# ANNUAL REPORT 2020

CINELDI

Centre for intelligent electricity distribution

# CINELDI develops the electricity grid of the future

The consumption and production of electricity is rapidly changing. This leads to changes in our relationship with electricity. Increased electrification of society means more demand, more connections, a more variable load from the increasing share of renewable generation and customers who play a more active part in the operation of the grid, i.e., you and me will consume, produce and store electricity to provide greater flexibility to the grid.

To deal with these changes, our distribution grid will have to adapt into a digitised smart grid. Modernisation is required to give increased efficiency, flexibility and resilience of the grid. While modernisation brings new opportunities, it also poses risks to the security of electricity supply due to the increasing interdependencies with ICT-systems and increasing complexities.

Private companies, government organisations and research institutes have come together in CINELDI to conduct the long-term, industry-driven research that is needed to make the necessary transformation of the grid, maximise these opportunities and mitigate against these risks.

The research looks at solutions for 2030-2040, which is around 10-20 years after all electricity consumers have a smart meter installed. The research addresses system planning, operation and management, with a particular emphasis on new and emerging topics like microgrids, utilization of load/generation flexibility, and cyber security.

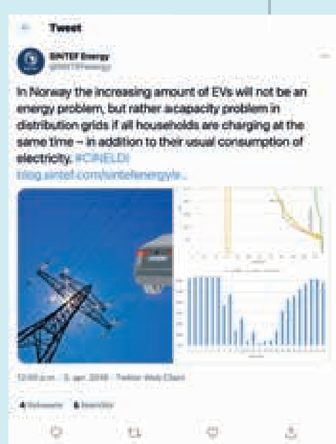
# CINELDI best of
# 2016-2020

## CINELDI kick-off




**2016 kick off** **2017** **2018** **2019**









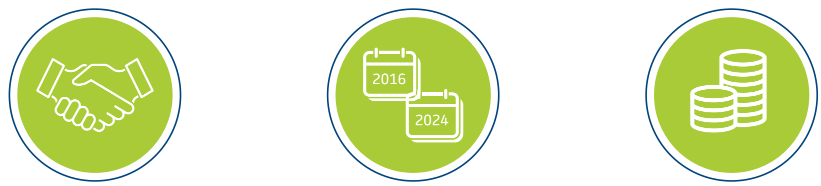
2020




@CINELDI _FME

# Contents

# By numbers

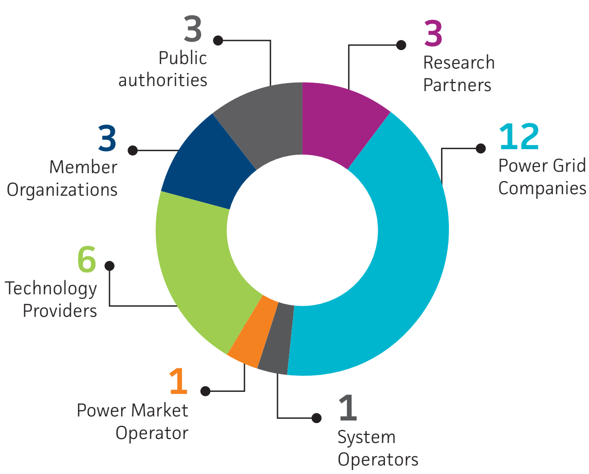


**29** PARTNERS

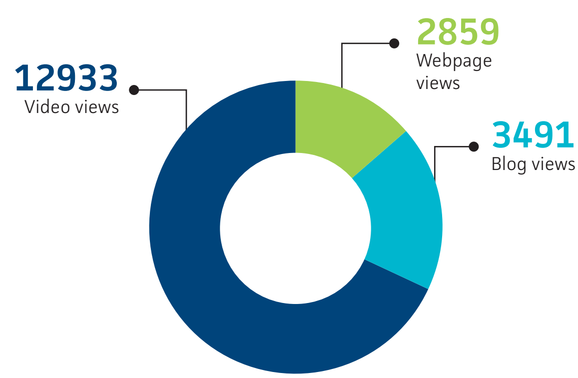
**8** YEARS

**365** MNOK

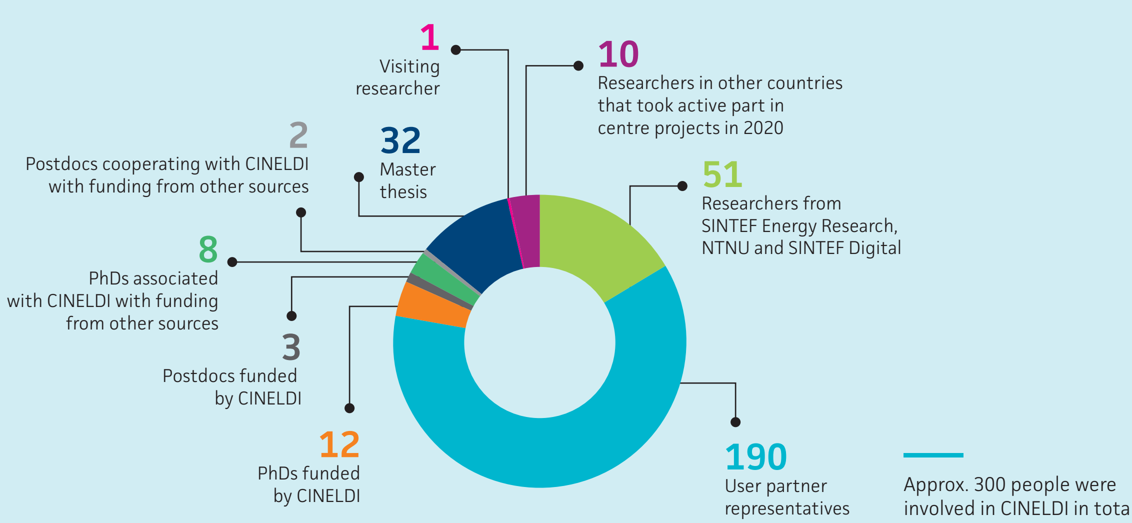
## Partners



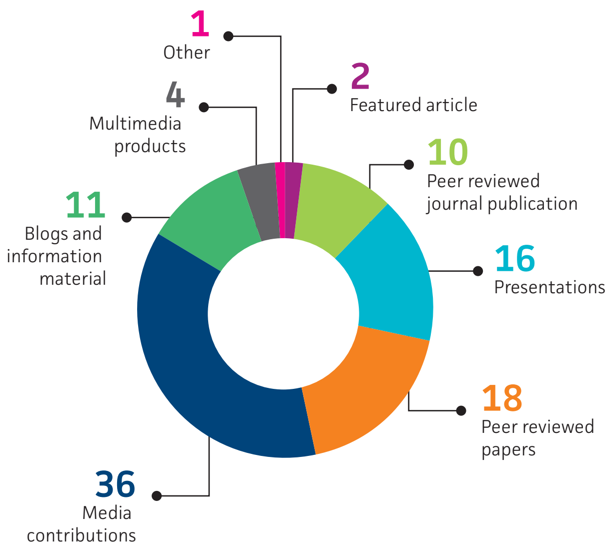

## Visibility



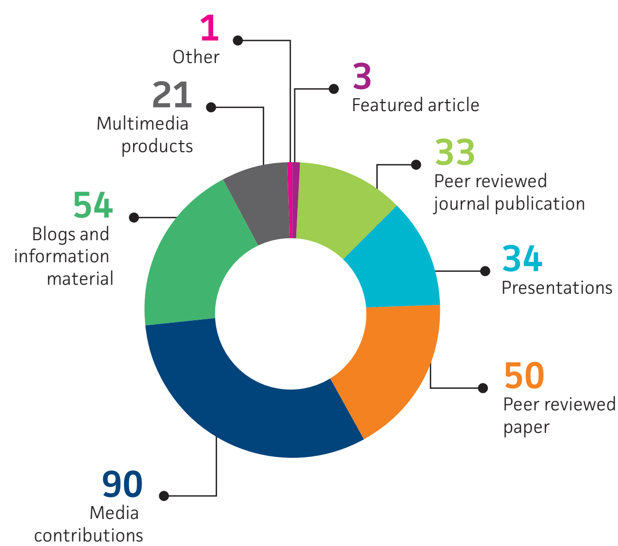

## People



## Communication and dissemination 2020*



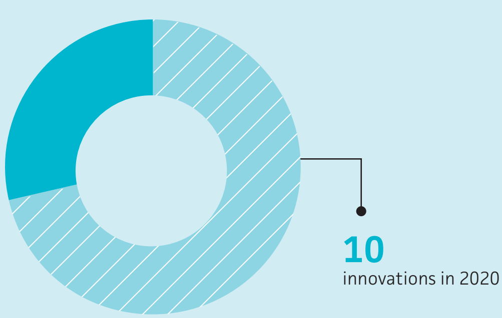

## Communication and dissemination 2016-2020*



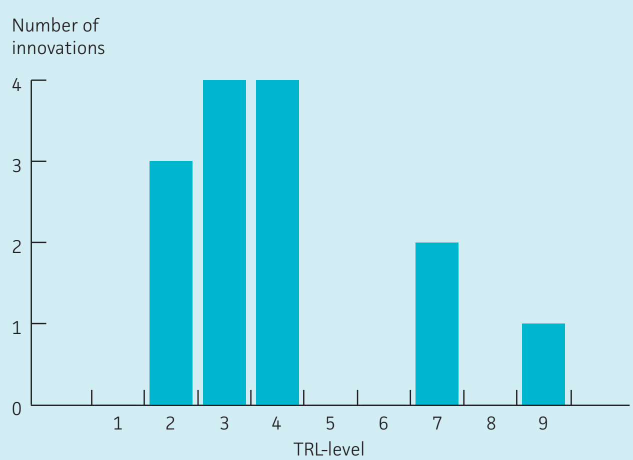

*There might be some discrepancies between the numbers in the figures and the numbers registered in Cristin, mainly due to FME partners that do not have a university or research institute affiliation or because the FME project code har not yet been registered in the post

## Innovation

**CINELDI has identified 14 innovations**




**Innovation TRL-levels**

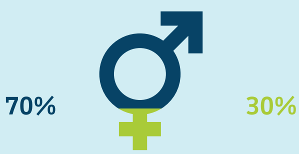


## Gender balance

Executive Board:
60% men, 40% women

PhD/Postdoc:
60% men, 40% women

Master students:
79% men, 21% women




Researchers:
70% men, 30% women

Centre management:
2 of 3 are women

3 of 7 WP leaders are women

In CINELDI we aim to have at least 30% women in all positions. The share of female master students varies from year to year, from slightly above 30 % to the all-time high of 48 % in 2019, and reduced to 21 % in 2020. These numbers are quite in line with the recruitment basis for the studies within the CINELDI disciplines.

# Main results from 2016 – 2020

Since the Centre's beginning in 2016, the list of important results with potential for innovation and value creation has grown long. Here we have listed a few examples of our most important results:

- An EV Power Share Charging System is a new product from industry partners in CINELDI. It is a building-integrated system for smart EV charging based on a multi-period AC optimal power flow algorithm developed in CINELDI.
- Driving forces for electricity distribution system innovation are identified and scenarios for the future electricity distribution grid in Norway anno 2030-2040 are established. These form a basis for the research and transition strategies.
- Methods for cyber security risk analysis customized to smart grids are developed and tested in cooperation with grid companies.

- A method for analysing 5G communication failures and a planning framework for active distribution grid accounting for active measures e.g. flexibility.

- A novel mechanism for checking the integrity of synchrophasor measurements (PMU) without adding delay to the time-critical synchrophasor transmission.

- State estimation algorithm for monitoring distribution grids is developed, able to estimate the states of a partially known system with system-wide unknown inputs.

- The established real-time power hardware-in-the-loop microgrid simulation platform allows physical components behaviour to be tested in a simulated environment.

- New control strategies for robust Microgrid operation are enabled using Virtual Oscillator Control (VOC) as an alternative to Conventional Droop Control in synchronization of power electronic converters in island microgrids.

- A memory efficient and high-performance multi-period AC optimal power flow solver is developed including energy storage and RES representation.

- A method for cost benefit analysis of batteries in the distribution grid.

- A Stochastic Dynamic Programming (SDP) model for operation planning of flexible resources in buildings is developed to find the value of flexibility for buildings in a long-term operational setting.

- Data-driven models are developed for loads that can be shifted. The models can be used to estimate aggregated flexibility potential from group of households.

# Why CINELDI's smart grid research is unique

Four years have passed since the first seeds of CINELDI, one of the world's largest research centre on Smart Grids, were sowed. The centre's work is only half complete, but we are already seeing the first fruits.

## A flexible and robust electricity grid

The electricity distribution grid must adapt to the ever-changing ways we generate and use energy. To cope with these changes and the increased demand, better solutions have to be developed across many facets. Since day one, CINELDI's vision has been clear: To enable a cost-efficient realization of the future flexible and robust electricity grid.

Due to the ongoing electrification of society, Norwegian grid companies must balance an aging grid with an increasing demand for power, changing consumption patterns and the introduction of solar and wind energy. Solar and wind puts strains on the grid which it was not designed for. The grid is in dire need of innovative new methodologies and technologies, but no one company can come up with the best solutions on their own.

Working together within CINELDI, Norway's leading power grid companies, technology providers and research institutions, power market operators, system operators, member organizations and Norwegian authorities develop innovative knowledge and research results for the Centre's partners and the industry in general.

All Smart Grid research projects create results and knowledge, so what is it about CINELDI that makes it so unique? We asked the partners.

NORDLANDSNETT

Nordlandsnett is a DSO in Northern Norway. They own and operate the distribution grid in Bodø, Beiarn, Gildeskål, Saltdal, Rødøy, Lurøy and Træna municipality, as well as the regional grid in Salten.

## When bigger is better

The broad nature of partner categories, high number of partners in each category and the Centre's duration are key factors pointed out by most partners when asked what makes membership in CINELDI so valuable.

- Being part of a collaborative effort like CINELDI, where representatives from the entire industry are gathered, makes a lot of sense. It gives us an opportunity to see problems and solutions from all angles, says Tarjei Solvang from Nordlandsnett.

- Through CINELDI we can collaborate with our largest and most important customers in Norway. We can also test solutions that would be difficult to do otherwise, because we have access to greater resources. It reinforces our position in Norway, says ABB Electrification's Stian Reite.

– What makes CINELDI unique compared to shorter projects with fewer partners is the Centre's ability to see and work on the whole picture. Each work package is like a piece of Lego; It takes all of us to build the future grid, says Inger Lundetræ from BKK Nett.

Grid companies' technological needs in 2040, or 2030 for that matter, will be completely different to 2020. That means technology providers must already "predict" which technologies their customers will demand in the future.

- The investments we do and what we create will have an incredibly long lifespan, so it means a lot to us to make the right choices now. We will live with those choices for many years to come, says Sigurd Kvistad from Elvia.

Having both "supplier and customer" under one roof is therefore a huge advantage.

- The strong representation of grid companies in the consortium, together with science and technology partners, ensures that our challenges serve as a basis for research and technology development. It connects the industries's future needs and future solutions in a unique way compared to smaller projects, says Nordlandsnett's Solvang. Stian Reite from ABB Electrification, agrees.

- We are completely dependent on having close contact with the market to develop the right solutions. But there aren't many arenas where we can sit down with our customers and discuss new functionalities.

ABB Electrification Norway deliver products and solutions to both LV and MV distribution systems, ensuring a reliable power supply through the whole value chain.

ABB ELECTRIFIACTION ABB

CINELDI has created an arena where we as technology providers can do just that, he says.

- This is also valuable for the grid companies, he adds.

- The Centre gives us the advantage of working with many grid companies in a coordinated manner. This way we can get input from several at a time, which lowers our risk of failure when innovating. That ensures the science is more relevant and we can develop more relevant solutions because of it, Rolf Pedersen from Aidon explains.

Aidon's main products are AMR solutions and services. Pedersen also points out that CINELDI does not only grant access to a large consortium, participation in the centre also grants access to world class research infrastructure and research scientists at the same time.

- The quality and speed of innovation is increased because of facilities like the National Smart Grid Laboratory. Here, we can test AMR innovations and new solutions more precisely and faster than in the live-grid. This not only creates value for us as a technology provider. It gives grid companies better and faster return on their AMR investment.

## When the sum is greater than the individual parts

The sharing of experiences and results between companies that would otherwise consider each other competitors is one of CINELDI's big wins according to the partners, because everyone doesn't have to do the same pilot projects or the same research.

BKK NETT

BKK Nett is one of Norway's largest DSOs, located on the West-Coast. They have a strong focus on digitizing their grid to ensure an effective and future-proof operation of their grid.

- Access to knowledge is a tool for development but it does not in itself define our success as a grid company. How we implement and use the knowledge is what will define our success, says Solvang from Nordlandsnett.

Kvistad from Elvia sees great benefits to more people being able to share and have access to the same knowledge through CINELDI.

- Norway is a small country, so the fact that we cooperate and get an overview of each other's pilot projects, is very good. Even if we gain access to the same knowledge, what sets us apart is how we apply the knowledge. I think we all grow from sharing knowledge. It lifts the whole industry. In relation to the challenges that lie ahead, we are dependent on elevating knowledge levels.

For Sven Arild Kjerpeset, from the grid company Linja, CINELDI's big consortium acts as an incentive to stretch further.

- The involvement in CINELDI creates a kind of incentive. We enter with certain obligations to the other partners and there is a pride in meeting these obligations. We end up stretching a little further when testing things, than we would otherwise, he says.

- It feels safer to start a project when you have someone to confer and run a dialogue with. It creates a safe environment for throwing yourself into the unknown. By being a part of CINELDI we have been given opportunities we would not else have had. For example, our pilot project cooperation with NODES, he continues.


Photo: Elvia

ELVIA

DSOs Hafslund Nett and Eidsiva Nett merged to become Elvia on January 1. 2020, providing electricity for around 2 million people in East-Norway.

NODES is a new marketplace for local flexibility, providing insight and support to projects like CINELDI where all stakeholders can develop their knowledge and increase their understanding of local flexibility markets.

– Both NODES and grid companies have a mutual need to develop their knowledge on how flexibility data needs to be captured and managed so that it can be used to provide transparency. E.g. who owns the flexibility, can it be made commercially available and at which price will a transaction happen? Gaining and sharing this is easier through CINELDI, says Hallstein Hagen from NODES.

## Reaping the first fruits: The scenarios

Up until now, CINELDI has documented almost 50 (partial) results and 14 innovations have been identified. One in particular stands out from the pack having already been implemented by several partners: The scenarios.

- CINELDI prepares us for the future. Digitalisation is disrupting the power-industry and it's demanding to navigate an unmapped future, says Linja's Kjerpeset No one can know exactly what the future looks like, but there are ways to dissect what the most likely paths are. To map possible future directions the power grid industry may take, CINELDI have developed about 100 mini-scenarios. I.e. different ways the grid can develop over the next two decades, depending on factors like societal trends and values, politics, and technology development.


Photo: Aidon

To make the scenarios more tangible, they are clustered into four main scenarios. These scenarios provide insights on knowledge and technology gaps science and industry must fill. They have been used to direct the Centre's research and they have been adopted by several of the partners for strategic planning.

- When I talk about CINELDI to others I tend to fall back on the scenario-work we did. The scenarios gave us a clear picture of the driving forces affecting smart grid development and where the industry is headed. That is a picture we did not have earlier, Kjerpeset from Linja continues.

- The scenario-work we did in the work packages gave us a very clear picture of what is likely to happen over the next couple of decades. When you have an idea of that, you can start working on strategies, Rolf Pedersen from Aidon explains.

### AIDON

Aidon is a supplier of smart grid and smart metering technology and services in the Nordics. They help distribution system operators boost the reliability of electricity distribution and cope with the big changes that are under way in the energy sector.

## A place to sow and grow new ideas

R&D is typically done between a limited number of industry partners and with a limited, specific research agenda. CINELDI is in many ways the opposite; many partners with a much broader goal, i.e. enabling the future smart electricity grid. That opens new doors for the partners and the science.

- It has given us good opportunities to create pilot projects and to test new technology, without too much bureaucracy. Within the R&D scheme, one must go through an application process and satisfy a number of criteria. But in CINELDI you already have these funds available, making it easier to try out new technology and carry out pilot projects, Kvistad from Elvia explains.

A common denominator among the partners we talked to is that CINELDI has been very good at exploiting its size to generate ideas and knowledge transfer. New ideas formed through both organized workshops and informal conversation at events.

- CINELDI is an industry-hub we would not have had with more fragmented R&D. The Centre provides unique opportunities to cluster both similar and different partners in work-packages and working groups, creating a platform cross-industry development, and sharing of new knowledge, Inger Lundetræ from BKK explains.

- It's easier to start projects when you have someone to confer with., Kjerpeset from Linja ads.

- The most useful for us have been the workshops where we can sit down with our customers and discuss technology. In other countries these types of workshops are difficult to arrange, Reite from ABB Electrification tells us.

The CINELDI Days are popular with the partners for good reasons. It's an arena for new input, sharing of research results and curating new ideas.

- My favourite CINELDI-moments have been the plenary discussions after keynotes on the CINELDI Days, and when you discuss challenges with other grid companies and hear approaches to solutions haven't heard before, says Solvang from Nordlandsnett

## The next four years

Four years have passed, four more years are left. To establish a research centre like CINELDI takes time, but the partners have clear ambitions for the years to come and that further important work has to be done.

- I experience that CINELDI is at a point where they can escalate on the production side. I hope that we can put together the pieces of the puzzle that the work packages constitute, even more than what one has done so far. We have flexibility as the common thread, but getting it even closer to the industry will be important, BKK Nett's Lundetræ says.

The partners see great value in working together on finding the best solutions for the future distribution grid. They are especially focused on getting more pilot projects done and tests in the live distribution grid.

- We are dependent on being a part of pilot projects with the grid-companies. We can´t just make something on our own and "put it out there", so we want to participate in even more pilot projects or expand the ones that already exist, says Stian Reite from ABB Electrification. Aidon's Rolf Pedersen agrees. He is especially looking forward to getting more concrete results.

- I think CINELDI's focus, and the mandate that the Research Council gives, is much more demanding when it comes to results, which is very good. That there will be results that both society, the grid companies and the technology companies can profit from.

- We need projects like CINELDI because they manage to point out further possible directions in a larger perspective. I think there will be useful projects and more concrete things that will come out of CINELDI, things you want to take a closer look at, both within the Centre and after these eight years, Tarjei Solvang from Nordlandsnett says.

Kvistad from Elvia thinks that the biggest value from a centre like CINELDI, is that it will make Norway better equipped for the electrified society.

- In many contexts, the grid will be the hub that will bind the various actors together, both those who produce and consume electric power. We become a catalyst for moving towards the carbon-free society, he says.


Photo: Linja

## LINJA

Linja is a DSO located on the Norwegian West Coast, stretching from the smallest islands to the deepest fjords. Their focus is on providing reliable electricity which can contribute to growth and development for both businesses and society.

# 2020: The year of flexibility

**Throughout 2020, flexibility in the grid has been the read thread of our work across all WPs.**

We're developing technologies and methodologies that in a socio-economically cost-efficient way transforms the grid into an infrastructure that can handle the electrification of Norway.

One of the main challenges we have to overcome when using more power, is higher peak loads. Now, the simplest solution to increasing peak loads is to build new power-lines, which will increase the grid's peak capacity. But the thing is, the problem of higher peak loads will only occur in limited timeframes (E.g., peak hours during the winter). And to build new lines is expensive, meaning the cost/benefit will typically be low. What might be a cost-efficient alternative to building new lines, which also takes good care of security of supply, is making the grid more flexible.

Although building new lines is expensive, we cannot know that flexibility always is the right solution.

**Our aim is therefore to develop methods and tools to evaluate *where*, *when* and *how* flexibility is the right solution to ensure a robust and cost-effective grid.**

In CINELDI flexibility is defined as follows:
An individual or group's ability and willingness to modify their production- and/or consumption patterns, often as a reaction to an external signal. This modification is done to offer services to the power system, or to maintain stable grid operation.

We define flexible resources as production, and/or consumption resources, and/or energy storage where injected or consumed power can be modified on an individual or group level, as a response to e.g., a price signal.

## Flexibility research activities in 2020

Using all three corners of our multidisciplinary research platform (which you can read more about on page 45) we have worked on the following flexibility-topics in 2020:

- characterisation of the flexible resources (demand, generation and storage) and microgrids
- grid operation incorporating flexible resources
- flexibility as ancillary services
- flexibility as an alternative to or as enabler for postponed grid investments
- flexibility markets

# A different but successful year

For many of the almost 250 people involved in CINELDI, 2020 was naturally a very challenging year. But it was also the most productive year CINELDI has ever had. That's something we are fiercely proud of, and it gives us a big momentum to build on, as we move into the Centre's four final years.

## Adapting to the new normal

Just as we are trying to adapt the distribution grid for tomorrows challenges, we quickly had to adapt to *the new normal* in March 2020.

