

# Final report

## 1. Project details

<b>Project title</b>	Deltagelse i IEA ISGAN Annex 7 Smart Grid
<b>File no.</b>	64017-05203
<b>Name of the funding scheme</b>	EUDP
<b>Project managing company / institution</b>	Danmarks Tekniske Universitet (DTU)
<b>CVR number</b> (central business register)	30 06 09 46
<b>Project partners</b>	Rådet for Grøn Omstilling/RGO. English name: Green Transition Denmark. Teknologisk Institut/TI. English name: The Danish Technological Institute.
<b>Submission date</b>	23 April 2024

## 2. Summary

### *English version*

The aim of the project is to strengthen Danish participation in ISGAN Annex 7 Smart Grid Transitions and to help disseminate knowledge on smart grids between Danish stakeholders and the ISGAN international community. This includes participation in Annex 7 meetings and dissemination of information from ISGAN activities to Danish stakeholders and vice versa through an annual seminar (or webinar).

The project has created a more nuanced and people/actor-centred understanding of the barriers and opportunities for the development of a smart grid and flexible energy system, applying a transitions perspective that integrates socio-economic and technical disciplines. The results are presented in the report "A transition perspective on demand-side flexibility in the integrated energy system: insights from the Danish ISGAN Annex 7 project 2017-2021" co-authored by experts involved in the project's activities. It develops an integrated socio-technical framework for analysing and promoting flexibility services in the smart and integrated energy system, focused on the interplay of actors, institutions (especially regulation), and technologies.

The project showed that these three pillars of the energy transition are constantly interacting and evolving. A focus on this dynamic interplay is important, partly because of the rapid technological progress, as demonstrated by the progress made in low-carbon production and data management, but also to take the social dimension of the energy transition into account. In between, regulators must design a body of rules that ensures the coordination of all actors in terms of their integration in the electricity value chain and across energy

sectors, to balance the volatile production of renewable energy resources. In the Nord Pool market area, for example, the successive evolution of electricity market rules demonstrate how industry players are progressively completing the market design to meet the constraints imposed by the rapid growth of wind energy. A key facilitator is a transparent, well-organised and inclusive discussion forum for the sector's stakeholders.

#### *Danish version*

Formålet med Annex 7 i Det Internationale Energi Agentur's (IEA) Internationale Smart Grid Action Network (ISGAN) er at undersøge smart grid transitionsprocesser i samfundet og institutionelle ændringer forbundet med disse. Annexet understøtter og supplerer teknologiorienterede smart grid aktiviteter. Projektets formål er, at styrke dansk deltagelse i ISGAN Annex 7 Smart Grid Transitions, herunder at formidle viden om smart grids mellem danske interessenter og det internationale ISGAN fællesskab. Det indbefatter deltagelse i Annex 7 møder og formidling af information om ISGAN aktiviteter til danske interessenter or vice versa, primært igennem afholdelse af et årligt ISGAN seminar (eller webinar) i Danmark. Projektets fokus er institutioner, markeder og aktørinvolvering på smart grid området, med vægt på markedsskabelse for et mere fleksibelt energiforbrug, der skal understøtte indfasning af store mængder fluktuerende vedvarende energi i energisystemet.

Projektet har udviklet og formidlet en mere nuanceret og aktør-fokuseret forståelse af barrierer og muligheder for udviklingen af et smart grid og fleksibelt energisystem, ved at anvende et transitionsperspektiv, som integrerer socioøkonomiske og tekniske fagligheder. Resultaterne er formidlet i rapporten "A transition perspective on demand-side flexibility in the integrated energy system: insights from the Danish ISGAN Annex 7 project 2017-2021" forfattet af eksperter der har været involveret i projektets aktiviteter.

Rapporten præsenterer blandt andet en integreret socioteknisk metodisk ramme, der kan bistå i analyser og promovering af fleksibilitetsservices i det smarte og integrerede energisystem, med fokus på samspillet mellem aktører, institutioner (især regulering) og teknologier. Projektet viste, at disse tre centrale elementer i omstillingen til et bæredygtigt energisystem udvikles hele tiden i samspil med hinanden. Et fokus på dette dynamiske samspil er vigtigt, dels på grund af den hurtige teknologiudvikling og for at tage højde for den sociale dimension af energisystemet og -omstillingsprocessen. Projektet understreger også, at der er behov for et regelsæt som sikrer en effektiv koordinering af alle relevante aktører med hensyn til deres integration i elektricitetsværdikæden, samt på tværs af energisektorer, for at kunne balancere energisystemet i en situation med en høj andel af fluktuerende vedvarende energi. For eksempel viser den stadige udvikling i regelsættet i Nord Pool markedsområdet hvordan aktørerne her skaber et nyt markedsdesign, der adresserer de udfordringer, som den hurtige vækst i vindenergiproduktionen skaber. En nøglefaktor i den udvikling har været en gennemsigtig og velorganiseret proces og diskussionsforum, der har inkluderet alle interessenter i sektoren.

### 3. Project objectives

The aim of the project is to enable and strengthen Danish participation in EIA-ISGAN Annex 7 (Smart Grid Transitions) and to help disseminate knowledge on smart grids between Danish stakeholders and the ISGAN Annex 7 international community. The project includes participation in the international meetings of Annex 7, and ISGAN generally to some extent. In addition to bringing Danish perspectives to International smart grid discussions, the project will disseminate information from its international and domestic activities to Danish stakeholders broadly. This is done through an annual smart grid transition seminar held in Denmark and through presentations at other workshops and meetings in Denmark. Stakeholders include industry, central and local governments, non-governmental organizations, and research. The contribution to the ISGAN Smart Grid Transition Annex is made in dialogue with the lead operating agent on the Annex, Austrian Institute of Technology. It is expected that the Danish contribution will continue to offer valuable new insight, be a good activity injection to the Annex, and support dialogue about future ISGAN efforts.

Neither Annex 7 nor this project focuses on a specific technology area but is rather concerned with how the interplay of technologies, actors and institutions (see section 5 below) affect transition to a smart grid and a clean energy system more broadly over longer time periods. The main focus of the project is the role of flexibility in this transition, particularly on the demand-side. A key premise is that while there is need of flexibility in the consumption end of smart grid, it is not obvious that this flexibility actually will be obtained or that it will be of benefit to and supported by consumers. Moreover, large changes and not just small, unnoticeable changes can be expected at consumers. Major new technology components will often be involved, e.g. heat pumps, solar cells, electric vehicles, and low-energy buildings. A role as prosumer that both produce and use energy will be more frequent and a degree of decentralization can take place. The strong international perspective of the project acknowledges the fact that smart grid challenges, driving forces, energy systems, governance structures and consumption patterns to some degree differ from country to country.

