in the annex.

Denmark is well represented in Annex XVII. This contribution is not part of the grant. It will be considered if the group participating in the annex will apply for funding for future activities.

Denmark has contributed to the development of the new annexes under IETS during the project period.

Annex XVIII Digitalization, Artificial Intelligence and Related Technologies for Energy Efficiency and GHG Emissions Reduction in Industry has been initiated and Task 1 has been completed with the aim of defining a common scope of the future work. Denmark has contributed to this by contributions from SDU, University of Southern Denmark, which are not part of the funding related to the grant. It is expected that Denmark will engage further in the work in the coming tasks. The annex is managed by Canada.

Annex XIX Electrification in Industry was started by task 1 which was carried out during 2020. The specification of the annex has been under discussion since 2018 and it has involved a number of workshops, meetings and interviews. The work in task 1 involved definition of the scope of the term electrification as related to industry, and discussion of the contributions from the participants and the next tasks to be conducted during the period 2021 to 2023. The annex is highly relevant for the transition of the Danish industry energy system, and further participation is expected. The annex is managed by the Netherlands.

New Annex on Decarbonizing industrial systems in a circular economy framework will be started in 2021. This is an outcome of the workshop on deep decarbonisation in Vienna in October 2019. Denmark has contributed to the definition by participation in interviews, workshops and discussions on this. The scope is mainly on industrial symbiosis related to the carbon cycle of industry focusing on CCUS carbon capture, utilization and storage. We have identified potential Danish partners and hope that a Danish consortium will join the first task of the annex on the definition of common interests and future tasks to be conducted during 2021. The annex is proposed by Austria.

New Annex on Industry Roadmaps will probably be started in 2021. The decision will be taken by the ExCo by End January 2021. Denmark supports the proposal. Denmark has contributed to the definition by participation in discussions about the scope. We hope that a Danish consortium will join the first task of the annex on the

definition of common interests and future tasks to be conducted during 2021. The annex has been proposed by France.

Participation in Annex XVI Energy Efficiency in SMEs was intended to be an activity of the project. However, the annex period has been under completion. We will work on further development in the field and initiation of a new task.

We have been involved in the review of the report of task 2 of Annex XV. This work has led to a more formal definition of the review process of IETS reports.

Academic institutions and public funding bodies have focus on publications in international peer-reviewed journals and conferences with the aim of Open Access to the papers. This aim is not fully correlated with the conventional aim of publishing reports in the TCP. We have entered into the discussion of better alignment of these aims.

## 4. Project results

The results of the work are well aligned with the purpose and the milestones defined in the project application.

### *WP1. Participation in the IEA-IETS Executive Committee*

We have participated actively in the ExCo work and we have contributed to communication and development of the results of the TCP. This includes work on report quality and review and alignment between reporting and scientific publication in open access.

Three new annexes have been formulated. We have contributed actively to their definition.

### *WP2. IEA-IETS National Support Group*

The Danish National Support Group has been defined, initially as the consortium participating in the grant. The latest meeting in December 2020 was held as a webinar, and it involved all Danish participants in the present IETS activities. In addition, potential partners of the future activities were present.

### *WP3. Danish participation in Annex XV – Industrial Excess Heat Recovery*

We have been involved in the workshops of the annex – involving DTU Mechanical Engineering and Weel & Sandvig. This has led to a complete survey of projects available on energiforskning.dk and other sources, which has resulted in a report on 33 identified Danish projects that are relevant as contributions to the annex. We will present these in a workshop January 2021, and we will contribute further to the annex work until the end in 2021.

### *WP4. New annex on energy-efficient control*

The annex proposal was revised by the TCP ExCo during the period. It was suggested to connect it and Advanced Process Control (APC) to Annex XVIII. In order to promote Danish technology related to APC and energy systems a number of activities and workshops with Danish and international institutions and companies was undertaken in order to disseminate the potential of APC in relation to energy systems; and to promote Danish APC technology. The work has led to commercialization of Danish APC technology and the methods and potentials have been disseminated at conferences and workshops. Also the participants of the annex have been invited to open workshops in relation to APC in which several national and international partners have participated and reported the potential and concrete results related to APC. The huge interest in these work-

shops may lead to increased national and international collaboration concerning the concrete application of APC for process and energy systems.

#### WP 5. Danish participation in future IEA-IETS activities

We expect to extend the Danish participation in the future work of IETS. The new annexes on electrification, decarbonisation and roadmaps as well as the present ones on digitalization, excess heat and membrane technology have significant importance for Danish industry. We have contributed to the formulation of these for covering Danish interest and potential impact mostly.

## 5. Utilisation of project results

The results of the project are mainly related to the communication of Danish work in the field of industrial energy systems and the dissemination of results from Denmark to the international community and vice versa. This has been implemented by extending the National Support Group and by encouraging more Danish stakeholders to join the relevant annexes of the TCP. This is expected to result in further involvement during the coming years. We also aim at involving the TCP in other international networks and conferences, e.g., the ECOS 2022 to be held in Copenhagen.

## 6. Project conclusion and perspective

The IETS TCP is highly active in the important work on the green transition of the industrial production and energy processes related to this. Accordingly, the TCP is an important platform for promoting Danish results and disseminating to and from the national support group – perceived as any relevant stakeholder. Denmark is very ambitious in the policies related to reaching climate neutrality, which means that many important Danish results will be fruitful for the international collaboration, and that the TCP work may support the impact of the national Danish work.

Results of Danish research, development and demonstration projects in the fields of digitalization, electrification, energy efficiency and decarbonisation are highly relevant for the IETS annexes and have provided important contributions to the recent results of the work in the TCP.

## 7. Appendices

Presentations from ExCo meetings and related workshops are available for TCP members on the website of the program: <https://iea-industry.org/members/>

The topic sheets and reports of the IETS TCP are available on the website of the program: <https://iea-industry.org/publications/>

The report of *Annex XV – Industrial Excess Heat Recovery Task 3 on Combination of Methods and Operational Aspects for Industrial Excess Heat-Available Resources, Risk Minimization and Consequences of Future Changes in the Energy System* will be available when the task is completed by October 2021.