As everyone moved into their home offices, we quickly got an overview of how it would and could affect ongoing and planned activities. Our biggest concern was our labs at SINTEF and NTNU closing down. Fortunately, SINTEF and NTNU quickly adapted to new routines and precautions, labs reopened and our activities at the National Smart Grid Laboratory were able to proceed as normal. Our partners adapted well too, so no living-lab activities in pilot projects had to stop. In fact, we were able to increase the activity in some of the pilot projects this year.

Due to the pandemic we had to cancel ongoing research exchanges and postpone planned stays abroad. A couple of master and PhD projects were slightly delayed as well. But all things considered, we have not been significantly affected by the Coronavirus.

## Going digital

All non-lab activities have been able to proceed as normal, and with a lack of physical meetings moved onto digital platforms. We arranged more webinars

than ever before and CINELDI researchers were featured in several podcasts. We even made our own podcast series on Flexibility, which you can read more about in the communications chapter on page 88.

One of 2020's highlights was the CINELDI Days in November. We arranged a digital version of it and set a record attendance.

## A focus on flexibility

Europe is aiming to become the world's first climate neutral continent. And about 30% of the necessary emission cuts can be achieved through electrification.

*The green transition* and *electrification of society* means more renewable electricity production, new electrical loads through electrification of more sectors such as transport, increased use of energy storage e.g. batteries etc. The electricity grid is the backbone of this transition, as an important enabler for the electrification of society.

Increased electrification will pose new challenges and requirements to the electricity grid, through connection of more renewable electricity production, increased electricity demand and new loads. The challenges must be met in a cost-efficient way without jeopardising security of electricity supply. That is why we aim to make the grid intelligent, flexible, cost-efficient and robust.

Flexibility is one of the most important aspects of the grid as we aim for the transition to the future. We therefore decided that in 2020-2021 we would dedicate our focus to flexibility in the grid, with each work package looking into it from different angles.

Most of our work on flexibility in 2020 was focused on technologies and methodologies regarding flexibility. Moving into 2021 our goal is to put it all together and test results from last year in different case studies, to document the effects of a flexible grid. This work will be documented in a White Paper and lay the foundations for our next thematic focus: Security of supply. You can read more about our flexibility priority area on page 12.

## 2021, the next four years and beyond

The last half of CINELDI is about creating the foundations we need to make a transition strategy for the grid. That's our biggest goal, and to reach it we'll continue to focus on more concentrated and focused efforts across all WPs.

When CINELDI's eight years are up and the transition strategy has been established, we are going to look back at a centre that made crucial contributions to upgrading one of our most important infrastructures: the electricity distribution grid. CINELDI can't solve everything, but we can do a lot.

Thank you to everyone involved in CINELDI, directly or indirectly, for your efforts through four years. We look forward to working with you for four more.

*Gerd Kjølle & Sigurd Kvistad*

## Gerd Kjølle

Dr. Gerd H. Kjølle is the CINELDI Centre Director and Chief Scientist in the Energy Systems Department at SINTEF Energy Research.

She holds a PhD in Electric Power Engineering from NTNU and has more than 30 years of R&D experience from the electric power sector.

Her main fields of expertise are power system reliability and security of electricity supply. Her work has resulted in solutions which are in use by grid operators and energy regulators, foundations for handbooks, decision support tools, guidelines of good practice, standards as well as regulations of grid companies.

She has also contributed to the education and recruitment of PhD and Master candidates to the electric power sector.

## Sigurd Kvistad

Sigurd Kvistad is the CINELDI Chairman of the Board, and head of the Operational Control department at Elvia. Kvistad is also the Chairman of the board in the Norwegian Smart Grid Centre.

Through more than 30 years in the electricity grid sector, he has been responsible for contractor operations, development projects, grid planning and grid operation.

As the project owner of several ongoing projects at Elvia Kvistad has taken part in many R&D projects within Smart Grids throughout his career. Kvistad also takes part in different fora in the electricity grid sector related to the future grid as well as regulation of the grid companies.

# How we contribute to the UN Sustainable Development Goals

**Electrification of society may provide more than 30 % of the potential $CO_2$ emission reductions.**

Electrification is highlighted as one of the most important climate actions, both nationally (Klimakur 2030) and internationally (IEA Energy Technology Perspectives 2020).

In CINELDI we develop the electricity grid of the future, by retrofitting the old grid and creating and introducing innovative technologies. This will be a grid that'll enable large scale electrification of society by being intelligent, flexible, robust and cost-efficient. It will allow more variable, renewable and distributed power generation, new types of electrical loads like solar and wind, and increased demand.

More specifically, our work supports the following UN Sustainable Development Goals:

SUSTAINABLE DEVELOPMENT GOALS

**7 AFFORDABLE AND CLEAN ENERGY**

**Ensuring access to affordable, reliable, sustainable and modern energy for all**

**9 INDUSTRY, INNOVATION AND INFRASTRUCTURE**

**Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation**

**11 SUSTAINABLE CITIES AND COMMUNITIES**

**Make cities and human settlements inclusive, safe, resilient and sustainable**

**13 CLIMATE ACTION**

**Take urgent action to combat climate change and its impacts**

## Causes of Information Inconsistencies in Smart Distribution Grids

The ongoing digitalization of the power distribution grid will improve the operational support and automation which is believed to increase the system reliability. However, in an integrated and interdependent cyber-physical system, new threats appear which must be understood and dealt with. Of particular concern and interest are the causes of an inconsistent view between the physical power grid (PG) and the ICT system (Distribution Management System-DMS).

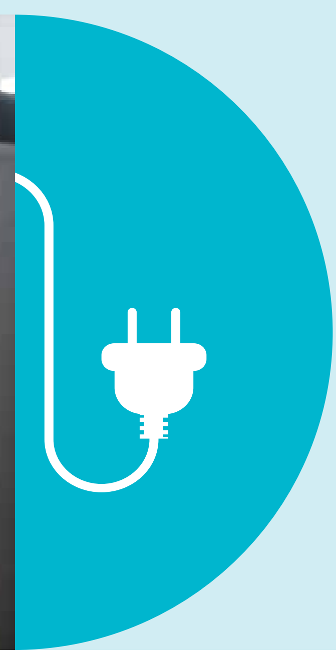
Read the full story on the SINTEF blog or on cineldi.no: **https://blog.sintef.com/sintefenergy/gridsmartgrids/causes-of-information-inconsistencies-in-smart-distribution-grids**

## Security of electricity supply in the future flexible and intelligent grid

These ongoing changes in the power system may have implications for the security of electricity supply (SoS). The rapidly ongoing electrification of society makes it even more important to better understand these implications.

Therefore, CINELDI has carried out a critical review of existing research on the impact that flexible resources may have on SoS. In this blog post, we summarize the findings and discuss the need for more holistic and comprehensive assessments of SoS considering flexible resources. We also discuss what it may mean for how SoS is managed in the future.

Read the full story on the SINTEF blog or on cineldi.no: https://blog.sintef.com/sintefenergy/security-of-electricity-supply-in-the-future-flexible-and-intelligent-grid/



# A useful and "living" energy lab

As the electrification of transport and other sectors is moving forward, CINELDI researchers are ever on the lookout for solutions to challenges that appear on the way to the full-electric society of the future. One tool to help them achieve that goal is the Skagerak Energy Lab.

Skagerak Energy Lab consists of 4300 square meters of solar panels on top of the stadium of Odd football club in Skien, plus an 800 kW battery and control systems. When the battery is charged, it has sufficient capacity to provide floodlighting for the stadium during the two hours it takes to complete a football match. The system also serves as a back-up source of electricity for households in the neighbourhood. The objective of this "living lab" is to establish the possibilities and challenges linked to large solar panel installations; to run pilot projects and build knowledge around the themes of energy storage and battery technology; to gather experience linked to the practical ramifications of operating such a system.

"The lab is a great place for us to test research results", says CINELDI centre director Gerd Kjølle. "Through the pilot projects we run at the lab, we get our research to progress towards the goal of having a new, useable technology."

One such project aims to figure out exactly how flexible resources (such as a battery plus solar panels system) can be used in an optimal way both by their owner and by the grid itself. Is it best to use the solar panels' output right now to charge batteries or to meet a peak in local electricity demand? These questions will become increasingly relevant in the future, as more and more homes and businesses will contribute to their local energy markets by installing (for example) solar panels.

Skagerak Nett, through its partnership with CINELDI, gets access to top researchers. "It helps us to get our results analysed and quality-checked by specialists", says project owner at Skagerak Energi, Stig Simonsen. As a power company, Skagerak Energi is very interested in such topics as the use of large batteries as a part of the distribution grid.

How those batteries can best meet the demands of the users is another topic that will be researched further. "We're looking forward to test Model Predictive Control together with CINELDI in 2021, says Simonsen. This kind of modelling will be a more sophisticated control system than what we have currently, and will hopefully allow us to take a peek at the future and meet the demand more accurately."

## System innovation

Another advantage of the lab is the way it helps highlight surrounding issues that need to be solved. "An innovation is often a very specific and concrete thing, says Gerd Kjølle. But for this innovation to be put to use, a number of factors need to fall into place – be they economic, regulatory or societal. That's when we start talking about *system innovation*."

The power grid that's in use today was very much developed with a unidirectional power flow in mind: large numbers of users drawing power from a grid fed by a smaller number of power plants. But as this ecosystem evolves to one with an increasing number of smaller power generators and a flow that goes in both directions, new challenges will arise.

A very specific example of this type of challenge was highlighted at the Skagerak energy lab. Since the battery, the solar panels and the lighting system of the stadium are not immediately adjacent, the power grid is used to transfer electricity from one to the other. Current regulation would mean having an electricity meter at every point of connection, which would mean the electricity would effectively be sold and bought several times throughout the process (with the increased costs that would entail). In this case, the lab got a special dispensation from the rules. But the issue exemplifies how innovations don't live in a vacuum, and how there is a need for system innovation for new ideas to be put to use.

# This PhD's results will be important for technology providers

You probably know very well that solar panels, wave power and wind power will give us the green energy we need when cars, factories and light aircraft are to run on electricity. But today, this electricity is transported from the solar panels to the electric cars via an ageing electricity grid. As the ways we produce and use electricity are modernized, so too must the electricity grid be modernized. There is a lot of research on completely new technologies that will revolutionize the electricity grid. But there is a technology first invented long ago that will be crucial to the success of the future of electricity grids: Converters.

Fredrik Göthner is writing a PhD thesis in CINELDI. This is where he is researching converters. We talked to him to hear what converters actually are, the role they will play in the future, and why he is researching them when the technology already exists.

## From one type of electricity to another

The role of converters in the electricity grid is to convert the electricity from one type to another, according to Göthner.

"Different energy sources can produce different forms of electricity. For example, the power coming from solar cells is completely different from that coming from wind turbines. In order to be able to connect these energy sources in an electricity grid, it is a prerequisite that the currents are converted to the same type, and this is where the converters come into play.

Put in a more technical way: the low-voltage electricity grid in Norway, i.e. the grid that supplies our homes, uses alternating current (AC) with a voltage of 230 volts and a frequency of 50 hertz. However, solar cells produce direct current (DC), while wind power often produces alternating current at a different frequency than the grid frequency. The job of the converters is to convert the current from the various sources so that it matches the grid voltage and frequency."

## The converters of the future in the electricity grid of the future

Most people have traditionally used electricity in a predictable way. Now, however, the consumption pattern is changing rapidly.

At the same time, Norway has traditionally had a few large production facilities, often hydropower plants, outside the cities. More and more small production facilities close to customers are now being introduced. For example, solar cells on private rooftops.

As most people know, electricity must also be produced and used at the same time. Unfortunately, the sun is not always up when you need to turn on the light. One solution to this is to insert batteries into the electricity grid so that we can store the power until we need it.

"These trends also present some challenges. For example, it can be demanding to coordinate many small converters, instead of a few large production facilities. On the other hand, the converters also provide opportunities to improve other things, such as the voltage quality in the grid," says Göthner.

"What I am working on definitely has a high utility value for industrial companies that make converters," Göthner states.

## Unique access to expertise in CINELDI

Because Göthner is writing his PhD thesis at the research centre CINELDI, he is able to participate in a world-leading research environment on the electricity grid of the future. This has its benefits.

“There are undoubtedly many more resources, both in terms of people and laboratories, that I can make use of. Here, there are many people with a high level of expertise, from industry, grid companies, Statnett and SINTEF, who all have different perspectives. This is valuable in a large centre.”

In his research, a lot of Göthner’s work involves simulating reality to see how the converters react in different situations. In the so-called Smart Grid Lab (the National Smart Grid Laboratory), he tests the results from his simulations in more realistic situations.

“In the lab, I try to see if the things I have thought of and simulated actually hold up in a more real setting too. I can then connect real converters to advanced lab equipment that mimics a real electricity grid. I often run smaller tests with one, two or three converters that try to validate or falsify what I have been working on and simulated. This is important to ensure the quality of my results.”

# Vision, mission and goals

## VISION

CINELDI develops the electricity grid of the future.

## MISSION

CINELDI works towards digitalising and modernising the electricity distribution grid for higher efficiency, flexibility and resilience.

## MAIN GOAL

CINELDI enables a cost-efficient realisation of the future flexible and robust electricity distribution grid.

**Robust grid:** A grid that safeguards the security of electricity supply (energy availability, power capacity, reliability of supply and voltage quality), safety, privacy and cyber security.

## Realising the mission

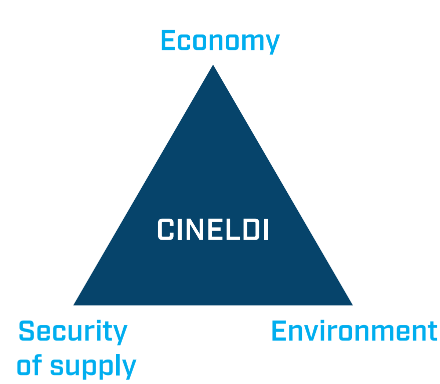
By acting as a national hub for long-term research and innovation within intelligent electricity distribution, we bring together innovative stakeholders to develop and implement new technologies, work processes and solutions to develop the electricity grid of the future.

In CINELDI we are equipped to tackle this challenge with our unique combination of academic resources, computer modelling and simulation facilities, the National Smart Grid Laboratory infrastructure, and pilots and demos integrating the involvement from industry partners.

## Reaching the goals: The energy trilemma

One of the main reasons for transforming today's ageing and passive electricity grid into an active, flexible, robust and intelligent grid, i.e. a smart grid, is to lay the foundation for reaching national and international energy and climate goals.

Making the grid smart is not the main challenge though. The main challenge is to do it in an affordable



way while showing consideration for the environment and ensuring a high security of supply. In CINELDI we have coined this *the energy trilemma*.

### Economy

With our research and innovation we shall enable a socio-economic, cost-efficient realisation of the future flexible and robust electricity distribution grid and reduce the total distribution system costs compared to the "business as usual"- solutions by reducing operational (OPEX) and investment costs (CAPEX).

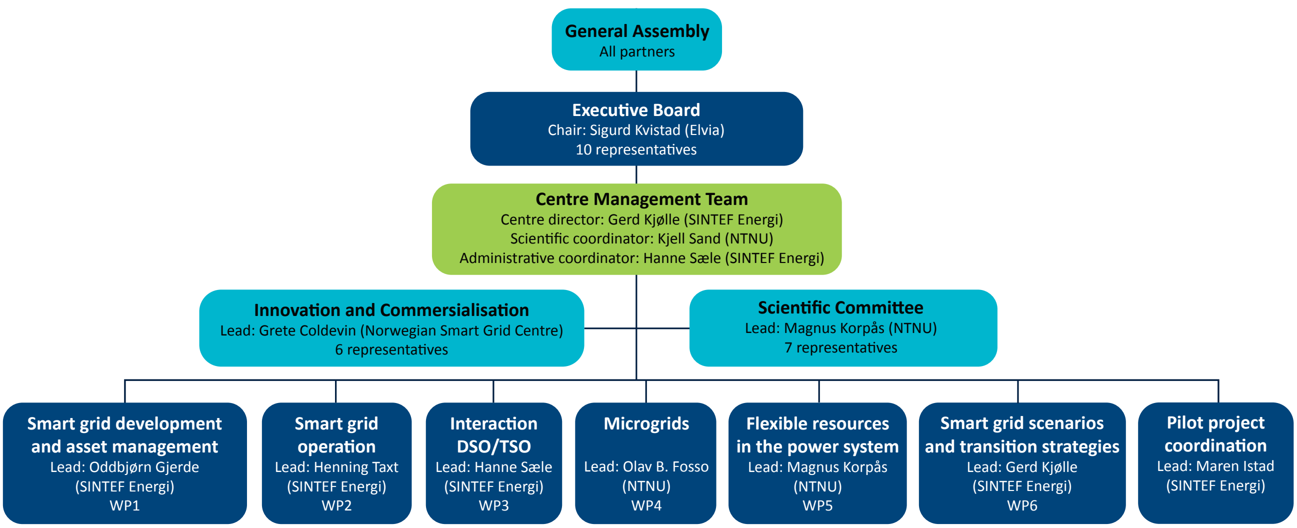
### Environment

Our work paves the ground for increased distributed generation from renewable energy sources, electrification of transport and efficient use of electric power and energy.

### Security of electricity supply

We ensure the security of electricity supply, comprising the energy availability, power capacity, reliability of supply and voltage quality, as well as the cyber security, safety – as important parts of developing the electricity grid of the future.

# Organisation




## Scientific Committee (SC)

The Scientific Committee is a platform for dialogue between CINELDI and key international partners. The Committee discusses matters regarding the direction of the Centre, lab activities, scientific ambition, and international relevance of research.

**The purpose of SC is to:**

- Give advice to the research in CINELDI, input to plans and advice in emerging research topics.
- Contribute to coordinate research and laboratory activities between participating institutions
- Identify new areas of collaboration and contribute to organizing and coordinating international research proposals.

The SC meets twice a year: once in the spring, once in the autumn. The spring meeting focus on ongoing research and collaboration, while the autumn meeting looks at the next year's work plan.

There was a SC meeting planned as part of the CINELDI-conference in the spring of 2020, but it was cancelled due to Coronavirus. Instead, a digital meeting was arranged in both the spring and autumn.

The WP-leaders and Centre Management participate in all SC-meetings to ensure close contact between the researchers and international advisors.

The next meeting is planned for the CINELDI Conference in the spring of 2021.

The scientific committee had the following members in 2020:

- **SC leader: Professor Magnus Korpås, NTNU, Norway**
- Reader Ivana Kockar, University of Strathclyde, UK
- Associate professor Mattia Marinelli, DTU, Denmark
- Professor Fabrizio Pilo, University of Cagliari, Italy
- Director Angel Diaz, Tecnalia, Spain
- Professor Bruce Mork, Michigan Technological University, USA
- Research Professor Kari Mäki, VTT, Finland

Several SC members are involved in more of the international research related to CINELDI, such as participation in EERA JP Smart Grids, EU-projects, researcher exchange and PhD exchange. SC member Associate professor Mattia Marinelli (DTU) was supposed to be a guest scientist in CINELDI through NTNU in 2020. This has been postponed to 2021 due to Coronavirus.

## Partners

We are proud to have partners who showed resourcefulness in a challenging year.

Thank you for all your hard work and dedication. Not only in 2020, but throughout the past four years. We look forward to working together and reaching our goals over the next four.

### About the partners

Building the smart, flexible, robust grid of tomorrow in a cost-effective way requires a huge effort from all aspects of the industry: From authorities setting the industry's framework conditions, to DSOs and TSOs operating the grid within that framework and everyone in between. In CINELDI we have representatives from all corners of the industry, giving us the perfect platform to develop the future grid.

The twelve DSO partners in CINELDI cover about two thirds of the total Norwegian end-users. The national knowledge building this width of companies allows is an impactful factor on the sector in itself. And if most of these partners utilise CINELDI results, it will impact society at large through a more cost-efficient and flexible grid. This will in turn pave the ground for electrification of society and reaching climate goals, as well as value creation and innovation in related sectors in society as a whole.

However, to truly realise our vision, a co-evolution needs to take place within more areas than those covered by our research. Regulation of the DSOs and the TSO is for example of particular importance. Therefore, it is important that the public authorities DSB, NVE and the Norwegian Communications Authority are partners in CINELDI.

## Research partners

SINTEF Energy Research

NTNU - Norwegian University of Science and Technology

SINTEF Digital

## Power Grid Companies

Agder Energi Nett

BKK Nett

Elvia

Haugaland Kraft Nett

Linea

Istad Nett AS

Linja AS

Lyse Elnett AS

Nordlandsnett AS

Norgesnett

Skagerak Nett AS

Tensio

## System Operators

Statnett

## Power Market Operators

Nodes

Nord Pool

## Technology Providers

ABB AS

Aidon

Disruptive Technologies

Embriq

Smartgrid Services Cluster

Prediktor

## Member Organizations

Energy Norway

KraftCERT

The Norwegian Smart Grid Centre

## Public Authorities

Directorate for Civil Protection and Emergency Planning (DSB)

The Norwegian Water Resources and Energy Directorate (NVE)

Norwegian Communications Authority

**In 2020, several of our partners merged and/or changed their company names.**

- Embriq: Previously Rejlers Embriq
- Tensio: Previously NTE Nett
- Linja AS: Previously Sogn og Fjordane Nett (SFE Nett)
- Elvia: Previously Eidsiva Nett and Hafslund Nett

## Welcome to our new partners

We are thrilled to welcome two new partners to the Consortium in 2020: NODES and Prediktor.

NODES (joined August 10) is an independent marketplace where grid owners, producers and consumers of electricity can trade decentralised flexibility and energy. Their mission is to facilitate optimal use of flexibility in the grid by offering an open, integrated marketplace to all flexibility providers and grid operators.

They established two pilot projects in 2020 to test the marketplace: One with Haugaland Kraft Nett and one with Linja. You can read more about the projects on page 80.

Prediktor (joined November 10) develop systems for process monitoring and optimization. They will make their software for power production in microgrids available to CINELDI and the National Smart Grid Laboratory.

## Cooperation between partners

One of the keys to success in CINELDI is cooperation and sharing of knowledge between partners, as pointed out by the partners themselves on page 18 to 24. Thanks to our multidisciplinary research platform (which you can read more about on page 45) the R&D partners cooperate closely in all WPs.

The partners are tightly integrated in the Centre work. For example, idea generation, activity selection, planning and review involve representatives from the whole centre. Partners are involved through discussion of new ideas at workshops and dedicated expert groups within each WP.

The WPs have actively used the expert groups in the development of the work plans for 2021. The expert groups have also been involved in planning partner workshops.

The user partners have been involved in six case studies in 2020, as part of the research activities.

Pilot projects are also an arena for cooperation between the different R&D partners and user partners, see section on "Pilot projects in CINELDI".

Throughout the year we arranged several digital meetings, workshops and seminars. In April, we replaced our annual CINELDI Conference with a two day digital partner-workshop, due to the Coronavirus pandemic. It was a success with a high attendance (60-70 people) and good discussions between partners and researchers.

EERA JP Smartgrids were meant to attend the Conference and have their steering committee meeting parallell to it. We are working to reschedule that for the 2021 Conference.

Flexibility has been a red thread for all CINELDI work in 2020, which you can read more about on page 12. In September we had a digital workshop on flexibility for the whole consortium, and in November we arranged a digital version of the annual CINELDI-days.

Since March, we have arranged 25 webinars for the consortium. Both CINELDI WP-leaders, researchers and partners presented. In the webinars, the latest research progress was presented and discussed. We also discussed plans moving forward. We also had three webinars together with the Norwegian Smart Grid Centre.

Photo: Ronny Solheim

# Research and results

## Our research targets the electricity grid situation in 2030-2040

The research in CINELDI addresses advances of electricity distribution system planning, operations and management, where new and emerging topics are emphasised. A few examples are utilisation of innovative sensors and smart components for monitoring and control, microgrids and utilisation of the flexible resources inherent in distributed generation, consumption and electricity storage, and cyber security.

The research activities are organised in six work packages (WPs), reflecting the main aspects of power system operation and management. E.g. power engineering, cybernetics, information and communication technology, social sciences (socio-economics and consumer behaviour related to flexibility).

The WPs are tightly integrated to ensure that each work package addresses research questions of high relevance for industry and society, enable academic partners to work in close collaboration regardless of discipline and facilitate interaction and communication between research and industry partners.