## 4. Project implementation

The project evolved with the Danish ISGAN Annex 7 seminars as the project's Danish focal activity, and an ISGAN Annex 7 session at the annual International Sustainability Transitions (IST) conference as another, international focal activity. A third important international Annex 7 activity-type has been the regular - mainly online - meetings in the Annex 7 group of national experts comprising members from Austria, Belgium, Denmark, France, Italy, India, the Netherlands, Sweden and Germany. The project's participants from DTU, TI and RGO) furthermore participated in various smart-grid related meetings and workshops including policy, technical and scientific meetings (see annual reports for details).

A summary of these activities are presented below along with a reflection on their development, milestones and problems encountered, where relevant.

### 4.1 Participation in ISGAN meetings and communications (WP1)

#### *Regular meetings in the Annex 7 group of national experts*

Regular - mainly online - meetings we held in the Annex 7 group of national experts comprising members from Austria, Belgium, Denmark, France, Italy, India, the Netherlands, Sweden and Germany. The meetings were chaired by the Annex 7 Operating Agent, and members presented their ISGAN-related research activities, discussed the Annex's Programme of Work, and provided inputs to the ISGAN Executive Committee meetings. The meetings, attended mainly by DTU participants, were a good occasion to present our research activities within clean, flexible energy and smart grids and be updated on research and policy activities in other, mainly European countries. These meetings also served to plan and discuss external activities such as the organisation of a joint smart-grid session at the annual IST conferences, and get input to the planning of the Danish stakeholder seminars. The following gives an example of the content of the Annex 7 meeting on 24/05/2019 (see project report to EUDP 2018-19):

- General Annex issues,
- Presentation of country activities related to ISGAN Annex 7 (Part 1 and 2),
- Annex 7 Program of Work 04/2019 – 03/2020,
- Activities and deliverables until 03/2020,
- Strategy beyond 2020,
- Resources.

A further topic of the Annex 7 meetings was collaboration with ISGAN Annex 6 on Power Transmission and Distribution Systems. A physical meeting with both annexes was planned in conjunction with the second Danish stakeholder seminar, but was cancelled due to COVID-19; instead the Annex 6 Operating Agent (Joni Rossi, RISE in Sweden) participated in the third Danish seminar (webinar) and has provided substantial input to the reporting from the seminars (see section 4.2).

The project participated in the ISGAN meeting held on 23 May 2018 during the Nordic Clean Energy Week, titled "Intelligent market design – boosting global smart grid deployment" (<http://swedishsmartgrid.se/aktuellt/kalendarium/cem-side-event-intelligent-market-design--boosting-global-smart-grid-deployment/>), Claire Bergaentzlé, DTU.

At the ISGAN Annex 7 meeting on 18 December 2020, it was decided to create **two Annex 7 thematic groups** for which there would be regular (bi-monthly) meetings ("deep-dive knowledge workshops") in 2021: Topic 1 - Sandboxes: (as part of Sandbox 2.0 Inter-Annex collaboration) and Topic 2 - Decentralization and integration.

During the period 9 February - 12 July 2021, the project participated in these knowledge workshops. The first series of workshops concerned so-called **regulatory sandboxes** (experiments with new regulatory setups with respect to e.g. enabling demand-side flexibility), led by the organisation LightSwitch in Sweden. The interactive workshops, as well as national stakeholder dialogues in some countries (although not in Denmark), resulted in a document presenting four policy messages on sandbox experiments presented to the 12th Clean Energy Ministerial (CEM12) meeting hosted by Chile, supported by a video placed on the official CEM12 website. See <http://www.cleanenergyministerial.org/> and <https://cem12mi6chile.com/>). The project was also presented at the ISGAN Academy webinar on 10 June 2021, and resulted in an update of the case book of sandbox regulatory experiments available from the ISGAN publications website.

The thematic group and bi-monthly workshops on the topic of **decentralisation and integration** in relation to the transition to a clean energy system and was led by Eindhoven University of Technology, the Netherlands. This work has resulted in a draft paper titled "**Decentralised energy futures**" that will be submitted to a scientific journal in September-October 2021.

### ***Smart-grid transitions session at the annual IST conference***

The project participated in the sessions organised by ISGAN Annex 7 in the annual International Sustainability Transitions (IST) conference:

- **IST 2018**, 11-14 June, Manchester. <http://www.conferecare.manchester.ac.uk/events/ist2018/>. Participation in the session "Regulatory Innovation Zones as New Transformative Innovation Policy Instruments" (13/06) organized by ISGAN Annex 7 network and Operating Agent.
- **IST 2019**, 23-26 June, Carleton University, Ottawa. <https://carleton.ca/istconference/> Participation in the session "2D Governing Transitions" (24/06). Talk by the ISGAN Annex 7 leader Klaus Kubeczko (AIT) on "Experimental Sandboxes as tools for Transformative Innovation Policy for the Energy Transition" and one by Kevin Jones (Vermont Law School) on "Carbon Pricing in Electricity Markets: Expediting the Low Carbon Transition while Mitigating the Growing Conflict between Renewable Goals and Regional Electricity Markets".
- **IST 2020**, 18-21 August, Vienna (online). [www.ist2020.at](http://www.ist2020.at). Participation in the dialogue session "Learning and Evaluation Concepts for Regulatory Experimenting - from Energy Communities to renewable Hydrogen" (21/08) co-organized by ISGAN Annex 7. Simon Bolwig, DTU, served in the conference's scientific committee.
- **IST 2021**, 5-8 October, Karlsruhe/Online. ISGAN Annex 7 submitted a proposal for a dialogue session on "Visions of decentralization in the energy transition" as part of the conference track "Mainstreaming transitions: from research towards impact".

**Participation in other meetings and workshops related to smart grid transitions**

The project participants participated in a range of other meetings of relevance to smart grid transitions and flexible energy system, listed below.