Smart grid development and asset management (WP1)

Smart grid operation (WP2)

Interaction DSO/TSO (WP3)

Microgrids (WP4)

Flexible resources in the power system (WP5)

Smart grid scenarios and transition strategies (WP6)

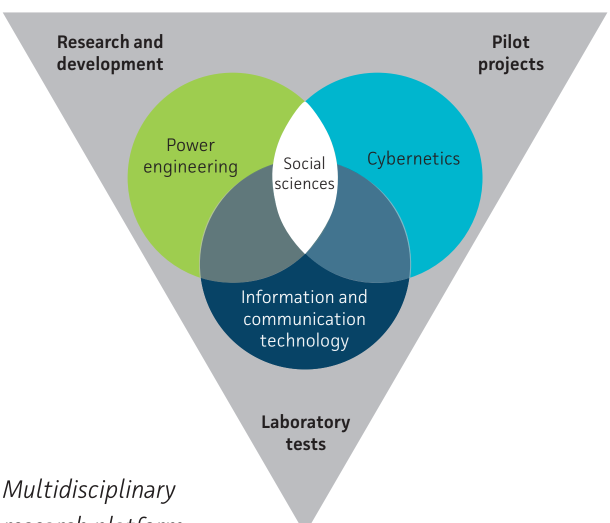
Pilot project coordination (WP Pilot)

WORK PACKAGES

### Multidisciplinary research platform

Advanced basic and applied research provide in-depth knowledge, methods, and tools that are tested in laboratories, simulated environments and small-scale field pilots. This reflects the multidisciplinary platform CINELDI's research is based on. The platform consists of three pillars:

- Research and development
- Pilot projects
- Laboratory tests




*Multidisciplinary research platform.*

### Use Case Methodology, Laboratories and infrastructure

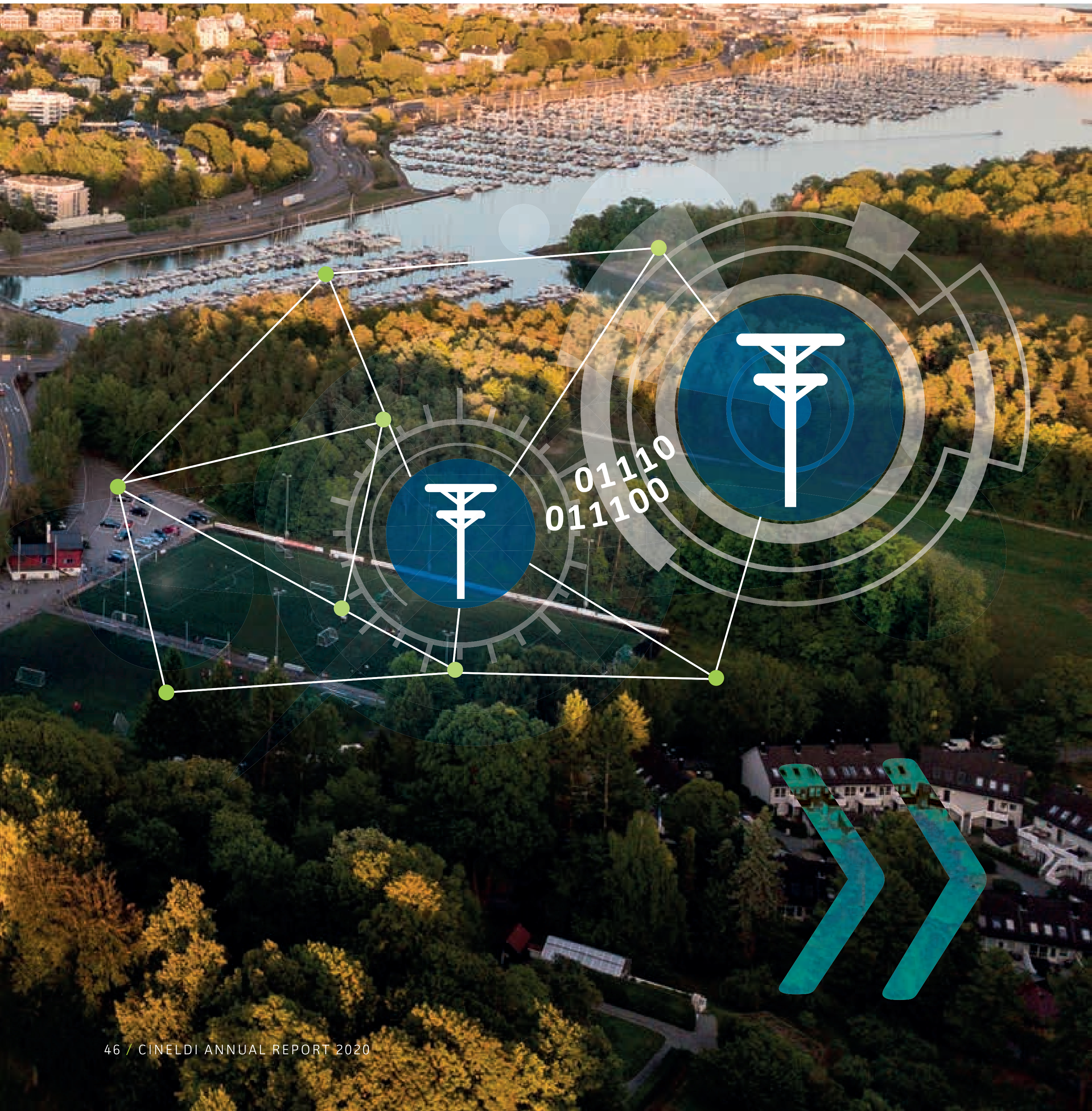
We actively use Use Case Methodology (UCM) in our research. The UCM is based on the IEC standard and is well suited for multidisciplinary research because it allows us to cooperate across domains instead of each specific research area working in silos.

With our unique combination of academic resources, computer modelling and simulation facilities, the National Smart Grid Laboratory (NSGL) infrastructure and pilot projects we are well equipped to develop the electricity grid of the future.

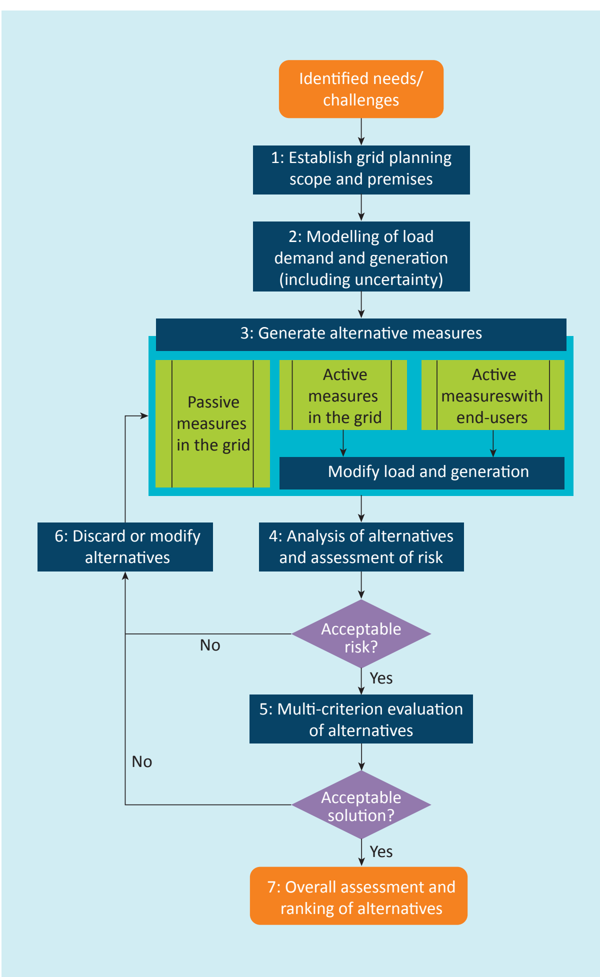
The NSGL is a system-oriented laboratory providing state-of-the-art infrastructure for R&D, demonstration, verification, and testing over a wide range of Smart Grid use cases. This lab is frequently used in PhD works, research- and pilot projects, testing technologies and solutions still too immature to be tested in real grids.

In addition, CINELDI has access to several living labs, i.e., the physical grid owned by the DSOs and TSOs. Per 2020 about 25 pilot projects are being run. The vast majority are related to living labs. (Read more about the pilot projects on page 78).

# Smart grid development and asset management **(WP1)**



Our primary objective in WP1 is to develop the decision support methodologies and tools needed for optimal planning and asset management in a smart grid. The methodologies and tools will make the grid more efficient through better utilization of both existing and new infrastructure, more target-oriented investments, and better risk-control.




In 2020 we used a case study to show how the framework for *active* distribution grid planning we developed in 2019, can be used as decision support to reduce socio-economic costs and risks of lost energy production or overvoltage.

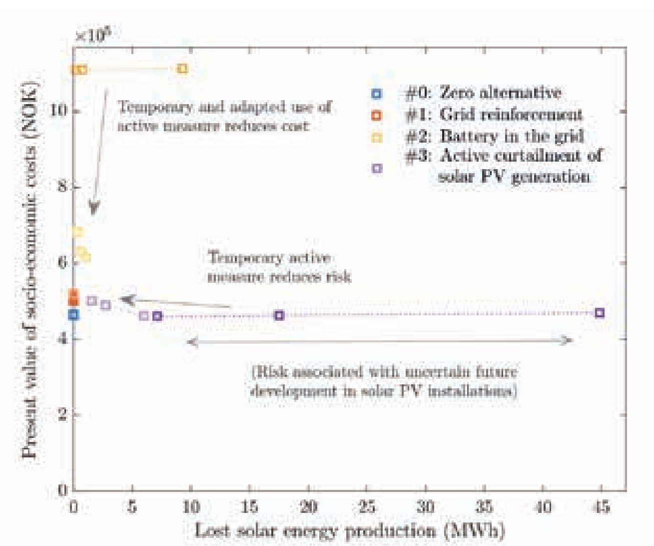
We also showed new useful applications of the Vulnerability Analysis Framework in 2020. The framework was developed in a KSP-project called *Vulnerability and security in a changing power system* and is used to identify and analyse extraordinary events in a power system. We made small modifications to the framework to include the digital part of the grid and were able show clear benefits of a combined analysis including both power and cyber aspects.

## Active distribution grid planning

The traditional *passive* framework for distribution grid planning must be augmented to handle the new challenges (such as variability and uncertainties due to variable distributed generation) and opportunities (such as new active grid operation technologies) emerging in the distribution grid.

The framework for *active* distribution grid planning we developed back in 2019 was based on these challenges and opportunities. In 2020 we proved how the framework can be used for decision support. To do that, we used a concrete and simple, yet realistic case: A Norwegian low-voltage distribution grid with increasing solar photovoltaic generation.

We use the new framework to compare costs, benefits and risks of both active and passive measures as the figure below illustrates. We found that for this case, temporary active measures can defer grid reinforcement. Deferring grid reinforcement can reduce socio-economic costs and risks of lost energy production or overvoltage.




The case also gave insight into the needs for methods and models to be developed and used as part of the framework. It is therefore a starting point for further work in CINELDI and possible spin-off projects. It is also a starting point for specifying requirements for planning tools for active distribution grids. Continued application and refinement of the framework will provide more experience on how to best develop the active distribution grid in the future.

## Security of supply in cyber-physical power systems

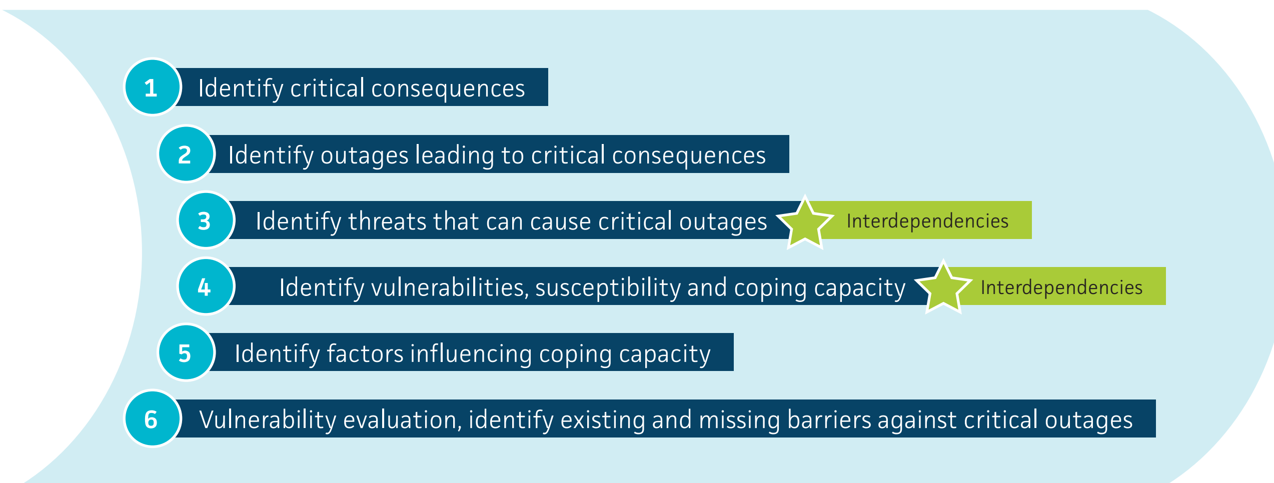
Power technology and digital technology is interconnected at various levels throughout the whole grid. Digital components rely on power to operate, and the electric power system is becoming increasingly dependent on the functioning of digital technology. These interdependencies are important to understand, and they need to be considered in future risk analysis.

In a KSP-project called *Vulnerability and security in a changing power system*, a Vulnerability Analysis Framework has been developed to offer a concrete approach to identify and analyse extraordinary events in a power system. This framework has previously been used with success to analyse both realistic cases and real power system, but without particular emphasis on the digital part of the grid.

In CINELDI we wanted to find out if the Vulnerability Analysis Framework would be useful to perform analysis that cover power and cyber aspects in a combined analysis, and whether this framework would help identify and understand interdependencies.

Overall, we found the Vulnerability Analysis Framework to be useful for a combined analysis. We managed to include both power and cyber aspects in the analysis and found that this gave clear benefits: It helped keep a whole-system perspective, and it helped build a common understanding across these domains. All the power and cyber researchers and DSO representatives involved were able to understand and apply the framework.

However, we found that it was easy to lose sight of the interdependencies. Thus, we made modifications to the original Vulnerability Analysis Framework to increase support in identifying and including interdependencies in the analysis. This was done by including interdependencies as something that should be considered for all threats, susceptibility and coping capacity identified, as can be seen in the figure.



# Smart grid operation (WP2)

We develop and test a set of new concepts and solutions that optimally utilise new emerging control and monitoring technologies, which are capable of exploiting extensive, real time monitoring to/from all assets and network customers and flexible resources.

We expect our work to result in a more flexible operation of the distribution grid, contributing to cost reductions, enhanced energy efficiency, improved system reliability and security, as well as standardised solutions.

As more distributed generation is integrated into the distribution grid, DSOs and TSOs must adapt new ICT solutions to coordinate activation of resources in the grid (like solar and wind power) for reactive power. Some of the technology to do this is needed, but it has to be tested further. We have started to set up a case study in the lab where we can test scenarios that are too difficult to test in regular pilot projects due to system security.

More integration of ICT has a possible downside though – it opens the door to cyber-attacks on the grid. We have therefore spent time in 2020 specifying lab tests where we will test the impact of cyber-attacks. More specifically, attacks on the DSO/TSO coordination of voltage regulation.

## Use case: Voltage regulation TSO-DSO - joint management of reactive power

In the future, we expect a reduced contribution of reactive power from generators in large hydropower plants. At the same time, there is increasing integration of distributed production in the distribution network (for example solar and wind power). The system operator therefore has a growing interest in using resources for reactive power located in the distribution network itself.

The technology needed in the operations centre at both the TSO and the grid company (DSO) to integrate advanced functionality such as Volt/Var control is mature. This makes it possible for us to study a use case where TSO and DSO coordinate activation of resources for reactive power in more detail. This involves coordination and exchange of information between operations centres at the TSO and the DSO.

Ongoing research activities include lab implementation of both ICT and power systems in the use case aim to:

1. Test the potential (quantification with specific KPIs) for this use case
2. Evaluate the benefits of different control architectures for voltage regulation
3. Evaluate vulnerabilities related to ICT systems
4. Identify and prevent cyber-attacks

Thus far we have tested details for the lab work and the test network has been chosen. Relevant project partners and related pilot activities have also given us feedback. A full implementation of the use case in the lab is in progress. Going forward, the lab implementation can be used for research activities that cover both power system and ICT issues.

Some current topics are:

- Integration of functions in the distribution network's operations centre, such as AMS infrastructures and state estimation, which in turn supports Volt/Var optimisation.

- A study of which services flexible resources can contribute to.

With the lab implementation, we aim to represent the actual system, including communication protocols and to some extent connection to physical devices (for example transformers or boosters). This way, it is possible to run different scenarios in the lab which can be difficult to test in pilot due to system security.

## Cyber security in use case concerning voltage regulation

Coordination between TSO and DSO for voltage regulation requires more digital interconnection and extensive use of sensors/IoT. The backside of this digitization is an increased cyber security risk. We are therefore studying the possible consequences of attacks on the coordination of voltage regulation, and we look at the possible impact of some measures that can be used to reduce the risk.

Earlier in CINELDI, a memorandum was drawn up listing a number of misuse scenarios related to the network of the future. The following are particularly relevant for this use case:

- *False measurement data:* An attacker changes the measurement data to trigger an unwanted action in the system, or to hide another attack. For example, this can be done by having malicious software installed on sensors, or by modifying the data packets that are communicated. The attacker requires enough knowledge about the system to know how to change the measurement data to achieve the desired effect.
- *Unauthorised modification of control signals:* An attacker changes control signals related to (for example) flexible resources so that unwanted things occur.
- *Prevention of control signals reaching their destination:* An attacker who stops control signals will make it difficult to digitally control the system.

We are now in the process of specifying lab tests for the purpose of studying the impact of such attacks. We are also in the process of carrying out an analysis of cyber threats (threat modelling), which will provide a more thorough overview of the different ways in which cyber-attacks can take place in this use case.

There are various ways to deal with risks associated with attacks on measurement data and control signals. We have identified two strategies we wish to examine:

- 5G as an enabler for secure IoT in the smart grid, particularly with regard to authentication
- An integrity monitoring solution that can be used in real-time communication (which requires extremely low latency)

The activity also help us build a good level of competence in joint lab work that covers both cyber security and power issues, which is important due to the increasing integration of power and ICT. It is important to better understand the issue of cybersecurity related to measurement data because we expect an increasing degree of autonomy and self-healing. Computer systems themselves will then make decisions based on measurement data without people being directly involved in the assessments.

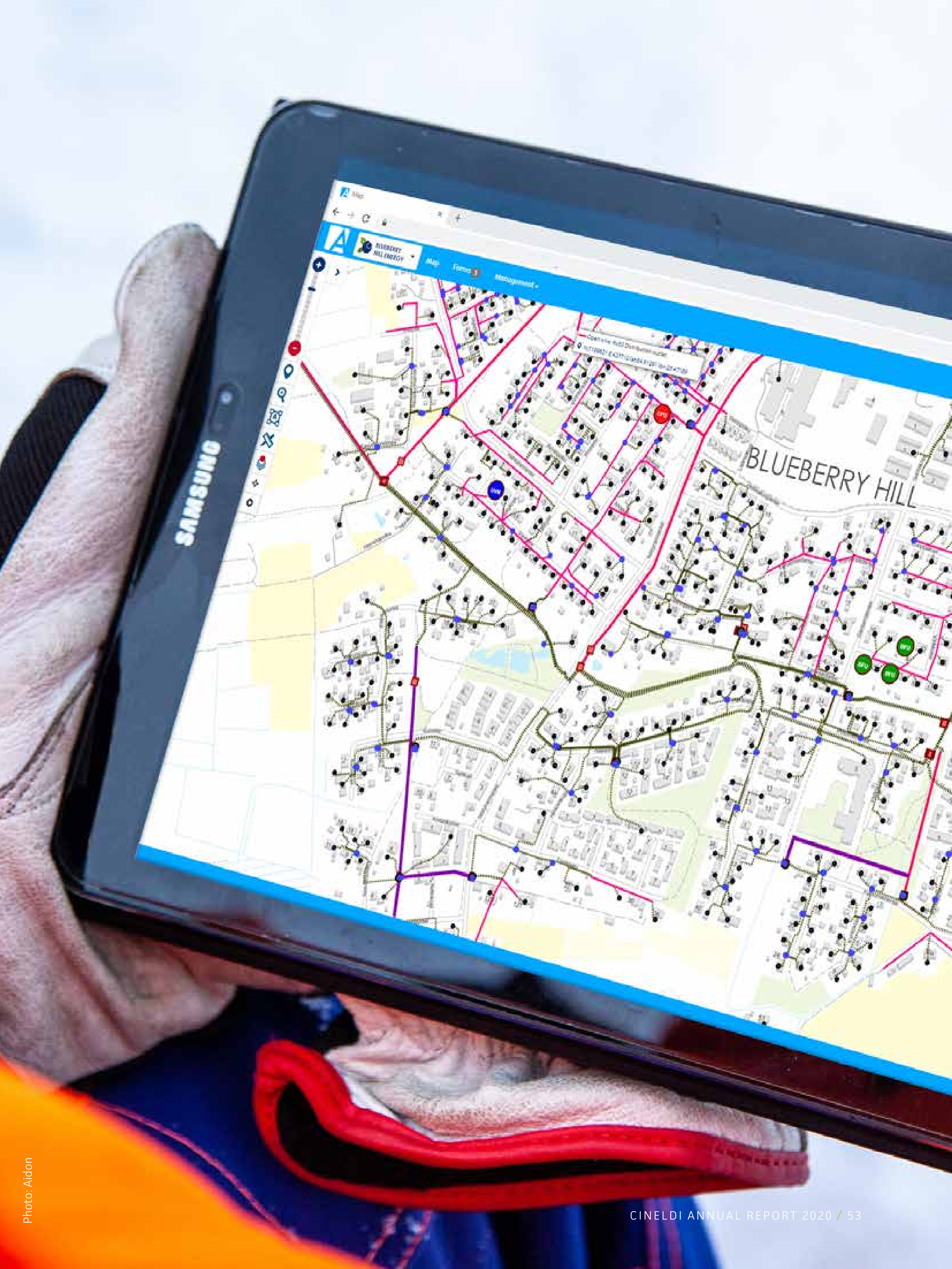
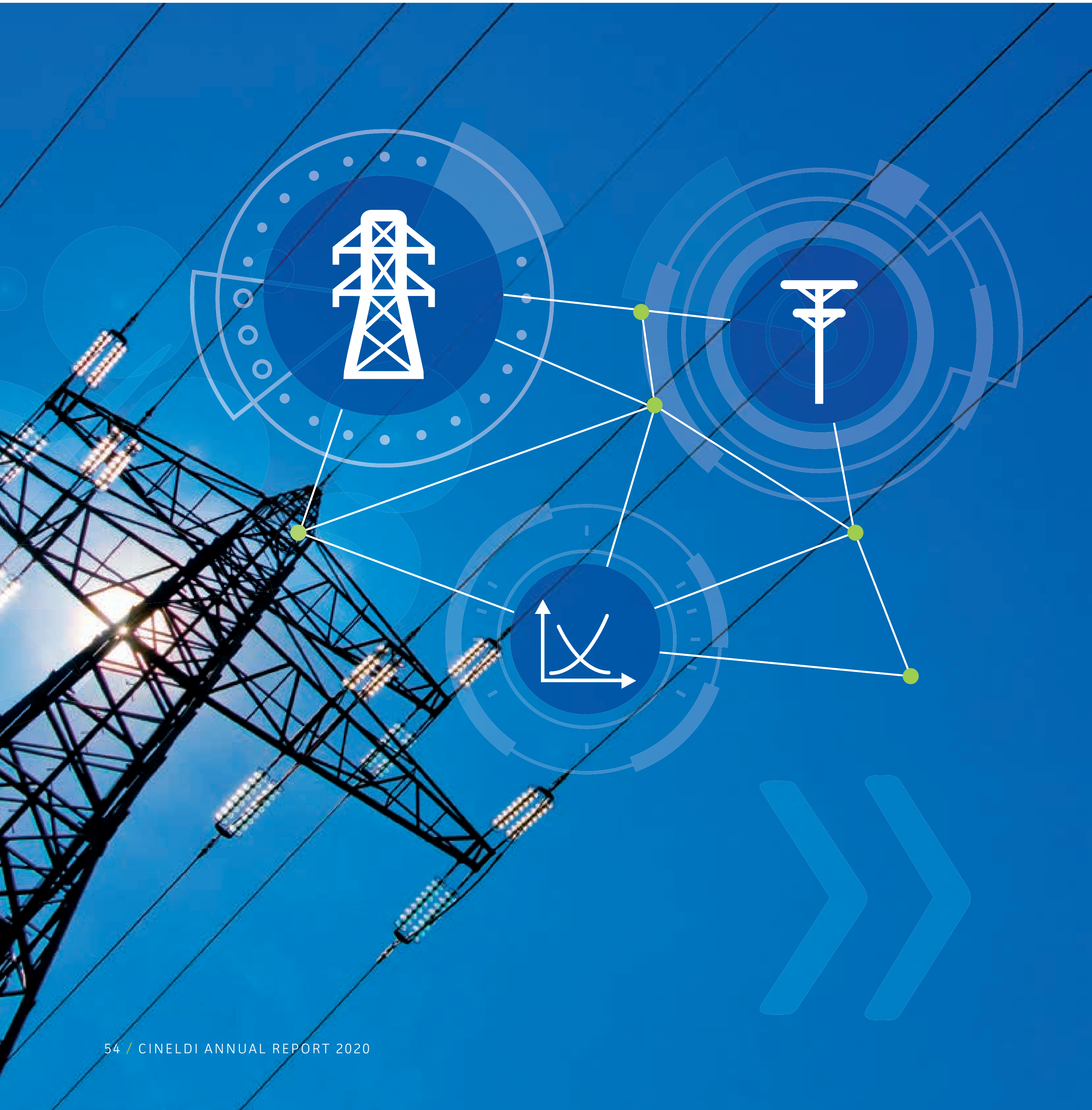


Photo: Aidon

# Interaction DSO/TSO **(WP3)**



In WP3 we are developing concepts and solutions for utilizing flexible resources in different market products and ancillary services, for increased observability between the distribution and transmission systems and business models regarding utilisation of customer flexibility.