**2018**

Presentation at the Nordic Clean Energy Week event: "Sustainable Future Energy Systems" 24 May 2018 at Aalborg University, CPH Campus. Title of presentation: "Nordic solutions for unlocking a decarbonised, sustainable energy future", Klaus Skytte, DTU (presenter) and Simon Bolwig, DTU (participant).

Presentation at the workshop "Future opportunities for Danish-Korean Clean Energy collaboration" 25 May 2018 at Ministry of Higher Education and Science – Denmark. Title of presentation "Achieving flexible and sustainable energy systems", Klaus Skytte, DTU.

Participation in workshop "Behov for nyt tarifdesign for elnettet?" organized by the Danish TSO Energinet and Dansk Energi, 16 March 2018. Klaus Skytte, DTU.

Interview with Danish Energy and the Danish TSO Energinet about "New Design of Tariffs for the Future", 17 May 2018. Klaus Skytte, DTU, and Søren Dyck-Madsen, RGO.

Participation in the conference arranged by Intelligent Energy "Buildings as an active part of the Energy System", 4 April 2018. Søren Dyck-Madsen, RGO.

Participation part time in the conference arranged by Energiforum Danmark and DANVAK "Get ready for Big Data", 5 April 2018. Søren Dyck-Madsen, RGO.

Participation in the ISGAN meeting on 23 May during the Nordic Clean Energy Week, titled "Intelligent market design – boosting global smart grid deployment". <http://swedishsmartgrid.se/aktuellt/kalendarium/cem-side-event-intelligent-market-design--boosting-global-smart-grid-deployment/>. Claire Bergantzé, DTU.

Presentation at conference World Congress of Environmental and Resource Economists (WCERE), Gothenburg, 25-29 June 2018. Presenter of "Grid tariffs designs that enable a flexible coupling of electricity and heat markets. Can you teach old electricity markets new tricks in a renewable future?" Klaus Skytte, DTU.

Presentation at Sino-Danish iClimate workshop on sustainable energy, Aarhus University, 17 December 2018. Presenter of "Market and business model of Danish renewable energy systems", Klaus Skytte, DTU.

Presentation at workshop, Copenhagen School of Energy Infrastructure (CSEI), CBS, Denmark, 4 October 2018. Presenter of "Regulatory barriers for coupled energy infrastructures", Klaus Skytte, DTU.

**2019**

Participation in Intelligent Energy's meeting at Siemens on 3/4/2019, making a presentation on power tariffs in view of the future flexible and smart energy system. Søren Dyck-Madsen (presenter).

Participation in the final meeting of the IEA EBC Annex 67 on flexible buildings on 4/4/2019, making a presentation on flexibility in buildings and the remuneration hereof through both power and heat tariffs. Søren Dyck-Madsen, RGO (presenter).

Participation in Intelligent Energy's conference on energy flexibility on 20/6/2019. Søren Dyck-Madsen, RGO (presenter).

Presentations at the CONECT conference, 15-16 May, Riga, Latvia ([www.conect.rtu.lv](http://www.conect.rtu.lv)), on the topic of to the flexible energy system (results from the Nordic Flex4RES project):

- Transition pathways to a flexible and carbon-neutral energy system in the Nordic-Baltic region, Simon Bolwig, DTU.
- Flexibility as enabler for a carbon neutral energy system, Klaus Skytte, DTU.
- Comparative analysis of cross-border and cross-sector approaches for flexibility in the Nordic countries, Claire Bergaentzlé, DTU.

Participation in the research seminar "Seminar on electricity market design: Electricity networks and their operators in a time of change" organized by the Oslo Centre for Research on Environmentally friendly Energy (CREE) on 4/4/2019 ([https://www.cree.uio.no/outreach/events/seminar/2019/seminar\\_juss\\_electricity\\_market\\_v2019.html](https://www.cree.uio.no/outreach/events/seminar/2019/seminar_juss_electricity_market_v2019.html)) Claire Bergaentzlé, DTU.

Presentation at workshop "FLEX-Ergy 2019: Flexibility Roundtable", EnergyLab Nordhavn, Copenhagen, 5 March 2019, Klaus Skytte, DTU.

Presentation at the conference "The Lost Decade? Planning the Future", Aalborg University, Copenhagen, Denmark, 28 February 2019. Presenter of "Regulating the Green Energy Revolution Upcoming challenges and trends", Klaus Skytte, DTU.

Presentation at the workshop "IEA Experts' Group on R&D Priority Setting and Evaluation (EGRD)", Vienna, Austria, 13 May 2019. Klaus Skytte, DTU, presenter of "Choice of Flexibility sources towards a 100% renewable based Nordic energy system". <https://www.iea.org/workshops/egr-d-workshop-on-system-resiliency-and-flexibility.html>

Participation as speakers in the 42nd International Association for Energy Economics (IAEE) Annual Conference in Montréal, Canada, May 29 - June 1, 2019 ([https://iaee2019.org/wp-content/uploads/2019/05/IAEE2019\\_Programme\\_WEB.pdf](https://iaee2019.org/wp-content/uploads/2019/05/IAEE2019_Programme_WEB.pdf)):

- Unsealing a Fossil Free Energy System by Geographical, Sector or Market Coupling. The Case of Denmark, Klaus Skytte and Claire Bergaentzlé, DTU.
- Interconnection vs. Energy System Coupling: a Socio-Economic Analysis of Flexibility Benefits, Claire Bergaentzlé and Klaus Skytte, DTU.
- Chairperson of the "Regulatory Issues" session, Claire Bergaentzlé, DTU.

## 2020 and 2021

Participation in meetings, trainings and workshops on energy communities in Europe as part of the EU COMETS project (see under research below), June 2020 - June 2021, Simon Bolwig, DTU.

Participation in the General Assembly meeting of the EERA Joint Programme e3s (Economic, Environmental and Social Impacts of the Energy Transition), titled "Understanding the role of behavior in the energy transition", 21 October 2020, Simon Bolwig, DTU.

Participation in the COMETS Mid-Term Conference + EERA e3s Joint Programme event, titled "Engaging and Empowering Citizens in the Energy Transition through Social Innovation", 20 May 2021, Simon Bolwig, DTU.

Meeting with Andrea Stengel, Nordic Energy Research, about NER input to ISGAN report on flexibility services, 1 June 2021, Simon Bolwig, DTU.

Participation in the Nordic Energy Challenge, organized by the Nordic Energy Research Council. "Act fast and cooperate in the Nordics while paving the way to carbon neutrality", 3 November 3 2020, Claire Bergaentzlé, DTU.

Participation in the Data Center Summit Denmark as invited speaker with the presentation titled “Sustainable integration of data centers to energy systems.” Virtual event organized by the Danish Data Center Industry, 19 May 2021, Claire Bergaentzlé, DTU.

Participation in the 43rd International Conference of the International Association for Energy Economics (IAEE), with presentation titled “Fine-tuning policy for energy efficiency: A data-driven approach to support targeted policy-making for residential heating”, 4-7 July 2021, Claire Bergaentzlé, DTU.

Participation in the 43rd International Conference of the International Association for Energy Economics (IAEE), with presentation titled “Integration strategies of electric vehicles into the electricity system and impacts on investment decisions and prices”, 4-7 July 2021, Claire Bergaentzlé, DTU.

Participation on working group meeting about tariffs for flexibility in the electricity system in relation to Market Model 3.0, organized by the Danish Energy Agency, 21 September 2020, Søren Dyck-Madsen, RGO.

Participation in webinar on flexibility in the power grid, organised by Intelligent Energy, Danish Energy Association, 29 October 2020, Søren Dyck-Madsen, RGO.

Participation in webinar on flexibility organised by the Danish District Heating Association, 7 December 2020, Søren Dyck-Madsen, RGO.

Participation in workshop on tariffs and flexibility in energy consumption, organised by Intelligent Energy, Danish Energy Association, 25 March 2021, Søren Dyck-Madsen, RGO.

Participation in Webinar in flexibility in the electricity system as part of the working group on Market Model 3.0., organized by the Danish Energy Agency, 25 January 2021, Søren Dyck-Madsen, RGO.

Participation in the annual conference of Intelligent Energy, Danish Energy Association, which focused on market models for flexible energy consumption, 27 January 2021, Søren Dyck-Madsen, RGO.

### ***Research and policy-advice activities related to smart grid transitions***

Technical University of Denmark (DTU) project participants have conducted research related to Nordic and Danish flexibility, including the smart integration of storage (EV, boilers, short and seasonal storage etc.) and demand response. The results were disseminated using a country perspective of flexibility in Denmark, Norway, Finland, and in the Baltic countries. We also actively participate to the ongoing stakeholder discussions on flexibility and smart activation of the end users in Denmark led by Intelligent Energy of the Danish Energy Association. Among other things, our findings in terms of costs, CO<sub>2</sub> reduction and technology development are utilized in the elaboration of current stakeholder strategy for Danish deep decarbonization.

Since 2020, we have studied the impacts of different battery charging schemes with various degrees of flexibility on the integration of EV and showed the substitution effects between the most flexible charging schemes and RES technologies as well as the different impacts of increased flexibility at the local and regional level. We have also conducted a review of the Nord Pool financial and physical market rules that apply to Danish demand response including to the flexibility services from EV batteries. We have summarized good practices and regulatory barriers to the transition of cities and end-users in Denmark, based on a benchmark of 14 smart grids projects and interview with cities’ representatives.

A study on the system-wide effects of household demand-side flexibility incentivized by a mobile app was published in a high-ranking journal, based on the H2020 research project PEAKapp.

In 2018-2019, DTU participants won two European research projects of relevance to the ISGAN Annex 7:

*Collective action Models for Energy Transition and Social Innovation - COMETS (H2020-LC-SC3)*. The project aims to quantify the European-wide aggregate contribution of collective action initiatives (CAIs) to the energy

transition at national and European levels by investigating their evolution and scaling up at an in-depth level in six selected countries.

*Flexibility for Smart Urban Energy Systems - FlexSUS (ERA-NET/Smart Energy Systems)*. The project develops a decision-making tool to support smart urban energy systems based on digital solutions, which enable municipalities and city planners to optimize their energy systems while implementing climate-change mitigation efforts. It builds on optimization of existing and planned energy systems and develops bridges across them in the form of data management system and visualization tool to be used by system planners that adapt to the specific needs and energy resources of the cities.

The Danish Technological Institute (TI) monitors the development of grid-connected batteries and DSM (Demand Side Management). From e.g. the H2020 SMILE-project there are indications that battery storage systems behind the meter can enable increased demand side flexibility. To enable test and verification of actual smart grid flexibility from grid-connected equipment, DTI has established a flexibility lab-setup with heat pumps, BESS, EV charge, simulated consumers and PV-production. Battery storage systems may be able to offer essential stability services to grid paralleled with their primary energy buffer function, but research funding is yet to be approved.

Green Transition Denmark (RGO) has participated in several policy-advice activities, with emphasis on the development of flexible energy market in buildings as well as the Tariff 2.0 initiative (led by Danish Energy and Energinet) and the expert group on Electrical Market Model 3.0 (led by Danish Energy Agency), where Søren Dyck-Madsen was part of the specialist group concerning local flexible grid solutions. RGO has carried out these activities by participating and debating in the Danish forum of Intelligent Energy (public meetings and internal policy development meetings) and by participating in the work of Tariff 2.0 and the Market Model 3.0, led by Danish Energy Agency (<https://ens.dk/ansvarsomraader/el/markedsmodel-30>). Flexibility has been in focus in all this work: how to improve flexibility by setting the right tariffs and market models and how to do this in a simple and easily understood way in order to support the use of flexible solutions as a means to reduce the need for new grids and grid enforcement, as long as flexibility is cheaper than grid enforcement.

DTU partners are involved in the new cooperation with the *DTU Smart Energy Systems Coordination Committee*. They are also engaged in the development of the R&D Platform of *GreenLab Skive A/S*, which offers an open innovation platform: a physical facility where innovation, scale up and commercialization can happen. GreenLab Skive is a non-profit organization, backed by resourceful partners, including the Municipality of Skive, Denmark's largest energy and telecommunications company, Norlys, and local philanthropic funds. It aims to accelerate green growth by building and demonstrating a replicable model with high social impact, involving building new paradigm for producing, storing, exchanging, and applying green energy.