## Utilizing flexible resources in ancillary services

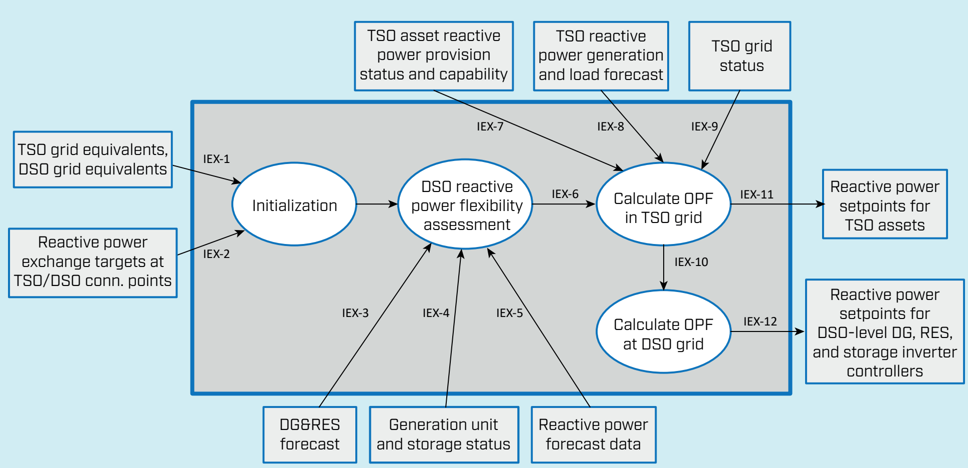
Coordination between TSOs and DSOs is essential to ensure that flexibility resources in distribution networks remain available for system balancing purposes without inducing unmanageable local congestions, which could affect the local grid. An optimal mix of flexibility resources can be obtained through a holistic approach considering technical, market and environmental aspects.

To get an overview related to how flexibility can be utilised, we have developed use cases focusing on voltage control, congestion management and balancing.

### Use case for voltage control

In this Use Case, reactive power is controlled for the benefit of both TSO and DSO. TSOs are responsible for keeping regional voltage levels to the standard limits while DSOs are responsible for keeping the voltages within limits both at customer premises as well as at the coupling point to the transmission network.

With the ever-increasing integration of power electronic devices, such as inverters, and due to the large variation of the generation of distributed generations, voltage level problems are becoming increasingly common. Hence, there is greater interest




*Sequence of actions for voltage control use case*

Interaction DSO/TSO (WP3)

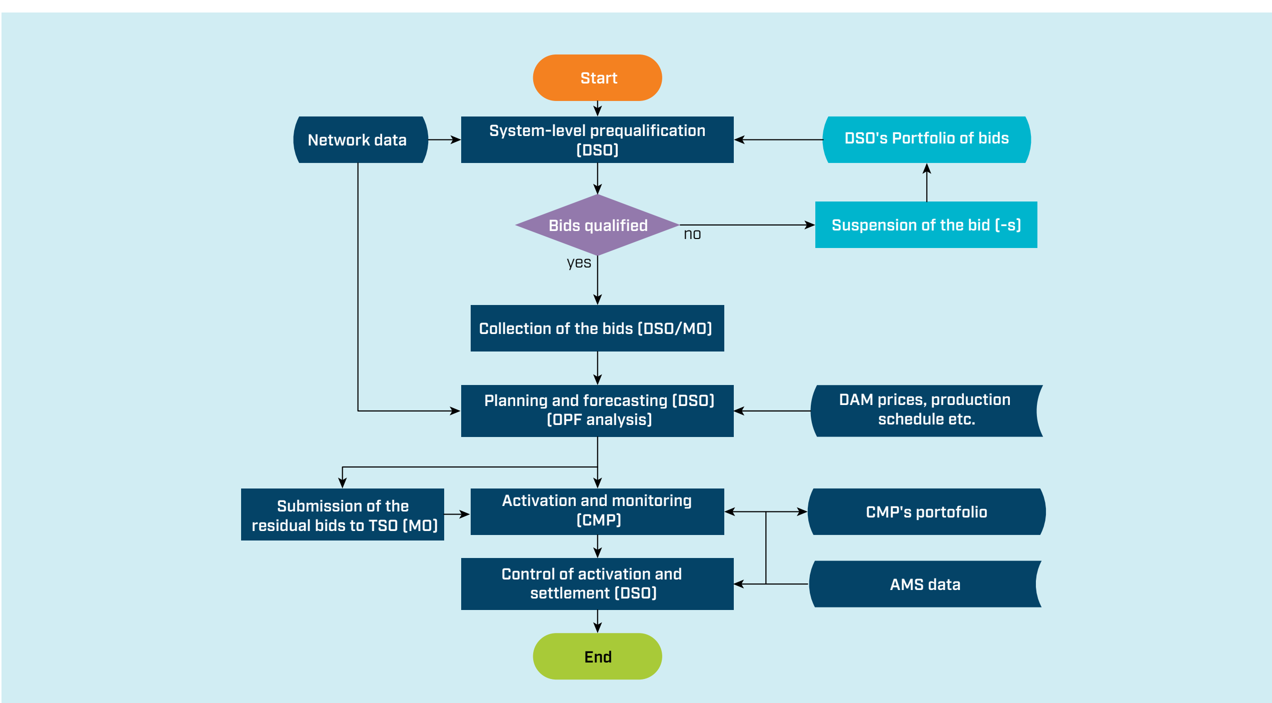
to deploy the controllable and distributed flexibility resources to solve voltage problems. In addition, there is greater interest to offer flexibility potential in DSO premises to voltage regulation in TSO areas and vice-versa.

With this use case we aim to utilize reactive power provision capabilities of RES and DERs as well as emerging technologies in the distribution grids to increase the hosting capacity and to improve voltage profiles both in transmission and distribution grids. This involves coordination between two real-time Optimal Power Flows (OPFs) running at the TSO and DSO control centres.

**Use case for congestion management**

There are growing concerns about congestions in the distribution networks in the next decades, including electrification of transport and space heating as well growth of DERs such as photovoltaics. Problems with congestions can result in voltage problems and overloads. Even if voltage problems occur in the distribution grid, they can also affect higher voltage levels. To avoid this, the problems should be solved locally.

In this Use Case we present a method to mitigate congestions in the distribution network by using flexible active power resources, procured via a specific




*Flow chart for congestion management*

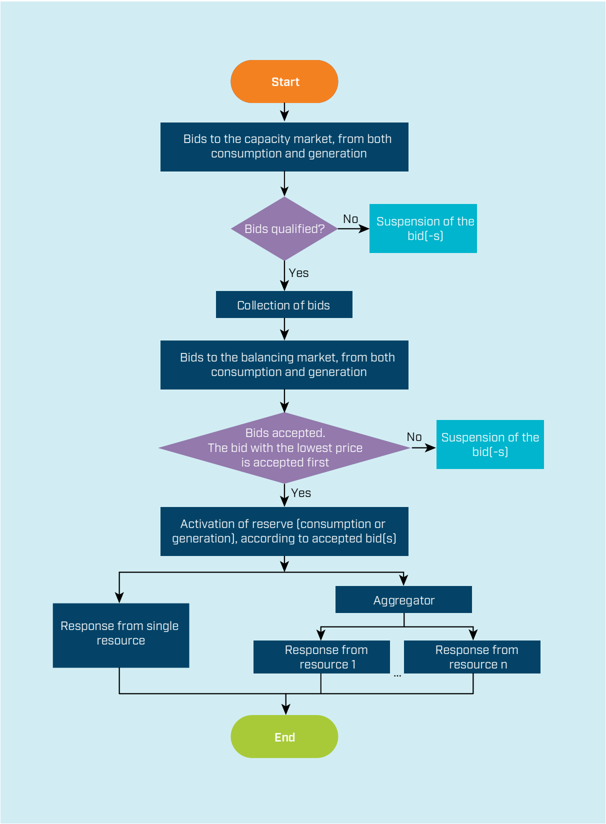
two-step market arrangement. The use case includes different phases related to congestion management: Forecasting phase, market phase, monitoring and activation phase, and measurement and settlement phase.

### Use case for balancing

To maintain the stability of the power system, the instantaneous generation and consumption have to be in balance at all times. But the increasing amount of non-dispatchable forms of generation in the power system makes it more challenging to balance it. Today, TSO is responsible for balancing the grid. But in the future, we expected that balancing services will be necessary in the distribution grid too.

This implies that flexible resources located in the distribution grid should be utilized in different ancillary services. By both DSO and TSO. Several ancillary services with the aim of keeping the power system in balance, have different requirements related to the response, from seconds up to 15 minutes.

We have therefore developed a Use Case describing how flexible resources can be included in system balancing, focusing on utilizing flexible resources as tertiary reserves is developed. Depending on the grid level where the balancing market is implemented, the buyer of flexibility services could be the TSO or DSO. Today the capacity and balancing markets are implemented on the transmission level and the TSO buys the flexibility. If the DSO in the future is responsible for balancing services in the distribution grid, the DSO can buy flexibility too.




*Flow chart for balancing use case related to tertiary reserves*

### Pilot project on flexibility markets

WP3 has also been involved in a pilot project on NODE's marketplace for flexibility trading. You can read more about the pilot project on page 78.

# Microgrids (WP4)

Our objective is to develop concepts, technologies and models for microgrids and their interaction with the distribution system.

Through our research we contribute to a cost-efficient and robust integration of microgrids with the distribution grid, and to the integration of more distributed and renewable energy resources (DER) in the system.

## Testing models in the Smart Grid Laboratory

In general, the microgrid system will be connected to the main system. But to preserve the security of supply they must also be operable in so-called island mode, i.e. not connected to the main grid. With an increasing number of loads and sources interfaced through Power Electronic (PE) converters, the dynamic behaviour of the system is getting more critical. The controllers have to be properly tuned to avoid oscillations and possibly unstability.

When the operating states of the (micro)grid changes frequently, the dynamic models of system components must fulfil the requirements to an acceptable response after disturbances as well as to the steady state behavior. Therefore, we have put significant effort into this in WP4.

## Testing components with Hardware-in-the-loop

To be able to verify such cases, a model of the international benchmark system from CIGRE has been implemented in the national Smart Grid Laboratory. Here we can run realistic tests using the Hardware-in-the-loop concept where physical components can be tested in a realistic environment. In such an environment, more extensive testing on different system conditions are possible and much less costly than in a real system.

However, the interaction between the microgrid and the distribution system is important from an energy balance and power flow perspective. Limited transfer capabilities must be handled in a way that makes it possible to keep the lights on in the microgrid in island mode, while dynamically exchanging power in connected state.

## Using master students to develop new tools

We need tools for the different modes and developing these is part of the WP4 activities. Load flow models as well as optimization and simulation tools are under development both within master projects and as tools integrated in CINELDI. They will be used jointly with other CINELDI WPs. Our close collaboration with NTNU makes it possible to test the feasibility of the new concepts.

We made quite extensive use of master students to develop prototype tools and to investigate alternative formulation for microgrid analysis. Below we have listed a few examples of Master degree topics completed in 2020:

- *DC-microgrids with Stability-Preserving Plug-and-Play Features* where the task was to develop a passivity-based control design of DC/DC converters for stability-preserving microgrids with plug-and-play features. The importance of this is the ability to preserve the stability for changes in grid topology.

- *Instantaneous Frequency Identification in Microgrids Through Adaptive Data Analysis* where the objective was to explore adaptive data analysis as an alternative to present methods used for monitoring and control in the power system. The thesis demonstrated the importance of using signal analysis techniques as a supplement to classical techniques based on physical modelling of the system.
- *Agent-based modelling of EV charging scheduling towards optimized operation in Smart Grids* where a pricing scheme based on Locational Marginal Pricing for the charging stations was studied. The purpose was to assess its efficiency in relocating the demand in both time and space, i.e., encouraging drivers to charge during periods of higher generation thus lower prices, while distributing the load among the stations with fewer congestion and losses costs. For this purpose, a real-time cooperative simulation tool was developed, integrating an Agent-Based Model of the drivers' behaviour, and the Optimal Power Flow of the network constraints, based on a real Norwegian local network with 856 consumers.


Photo: Disruptive Technologies

# Flexible resources in the power system (WP5)

We develop methods and models for cost effective integration of flexible resources in smart distribution grids. They will improve the efficiency of the system operation, when flexibility is utilized as an alternative to grid investments and serving flexibility to the transmission level.

As "Flexibility" was a common focus area in CINELDI in 2020, we increased our integration with the other WPs.

In particular:

- The integration of flexible resources in active distribution planning (Co-op with WP1)
- The impact of flexible resources on power system security (Co-op with WP1)
- The role of the end-users in the utilization of flexibility (Co-op with WP3)
- Utilization of local battery in Microgrid operation, linked to the Skagerak pilot (Co-op with WP4)
- Drafting of a White Paper on flexibility, to be completed in 2021 (Co-op with all WPs)

## Computer models for shiftable atomic loads

If we are to build a more flexible grid, modelling the flexibility potential in the distribution system is crucial. We need data from the models as input for network planning, flexibility aggregation and distribution network operational planning activities.

In 2020 we developed a model for shiftable atomic (uninterruptable) loads. They are shiftable because you can start them any time during the day, but once they start, they cannot be interrupted.

The model can be used to estimate aggregated flexibility potential from a group of households at any time of the day. Network operators can use it in both their operation and long-term plans. Aggregators and market participants can estimate the available flexibility from these appliances in the daily operation of their assets.

The model is data-driven, using statistical data and other previously available time series measurements. The model can be updated whenever time series and statistical data is available.

The models are developed by SINTEF Energy Research in the in-kind project KPN ModFlex. The model is available on zenodo:
https://zenodo.org/record/3859909#.Xvm3EZgzb-h

## Model for operation planning of flexible resources in buildings

As part of his PhD-project (co-financed by CINELDI and FME ZEN), Kasper Thorvaldsen has developed a model which finds the value of flexibility for long-term operation of buildings. Thorvaldsen won the Roy Billinton Best student paper award, gold, at the PMAPS-conference 2020.

The model captures the future (uncertain) impact of current decision-making and is inspired by water value calculation in hydropower. It considers both longer periods (from days to months) and uncertainty.

Including the future impact of current decision-making within buildings, energy system scheduling can be crucial when future long-term operational costs are considered. If the future long-term value is not included in a short-term setting, the operational planning can be inaccurate for the total picture.

The model can be further developed into a practical operational tool for scheduling of building energy systems. The long-term planning can be combined with a short-term operational model so that both the short-term and an overview of the future is also considered. It can also be utilized by grid companies who want to study in detail how flexible end-users can respond to different grid tariffs and grid limitations.

## High-Performance Multi-Period AC Optimal Power Flow Solver

AC Optimal Power Flow (AC OPF) is a necessary tool for modern grid planning, as wind, PV, energy storage and flexible demand become common parts of the system.

But energy storage and flexible demand makes AC OPF computational very challenging to solve. Computation time is also an issue when using commercial or free optimization solvers.

We have developed a new model which is able to solve the Multi-Period AC OPF problem in a fast way, making it highly attractive for simulation of large and complex grids. The method has been successfully tested on different test grids with different sizes and complexity.

The tool is relevant for DSOs facing new challenges in planning and operation of their grid, such as

- Increasing amounts of prosumers with PV and batteries. The grid operators must be able to predict their net load profile and give the right price or control signals for activating use of flexibility for grid services.
- Increasing amounts of medium-scaled distributed generation, such as smaller wind farms and solar PV farms. These can be in areas where the grid is weak. Energy storage can be an alternative to grid reinforcements.

## Flexibility capital

We have developed an empirically anchored analysis of the concepts of 'flexibility capital'. Having flexibility capital entails both owning technologies and using electrical loads that can be flexibly managed.

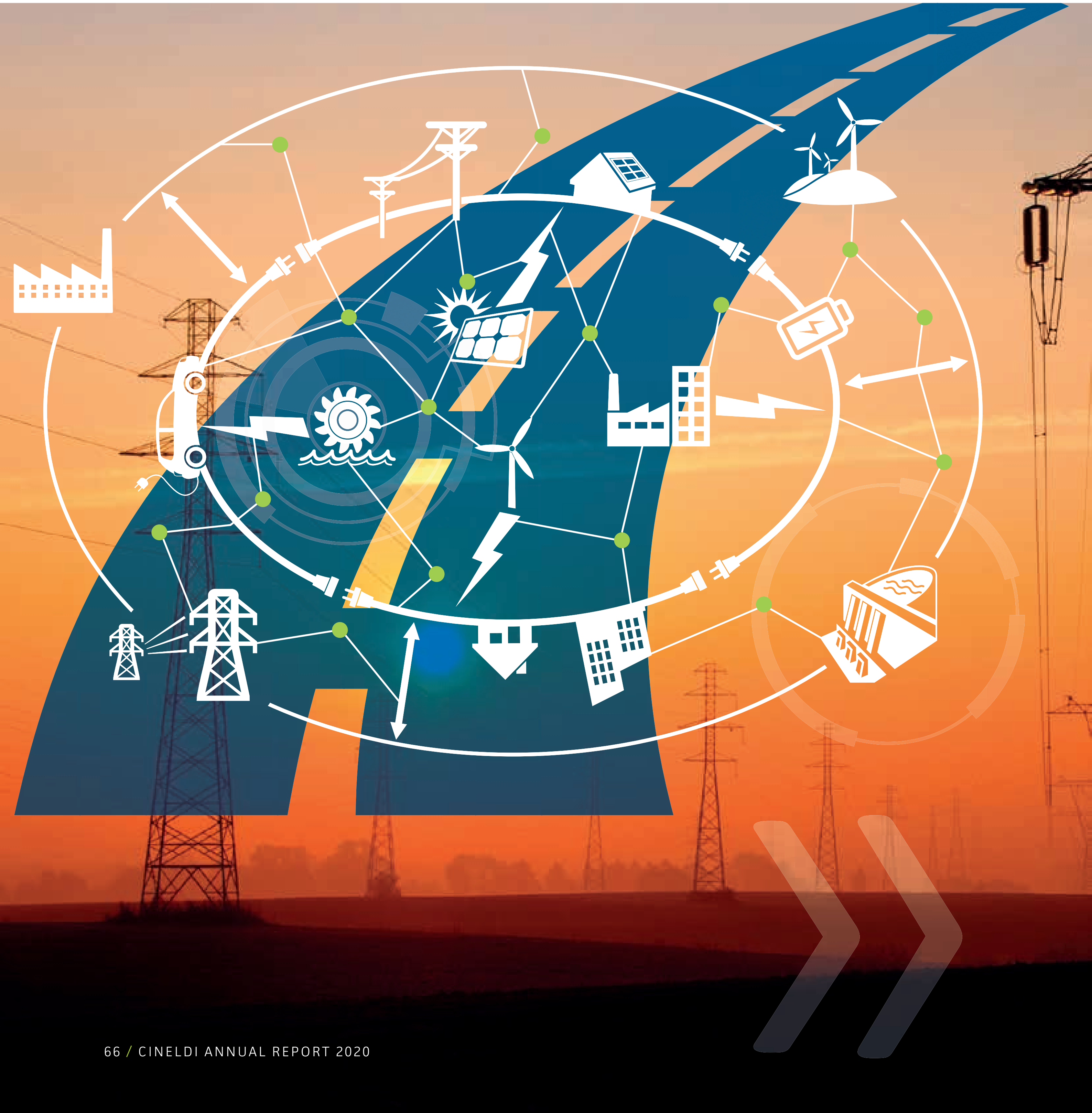
Affluent energy users are more likely to own energy technologies that afford flexibility (such as batteries and smart appliances) and consequently have significant loads that are possible to manage.

Less affluent energy users are less likely to own such technologies that can act as buffers between their daily practices and the flexibility adjustments. Consequently, their flexibility capital is mostly derived from changes to daily activities and routines.

This work adds to improve the understanding of how different grid customer groups can and will contribute with flexibility, and how DSOs and other stakeholders can utilize this knowledge to improve their services and profitability.


Photo: Lyse

# Smart grid scenarios and transition strategies (WP6)



**The industry needs a robust strategy to make a cost-efficient transition to the future flexible and intelligent grid. In WP6, we are developing scenarios for the future electricity distribution grid and that transition strategy.**

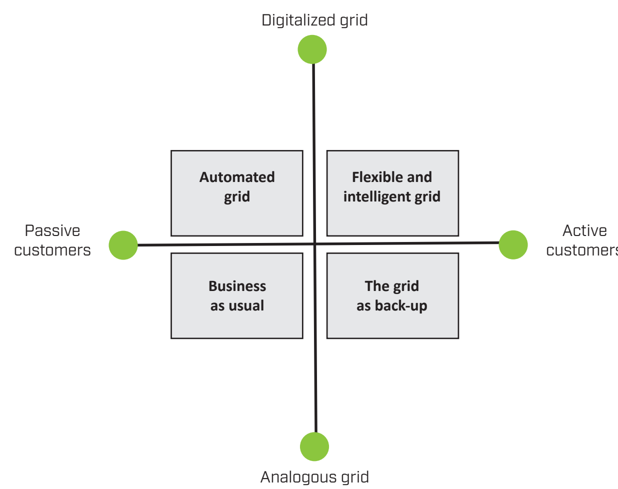
As with any strategy, it is necessary to make presumptions about the future. But we cannot look into a crystal ball and guess what the future will look like, and then know which aspects of it we will have to consider in the strategy.

In 2018-2019, we used a foresight process to identify driving forces for intelligent electricity grid system innovation and to develop mini scenarios.

Probable events, developments or actions of significance for the future electricity distribution system.

We have spent 2020 further structuring and analysing the scenarios. Based on the driving forces and mini scenarios, there are two dimensions that stand out as the most important for the development of the future electricity grid:

- The grid customer dimension: The future grid is a consequence of the customers' needs for grid services, related to their behaviour and their technologies for power generation, storage, electrical loads, control solutions etc.
- The grid dimension: To what degree the grid companies start using new technologies, new work processes and other innovations.




*Four scenarios for the future electricity distribution grid in Norway anno 2030-2040: Automated grid, Flexible and intelligent grid, The grid as back-up and Business as usual.*

These two dimensions were put together in a two-dimensional system of coordinates as shown in the figure.

Several CINELDI partners have already adopted the scenarios. They are used as a basis for research and development strategies, human resource and expertise development, developing demonstration and pilot cases, and the overall company strategies.

The scenarios are described in the CINELDI-report "Scenarios for the future electricity distribution grid anno 2030-2040", CINELDI-report no 01:2020 (in Norwegian) and in a paper to be presented at CIRED 2021 in September in Geneva.

Active customers are here defined as grid customers with consumption and/or power production/energy storage, that contribute with flexibility in the power system.

Flexibility is the ability and will to modify generation injection and/or consumption patterns, on an individual or aggregated level, often in reaction to an external signal, to provide a service within the energy system or maintain stable grid operation.

Passive customers are defined as those that do not contribute with flexibility in the power system.

A digitalised grid is a distribution grid where new technology is extensively in use for digitalisation and automation of the physical grids as well in tasks related to grid planning, operation and asset management.

Similarly, in an analogous grid, new technology for digitalisation is in limited use beyond the current level, and grid management tasks are to a limited degree automated. An analogous grid resembles the current grid (2020).

# Innovation

Innovation is a key factor to succeed with CINELDI. Our focus is on the research driven innovation chain between "blue sky" research, and pilots and testing at lower TRL levels.

But there is no use in revolutionary technologies or methodologies if no-one is willing to put them into use, they're too expensive or regulations prevents them from being applied. We therefore target *system innovation* for the electricity distribution system.

By system innovation we mean the co-evolution of technical, social, economic and regulatory change that's needed to build the electricity grid of the future.

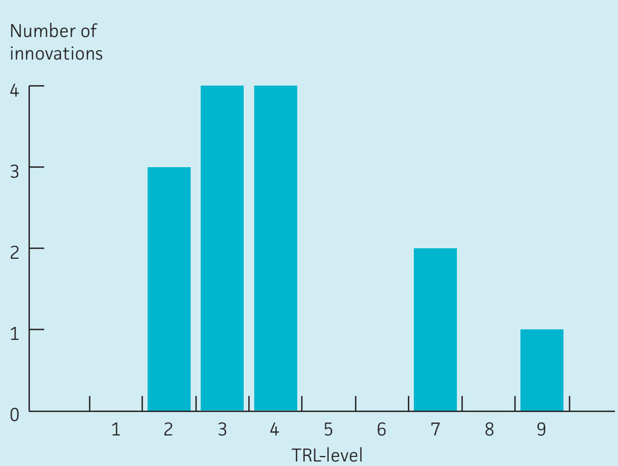
Moving into 2021 we have around 50 scientific results, and we have identified 14 innovations, 10 of which were identified in 2020.