DTU partners started the *Cool-Data project* that investigates smart solutions to flexibly integrate data centres to the electricity system and to district heating and aims at significantly reducing the energy need for cooling data centres and at minimizing the carbon footprint of the sector. The project develops, assesses and implements an artificial intelligence-based integrated cooling energy-system for data centres. The cooling solution supports the utilization of electricity from renewable energy sources by storing surpluses in time and allows the decarbonized surplus heat generated by the data centres to be used and valorised in district heating. By using AI methods to operate flexibly the cooling and storage solution, the research team in Cool Data targets up to 80% energy efficiency gains in data centres, resulting in severely limiting the impact of this sector's growth on carbon emissions. DTU partners also started a *partnership with UNEP and the Danish Data Centre Industry* through which we promote the smart solution we develop and disseminate our research project outputs and solutions to the data centres industry.



## 4.2 The Danish smart grid transitions stakeholder seminars (WP2 and WP3)

Three Danish stakeholder seminars were held as laid out in the project's dissemination plan. The project team decided to address three themes in these seminars that were deemed central for smart grid transition: system coupling, storage, and digitalisation. The seminars were held in 2018, 2020 and 2021. The three seminars/webinars are summarised below:

### 1) *Smart grids and smart energy systems for the low carbon energy transition, 22 October 2018, Nordhavn Energy Lab, Copenhagen.*


The seminar discussed the key concepts of smart grids in a context of smart energy systems coupling for a low carbon future, and focused on the regulatory and market challenges to achieve a fully flexible and decarbonized energy system. The seminar was opened by Karin Widegren, Chairman of ISGAN's Executive Committee. Experts from the industry (Danish Energy), academia (DTU) and policy (Karin Widegren) presented their views on the topic and debated in a panel discussion on the business opportunities and challenges emerging from flexible integrated solutions across energy systems. Around 25 participants attended.

Seminar Programme	
13.30 – 13.45	<b>Simon Bolwig</b> - Systems Analysis Division, DTU Management Engineering Welcome words
13.45 – 14.45	<i>Session 1 - The concept of smart energy systems coupling</i>
13.45 – 14.15	<b>Karin Widegren</b> – Chairman of ISGAN's Executive Committee "Smart grids as an enabler for smart energy systems coupling – International experiences"
14-15 – 14.45	<b>Klaus Skytte</b> – Head, Energy Economics and Regulation, DTU Management Engineering "Nordic experiences with and barriers for smart systems coupling"
14.45 – 15.00	Coffee break
15.00 – 16.00	<i>Session 2 - Enabling systems coupling and flexibility through energy policy and new business models</i>
15.00 – 15.30	<b>Daniel Høller Sørensen</b> – DTU Management Engineering "The downright dull uncomplicatedness of flexibility in the heating-electricity interface"
15.30 – 16.00	<b>Nicola J. Møgaard Jakobsen</b> – Chief Consultant, Danish Energy "An Industry take on tariffs and flexibility: ensuring meaningful incentives and transparency"
16.00 – 16.45	<b>Panel discussion with all presenters and the audience</b>
16.45 – 17.30	Tour of the EnergyLab Nordhavn showroom and networking reception

### 2) *A Nordic carbon-neutral energy system enabled by flexibility and storage, 30 June 2020, webinar.*

This webinar ([link here](#)) zoomed in on the role of storage technologies and enabling factors for developing a clean, flexible energy system and smart grid. 143 participants signed up for the webinar and at least 71 unique names logged in. The interest for the webinar exceeded all expectation with respect to the very international and diversified response. There was diversity in terms of countries (at least 18 countries within and outside

Europe), sectors (industry, consultancy, research, government, regulators, NGOs, funders, smart grid networks) and institutions. For example, there were participants from energy authorities in 6 countries, and from energy companies in around 6 countries. The technical execution of the webinar via TEAMS worked well. Questions and comments were given via the chat function. The presentation and panel discussion format worked well but short presentations in the panel-discussion slot took too much time from the discussion. The presentations from the webinar were distributed to all those who had signed up for the webinar.

<b>Programme</b>		
12:45 – 13:00	Webinar link is open for verification of connection and registration	
13.00 – 13.05	<b>Welcome</b> <b>Simon Bolwig</b> , DTU, leader of the Danish ISGAN Annex 7 project	
13.05 – 13.15	Storage in a carbon-neutral Nordic energy system: Pathways to 2050 <b>Claire Bergaentzlé</b>   Technical University of Denmark - DTU	
13.15 – 13.20	Q&A	
13.20 – 13.30	Measures to reach a stable carbon neutral electricity supply <b>Anders Bavnhøj Hansen</b>   Chief Engineer at Energinet	
13.30 – 13.35	Q&A	
13.35 – 13.45	Electric Storage to help balance Energy and Power. <b>Kjeld Nørregaard</b>   Danish Technological Institute - DTI	
13.45 – 13.50	Q&A	
13.50 - 14.35	Panel debate	

### **3) Flexibility services in the zero-emission smart grid: market models, regulations, actors and technologies, 15 June 2021, webinar.**

This webinar ([link here](#)) explored the role, potential and implications of data and digital solutions for a timely transition to a zero-emission and flexible energy system characterised by stability, cost effectiveness, fair distribution of costs and benefits, and citizen/community engagement and participation. In line with the focus on institutional change and transitions management of the ISGAN Annex 7 Smart Grid Transitions, the webinar discussed the importance of innovations within and linkages between these central building blocks - actors, institutions and technologies - for a clean energy transition that also ensures citizen engagement, fairness and cost effectiveness. Experts from research and industry shared their knowledge and experience from projects in Europe and the Nordic countries, followed by questions and discussion.

The webinar was conducted using a specialised software and drawing on expertise from communications staff of the UNEP DTU Partnership (UDP). It was announced through the UDP international mailing list, the Power Globe email list, other mailing lists, the event website of the Danish Intelligent Energy Alliance, and the ISGAN Annex 7 LinkedIn group. A report was prepared after the event based on data generated by the webinar software, which produced the following key insights regarding attendance and attention:

- With 233 clicks on the link to the registration page, the topic of the webinar drew what is considered a 'good level of attention' by our webinar specialists. 161 attendees actually registered for the event, while 80 or 50% actually logged on to the webinar, which is also considered 'good'.

- The webinar was relatively long (programmed to 2 hours, and extended into 2 hrs and 20 minutes) and this was also reflected in a steadily declining number of attendees starting about one hour into the programme.
- The webinar enjoyed a broad attendance geographically: participants from 24 countries attended the webinar (total of 81 attendees), while people from 57 countries had registered for it (total of 161 registered). Most attendees came from Europe and the Americas, but the Middle East, South Asia and West Asia were also represented. Due to the time of day, relatively few attendees were from the western part of Asia and Oceania.
- Most attendees came from academia (37), followed by business and consultancy (12), government (10) and civil society (7). In terms of gender, 54 attendees were men and 22 women, while 4 did not state a gender, illustrating the male bias in the energy field.

The webinar was recorded and subsequently video-edited. The video was posted on [YouTube](#) and a link provided on the event page ([URL](#)) and in the Smart Grid Transition LinkedIn group ([URL](#)). The video has so far been accessed 107 times.

Programme. Times are in CEST (Copenhagen time)		
15:00 – 15:02	2 min	Welcome, logistic information and present the speakers. Thibaut R.T. Pasquet, UNEP DTU Partnership.
15:02 – 15:07	5 min	Project (ISGAN) Introduction. Simon Bolwig, UNEP DTU Partnership, DTU Management
15:07 – 15:19	12 min	Market models and regulatory changes for flexibility services in local grids. Experiences from the Danish ‘Market Model 3’. Helle Juhler-Verdoner, Danish Intelligent Energy Alliance
15:19 – 15:31	12 min	Digital tools and data platforms in support of flexibility. Experiences from the living labs of the Flexible Energy Denmark project. Razgar Ebrahimi, Center Denmark and DTU Energy.
15:31 – 15:43	12 min	Building institutions for flexibility services through regulatory ‘sandbox’ experiments. Klaus Kubeczko, Austrian Institute for Technology; Operating Agent ISGAN Annex 7.
15:43 – 15:59	16 min	Unlocking flexibility in local networks – learnings from the UNITED-GRID and Flexigrid projects. Joni Rossi, RISE Research Institutes of Sweden; Operating Agent ISGAN Annex 6.
15:59 – 16:011	12 min	Smart integration of data centers to energy systems: for enhanced RES flexibility and waste heat utilization. Claire Bergaentzlé, Sustainability Division, DTU Management.
16:11 – 16:23	12 min	Community energy meets smart grids: the aspirations and multiple roles of community-based virtual power plants. Anna Wieczorek, Eindhoven University of Technology.
16:23 – 16:39	16 min	Panel Discussion: New models, actors and technologies for flexibility services. Klaus Skytte, Nordic Energy Research.
16:39 – 17:00	21 min	Q&A/Discussion. Moderated by Thibaut R. T. Pasquet

## Reporting on the seminars

Aside the power points and video produced at the individual seminar/webinars, a report was written that takes point of departure in the contributions and insights from the three seminars, supplemented by insights from literature and practical experiences. The report is titled "A transition perspective on demand-side flexibility in

the integrated energy system: insights from the Danish ISGAN Annex 7 project 2017-2021" and is co-authored by 10 researchers and experts that have been involved in the seminars or otherwise collaborated with the project. See Section 8.

### 4.3 Experiences and problems encountered

The project met all its milestones, but the project was extended twice due to delays caused by the corona pandemic, particularly regarding the Danish smart grid stakeholder seminars, of which two were delayed and held as webinars. See table below.

#	Milestone description	Scheduled month	Date achieved	Type of event
M1	First Danish smart grid seminar has been held	12	22/10/2018	Seminar
M2	Second Danish smart grid seminar has been held	24	30/06/2020	Webinar
M3	Third Danish smart grid seminar has been held	36	15/06/2021	Webinar
M4	Participation in first international ISGAN Annex 7 meeting	9	13/06/2018 23/05/2018	IST 2018 conference ISGAN at Nordic Clean Energy Week
M5	Participation in second international ISGAN Annex 7 meeting	21	24/06/2019	IST 2019 conference
M6	Participation in third international ISGAN Annex 7 meeting	33	18/12/2020 February-July 2021	ISGAN Group of Experts meeting Meetings in two Annex 7 thematic groups on Regulatory sandboxes and Decentralisation

Specific experiences and problems related to each work package are outlined below.

#### ***The ISGAN Annex 7 meetings and communications (WP1)***

The meetings in the ISGAN group of experts have evolved from reporting on the general activities of the members to be more topic and output oriented, which has been a good development. The regular online meetings on different topics (sandbox experiments, decentralisation) have been quite productive, but the corona pandemic has meant that group members have not met in person for almost two years, which has hampered networking, also with respect to linkages to other ISGAN annexes.

#### ***Participation in other meetings and workshops related to smart grid transitions (WP1)***

In 2020-21, dissemination and debate at international meetings and conferences have been much less than in the previous years. The COVID-19 situation, which has caused the cancellation of many such meetings, has been the main reason for this.

#### ***The Danish stakeholder seminars (WP2 and WP3)***

The first Danish stakeholder seminar went as planned, but due to the COVID-19 pandemic, it was decided to organise the second and third seminar as webinars. The seminars were originally scheduled to 2018, 2019 and 2020 respectively, but the second seminar (on storage) was postponed from the fall of 2019 to June 2020

due to an initial low number of participants registering (related to several competing seminars on storage), followed by the onset of corona pandemic, which in turn pushed the third seminar to 2021.

As outlined above, the two webinars enjoyed a larger and much more international participation than the first physical seminar, which had mainly Danish attendance. The webinars still relied mainly on Danish (or Nordic) presenters, and this format therefore has meant a much greater exposures of Danish/Nordic experiences than would have been possible with physical seminars. The drawback is that webinars are not well suited for networking activities and in-depth discussions, and this has affected especially networking with and among Danish stakeholders. In a future post-pandemic situation, it should be considered to serve both purposes by using a hybrid (online/physical) format, including video recording for later viewing.

## 5. Project results

### 5.1 Meeting of project objectives

The original objective of the project was obtained, which was to enable and strengthen Danish participation in EIA-ISGAN Annex 7 (Smart Grid Transitions) and to help disseminate knowledge on smart grids between Danish stakeholders and the ISGAN Annex 7 international community. The project members participated in a variety of ISGAN Annex 7 activities, as outlined in this report. The Danish stakeholder seminars/webinars (and report) disseminated knowledge to an international audience, in particular on Danish and Nordic experiences with smart grids and the flexible energy system, but the seminars also facilitated exposure of Danish stakeholders to international perspectives on smart grid, e.g. through the participation of international speakers in the seminars/webinars, including the Annex 7 Operating Agent, the Chair of the ISGAN Executive Committee, the ISGAN Annex 6 Operating Agent, and an expert in the contribution of energy communities to flexibility.