The innovations we identify in CINELDI can reduce both investment costs (CAPEX) and/or operation and maintenance costs (OPEX) compared to the "business as usual"-solutions.

Qualitative aspects of grid operation, such as improved security of electricity supply (decreased interruption costs), increased cyber security and personnel safety may improve too.

We also expect several of our innovations to leverage business opportunities for technology providers in the Norwegian and international markets.

**Innovation TRL-levels**




**CINELDI has identified 14 innovations**

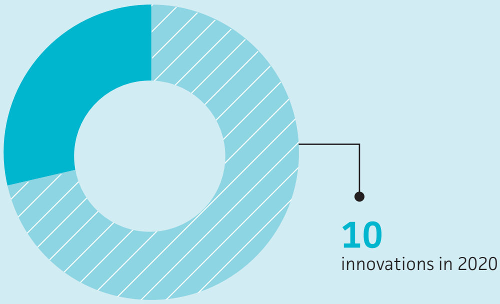


Photo: Disruptive Technologies

# Innovations

## Planning framework for active distribution grids

The long-term planning frameworks currently used by electricity distribution grid companies are not designed to account for more variability and new uncertainties due to e.g. variable distributed generation. The solution? An adaptation and extension of the traditional grid planning framework in the Norwegian handbook on power system planning and the active distribution grid planning framework by CIGRE WG C6.19., among other innovative elements like more detailed modelling of the variability. This allows for active grid measures and related technologies to be considered consistently along with traditional measures in distribution system development, which may lead to cost reduction.

TRL: 4

Actor/ purpose

- DSO, TSO
- Research/ Consultancy
- Teaching

FACTS

Get more details on sintef.no/projectweb/cineldi/innovation

## Method for cybersecurity risk analysis customized to smart grids

Smart grids are socio-technical systems characterized by complexity, interdisciplinarity and dynamics, introducing new risks that have previously not been dealt with. To improve decision making in these complex system, we need an efficient risk analysis. We have developed a new method that provides an easy-to-understand risk picture. The method will improve our understanding of the effects of power grid digitalization on cybersecurity and it provides decision support for management of reliability of power supply and cybersecurity. This in turn improves security of supply. The approach is based on parts of the "CORAS" method for risk analysis.

TRL: 7

Actor/ purpose

- DSO, TSO
- Technology provider
- Member organisation
- Research/ Consultancy
- Teaching

FACTS

Get more details on sintef.no/projectweb/cineldi/innovation

## State estimation algorithm for monitoring distribution grids

Power system state estimators are extremely critical in modern power grids. However, state estimation cannot be easily achieved in smart grids. We have therefore developed a simultaneous input and state estimation method (SISE) to estimate the states of a partially known system with system-wide unknown inputs. The method can be used for several purposes: To prevent system-wide failures or blackouts, tune power system stabilizers or to improve the reliability of system models utilized for dynamic security assessment (DSA), and to design state estimator-based fault detectors.

FACTS

TRL: 2

Actor/ purpose

- DSO, TSO
- Technology provider
- Research/ Consultancy
- Teaching

Get more details on
sintef.no/projectweb/cineldi/innovation

## Concept for Delayed Integrity Check of PMU measurements

Future power system operation is expected to rely on the use of synchrophasor measurements (PMU). The IEC 61850 standard defines communication protocols for electrical substations, including synchrophasor measurement transmission. However, it does not properly address cyber security, leaving this critical infrastructure highly vulnerable to cyber-attacks. We have developed a novel mechanism for delayed integrity check for synchrophasor measurements. The solution manages to detect when integrity is compromised, without adding any overhead or delay to the time-critical synchrophasor transmission itself.

FACTS

TRL: 3

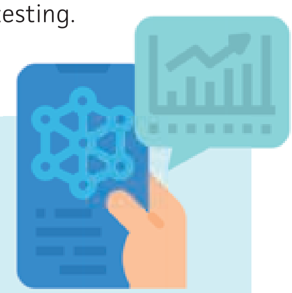
Actor/ purpose

- DSO, TSO
- Technology provider
- Research/ Consultancy

Get more details on
sintef.no/projectweb/cineldi/innovation

## Real-time Power Hardware-in-the loop microgrid simulation platform

Microgrids contain distributed generators, energy storage systems, controllers and passive loads where the components and controllers have different characteristics. Therefore, the interaction of all these devices and their controllers results in very complex systems where the dynamic performance may be unpredictable. To test the closed loop interaction of these devices, we have installed a Power Hardware In-the-Loop (P-HIL) simulation facility in the Norwegian National Smart Grid Laboratory. P-HIL is a virtual simulated system and actual hardware coupled together using a real-time simulator plus a power amplifier. This approach offers high flexibility, which can extend the test coverage compared with a prototype or even full-scale testing.



**FACTS**

TRL: 7

Actor/ purpose

- DSO, TSO
- Technology provider
- Research/ Consultancy
- Teaching

Get more details on
sintef.no/projectweb/cineldi/innovation

## Virtual Oscillator Control

Synchronization in island electrical grids dominated by power electronics is a challenge due to the absence of a grid reference to follow, lack of inertia sources and the usual lack of communication among the units. A new technique for synchronization of Voltage Source Converters in microgrids has been developed. The technique was successful in cases where the conventional droop controller failed. The results provide convincing evidence for the adoption of a more complex controller as the Virtual Oscillator Control in island grids will naturally be more vulnerable to voltage distortions.

**FACTS**

TRL: 3

Actor/ purpose

- Technology provider
- Research/ Consultancy
- Teaching

Get more details on
sintef.no/projectweb/cineldi/innovation

## Energy Storage and RES Representation in Multi-Period Optimal Power Flow

The optimal operation of a distribution system with energy storage can be formulated as a multi-period optimal power flow (MPOPF). The challenge is to decide when to charge and discharge the storage, taking into account grid constraints and wind and PV uncertainties. We have developed a method for storage valuation inspired by optimization principles from hydropower scheduling, including the energy storage model in MPOPF, together with stochastic wind and PV. This is relevant for DSOs facing new challenges in planning and operation of their grid, such as increasing amounts of prosumers with PV and batteries and increasing amounts of medium-scaled distributed generation, such as smaller wind farms and solar PV farms.

FACTS

TRL: 3-5
Actor/ purpose
- DSO, TSO
- Technology provider
- Market operator
- Research/ Consultancy
- Teaching

## BATTPOWER Toolbox: Memory Efficient and High-Performance Multi-Period AC Optimal Power Flow Solver

Energy storage and flexible demand makes AC OPF computational very challenging to solve, and computation time is an issue when using commercial or free optimization solvers. Our solution is to derive a tailor-made optimization solver for the problem, utilizing the structure of the underlying mathematical formulation of the system. This innovation is relevant for DSOs facing new challenges in planning and operation of their grid, e.g. increased amounts of medium-scaled distributed generators.

FACTS

TRL: 3-5
Actor/ purpose
- DSO, TSO
- Technology provider
- Market operator
- Research/ Consultancy
- Teaching

## SDP model for operation planning of flexible resources in buildings

When future long-term operational costs are considered, including the future impact of current decision-making within building energy system scheduling can be crucial. We have made a long-term operational model inspired by water value calculation in hydropower. It captures the future impact of current decision-making through the use of non-linear cost curves. The model can be further developed into a practical operational tool for scheduling of building energy systems.

FACTS

TRL: 3
Actor/ purpose
- DSO, TSO
- Technology provider
- Member organisation
- Market operator
- Research/ Consultancy
- Teaching

## Method for analysing communication failures in smart grids

The power system's high dependency on Information and Communication Technologies establishes new interdependencies and vulnerabilities that need to be properly analyzed. We have developed a novel dependability analysis method which combines Stochastic Activity Network (SAN) modelling and numerical analysis. The method application returns a set of metrics that assess the impact of ICT architecture vulnerabilities, cyber-physical system interdependencies and dependency on environmental conditions on WAMS data accuracy. The software represents a valuable tool to assess ICT architecture capability to reliably deliver data for correct monitoring.

FACTS

TRL: 3

Actor/ purpose

- DSO, TSO
- Technology provider
- Research/ Consultancy

## Data-driven flexibility model for shiftable atomic loads

Modelling flexibility can be a difficult task especially when it involves the considerations of user habits. Appliances such as dish washing machines and dryers are such sources of flexibility where the frequency of use and the selected program during operation varies a lot. We have developed a data-driven model which utilizes statistical data and other previously available time series measurements to extract the required features in the calculation of the expected flexibility potential as well as rebound effects after activation. Network operators may use it in their operation and/or long-term plans.

FACTS

TRL: 4

Actor/ purpose

- DSO, TSO
- Technology provider
- Member organisation
- Market operator
- Research/ Consultancy
- Teaching

## Method for cost benefit analysis of batteries in distribution grids

Batteries can be deployed at strategic locations in the grid and perform active and reactive power control for better utilization of the grid, as an alternative to reinforcements. We have established a general framework suited for grid planning incorporating batteries. The proposed methodology is the first step towards a holistic planning approach for grids where batteries can help mitigate congestions and other problems.

FACTS

TRL: 2

Actor/ purpose

- DSO, TSO
- Research/ Consultancy
- Teaching

## Driving forces and mini scenarios for the future distribution grid

The interaction between various technological, regulatory and social factors add complexity to the future electricity grid, which need to be addressed in a holistic and coordinated way to support the system innovation. To better understand the complexity of the future Norwegian distribution grid, the driving forces for system innovation have been identified and structured. Based on the driving forces, a repository of 109 mini scenarios have been developed. The driving forces and mini scenarios can be used as input to strategic processes such as grid development, competence building, R&D strategy, etc.

**FACTS**

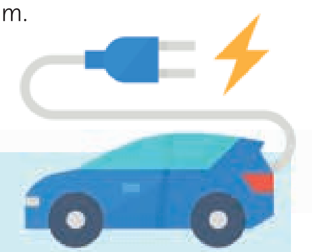
TRL: 2

Actor/ purpose

- DSO, TSO
- Technology provider
- Member organisation
- Market operator
- Research/ Consultancy
- Teaching

## EV Power Share Charging System

Charging electric cars in an area cause major power surges both locally and in the grid. A system incorporating POWER SHARE means that power for charging can be regulated dynamically, based either on a maximum value for the respective circuit or dynamically, based on input signals that regulate the maximum value for all cars. With the Power Share solution, it will be possible to control the maximum load either statically by setting a fixed maximum value, or dynamically based on other consumption for the same master fuse, data from smart transformers or the requirements in the network in general based on the published ACOPF algorithm.



**FACTS**

TRL: 9

Used by/of use to:

- Operator/purpose
- DSO, TSO
- Technology provider
- Researcher/Consultant


*Driving forces and mini scenarios for the future distribution grid*

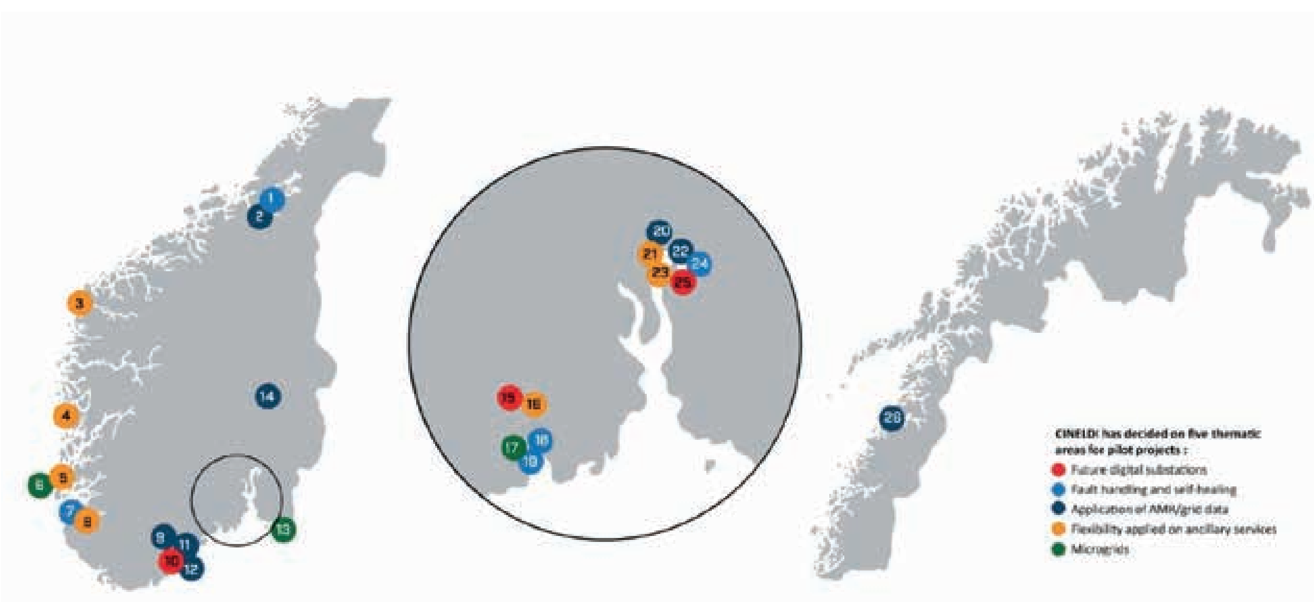
# Pilot projects

**In the pilot projects we test and verify new research results, technologies and solutions for the future intelligent electricity distribution system. In real environments. They are important contributors to system innovations (see page 70) and ensures standardised and cost-effective solutions for the future distribution grid.**

The projects are organised into five priority areas, each area covering more than one of the other six CINELDI work packages. This ensures a holistic approach to the pilots, making the results more applicable and relevant for more partners.

CINELDI partners are involved in approximately 25 pilot projects ranging from testing of new technologies and algorithms, to testing of new tariffs and flexibility markets. This has already given results that have been taken into use and there is a large potential for innovations, as well as new spin-off projects in the years to come. Results are reported in the WPs the pilot project belongs to.

Read a description of each pilot project on **sintef.no/projectweb/cineldi/pilot-projects-in-cineldi**




*Geographic overview of the CINELDI pilot projects.*

### Application of AMR/grid data

9 Machine learning in grid inspection - Agder Energi Nett
11 Risk-based distribution network planning - Agder Energi Nett
12 Predicting peak load in secondary substations - Agder Energi Nett
2 Smart meters in the Smart Grid Lab - Aidon
20 Smart Cable Guard - Elvia
26 Development area Molobyen - Nordlandsnett
22 Probabilistic planning methodology - Norgesnett

### Fault handling and self-healing

14 Faster fault location - Elvia
1 New relay concept - Elvia
24 Fault handling and self-healing - Elvia
7 Automated recoupling in smart secondary substation - Lyse Elnett
18 An algorithm for self-healing - Skagerak
19 Fault indicators – Skagerak

### Flexibility applied on ancillary services

21 Active homes - Elvia
8 Batteries as voltage support- Lyse
3 NODES flexibility platform - Linja
5 Flexibility marked - Haugaland kraft
23 iFleks - Statnett
4 Batteries as voltage support Two - BKK Nett
16 Optimisation of local balancing with battery - Skagerak Nett

### Future digital substations

15 Digital Inspection - ABB Electrification
10 Digital Inspection - Agder Energi Nett
25 Digital Inspection - Elvia

### Microgrids

6 Utsira: An islanded grid on an island - Haugaland kraft
13 Sandbakken microgrid - Norgesnett
17 Transition to and from island mode - Skagerak

In 2020, our focus for the pilot projects was to start more pilot activities on Microgrids, Application of AMR/grid data and Flexibility applied on ancillary services. In total we started 9 pilot projects in 2020.

Moving into the second half of the Centre's lifetime, our pilot project focus will shift. We will be looking to create more innovations by facilitating the implementation for pilot results such as new work processes, application of new methods and technologies into the everyday work of the CINELDI partners.

In the 2019 annual report we highlighted the importance of dissemination from the pilot projects. In 2020, four pilot project expert meetings and webinars were held to share information between the projects. We also presented several pilot projects, and the pilot set-up in the Smart Grid Lab during the CINELDI Days.

A dissemination-focus moving forward is to communicate pilot project results to more partners than those directly involved in the pilots, and give them the opportunity to implement results themselves.


*Parts of the distribution network in Sogn (pictured) and in Haugalandet are venue for the development of new trading marketplaces for flexibility in the network.*

## Testing flexibility trading

NODES established two pilots for flexibility trading in 2020, with Haugaland Kraft Nett (HK Nett) and Linja respectively. The pilots will last for one year, and results are expected by the summer of 2021. We had a talk with the three companies to find out more about their pilot projects, which are linked to WP3.

"We have a large network, high production, but relatively few customers. This results in challenges with regard to long, weak radials and bottleneck problems that we want to solve," says project manager Kristian Vassbotn at Linja.

"We have areas such as Utsira, which is supplied by a long submarine cable with limited capacity on a long radial. An increasing share of unregulated production from wind and solar power will lead to major voltage fluctuations in the grid," says project manager Kristian Finborud Hansen at HK Nett.

### Flexibility trading market

The market operator NODES has developed a marketplace and processes for flexibility trading (see fact box). Through the collaboration with HK Nett and Linja, the participants will gain experience the correct time to buy flexibility, how much should be purchased and at which price, says senior consultant Hallstein Hagen in NODES.

"We are therefore very happy to have Linja and HK Nett with us on this pilot. These are issues that are common to almost all the grid companies in the country, and it is important that solutions are developed that suit everyone and not just one single grid company," he emphasises.

Hansen at HK Nett points out that they will utilise flexibility as an alternative to traditional reinforcement of the network.

"To do that, we will need applications that can predict when we need to regulate the capacity in the network. The project aims to develop applications that use AMS data, consumption patterns, local grid data and weather forecasts to predict when the power flow will create problems in the network, and then solve this with flexibility.

### Living lab

Haugaland Kraft Energi is a participant in the project that offers flexibility to Nodes' marketplace that HK Nett can use. The sister company HK Energi will, with the help of load management for selected customers, offer flexibility to meet the grid company's requirement for load regulation.

Hansen points out that they have already established a "living lab" at Utsira with a lot of test equipment and other installations for R&D projects in the grid.

"We are responding to signals from the regulator NVE to take advantage of the opportunities that income framework-financed research provides us. The goal is also for the project to benefit online customers in the form of lower network tariffs and increased security of supply. There will also be an environmental benefit if we can reduce the need for investments in physical grid systems through flexibility.

### Pulling its weight

His colleagues in Linja agree completely. "We have a tradition of helping to carry our share of the R&D for the entire industry, and then some. We have a production surplus that we have problems exporting. We need better flexibility products and not least an efficient marketplace that helps us to solve such acute challenges quickly," Vassbotn points out.

He points out that price incentives alone have proven to be ineffective for customers.

"In particular, household customers barely respond to price signals. To solve acute power challenges, for both surpluses and deficits, we need to have effective tools that handle flexibility."

Vassbotn points out that even though they are collaborating with Nodes on this project, he hopes that the result will be interesting for all suppliers of ICT platforms.

"But so far we have only found that Nodes is on the ball."

**NODES**

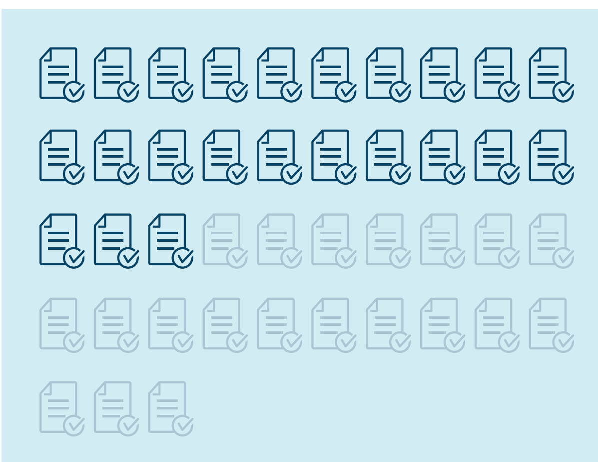
An independent market operator of marketplace services. Will offer marketplaces for, among other things, energy and local flexibility.

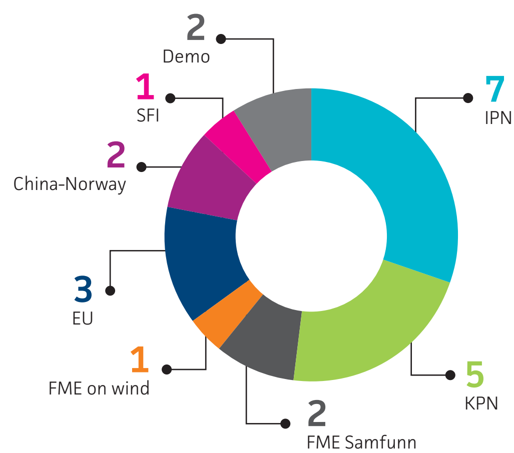
Owned by TSO Holding (Nordic grid system companies) and Agder Energi Flexibility. The majority of customers become operators who supply and demand flexibility and related products.

# Spin-off projects

In CINELDI we actively contribute to spin-off project-applications that contribute to building the electricity grid of the future. We are proud to say that between 2017 and 2020, 55 CINELDI-supported applications have been submittet. By 15 December 2020, 43 had been evaluated and 23 were granted. That is a successrate of 53%.

Most of the new knowledge building projects (KSP/RCN) and the EU Horizon 2020-projects are integrated as in-kind-projects in CINELDI. We also cooperate closely with a few demo projects and innovation projects, typically funded by Enova and the RCN.





# International cooperation

We aim to establish CINELDI as an international reference project on flexible, intelligent, robust and cost-efficient electricity distribution grids for the future.

To do that, we cooperate with leading international smart grid researchers, projects, research institutions and universities. Our scientists also actively participate in international expert groups, networks, standardisation bodies and international project cooperation including CIGRE, CIRED, ISGAN, IEC and CENELEC. These participations emphasise the international level of our scientists.

We typically have guest researchers, associate professors and internationally located PhD students visit us for anything between a week and month throughout a year. Due to the Coronavirus though, all planned visits are cancelled or delayed to 2021. CINELDI PhD candidate Kasper Thorvaldsen's visit to MIT has also been delayed due to Coronavirus.

CINELDI associated PhD Sigurd Bjarghov was able to complete research stays at EPFL in Switzerland both in the spring and autumn of 2020.

Further, through WP1 we cooperate with the University of Cagliari on a Norwegian case study using the SPREAD tool to plan active distribution networks. We worked with professor Vicente Casares Giner, University of Valencia, on grid monitoring and control through WP2.  A WP3 scientist attended the CIGRE WG6 C6/C2.34 "Flexibility provision from distributed energy resources" workshop in 2020 and PhD student Mohammad Ali Abooshahab (WP3) cooperated with Professor Robert Bitmead, Professor Giorgio Valmorbida and Mr. Pouria Talebi.

Through WP4 we cooperated with Aalborg University and DigSilent in the EUDP-project COPE. Together with VTT, Fraunhofer, AIT and DTU we work on the technical-economic value of stationary energy storage in the grid in WP5. The work is done through the European Energy Research Alliance's Joint Program on Smart Grids.