The project member from Green Transition Denmark (RGO) was particularly active in Danish fora and working groups on smart grid and flexibility, and DTU provided inputs to the stakeholder discussions on flexibility and smart activation of end-users in Denmark led by the Intelligent Energy Alliance of the Danish Energy Association (iEnergy). There was also interaction between the project and iEnergy in terms of planning the seminars and providing input to the final seminar report. TI was particularly instrumental in creating awareness of the role of short term storage (batteries) in the smart grid and flexible energy system, and in reminding stakeholders that many technical barriers still exist to activating flexibility and smart grid.

The COVID-19 pandemic was an obstacle to networking, especially with and among Danish stakeholders such as iEnergy, but also internationally. The webinars organised as a result of the pandemic required more staff resources than would have the seminars, and the webinar format also inhibited longer and more in-depth discussions. On the other hand, the attendance was much larger and more international.

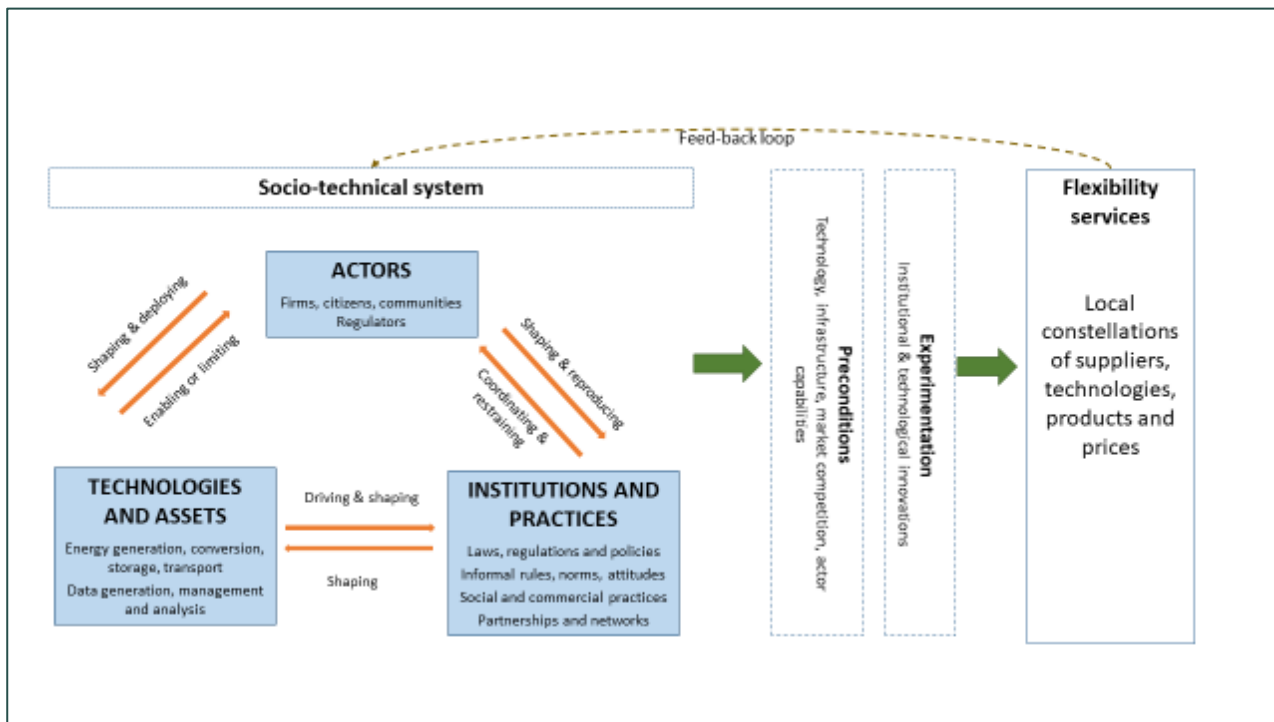
As mentioned, to mitigate the effects of COVID-19, the project was extended twice and two seminars were converted into webinars, while unspent travel funds were transferred to staff salaries needed to prepare the webinars. Many international ISGAN meetings and conference sessions were held online.

### 5.2 Technological results

The main technological results obtained was a much more nuanced understanding of the barriers and opportunities for the development of a smart grid and flexible energy system, drawing on both socio-economic and technical disciplines and applying an overall transition perspective. The results are presented in the report titled "A transition perspective on demand-side flexibility in the integrated energy system: insights from the

Danish ISGAN Annex 7 project 2017-2021". It is co-authored by 10 researchers and experts that have been involved in the seminars or otherwise collaborated with the project. See Section 8.

The report develops an integrated socio-technical framework for analysing and promoting flexibility services in the integrated energy system, focused on the interplay of actors, institutions, and technologies, as depicted below.



Based on this framework, the report discusses: actors, actor roles and markets; new technologies including data, data management and storage; regulatory barriers and required regulatory reforms and experiments. Based on these insights, conclusions and recommendations are offered (see section 7).

### 5.3 Where and to whom have the results been disseminated

Chapter 4 in this report describes in detail the project's dissemination activities, which were the main content (activity-type) of the project. In summary, dissemination took the form of:

- Danish stakeholder seminars/webinars, with participation of Danish and international professionals from government, academia, the private sector, and civil society.
- Meetings in the ISGAN Annex 7 group of national experts, mainly from academia but also regulators. Participation in other ISGAN and EIA meetings.
- Sessions on topics related to smart grid transitions at the International Sustainability Transitions (IST) conference (2018 - 2021), attended mainly by academics.
- Participation in other international scientific conferences and policy meetings, in the Nordic-Baltic countries, Europe and Canada, including presentations and conference papers.
- Participation in Danish policy-focused workshops and meetings, organised by government authorities, private sector organisations and NGOs, including Energinet, Danish Energy Authority, Danish Energy Association (Intelligent Energy), Energiforum Danmark, EnergyLab Nordhavn.
- Participation in Danish working groups on electricity tariffs and market models.