**In 2020, we cooperated with the following projects**

| H2020 | ERA-Net | China-Norway | India-Norway |
|---|---|---|---|
| FlexPlan | Honor | ChiNoZEN | ROME |
| SDN-μSense | | KeyTech-NeVe-ChiNo | Multigrid |
| ERIGrid 2.0 | | | |
| PAN-T-ERA | | | |
| eNeuron | | | |
| STOP-IT | | | |

**In 2020, the following foreign organisations took active part in centre activities**

| Organisation | Country | Time period |
|---|---|---|
| EERA | Belgium | 2016 – |
| Massachusetts Institute of Technology (MIT) | U.S. | 2018 – |
| University of Cagliari | Italy | 2016 – |
| IMDEA | Spain | 2018 – |
| Kalasingam university | India | 2018 – |
| VTT Technical Research Centre of Finland | Finland | 2016 – |
| University of Strathclyde | Scotland | 2016 – |
| Technical University of Denmark (DTU) | Denmark | 2016 – |
| Tecnalia Research and innovation | Spain | 2016 – |
| Michigan Technological University (MTU) | U.S. | 2016 – |

**The following foreign researchers took active part in centre activities in 2020**

| Name | Position | Organisation | Country | Time period |
|---|---|---|---|---|
| Mattia Marinelli | Associate Professor | DTU | Denmark | 2017-2020 |
| Robert R. Bitmead | Professor | Univ. of California | U.S. | 2018-2020 |
| Ivana Kockar | Reader | Univ. of Strathclyde | Scotland | 2017-2020 |
| Kari Mäki | Research Professor | VTT | Finland | 2019-2020 |
| Fabrizio Pilo | Professor | Univ. of Cagliari | Italy | 2017-2020 |
| Angel Diaz | Director of smart grids | Tecnalia | Spain | 2017-2020 |
| Bruce Mork | Professor | MTU | U.S. | 2017-2020 |
| Giorgio Valmorbida | Associate Professor | CentraleSupélec | France | 2019-2020 |
| Andreas Sumper | Professor | UPC Barcelona | Spain | 2019-2020 |
| Javier Roldan | Senior assistant Researcher | IMDEA | Spain | 2020 |

## Participation in international fora

Active participation in international standardisation bodies, networks and expert groups is strategically important to influence the development within Smart Grids through knowledge sharing, innovation and standardisation. CINELDI partners and scientists are participating in various international fora:

- IEC TC8, IEC System Committee Smart Energy, and CENELEC TC8X: Kjell Sand is a member of the International Standardisation Committees.
- Mission Innovation: Kjell Sand is a Norwegian representative in the Mission Innovation challenge no 1 - #IC1 on Smart Grids on behalf of the Norwegian Ministry of Petroleum and Energy, the Research Council of Norway and FME CINELDI.
- ETIP SNET: Andrei Z. Morch member of WG5 "Innovation implementation in the business environment".
- PANTERA regional virtual workshop MedPower 2020: Andrei Z. Morch participates Round Table.
- EERA JP Smart Grids, SP on Energy Storage: Magnus Korpås is a sub-task leader for Economic evaluation of energy storage.
- EERA JP Smart Grids: SINTEF Energi (Knut Samdal) is the leader of SP5 "Flexible Transmission Networks" and member of the Steering Committee.
- CIRED: Gerd Kjølle and Oddbjørn Gjerde are members of the Working Group on Resilience of Distribution Grids.
- CIRED: Dag Eirik Nordgård is a member of the Directing Committee and the Technical Committee.
- CIGRE: Dag Eirik Nordgård is a member of the Study Committee C6 Distribution systems and Dispersed generation.
- CIGRE JWG C6/C2.34 "Flexibility provision": Hanne Sæle and Andrei Morch are members of the working group.
- IEA Task 25 Collaboration on wind and solar integration and use of flexibility: Magnus Korpås is a member.
- PSCC: Magnus Korpås is a technical committee member.
- PMAPS 2020, Smart grids, micro grids & cyber-physical systems: Gerd Kjølle is session chair.
- PMAPS 2020: Gerd Kjølle is a member of the international technical advisory committee.
- EEM20 (P42 Energy Policy): Hanne Sæle is session Chair.
- EEM20 (P23 Demand Response II): Hossein Farahman is session chair.
- EERA JP Smart Grids, Sub-program for Energy Storage: Iver B. Sperstad coordinates sub-task “Economic and technical benefits of incorporating an ESS (Energy Storage System) into the network”.
- PMAPS 2020: Kasper Thorvaldsen is gold winner of Roy Billinton Student Paper Gold award.
- MIT, USA: Magnus Korpås has a research stay 2018-2019. Host: Laboratory of Information and Decision Systems (LIDS), MIT.
- Applied Energy Symposium MIT A+B (MITAB): Magnus Korpås is key-note speaker.
- EERA JP Energy System Integration: Magnus Korpås is a member of steering committee for NTNU.
- PMAPS 2020, Distribution systems planning: Oddbjørn Gjerde is session chair.
- 17$^{th}$ International Conference on the European Energy Market (EEM): Sigurd Bjarghov, Magnus Askeland and Stian Backe receives second-best paper award.

# Recruitment

Per 2020, we have 15 PhD- and 3 Postdoc-positions in CINELDI. The positions are spread across all the disciplines covered by the Centre, and 2-3 of the PhD-candidates are about to finish their thesis. 2 PhDs are completed. 3 PhDs/Postdocs have recently started, while for three of the positions, the evaluation is in progress and candidates will be employed in 2021. In addition, there are 9 associated PhDs/Postdocs funded by other sources, incl. two industrial PhDs.

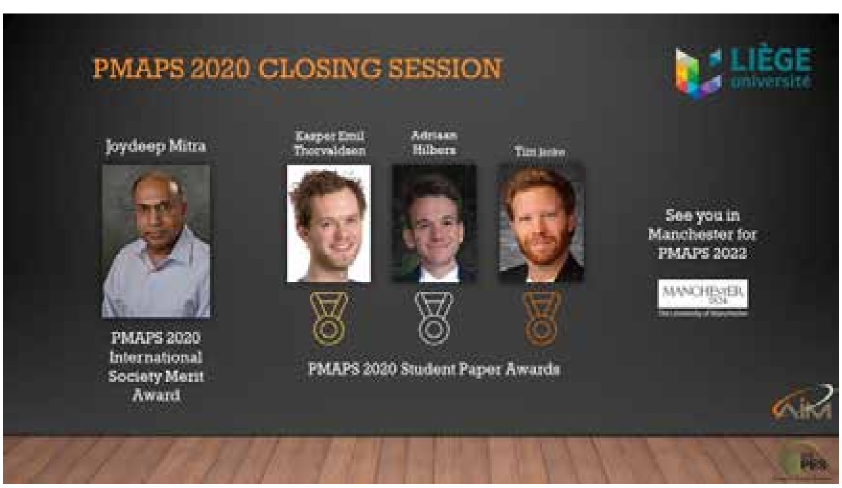

Master's theses and at the end of 2020 it has been 95 in total, with 31 Master Thesis in 2020. The Master projects contribute to the research in CINELDI and better recruitment to the industrial partners, as well as being a recruitment platform for PhDs.

## PhD-awards

Two CINELDI PhDs received international recognition for their papers in 2020.

PhD student Kasper Thorvaldsen won the Roy Billinton Best Student Paper Gold Award for 2020 at the PMAPS2 2020 conference. Associate PhD student Sigurd Bjarghov won the second-best paper award out of the 130 published papers at the EEM203-conference.

Congratulations!



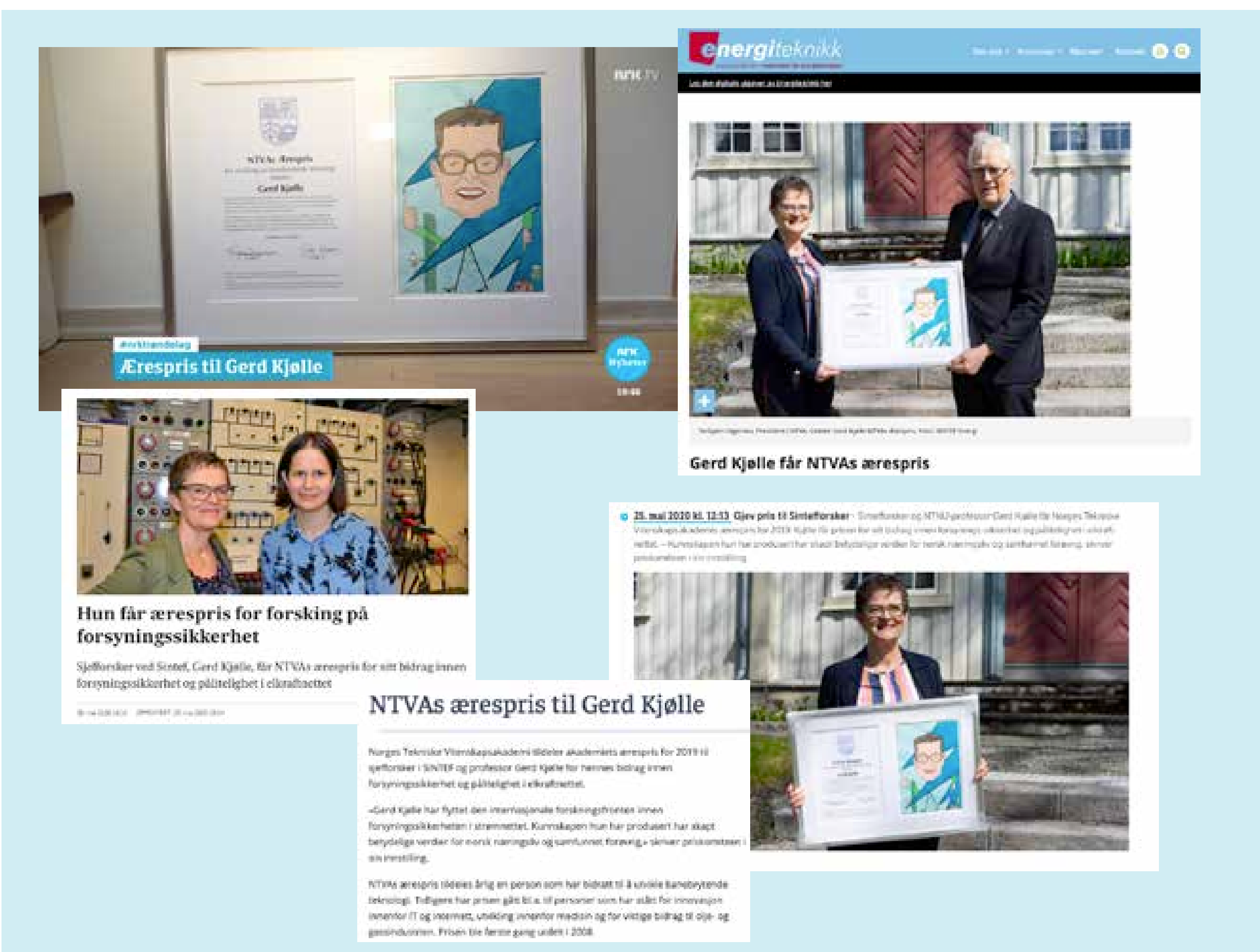
# Communication

Innovation never happens in a vacuum, and new technology will not be taken into use without public acceptance. To maximise impact, we therefore prioritise to communicate and disseminate CINELDI results both between our partners as well as to political bodies and the industry in general.

Our main platforms since 2016 have been our website and newsletter, the SINTEF blog and conferences like the CINELDI Days. As physical events were not possible for most of 2020, we successfully adopted new digital platforms to ensure we maintained our outreach and visibility.

## Media

In CINELDI we strive to not only to be the leading smart grid actor when it comes to research and innovation.



We also strive to be highly visible and broadly recognized as the leading actor. Being visible in the media is both an important factor for achieving that, and a KPI for measuring how visible we are.

For the second consecutive year we have a record number of media contributions, indicating we are well on the right track. In 2020 CINELDI was featured in 36 news stories and 2 features articles, up from 29 news stories and no featured articles in 2019.

A big highlight of 2020 was Centre Director Gerd Kjølle receiving NTVA's Honorary Award for her research on security of electricity supply.

When Kjølle revieced the award, SINTEF CEO Alexandra Bech Gjørv stated that "Her work has helped ensure a more cost-effective and sustainable power grid than before. SINTEF's mission is to create value for both industry and society. Kjølle's work is an excellent example of this."

## Webinars

To compensate for the lost physical events, we hosted 25 webinars throughout the year. Among them was a two-day digital partner workshop with around 70 participants, as replacement for the cancelled CINELDI-conference in April.

Through the autumn we also hosted a four-part webinar-series on flexibility together with The Norwegian Smartgrid Centre.

## Podcasts

As far as digital communication goes, podcasts may be the most easily consumable format there is. And 2020 was a great year for CINELDI to dive into it.

Centre director Gerd Kjølle was featured in two popular science podcasts, where she talked about smart grids and their role in the green transition.

A clear highlight of 2020 from a communications point of view was recording our very own five-part podcast-series. Supporting the Centre's overarching flexibility topic, the podcast explained what we know so far about how flexibility can be used if we electrify the entire Norwegian transport sector.

To ensure we reached the right audience with the podcast-series, we cooperated with enerwe.no, an online news outlet for the energy industry. Through enerwe.no we reach policymakers, other researchers and the energy industry as a whole.


*Energy Norway's Fornybaren podcast*

We have also used our own CINELDI-channels, SINTEF Energy Research and our partners to distribute each episode. The series features CINELDI's WP-leaders and partner representatives and has thus far reached 4300 people! (As per Feb. 2 2021).

## Website, newsletter and blogs

Cineldi.no had **2850 pageviews** in 2020. The website's primary objective is to provide information about the Centre, its research and other activities like events. The webpage has been updated regularly with research results, new innovations and events. A big effort was also put into updating the pilot project presentation on the website.

In 2020, we continued to send regular newsletters, eight being sent out in total. An update to the CINELDI website and all blog posts made it much easier for readers to join the newsletter. This resulted in an increase **from 58 to 118 subscribers** over the course of 2020.

CINELDI researchers are encouraged to create blog posts about their work throughout the year. Many posts summarise project results or scientific publications, but targeted at different groups such as private industry or decision-makers in governments.

Other blogs are aimed at fellow researchers working with smart grids and related fields.

Altogether, CINELDI published **13 blog posts** in Norwegian and English on the SINTEF blog, accumulating **3 500 views**. The posts are included on the CINELDI website and shared widely on both CINELDI and SINTEF social channels and newsletters.


The best-performing blog post was a Norwegian post on "flexibility as an alternative to traditional grid reinforcement". It had 584 pageviews and readers on average spent 4 minutes reading it, compared to CINELDI's 2020 average of 270 pageviews and 2,5 minutes reading time.

## Video and social media

Video in social media has long been an effective way to communicate science at the popular science level. 2020 was a good year for us with **13 000 video views**. Our best performing video was called "Heading for the Future Electricity Distribution Grid – One Scenario at a Time" and had **9 000 views**. It was based of the 2019 annual report, with special focus on the mini scenarios. You can read more about them on page 67.

Twitter continues to be an important platform. Our tweets were seen more than 18 000 times, according to Twitter's built-in analytics. The number of followers


at the end of 2020 stood at 217, an increase from 184 a year ago.

## Charge award

In CINELDI we are thrilled that SINTEF won the CHARGE Energy Award in September 2020 for best organisation brand. The award celebrate excellence in energy branding and communication. The team that won the award is responsible for CINELDI communication and their nomination was partly based on CINELDI communication activities.

Read the full story about the award on https://blog.sintef.com/sintefenergy/why-science-communication-matters

# Appendix

## Personnel

### Key Researchers

| Name | Institution | Main research area |
|---|---|---|
| Asgeir Tomasgaard | NTNU | Interaction DSO/TSO |
| Irina Oleinikova | NTNU | Interaction DSO/TSO |
| Kjell Sand | NTNU | Centre Management |
| Magnus Korpås | NTNU | Flexible resources in the power system |
| Morten Hovd | NTNU | Interaction DSO/TSO |
| Olav B. Fosso | NTNU | Microgrids |
| Poul Einar Heegaard | NTNU | Smart grid operation |
| Sule Yildirim Yayilgan | NTNU | Smart grid development and asset management |
| Thomas Sagvold Haugan | NTNU | Smart grid operation |
| Aida Omerovic | SINTEF Digital | Smart grid development and asset management |
| Borgaonkar Ravishankar | SINTEF Digital | Smart grid operation |
| Geir Mathisen | SINTEF Digital | Smart grid operation |
| Giancarlo Marafioti | SINTEF Digital | Microgrids |
| Henrik Lundqvist | SINTEF Digital | Interaction DSO/TSO |
| Inger Anne Tøndel | SINTEF Digital | Smart grid operation |
| Johannes Phiilip Maree | SINTEF Digital | Microgrids |
| Kristoffer Nyborg Gregertsen | SINTEF Digital | Interaction DSO/TSO |
| Martin Gilje Jaatun | SINTEF Digital | Smart grid operation |
| Sture Holmstrøm | SINTEF Digital | Centre Management |
| Synne Fossøy | SINTEF Digital | Smart grid operation |
| Tokas Shukun | SINTEF Digital | Smart grid development and asset management |
| Åsmund Hugo | SINTEF Digital | Smart grid development and asset management |
| Berg Kjersti | SINTEF Energi | Microgrids |
| Brubæk Maren | SINTEF Energi | Microgrids |
| Crespo del Granado Pedro Andr | SINTEF Energi | Interaction DSO/TSO |
| Degefa Merkebu Zenebe | SINTEF Energi | Interaction DSO/TSO |
| Garau Michele | SINTEF Energi | Smart grid development and asset management |
| Gjerde Oddbjørn | SINTEF Energi | Smart grid development and asset management |
| Haugen Eirik | SINTEF Energi | Smart grid development and asset management |
| Hermansen Tonje Skoglund | SINTEF Energi | Smart grid scenarios and transition strategies |
| Høiem Kristian Wang | SINTEF Energi | Smart grid operation |
| Istad Maren | SINTEF Energi | Centre Management |

| Name | Institution | Main research area |
|---|---|---|
| Jakobsen Sigurd Hofsmo | SINTEF Energi | Smart grid development and asset management |
| Kjølle Gerd | SINTEF Energi | Smart grid scenarios and transition strategies |
| Klemets Jonatan | SINTEF Energi | Smart grid operation |
| Lakshmanan Venkatachalam | SINTEF Energi | Flexible resources in the power system |
| Ljøkelsøy Kjell | SINTEF Energi | Microgrids |
| Löschenbrand Markus | SINTEF Energi | Flexible resources in the power system |
| Morch Andrei Z | SINTEF Energi | Interaction DSO/TSO |
| Nguyen Tuan Thanh | SINTEF Energi | Microgrids |
| Resch Matthias Johannes | SINTEF Energi | Microgrids |
| Sanchez-Acevedo Santiago | SINTEF Energi | Microgrids |
| Solvang Eivind | SINTEF Energi | Smart grid development and asset management |
| Sperstad Iver Bakken | SINTEF Energi | Flexible resources in the power system |
| Sæle Hanne | SINTEF Energi | Interaction DSO/TSO |
| Taxt Henning | SINTEF Energi | Smart grid development and asset management |
| Torres-Olguin Raymundo E | SINTEF Energi | Microgrids |
| Torsæter Bendik Nybakk | SINTEF Energi | Microgrids |
| Vefsnmo Hanne Merete | SINTEF Energi | Smart grid development and asset management |
| Zerihun Tesfaye Amare | SINTEF Energi | Smart grid operation |
| Øye Erlend | SINTEF Energi | Smart grid development and asset management |

## Visiting researchers

| Name | Affiliation | Nationality | Duration | Topic |
|---|---|---|---|---|
| Lakshya Nagaraj | SINTEF Digital (Internship) | India | 10.01.2020 – 15.03.2020 | ROME project: one-line-diagram model of Froan Network (WP4) |

## Researchers in other countries that took active part in centre projects in 2020

| Name | Position | Organisation | Country | Period |
|---|---|---|---|---|
| Mattia Marinelli | Associate Professor | DTU | Denmark | 2017-2020 |
| Robert R. Bitmead | Professor | Univ. of California | U.S. | 2018-2020 |
| Ivana Kockar | Reader | Univ. of Strathclyde | Scotland | 2017-2020 |
| Kari Mäki | Research Professor | VTT | Finland | 2019-2020 |
| Fabrizio Pilo | Professor | Univ. of Cagliari | Italy | 2017-2020 |

| Name | Position | Organisation | Country | Period |
|---|---|---|---|---|
| Angel Diaz | Director of smart grids | Tecnalia | Spain | 2017-2020 |
| Bruce Mork | Professor | MTU | U.S. | 2017-2020 |
| Giorgio Valmorbida | Associate Professor | CentraleSupélec | France | 2019-2020 |
| Andreas Sumper | Professor | UPC Barcelona | Spain | 2019-2020 |
| Javier Roldan | Senior assistant Researcher | IMDEA | Spain | 2020 |

### Postdoctorial researchers with financial support from the Centre budget

| Name | Nationality | Period | Topic |
|---|---|---|---|
| Blazquez De Paz | Spanish | 01.09.2017-29.02.2020 | Modelling transition strategies towards smart distribution grids |
| Michele Garau | Italian | 11.04.2018-10.04.2020 | Modelling of Interactions and Interdependencies in Complex Systems of Power Grid and ICT Systems (Postdoc) |
| Ida Marie Henriksen | Norwegian | 06.04.2020-01.05.2024 | The role of intermediaries in demand response service |

### Postdoctorial researchers working on projects in the centre with financial support from other sources

| Name | Funding | Nationality | Period | Topic |
|---|---|---|---|---|
| Chendan Li | NTNU - SO | Norwegian | 01/2019 - 01/2021 | Methods and tools for stability assessment of microgrid systems dominated by Power Electronic converters. |
| Soumya Das | ROME-project - Indnor | Indian | 02/2020 - 02/2022 | Integrated methods and tools for planning and operation of Microgrids |

### PhD students with financial support from the Centre budget

| Name | Nationality | Period | Topic |
|---|---|---|---|
| Mohammad Ali Abooshabab | Iran | 25.08.2017-31.12.2020 | Distributed and hierarchical dynamic state estimation for smart distribution grids |
| Fredrik T.B.W Göthner | Norway | 14.08.2017-10.12.2020 | Smart power control in microgrids with modern power converters |
| Ingvild Fjellså | Norway | 02.03.2017-10.06.2021 | Understanding mechanisms and incentives for motivating user flexibility |
| Güray Kara | Turkey | 01.06.2017-30.11.2020 | Techno-economic optimization for analysing consumer flexibility and related market structures |
| Fredrik Bakkevig Haugli | Norway | 01.09.2017-31.12.2021 | Distributed and centralized control to support smart grid operation with high quality in a cost-efficient way |
| Romina Muka | Albania | 18.01.2018-27.02.2021 | Self-Healing and Autonomous Smart Grid Operation |

| Name | Nationality | Period | Topic |
|---|---|---|---|
| Kalpanie Mendis | Sri Lanka | 08.01.2018-01.06.2023 | 5G for Low-Latency, Secure, and Dependable Communication Services for Fault Handling in Micro Grids |
| Kasper Thorvaldsen | Norway | 01.09.2018-31.08.2022 | The value of buildings' energy flexibility in the power market |
| Stine Fleischer Myhre | Norway | 01.08.2019-31.07.2022 | Risk and vulnerability in the future intelligent electricity distribution system |
| Maciej Grebla | Poland | 10.11.2019-09.05.2020 | Power system protection in microgrids |
| Outi Pitkänen | Finland | 27.04.2020-04.06.2023 | Integrating consumer (end-user) knowledge in demand-response technology and service design |
| Emil Dimanchev | Bulgatia | 01.08.2020-31.07.2023 | Utilization of electric vehicle storage flexibility in modern power grids |

## PhD students working on projects in the centre with financial support from other sources

| Name | Funding | Nationality | Period | Topic |
|---|---|---|---|---|
| Salman Zaferanlouei | NTNU | Iran | 2016-2020 | Integration of electric vehicles into power distribution systems |
| Sjur Føyen | NTNU - SO | Norwegian | 08/2018-08/2022 | Methods and tools for stability assessment of microgrid systems dominated by Power Electronic converters. |
| Per Aaslid | SINTEF - PhD | Norwegian | 08/2018-08/2021 | Optimal coordination of distributed flexible resources |
| Tesfaye Amare Zerihun | NTNU, IE | Ethiopia | 2015-2020 | Quantitative Modelling of Digital Ecosystems (Case study: smart distribution grid) |
| Charles Mawutor Adhra | KPN ProSmart | Ghana | 2015-2020 | Communication Networks for Protection Systems in Smart Transmission Grids |
| Mostafa Barani | RSO-TSO Energi, NTNU Project Number: 81770920 | Iran | 2018-2021 | Reliability Studies in Information and Communication Technology (ICT)-dominated Power Systems |
| Matthias Hofmann | Statnett/NFR (Industry PhD) | German | 2018-2021 | Flexible demand as an alternative to investments in the transmission grid |
| Sigurd Bjarghov | NTNU | Norge | 2018-2022 | Consumer-centric electricity market design integration peer-to-peer and flxibility markets |

### Master thesis in 2020

| Name | Title of thesis | Institution granting degree |
|---|---|---|
| Liv Ringheim | Grid Impact from Increased Prosumer Penetration in the Norwegian Distribution Grid | NTNU IEL |
| Mari Myrold Osnes | Analyse av lastendringer på nettstasjonsnivå som følge av solkraftproduksjon på privathus og næringsbygg | NTNU IEL |
| Håvard Refvik | Exploitation of big data and machine learning in the distribution grid operation | NTNU IIK |
| Bendik Balstad Deraas | Analysis of interdependencies between power systems and other critical infrastructures | NTNU IIK |
| Erik Log Rogne | Analysis and visualization of reinvestment scenarios for distribution networks | NTNU IEL |
| Bjørnar Veie | Balancing power production and consumption in nano grids | NTNU ITK |
| Øystein Molvik | Sensor for real time measurement of potential for electric power production from solar panels | NTNU ITK |
| Mohamed Farooq | Benefits of TSO-DSO coordination for voltage control: Simulation study and use case development | NTNU IEL |
| Sarmilan Gunabala og Sara Eriksen | Nettselskapers involvering av underleverandører i hendelseshåndtering ved cyberangrep | NTNU IIK |
| Bjørn O. Gjørven og Alexander Hansen Bakken | Design and Implementation of a Novel Architecture for Virtual Smart Grid Cyber Ranges | NTNU IIK, NTNU IEL |
| Racin Gudmestad | Delayed Integrity Check for IEC 61850 Communication | IDE (UiS) |
| Fabian Skarboe Rønningen | Adaptive Control of Distributed Generation Inverter Based on Impedance Estimation | NTNU IEL |
| Eirik Haugan Lillefosse | Development of a computational tool for assessing uninterrupted microgrid operation | NTNU IEL |
| Rune Steig | Model-based control of plug-and-play grid-connected inverters | NTNU IEL |
| Hannah Magnussen | Model predictive controller for charging of grid-connected battery | NTNU IEL |
| Markus Formo | Cont Power Flow as a tool for sequential simulation | NTNU IEL |
| Matias Lunde Ellingsen | Security-Constrained Optimal Power Flow | NTNU IEL |
| Erlend Westad | Harmonics Management through Data Analysis, Identification and Control | NTNU IEL |
| Erik-Anant Narayan | Dynamic simulation of power systems based on a second-order predictor-corrector scheme | NTNU IEL |
| Åsmund Sælen | Toolbox for specialized power system analysis | NTNU IEL |
| Manuel Perez Bravo | Electric Vehicles Integration – Charging Infrastructure | Erasmus Mundus |
| Christian Fredrik Marquez Træland | Grid Tariffs for Fast Charging Infrastructure in the Norwegian Distribution Grid | NTNU IEL |
| Eirik Ivarsøy | Load profiles of electric vehicles for fast charging stations | NTNU IEL |
| Tormod Habbestad Aarnes | High-power electric charging in the Norwegian distribution grid | NTNU IEL |

| Name | Title of thesis | Institution granting degree |
|---|---|---|
| Eirik Haugen | Optimization of battery energy storage system: A case study for an electric vehicle fast-charging station | NTNU IEL |
| Maren Refsnes Brubæk | Battery storage as alternative to grid reinforcement in the low-voltage network | NTNU IEL |
| Marthe Fogstad Dynge | Local Energy Market Potential between Positive Energy Blocks in Trondheim | NTNU IEL |
| Jon Hvideberg Holte | Analysis of seasonal variations for a multimarket energy storage system including uncertainty | NTNU IEL |
| Linnea Espevik | Techno-economic optimization of energy storage for increased wind farm integration | NTNU IEL |
| Olav Henrik Skonnord | Grid implications of local markets and peer-to-peer trading in Norwegian distribution grids | NTNU IEL |
| Doney Abraham | Application of Machine Learning in IoT enabled Smart Grids for Attack Detection | NTNU IIK |
| Ole Bendik Midtbust | Approach to software testing in the context of smart power grids | IFI (UiO) |

## Statement of Account

(All figures in 1000 NOK)
As an option the funding and cost for each partner may be presented and also how funding and cost is allocated to the subprojects in the centre.

**Funding**

| | Amount | In--kind | Sum |
|---|---|---|---|
| The Research Council | 24000,0 | | **24000,0** |
| The Host Institution (SINTEF Energi) | | 10021,5 | **10021,5** |
| **Research Partners*** | | | |
| NTNU | | 2343,9 | **2343,9** |
| SINTEF Digital | | 3127,7 | **3127,7** |
| **Enterprise partners*** | | | |
| DSOs | 4587,6 | 11345,0 | **15932,6** |
| TSO | 334,9 | 193,6 | **528,5** |
| Vendors | 267,9 | 3744,2 | **4012,1** |
| Member organisations | 133,9 | 278,4 | **412,3** |
| Public partners* | | | |
| Authorities | 200,9 | 71,6 | **272,5** |
| **Sum** | **29525,2** | **31125,8** | **60651,0** |

| | | | |
|---|---|---|---|
| **Costs** | | | |
| The Host Institution (SINTEF Energi) | 16116,0 | 10021,5 | **26137,4** |
| Research Partners | 13409,2 | 5471,6 | **18880,8** |
| | | | **0,0** |
| Enterprise partners | | 15561,2 | **15561,2** |
| Public partners | | 71,6 | **71,6** |
| **Sum** | | | **60651,0** |

*Give names for each group of partners

## Dissemination and communication 2020

### Peer reviewed journal publications

*From:* 2020 *To:* 2020 *sub-category:* Academic article *sub-category:* Academic literature review *sub-category:* Short communication *All publishing channels*

1. **Aaslid, Per; Geth, Frederik; Korpås, Magnus; Belsnes, Michael Martin; Fosso, Olav B.** Non-linear charge-based battery storage optimization model with bi-variate cubic spline constraints. *Journal of Energy Storage* 2020 ;Volume 32. ENERGISINT NTNU
2. **Backe, Stian; Kara, Güray; Tomasgard, Asgeir.** Comparing individual and coordinated demand response with dynamic and static power grid tariffs. *Energy* 2020 ;Volume 201. p. 1-11. NTNU
3. **Gil Gonzalez, Walter Julian; Garces, Alejandro; Fosso, Olav B.** Passivity-Based Control for Small Hydro-Power Generation with PMSG and VSC. *IEEE Access* 2020. NTNU
4. **Hodge, Bri-Mathias S.; Jain, Himanshu; Brancucci, Carlo; Seo, Gab-Su; Korpås, Magnus; Kiviluoma, Juha; Holttinen, Hannele; Smith, James Charles; Orths, Antje; Estanqueiro, Ana; Söder, Lennart; Flynn, Damian; Vrana, Til Kristian; Kenyon, Rick Wallace; Kroposki, Benjamin.** Addressing technical challenges in 100% variable inverter-based renewable energy power systems. *Wiley Interdisciplinary Reviews: Energy and Environment* 2020 ;Volume 9.(5). ENERGISINT NTNU
5. **Holttinen, Hannele; Kiviluoma, Juha; Flynn, Damian; Smith, Charles; Orths, Antje; Eriksen, Peter Børre; Cutululis, Nicolaos Antonio; Söder, Lennart; Korpås, Magnus; Estanqueiro, Ana; MacDowell, Jason; Tuohy, Aidan; Vrana, Til Kristian; O'Malley, Mark.** System impact studies for near 100% renewable energy systems dominated by inverter based variable generation. *IEEE Transactions on Power Systems* 2020. ENERGISINT NTNU
6. **Jackson Inderberg, Tor Håkon; Sæle, Hanne; Westskog, Hege; Winther, Tanja.** The dynamics of solar prosuming: Exploring interconnections between actor groups in Norway. *Energy Research & Social Science* 2020 ;Volume 70. p. 1-11. CICERO ENERGISINT FNI UiO
7. **Löschenbrand, Markus.** A transmission expansion model for dynamic operation of flexible demand. *International Journal of Electrical Power & Energy Systems* 2020 ;Volume 124. ENERGISINT
8. **Löschenbrand, Markus.** Modeling competition of virtual power plants via deep learning. *Energy* 2020 ;Volume 214. ENERGISINT
9. **Sperstad, Iver Bakken; Degefa, Merkebu Zenebe; Kjølle, Gerd Hovin.** The impact of flexible resources in distribution systems on the security of electricity supply: A literature review. *Electric power systems research* 2020 ;Volume 188. ENERGISINT
10. **Zerihun, Tesfaye Amare; Garau, Michele; Helvik, Bjarne Emil.** Effect of Communication Failures on State Estimation of 5G-Enabled Smart Grid. *IEEE Access* 2020 ;Volume 8. p. 112642-112658. NTNU

### Presentations

*From:* 2020 *To:* 2020 *Main category:* Conference lecture and academic presentation *All publishing channels*

1. **Fjellså, Ingvild Firman.** Fair Flexibility? Capabilities and framings of end-user flexibility in the electricity grid. EASST/ 4S PRAGUE2020; 2020-08-18 - 2020-08-21. NTNU
2. **Istad, Maren Kristine.** CINELDI Pilotprosjekter. Aidon Pro Day Online; 2020-10-28 - 2020-10-28. ENERGISINT
3. **Kjølle, Gerd Hovin.** Hvilke konsekvenser får elektrifiseringen for kraftnettet?. Smartgridkonferansen; 2020-09-08 - 2020-09-08. ENERGISINT
4. **Korpås, Magnus.** How Costs are Recovered in Electricity Markets with Wind, Solar and Storage Plants: An Analytical Approach. Applied Energy Symposium MIT A+B; 2020-08-12 - 2020-08-14. NTNU
5. **Myhre, Stine Fleischer.** Modeling Interdependencies with Complex Network Theory in a Combined Electrical Power and ICT System. 2020 International Conference on Probabilistic Methods Applied to Power Systems - PMAPS; 2020-08-18 - 2020-08-21. NTNU
6. **Omerovic, Aida.** Findings from evaluation of cyber security case studies. CINELDI SFI; 2020-09-07 - 2020-09-07. SINTEF

7. **Sperstad, Iver Bakken.** Cost-Benefit Analysis of Battery Energy Storage in Electric Power Grids: Research and Practices. 2020 IEEE PES Innovative Smart Grid Technologies Europe - ISGT-Europe; 2020-10-26 - 2020-10-28. ENERGISINT
8. **Sperstad, Iver Bakken.** Framework and methodology for active distribution grid planning in Norway. 2020 International Conference on Probabilistic Methods Applied to Power Systems - PMAPS; 2020-08-18 - 2020-08-21. ENERGISINT
9. **Sæle, Hanne.** Use case for fremtidens systemtjenester. Smartgridsenterets Webinarserie; 2020-11-26 - 2020-11-26. ENERGISINT
10. **Thorvaldsen, Kasper Emil; Bjarghov, Sigurd; Farahmand, Hossein.** Representing Long-term Impact of Residential Building Energy Management using Stochastic Dynamic Programming. 2020 International Conference on Probabilistic Methods Applied to Power Systems (PMAPS); 2020-08-18 - 2020-08-21. NTNU

### Presentations not in Cristin

1. **Martin Gilje Jaatun.** Emerging Threats: Understanding evolving hacker trends and implications of SCADA technology innovations. NextGen SCADA Global, Berlin, 2020-01-31
2. **Henning Taxt.** Hvilke potensialer ligger i teknologi-utvikling-hva kan vi forvente? Temadag Energi Norge: Effektiviseringspotensial og investeringsplanlegging, 2020-03-31
3. **Outi Pitkänen.** Integrating end-user knowledge in the implementation of end-user flexibility. NorRen PhD Summer School, 2020-08-10
4. **Korpås, Magnus.** Optimality Conditions and Cost Recovery in Markets with Variable Renewable Energy and Storage. NTNU Energy Transition virtual Workshop: Flexibility in integrated energy systems, 2020-03-26
5. **Hanne Sæle.** Research on flexibility in CINELDI - pilots and TSO/DSO coordination. IEEE PES Norwegian chapter webinar: Flexibility Markets, 2020-10-21
6. **Andreas Hovde Bø, Vegard Viken Kallset, Irina Oleinikova, Hossein Farahmand and Karl Ludvig.** The impact of Flow-Based Market Coupling on the Nordic region. European Energy Market (EEM 2020), 2020-08-17

### Peer reviewed papers

*From:* 2020 *To:* 2020 *sub-category:* Academic chapter/article/ Conference paper *All publishing channels*

1. **Abooshahab, Mohammad Ali; Hovd, Morten; Brekke, Edmund Førland; Song, Xianfeng.** A Covariance Consistent Data Fusion method for Power Networks with Multirate Sensors. I: *2020 IEEE Conference on Control Technology and Applications (CCTA)*. IEEE conference proceedings 2020 ISBN 978-1-7281-7140-1. NTNU
2. **Berg, Kjersti; Hjelkrem, Odd Andre; Torsæter, Bendik Nybakk.** A proposed methodology for modelling the combined load of electric roads and households for long-term grid planning. I: *2020 17th International Conference on the European Energy Market - EEM*. IEEE 2020 ISBN 978-1-7281-6919-4. ENERGISINT SINTEF
3. **Bjarghov, Sigurd; Askeland, Magnus; Backe, Stian.** Peer-to-peer trading under subscribed capacity tariffs - an equilibrium approach. I: *2020 17th International Conference on the European Energy Market - EEM*. IEEE 2020 ISBN 978-1-7281-6919-4. p. - NTNU
4. **Fjelldal, Bjørnar; Fodstad, Marte; Rosenlund, Gjert Hovland; Sæle, Hanne; Degefa, Merkebu Zenebe.** Exploring house-hold's flexibility of smart shifting atomic loads to improve power grid operation and cost efficiency. I: *2020 17th International Conference on the European Energy Market - EEM*. IEEE 2020 ISBN 978-1-7281-6919-4. ENERGISINT
5. **Fosso, Olav B.** PyDSAL - Python Distribution System Analysis Library. I: *2020 IEEE International Conference on Power Systems Technology (POWERCON)*. IEEE 2020 ISBN 978-1-7281-6350-5. p. - NTNU
6. **Føyen, Sjur; Zhang, Chen; Fosso, Olav B.; Suul, Jon Are; Isobe, Takanori.** Single-phase synchronisation with Hilbert transformers: a linear and frequency independent orthogonal system generator. IEEE COMPEL 2020
7. **Ilieva, Iliana; Bremdal, Bernt Arild.** Implementing local flexibility markets and the uptake of electric vehicles – the case for Norway. I: *2020 6th IEEE International Energy Conference - ENERGYCon*. IEEE 2020 ISBN 978-1-7281-2956-3. UiT
8. **Ivarsøy, Eirik; Torsæter, Bendik Nybakk; Korpås, Magnus.** Stochastic Load Modeling of High-Power Electric Vehicle Charging - A Norwegian Case Study. I: *2020 International Conference on Smart Energy Systems and Technologies - SEST*. IEEE 2020 ISBN 978-1-7281-4701-7. ENERGISINT NTNU
9. **Marinelli, Mattia; Calearo, Lisa; Ried, Sabrina; Pfab, Xavier; Carbera, Julio Cesar Diaz; Spalthoff, Christian; Braun, Martin; Sæle, Hanne; Torsæter, Bendik Nybakk; Divshali, Poria Hasanpor; Hänninen, Seppo; Ceraolo, Massimo; Barsali, Stefano; Larsson, Mats; Magdowski, Annika; Gimenez, Laura; Fernandez, Gregorio.** Electric Vehicles Demonstration Projects - An Overview Across Europe. I: *2020 55th International Universities Power Engineering Conference - UPEC*. IEEE 2020 ISBN 978-1-7281-1078-3. ENERGISINT
10. **Myhre, Stine Fleischer; Fosso, Olav B; Heegaard, Poul Einar; Gjerde, Oddbjørn; Kjølle, Gerd Hovin.** Modeling Interdependencies with Complex Network Theory in

a Combined Electrical Power and ICT System. I: *2020 International Conference on Probabilistic Methods Applied to Power Systems - PMAPS*. IEEE 2020 ISBN 978-1-7281-2822-1. ENERGISINT NTNU

11. **Omerovic, Aida; Vefsnmo, Hanne; Gjerde, Oddbjørn; Ravndal, Siri T.; Kvinnesland, Are.** An Industrial Trial of an Approach to Identification and Modelling of Cybersecurity Risks in the Context of Digital Secondary Substations. I: *Risks and Security of Internet and Systems : 14th International Conference - CRiSIS 2019, Hammamet, Tunisia, October 29-31, 2019 - Proceedings*. Springer Nature 2020 ISBN 978-3-030-41568-6. p. 17-33. ENERGISINT SINTEF
12. **Sperstad, Iver Bakken; Istad, Maren Kristine; Sæle, Hanne; Korpås, Magnus; Oleinikova, Irina; Hänninen, Seppo; Motta, Sergio; Panagiotou, Konstantina; Papadimitriou, Christina; Efthymiou, Venizelos; Træholt, Chresten; Marinelli, Mattia.** Cost-Benefit Analysis of Battery Energy Storage in Electric Power Grids: Research and Practices. I: *2020 IEEE PES Innovative Smart Grid Technologies Europe - ISGT-Europe*. IEEE 2020 ISBN 978-1-7281-7100-5. ENERGISINT NTNU
13. **Sperstad, Iver Bakken; Solvang, Eivind; Gjerde, Oddbjørn.** Framework and methodology for active distribution grid planning in Norway. I: *2020 International Conference on Probabilistic Methods Applied to Power Systems - PMAPS*. IEEE 2020 ISBN 978-1-7281-2822-1. ENERGISINT
14. **Sæle, Hanne.** Flexibility potential at Norwegian households - customer evaluations and system benefits. I: *2020 17th International Conference on the European Energy Market - EEM*. IEEE 2020 ISBN 978-1-7281-6919-4. ENERGISINT
15. **Sæle, Hanne.** Household customers' assessment to capacity based distribution grid tariff. I: *2020 17th International Conference on the European Energy Market - EEM*. IEEE 2020 ISBN 978-1-7281-6919-4. ENERGISINT
16. **Sæle, Hanne; Morch, Andrei Z; Degefa, Merkebu Zenebe; Oleinikova, Irina.** Assessment of flexibility in different ancillary services for the power system. I: *2020 17th International Conference on the European Energy Market - EEM*. IEEE 2020 ISBN 978-1-7281-6919-4. ENERGISINT NTNU
17. **Thorvaldsen, Kasper Emil; Bjarghov, Sigurd; Farahmand, Hossein.** Representing Long-term Impact of Residential Building Energy Management using Stochastic Dynamic Programming. I: *2020 International Conference on Probabilistic Methods Applied to Power Systems - PMAPS*. IEEE 2020 ISBN 978-1-7281-2822-1. NTNU
18. **Tøndel, Inger Anne; Borgaonkar, Ravishankar Bhaskarrao; Jaatun, Martin Gilje; Frøystad, Christian.** What Could Possibly Go Wrong? Smart Grid Misuse Case Scenarios IEEE Cyber Science 2020. London: Centre for Multidisciplinary Research, Innovation and Collaboration 2020 ISBN 9780993233814. s.41-48

### Report/thesis

*From:* 2020 *To:* 2020 *Main category:* Report/thesis
*All publishing channels*

1. **Korpås, Magnus; Botterud, Audun.** Optimality Conditions and Cost Recovery in Electricity Markets with Variable Renewable Energy and Energy Storage. Cambridge, MA, USA: MIT Center for Energy and Environmental Policy Research 2020 44 p. NTNU

### Media contributions

*From:* 2020 *To:* 2020 *Main category:* Media contribution *sub-category:* Popular scientific article *sub-category:* Interview Journal *sub-category:* Article in business/trade/industry journal *sub-category:* Sound material *All publishing channels*

1. **Istad, Maren Kristine.** Fullskala demoer fasiliterer framtidens energisystem: Paneldebatt. Smartgrid-konferansen 2020 [Internet] 2020-09-08. ENERGISINT
2. **Kjølle, Gerd Hovin.** - Det virker som at vi i vårt samfunn tar strømforsyningen for gitt. enerWE [Business/trade/industry journal] 2020-06-05. ENERGISINT
3. **Kjølle, Gerd Hovin.** A structured look at specific smart grid scenarios. sintef.no [Internet] 2020-04-23. ENERGISINT
4. **Kjølle, Gerd Hovin.** Arbeidet hennes kan spare Norge for store kostnader - nå mottar hun NTVAs Ærespris. Radio Nordkapp [Radio] 2020-05-25. NTNU
5. **Kjølle, Gerd Hovin.** Arbeidet hennes kan spare Norge for store kostnader – nå mottar hun NTVAs Ærespris. NTB [Internet] 2020-05-25. ENERGISINT
6. **Kjølle, Gerd Hovin.** Arbeidet til Gerd kan spare Norge for store kostnader - mottar ærespris. NT24 [Internet] 2020-05-25. NTNU
7. **Kjølle, Gerd Hovin.** CINELDI – Det grønne skiftet og elektrifisering – utfordringene løses igjennom samarbeid. www.aidon.com [Internet] 2020-06-11. ENERGISINT
8. **Kjølle, Gerd Hovin.** CINELDI – Et internasjonalt forskningssamarbeid. smartgridservices.no [Business/trade/industry journal] 2020-06-08. ENERGISINT
9. **Kjølle, Gerd Hovin.** Elektrifisering som klimatiltak – blir vi smarte tids nok? Paneldebatt. Smartgridkonferansen 2020 [Internet] 2020-09-08. ENERGISINT
10. **Kjølle, Gerd Hovin.** Elnettet må endre seg av mange grunner. Teknisk Ukeblad [Business/trade/industry journal] 2020-12-10. NTNU
11. **Kjølle, Gerd Hovin.** Gerd Kjølle får NTVAs ærespris. energiteknikk.net [Business/trade/industry journal] 2020-05-25. ENERGISINT

12. **Kjølle, Gerd Hovin.** Gerd Kjølle receives NTVA's honorary award for her smart grid research. ELECTRICE-NERGYONLINE [Internet] 2020-06-10. ENERGISINT
13. **Kjølle, Gerd Hovin.** Gerd Kjølle tildelt NTVAs Ærespris. bygg.no [Business/trade/industry journal] 2020-05-25. ENERGISINT
14. **Kjølle, Gerd Hovin.** Gjev pris til Sintefforske. NRK [Internet] 2020-05-25. ENERGISINT
15. **Kjølle, Gerd Hovin.** Gjev pris til Sintefforsker. NRK [Internet] 2020-05-25. ENERGISINT
16. **Kjølle, Gerd Hovin.** Heading for the future electricity distribution grid, one scenario at a time. sintef.no [Internet] 2020-04-20. ENERGISINT
17. **Kjølle, Gerd Hovin.** Her er årets mest populære podkaster - fikk du med deg alle?. Teknisk Ukeblad [Business/trade/industry journal] 2020-12-26. NTNU
18. **Kjølle, Gerd Hovin.** Hun får ærespris for forsking på forsyningssikkerhet. Europwer Energi [Business/trade/industry journal] 2020-05-25. ENERGISINT
19. **Kjølle, Gerd Hovin.** Inn i energisektoren. elektronikknett.no [Business/trade/industry journal] 2020-03-04. ENERGISINT
20. **Kjølle, Gerd Hovin.** NTVAs Ærespris til Gerd Kjølle. NRK Distriktsnyheter Midtnytt [Radio] 2020-05-25 ENERGISINT
21. **Kjølle, Gerd Hovin.** NTVAs Ærespris 2019 til sjefforsker og professor Gerd Kjølle. Ny teknikk [Internet] 2020-05-27. ENERGISINT
22. **Kjølle, Gerd Hovin.** Når norsk transportsektor går på strøm: Hvordan påvirker det deg, meg og strømnettet?. enerWE [Internet] 2020-12-10. NTNU
23. **Kjølle, Gerd Hovin.** Testing a battery that feeds the grid. sintef.no [Internet] 2020-04-14. ENERGISINT
24. **Kjølle, Gerd Hovin.** The big "Living energy lab". sintef.no [Internet] 2020-05-07. ENERGISINT
25. **Kjølle, Gerd Hovin; Korpås, Magnus.** Når norsk transportsektor går på strøm: Hvordan påvirker det deg, meg og strømnettet?. enerWe Partner 2020. ENERGISINT NTNU
26. **Korpås, Magnus.** Aktive kunder og fleksibilitet: paneldebatt. Smartgridkonferansen 2020 [Internet] 2020-09-08. NTNU
27. **Korpås, Magnus.** Er elbiler bra for klimaet? Fornybaren (Podcast) [Internet] 2020-10-27. NTNU
28. **Korpås, Magnus.** Sol og batterier i energisystemet. Solenergiklyngen (podcast) [Internet] 2020-10-21. NTNU
29. **Sperstad, Iver Bakken.** Nettutvikling og nettdrift i endring – alternativer til nett: paneldebatt. Smartgridkonferansen 2020 [Internet] 2020-09-08. ENERGISINT
30. **Sæle, Hanne; Fosso, Olav B.** PODCAST: Når fergesektoren helelektrifiseres: Hvordan påvirker det deg, meg og strømnettet? enerWe Partner 2020. ENERGISINT NTNU
31. **Taxt, Henning.** Tester AMS-målere som sensorer. Energiteknikk [Business/trade/industry journal] 2020-09-23. ENERGISINT
32. **Torsæter, Bendik Nybakk.** Sol- og vindkraft skal forsyne veier i hele Europa med strøm. Ny teknikk [Business/trade/industry journal] 2020-11-27. ENERGISINT
33. **Torsæter, Bendik Nybakk.** Sol- og vindkraft skal forsyne veier i hele Europa med strøm. Byggeindustrien [Business/trade/industry journal] 2020-11-16. ENERGISINT
34. **Torsæter, Bendik Nybakk.** Utvikler energihub-kart. Bygg Fakta [Business/trade/industry journal] 2020-11-12. ENERGISINT
35. **Torsæter, Bendik Nybakk.** Utvikler energihub-kart. Energiteknikk [Business/trade/industry journal] 2020-11-12. ENERGISINT
36. **Torsæter, Bendik Nybakk.** Utvikler energihub-kart. VVS Aktuelt [Business/trade/industry journal] 2020-11-12. ENERGISINT

### Featured article/Op-ed

*From:* 2020 *To:* 2020 *sub-category:* Feature article
*All publishing channels*

1. **Eriksen, Sara Waaler; Gunabala, Sarmilan; Bartnes, Maria; Myhre, Roy Thomas Selbæk.** Sviktende beredskap mot hacking i strømnettet. *Dagens næringsliv* 2020. NTNU SINTEF
2. **Torsæter, Bendik Nybakk; Mehammer, Eirill Bachmann; Berg, Kjersti.** Mikronett sikrer strøm ved avbrudd. *Teknisk Ukeblad* 2020. ENERGISINT