- The report "A transition perspective on demand-side flexibility in the integrated energy system: insights from the Danish ISGAN Annex 7 project 2017-2021" has been prepared. After layout, the report will be placed on the publications website of the UNEP DTU Partnership, and submitted to for consideration as an ISGAN Discussion Paper. See Section 8. The target group are smart-grid professionals from academia, government and private sector, in the Nordics, Europe and beyond.
- Scientific articles produced as part of related research projects, in journals such as Energy and Social Science, Energy Policy, Energies, Journal of Cleaner Production, and Renewable and Sustainable Energy Reviews. The target group is mainly academics.
- Research reports written as part of related research projects, published on organisational or project websites (e.g., [www.orbit.dtu.dk](http://www.orbit.dtu.dk)). The target group is academics, policy makers and industry.

## 6. Utilisation of project results

The results will be used by academics in the further development of a research agenda on the connected topics of smart grid, flexibility and energy transitions, backed up by concrete activities and collaborations. The broader smart-grid network created through the project, including professionals from industry, policy, advocacy and different academic institutions, will strengthen the transdisciplinary approach and practical relevance of this research.

It is the hope that policy makers will benefit from the transitions approach and the underpinning analyses and debates performed in the project to create the enabling environment for realising a clean energy system in the Nordics and beyond, building on well-coordinated policies and regulations, market models and actor roles, and digital technologies. A key lesson from the project is that achieving these goals is a multi-faceted and complex process that requires coordinated actions and expertise from a broad range of energy-system actors as well as from the digital sector, in an inclusive, transparent and experimental process. How such a process can be orchestrated in the different settings of EIA and ISGAN member countries would be an important topic for future research and policy.

## 7. Project conclusion and perspective

The efforts needed to decarbonise our energy rely heavily on the nexus between technology, regulation and people. These three pillars are constantly evolving, partly to keep up with rapid technological progress, as constantly demonstrated by the progress made in low-carbon production or data management, but also increasingly to take the social dimension of energy more fully into account. In between, institutions, policy-makers and regulators must design a body of rules that ensures the coordination of all actors.

The feedback from the Nordic countries, in this case Denmark and Sweden, sheds light on this nexus between technology, regulation and people by taking as its point of departure the flexible integration of all the actors in the electricity value chain and beyond, across energy sectors, to balance the volatile production of renewable energy resources.

The successive evolutions of electricity market rules in Denmark and generally in the Nord Pool market area demonstrate, for example, how industry players are progressively completing the market design to meet the constraints imposed by the rapid growth of wind energy. Across the board, what stands out as a facilitator for change is a stable, transparent, well-organised and inclusive discussion forum for the sector's stakeholders.

A well-functioning market is, of course, necessary, but alone it will not be sufficient.

#### *Next steps / recommendations*

*Integrate all the players.* While technology makes it technically possible to control all types of decentralised load or production, the human factor must be taken into account to a greater extent. This implies, in particular, a better understanding of what motivates energy users in the context of decarbonisation. The richness of the work done in the behavioural and social sciences, among others, that focuses on the motivations of consumers in their consumption or production of energy is beginning to shed new light supplementing traditional studies in which the consumer is treated as a simple rational agent seeking to maximize her utility. In reality, the effects of communities that build on attitudes, beliefs, etc., reveal an array of important levers to activate consumers that must be better understood and utilised in a smarter way.

*Make sure that regulation does not stand in the way.* How? By supporting a competitive, transparent and liquid market. This means abolishing rules that act as a barrier to the participation of players capable of providing flexibility services and that hinder investment in carbon-free generation or storage. This also requires the establishment of a level playing field between production and flexibility technologies, as well as between energy sources. It also implies the minimization of distortions of efficient prices set by the market and in particular implies a revision of grid tariffs. Finally it implies the protection of precarious consumers for a fair transition.

*Thinking out of the box, go hybrid when you need to.* The urgency of climate change requires that the full range of options be considered when it comes to developing innovative energy and flexibility solutions. In particular, the activation of certain diffuse flexibility potentials with high added value for society may still not generate a high enough return on investment for private actors to develop service products to harvest them. Clearly the climate objective must be placed on the same level as the market objective, while regulatory lock-ins that would hinder, for example, the operation of flexibility services by certain players when they are best able to drive them must be avoided. This may give rise to new, hybrid organisations with new types of participation between privately regulated stakeholders.

## 8. Appendices

Project sites:

<https://unepdtu.org/project/strengthening-danish-participation-in-the-isgan-annex-7-smart-grid-transitions/>

<https://www.energiteknologi.dk/en/node/15670>

ISGAN Annex 7 LinkedIn group: <https://www.linkedin.com/groups/7489503/>

ISGAN Annex 7 website: <https://www.iea-isgan.org/our-work/annex-7/>

DTU website for publications, researchers, projects etc.: <https://orbit.dtu.dk/>

Danish Technological Institute: <https://www.dti.dk/>

Green Transition Denmark: <https://rgo.dk/frontpage-english/>

The main **report** produced by this project is titled "A transition perspective on demand-side flexibility in the integrated energy system: insights from the Danish ISGAN Annex 7 project 2017-2021" and is co-authored by



10 researchers and experts that have been involved in the seminars or otherwise collaborated with the project: Claire Bergaentzlé<sup>1</sup>, Simon Bolwig<sup>1</sup>, Helle Juhler-Verdoner<sup>2</sup>, Klaus Kubeczko<sup>3</sup>, Kjeld Nørregaard<sup>4</sup>, Xiufeng Liu<sup>1</sup>, Joni Rossi<sup>5</sup>, David Steen<sup>6</sup>, Andrea Stengel<sup>7</sup>, and Anna Wieczorek<sup>8</sup>.

<sup>1</sup>Technical University of Denmark, <sup>2</sup>Danish Intelligent Energy Alliance, <sup>3</sup>Austrian Institute of Technology, <sup>4</sup>Danish Technological Institute, <sup>5</sup>RISE Research Institutes of Sweden, <sup>6</sup>Chalmers University of Technology, <sup>7</sup>Nordic Energy Research, <sup>8</sup>Eindhoven University of Technology.

After final editing and layout, it will be placed on the publications website of the UNEP DTU Partnership (<https://unepdtu.org/publications-database/>) and professional prints will be made for distribution at meetings and conferences. The report will also be submitted as an ISGAN Discussion Paper and if accepted will be available for download from the ISGAN publications website (<https://www.iea-isgan.org/publications/>).