### Blogs and information material

*From:* 2020 *To:* 2020 *Main category:* Information material(s) *All publishing channels*

1. **Abooshahab, Mohammad Ali.** State Estimation in Partially-Known Power Networks. NTNU
2. **Fjellså, Ingvild Firman.** Det fleksible mennesket 2.0: Om sosiale relasjoner i fremtidens digitale elektrisitetssystem. NTNU
3. **Hermansen, Tonje Skoglund.** How can the distribution grid be adapted to facilitate a large-scale electrification of the society?
4. **Hugo, Åsmund Pedersen; Vefsnmo, Hanne; Gjerde, Oddbjørn; Omerovic, Aida.** Slik skal vi ivareta cybersikkerhet også når strømnettet digitaliseres. ENERGISINT SINTEF
5. **Kjølle, Gerd Hovin.** CINELDI. ENERGISINT
6. **Kjølle, Gerd Hovin.** Forskning og utvikling i Elvia. ENERGISINT

7. **Kjølle, Gerd Hovin.** Mer kunnskap for et smartere nett. ENERGISINT
8. **Kjølle, Gerd Hovin; Istad, Maren Kristine.** Tester handel med fleksibilitet. ENERGISINT
9. **Muka, Romina.** Causes of Information Inconsistencies in Smart Distribution Grids. NTNU
10. **Sperstad, Iver Bakken.** Slik bør ein planlegge framtidas aktive distribusjonsnett. ENERGISINT
11. **Sperstad, Iver Bakken; Solvang, Eivind; Gjerde, Oddbjørn.** Slik bør ein planlegge framtidas aktive distribusjonsnett. ENERGISINT NTNU

### Multimedia products

*From:* 2020 *To:* 2020 *sub-category:* Multimedia product *All publishing channels*

1. **Kjølle, Gerd Hovin.** Arbeidet hennes kan spare Norge for store kostnader. SINTEF Energi 2020. ENERGISINT
2. **Kjølle, Gerd Hovin.** Gerd Kjølle recieves NTVA's honorary award. SINTEF Energi 2020. ENERGISINT
3. **Kjølle, Gerd Hovin.** Sensor Pilot - CINELDI. SINTEF Energi 2020. ENERGISINT
4. **Kjølle, Gerd Hovin.** The future electricity distribution grid, one scenario at a time. SINTEF Energi 2020. ENERGISINT

### Other

*From:* 2020 *To:* 2020 *Main category:* Artistic result *sub-category:* Book review *sub-category:* Reader opinion piece *sub-category:* Letter to the editor *sub-category:* Popular scientific chapter/ article *sub-category:* Abstract *sub-category:* Errata *sub-category:* Foreword *sub-category:* Introduction *sub-category:* Other *sub-category:* Chapter Translation *sub-category:* Book Translation *sub-category:* Digital learning tools *sub-category:* Model (architecture) *sub-category:* Music – recorded product *sub-category:* Software sub-categ

1. **Eriksen, Sara Waaler; Gunabala, Sarmilan; Bartnes, Maria; Myhre, Roy Thomas Selbæk.** El-Norges cyberforsvar trenger leverandørene. *Dagens næringsliv* 2020. NTNU SINTEF

## Dissemination and communication 2019

### Peer reviewed Journal publications

*From:* 2019 *To:* 2019 *sub-category:* Academic article *sub-category:* Academic literature review *sub-category:* Short communication *All publishing channels*

1. **Adrah, Charles Mawutor; Yellajosula, Jaya R. A. K.; Kure, Øivind; Palma, David; Heegaard, Poul Einar. An IP Multicast Framework for Routable Sample Value Communication in Transmission Grids.** *Journal of Communications* 2019 ;Volume 14.(9) p. 765-772 NTNU
2. **Berglund, Frida; Zaferanlouei, Salman; Korpås, Magnus; Uhlen, Kjetil. Optimal Operation of Battery Storage for a Subscribed Capacity-Based Power Tariff Prosumer—A Norwegian Case Study.** *Energies* 2019 ;Volume 12.(23) p. - NTNU
3. **Bernsmed, Karin; Jaatun, Martin Gilje; Frøystad, Christian. Is a Smarter Grid Also Riskier?** *Lecture Notes in Computer Science (LNCS)* 2019 ;Volume 11738. p. 36-52. SINTEF
4. **Bitmead, Robert R.; Hovd, Morten; Abooshahab, Mohammad Ali. A Kalman-filtering derivation of simultaneous input and state estimation.** *Automatica* 2019 ;Volume 108. p. - NTNU
5. **Foros, Jørn; Istad, Maren Kristine; Morch, Andrei Z; Mathisen, Bjørn Magnus. Use case applying machine-learning techniques for improving operation of the distribution network.** *CIRED Conference Proceedings* 2019. ENERGISINT SINTEF
6. **Hermansen, Tonje Skoglund; Vefsnmo, Hanne; Kjølle, Gerd Hovin; Sand, Kjell. Driving forces for intelligent distribution system innovation - results from a foresight process.** *CIRED Conference Proceedings* 2019. ENERGISINT NTNU
7. **Hofmann, Matthias; Lindberg, Karen Byskov. Price elasticity of electricity demand in metropolitan areas – Case of Oslo.** *International Conference on the European Energy Market* 2019 ;Volume 2019-September. NTNU SINTEF
8. **Lillebo, Martin; Zaferanlouei, Salman; Zecchino, Antonio; Farahmand, Hossein. Impact of large-scale EV integration and fast chargers in a Norwegian LV grid.** *The Journal of Engineering* 2019. NTNU
9. **Mendis, Handunneththi V. Kalpanie; Heegaard, Poul Einar; Kralevska, Katina. 5G Network Slicing as an Enabler for Smart Distribution Grid Operations.** *CIRED Conference Proceedings* 2019 p. 1-5. NTNU
10. **Skjølsvold, Tomas Moe; Fjellså, Ingvild Firman; Ryghaug, Marianne. Det fleksible mennesket 2.0: Om sosiale relasjoner i fremtidens digitale elektrisitetssystem.** *Norsk sosiologisk tidsskrift* 2019 ;Volume 3.(3) p. 191-208. NTNU
11. **Sperstad, Iver Bakken; Korpås, Magnus. Energy Storage Scheduling in Distribution Systems Considering Wind and Photovoltaic Generation Uncertainties.** *Energies* 2019 ;Volume 12.(7) ENERGISINT NTNU

12. Villanueava Revenga, Rodrigo; Crespo del Granado, Pedro; Oleinikova, Irina; Farahmand, Hossein. A Minute-To-Minute Unit Commitment Model to Analyze Generators Performance. *International Conference on the European Energy Market* 2019 ;Volume 2019-September. NTNU
13. Zecchino, Antonio; D'Arco, Salvatore; Endegnanew, Atsede Gualu; Korpås, Magnus; Marinelli, Mattia. Enhanced primary frequency control from EVs: a fleet management strategy to mitigate effects of response discreteness. *IET Smart Grid* 2019 ;Volume 2.(3) p. 436-444. ENERGISINT NTNU
14. Zepter, Jan Martin Wilhelm; Lüth, Alexandra Rebecca; Crespo del Granado, Pedro; Egging, Ruud. Prosumer integration in wholesale electricity markets: Synergies of peer-to-peer trade and residential storage. *Energy and Buildings* 2019 ;Volume 184. p. 163-176. NTNU

**Peer-reviewed papers**

*From:* 2019 *To:* 2019 *sub-category:* Academic chapter/article/ Conference paper *All publishing channels*

1. Aaslid, Per; Belsnes, Michael Martin; Fosso, Olav B. Optimal microgrid operation considering battery degradation using stochastic dual dynamic programming. I: *2019 International Conference on Smart Energy Systems and Technologies - SEST*. IEEE 2019 ISBN 978-1-7281-1156-8. ENERGISINT NTNU
2. Abooshahab, Mohammad Ali; Hovd, Morten; Bitmead, Robert R. wDisturbance and State Estimation in Partially Known Power Networks. I: *Proceedings of the IEEE2019 Conference on Control Technology and Applications*. IEEE 2019 ISBN 978-1-7281-2766-8. p. 98-105. NTNU
3. Almenning, Ola Mathias; Bjarghov, Sigurd; Farahmand, Hossein. Reducing Neighborhood Peak Loads with implicit Peer-to-Peer energy trading under Subscribed Capacity tariffs. I: *2019 International Conference on Smart Energy Systems and Technologies - SEST*. IEEE 2019 ISBN 978-1-7281-1156-8. NTNU
4. Borgaonkar, Ravishankar Bhaskarrao; Jaatun, Martin Gilje. 5G as an Enabler for Secure IoT in the Smart Grid : Invited Paper. I: *2019 First International Conference on Societal Automation*. IEEE 2019 ISBN 978-1-7281-3345-4. SINTEF
5. Degefa, Merkebu Zenebe; Sæle, Hanne; Andresen, Christian Andre. Analysis of Future Loading Scenarios in a Norwegian LV Network. I: *2019 International Conference on Smart Energy Systems and Technologies - SEST*. IEEE 2019 ISBN 978-1-7281-1156-8. ENERGISINT
6. Føyen, Sjur; Fosso, Olav B; Zhang, Chen; Molinas Cabrera, Maria Marta. Frequency Domain Modelling for Assessment of Hilbert and SOGI Based Single-Phase Synchronisation. I: *Proceeding 45th Annual Conference of the IEEE Industrial Electronics Society - IECON 2019*. IEEE conference proceedings 2019 ISBN 978-1-7281-4878-6. NTNU
7. Göthner, Fredrik T. B. W.; Brandao, Danilo; Tedeschi, Elisabetta. Unbalanced Load Compensation by PowerBased Control in the Synchronous Reference Frame. I: *2019 10th International Conference on Power Electronics and ECCE Asia - ICPE 2019 - ECCE Asia*. IEEE 2019 ISBN 978-89-5708-313-0. p. - NTNU
8. Göthner, Fredrik T. B. W.; Midtgård, Ole-Morten; Torres Olguin, Raymundo E.; Roldan-Pérez, Javier. Virtual Impedance Design for Power Quality and Harmonic Sharing Improvement in Microgrids. I: *2019 20th Workshop on Control and Modeling for Power Electronics - COMPEL*. IEEE 2019 ISBN 978-1-7281-1842-0. ENERGISINT NTNU
9. Grøttum, Hanne Høie; Bjerland, Siri Førsund; Crespo del Granado, Pedro; Egging, Ruud. Modelling TSO-DSO coordination: The value of distributed flexible resources to the power system. I: *2019 16th International Conference on the European Energy Market - EEM 2019*. IEEE 2019 ISBN 978-1-7281-1257-2. p. 1-6. ENERGISINT NTNU
10. Li, Chendan; Molinas Cabrera, Maria Marta; Fosso, Olav B; Qin, Nan; Zhu, Lin. A Data-driven Approach to Grid Impedance: Identification for Impedance-based Stability Analysis under Different Frequency Ranges. I: *2019 IEEE Milan. PowerTech*. IEEE 2019 ISBN 978-1-5386-4722-6. NTNU
11. Melby, Mathias; Fosso, Olav B; Molinas Cabrera, Maria Marta. Impact of Virtual Oscillator Control on the instantaneous properties of VSC output voltage in distorted island grids. I: *Proceeding 45th Annual Conference of the IEEE Industrial Electronics Society - IECON 2019*. IEEE conference proceedings 2019 ISBN 978-1-7281-4878-6. NTNU
12. Morch, Andrei Z; Sæle, Hanne; Siface, Dario; Migliavacca, Gianluigi; Gerard, Helena; Kockar, Ivana. Market architecture for TSO-DSO interaction in the context of European regulation. I: *2019 16th International Conference on the European Energy Market - EEM 2019*. IEEE 2019 ISBN 978-1-7281-1257-2. ENERGISINT
13. Muka, Romina; Haugli, Fredrik Bakkevig; Vefsnmo, Hanne; Heegaard, Poul Einar. Information Inconsistencies in Smart Distribution Grids under Different Failure Causes modelled by Stochastic Activity Networks. I: *2019 AEIT International Annual*

*Conference*. IEEE 2019 ISBN 978-8-8872-3745-0. p. 1-6 ENERGISINT NTNU

14. **Omerovic, Aida; Vefsnmo, Hanne; Erdogan, Gencer; Gjerde, Oddbjørn; Gramme, Eivind; Simonsen, Stig. A Feasibility Study of a Method for Identification and Modelling of Cybersecurity Risks in the Context of Smart Power Grids. I:** *COMPLEXIS 2019 - Proceedings of the 4th International Conference on Complexity, Future Information Systems and Risk 2019*. SciTePress 2019 ISBN 978-989-758-366-7. p. 39-51. ENERGISINT SINTEF
15. **Seijas Fernandez, Andres Antonio; Crespo del Granado, Pedro; Farahmand, Hossein; Rueda, Jose. Optimal battery systems designs for Distribution Grids: What size and location to invest in? I:** *2019 International Conference on Smart Energy Systems and Technologies - SEST*. IEEE 2019 ISBN 978-1-7281-1156-8. p. 1-6. NTNU
16. **Zerihun, Tesfaye Amare; Garau, Michele; Helvik, Bjarne Emil. Dependability Modeling and Analysis of 5G Based Monitoring System in Distribution Grids. I:** *VALUE-TOOLS 2019 : Proceedings of the 12th EAI International Conference on Performance Evaluation Methodologies and Tools*. Association for Computing Machinery (ACM) 2019 ISBN 978-1-4503-6596-3. p. 163-166. NTNU

### Peer-reviewed papers not in Cristin

1. Preventing DDoS with SDN in 5G, IEEE GLOBECOM Workshop on 5G wireless security, Mathias Kjølleberg Førland, Katina Kralevska, Michele Garau, and Danilo Gligoroski, 2019
2. Towards 5G Intrusion Detection Scenarios with OMNeT++, OMNeT++ Community Summit, Katina Kralevska, Michele Garau, Mathias Førland, and Danilo Gligoroski, 2019
3. An Industrial Trial of an Approach to Identification and Modelling of Cybersecurity Risks in the Context of Digital Secondary Substations, CRISIS 2019, Aida Omerovic, Hanne Vefsnmo, Oddbjørn Gjerde, Siri T. Ravndal, Are Kvinnes-land, 2019
4. Single-phase synchronisation with Hilbert transformers: a linear and frequency independent orthogonal system generator, NORPIE 2019 - The Conference on Energy, Power Systems and Power- and Industrial Electronics, Sjur Føyen, Chen Zhang, Olav B. Fosso, Jon Are Suul, Takanori Isobe, 2019

### Presentations

*From:* 2019 *To:* 2019 *Main category:* Conference lecture and academic presentation *All publishing channels*

1. **Abooshahab, Mohammad Ali; Hovd, Morten; Bitmead, Robert R. Disturbance and State Estimation in Partially Known Power Networks.** The 3rd IEEE Conference on Control Technology and Applications (CCTA 2019); 2019-08-19 - 2019-08-21. NTNU
2. **Fosso, Olav B. Cineldi - The Norwegian Research Centre for Intelligent Electricity Distribution (Smartgrid).** Smarter Grids and Storage in emerging energy ecosystems; 2019-01-07 - 2019-01-08. NTNU
3. **Fosso, Olav B. Renewable energy integration and role of storage in a distribution/microgrid environment. Expert Lecture At**: Indian Institute of Technology Delhi and Delhi Technological University, Delhi, India Affiliation: Indian Institute of Technology Delhi; 2019-01-09 - 2019-01-10. NTNU
4. **Kjølle, Gerd Hovin. CINELDI –innspill til pågående arbeid med gjennomgang av driftskoordinering i kraftsystemet.** NVE Seminar om Driftskoordineringen; 2019-10-23 - 2019-10-23. ENERGISINT
5. **Kjølle, Gerd Hovin. Fremtidens smarte energisystem.** Energidagen; 2019-10-31 - 2019-10-31. ENERGISINT
6. **Kjølle, Gerd Hovin. Hva står strømnettet overfor av utfordringer og utviklingsbehov fremover?** Lunsjseminar; 2019-10-29 - 2019-10-29. ENERGISINT
7. **Kjølle, Gerd Hovin. Scenarier for fremtidens nett 2030-2040.** Smartgridkonferansen; 2019-09-10 - 2019-09-11. ENERGISINT
8. **Kjølle, Gerd Hovin; Moe, Marie. Cyber security i fremtidens intelligente distribusjonsnett.** Workshop om cyber security i kraftnettet; 2019-08-22 - 2019-08-22. ENERGISINT
9. **Marafioti, Giancarlo; Sperstad, Iver Bakken. Methods for operation and sizing of flexible resources – a Model Predictive Control perspective.** CINELDI WP5 Webinar; 2019-09-02 - 2019-09-02. SINTEF ENERGISINT
10. **Omerovic, Aida; Vefsnmo, Hanne; Erdogan, Gencer; Gjerde, Oddbjørn; Gramme, Eivind; Simonsen, Stig. A Feasibility Study of a Method for Identification and Modelling of Cybersecurity Risks in the Context of Smart Power Grids.** COMPLEXIS 2019; 2019-05-02 - 2019-05-04. ENERGISINT SINTEF

### Media contributions

*From:* 2019 *To:* 2019 *Main category:* Media contribution *sub-category:* Popular scientific article *sub-category:* Interview Journal *sub-category:* Article in business/trade/industry journal *sub-category:* Sound material *All publishing channels*

1. **Coldevin, Grete Håkonsen. Forskningen skal gi verdiøkning.** Energiteknikk [Business/trade/industry journal] 2019-12-01. ENERGISINT
2. **Fjellså, Ingvild Firman. - Ikke like smart for alle.** Energiteknikk bilag [Business/trade/industry journal] 2019-12-01. NTNU

3. **Fosso, Olav B. Elbilparken som "living laboratory".** Energiteknikk [Business/trade/industry journal] 2019-12-01. NTNU
4. **Garau, Michele. 5G øker funksjonaliteten.** Energiteknikk [Business/trade/industry journal] 2019-12-01.NTNU
5. **Gjerde, Oddbjørn. Bedre digital nettplanlegging.** Energiteknikk [Business/trade/industry journal] 2019-12-01. ENERGISINT
6. **Gjerde, Oddbjørn. Strømbruddet i Argentina kan felle presidenten og gi ny økonomisk krise.** Aftenposten [Newspaper] 2019-06-18. ENERGISINT
7. **Göthner, Fredrik T. B. W. Mikronett gir bedre spenningskvalitet.** Energiteknikk [Business/trade/industry journal] 2019-12-01. NTNU
8. **Kara, Güray. Nettet kan driftes bedre.** Energiteknikk [Business/trade/industry journal] 2019-12-01. NTNU
9. **Kjølle, Gerd Hovin. Hafslund Nett fikk innovasjonspris.** Energiteknikk [Business/trade/industry journal] 2019-09-10. ENERGISINT
10. **Kjølle, Gerd Hovin. Hafslund Nett får innovasjons-pris.** Europower Energi [Business/trade/industry journal] 2019-09-11. ENERGISINT
11. **Kjølle, Gerd Hovin. Har laget omlag 120 miniscenarier.** Energiteknikk [Business/trade/industry journal] 2019-12-01. ENERGISINT
12. **Kjølle, Gerd Hovin. Hvordan kan vi få et smartere strømnett?** TU [Business/trade/industry journal] 2019-06-25. ENERGISINT
13. **Kjølle, Gerd Hovin. I går våknet 48 millioner mennesker i Sør-Amerika opp uten strøm. Heiser stoppet og trafikklys sluttet å fungere. Kan det samme skje i Norge, spør vi.** NRK Radio [Radio] 2019-06-17. ENERGISINT
14. **Kjølle, Gerd Hovin. Mer kunnskap for et smartere nett.** Energiteknikk [Business/trade/industry journal] 2019-12-01 ENERGISINT
15. **Kjølle, Gerd Hovin. Smarte distribusjonsnett vil gi store KILE-besparelser.** Energiteknikk [Business/trade/industry journal] 2019-04-05. ENERGISINT
16. **Kjølle, Gerd Hovin. SMARTGRID KONFERANSEN 2019: DIGITALISERINGENS MULIGHETSROM.** Sinus [Business/trade/industry journal] 2019-11-20. ENERGISINT
17. **Kjølle, Gerd Hovin. Tensio vil ruste strømnettet for fremtiden.** https://fornybarklyngen.no/2019/tensio-vil-ruste-stromnettet [Business/trade/industry journal] 2019-10-30 ENERGISINT
18. **Korpås, Magnus. Forsker på gode ladesystemer.** Energiteknikk [Business/trade/industry journal] 2019-12-01. NTNU
19. **Moe, Marie Elisabeth Gaup. Lager treningssimulator for cyber-angrep.** Energiteknikk [Business/trade/industry journal] 2019-12-01. NTNU
20. **Muka, Romina. Flere "øyne" på nettet.** Energiteknikk [Business/trade/industry journal] 2019-12-01. NTNU
21. **Sand, Kjell. Unikt laboratorie-konsept.** Energiteknikk [Business/trade/industry journal] 2019-12-01. NTNU
22. **Skjølsvold, Tomas Moe. "Smartgridutvikling" som samfunnsutvikling.** *sosiologen.no* 2019. NTNU
23. **Skjølsvold, Tomas Moe. Smartgridutvikling som samfunnsutvikling.** *#SINTEFblog* 2019. NTNU
24. **Sæle, Hanne. Økt fleksibilitet i nettet er viktig.** Energiteknikk [Business/trade/industry journal] 2019-12-01. ENERGISINT
25. **Taxt, Henning. Trener på framtidas nett.** Energiteknikk [Business/trade/industry journal] 2019-12-01. ENERGISINT
26. **Thorvaldsen, Kasper Emil. Vil redde verden!** Energiteknikk [Business/trade/industry journal] 2019-12-01. NTNU
27. **Torsæter, Bendik Nybakk. Bonde Lars Hoem skal bli sin egen energi-øy.** TU [Business/trade/industry journal] 2019-09-01.ENERGISINT
28. **Torsæter, Bendik Nybakk. Fem spørsmål og svar om mikronett.** TU [Business/trade/industry journal] 2019-12-26. ENERGISINT
29. **Torsæter, Bendik Nybakk. 5 spørsmål om mikronett.** TU [Business/trade/industry journal] 2019-11-19. ENERGISINT

### Blogs and information material

*From:* 2019 *To:* 2019 *Main category:* Information material(s)
*All publishing channels*

1. **Degefa, Merkebu Zenebe. How to estimate flexibility potential of household appliances? (To reduce peak load).** ENERGISINT
2. **Farahmand, Hossein. Consumer and prosumer cooperation may equal reduced electricity prices.** NTNU
3. **Foros, Jørn. Maskinlæring for bedre avbruddshåndtering i framtidens smartgrid.** ENERGISINT
4. **Fuchs, Ida. Innovation on the agenda for CINELDI PhDs.** NTNU
5. **Garau, Michele. Smart grid monitoring: new opportunities and challenges with digitalization and 5G integration.** NTNU
6. **Göthner, Fredrik T. B. W. Mikronett: Hva er det, virtuell impedans og øydrift.** ENERGISINT

7. **Gothner, Fredrik T. B. W. Microgrids: What are they, virtual impedance and a control concept for inverters in islanded microgrids.** NTNU
8. **Hermansen, Tonje Skoglund. CINELDI presenterte forskning på CIRED konferansen.** ENERGISINT
9. **Hermansen, Tonje Skoglund. En oppsummering fra CINELDI-konferansen 2019.** ENERGISINT
10. **Hermansen, Tonje Skoglund. Finding Smart Grid driving forces and how they affect Smart Grid development.** ENERGISINT
11. **Hermansen, Tonje Skoglund. Registration open for CINELDI Conference: Future electricity distribution grid R&D.** ENERGISINT
12. **Kjølle, Gerd Hovin. CINELDI årsrapport.** ENERGISINT
13. **Sperstad, Iver Bakken. Keeping solar and wind energy stored in the battery: What is the value?** ENERGISINT
14. **Sperstad, Iver Bakken. Kva er verdien av å spare på sol- og vindenergien lagra i batteriet?** ENERGISINT
15. **Sæle, Hanne. Electric vehicles in Norway and the potential for demand response.** ENERGISINT
16. **Sæle, Hanne. Elektriske biler i Norge og potensialet for forbrukerfleksibilitet.** ENERGISINT
17. **Taxt, Henning. Eksperter fra Europas fremste smartgrid laboratorier møttes i Trondheim.** ENERGISINT

### Multimedia products

*From:* 2019 *To:* 2019 *sub-category:* Multimedia product *All publishing channels*

1. **Kjølle, Gerd Hovin. CINELDI Annual Report 2018 video.** SINTEF Energi 2019. ENERGISINT
2. **Kjølle, Gerd Hovin. Effektstudien.** SINTEF Energi 2019. ENERGISINT
3. **Kjølle, Gerd Hovin. Pilotprosjekter i CINELDI.** SINTEF Energi - CINELDI 2019. ENERGISINT
4. **Steenstrup-Duch, Anne. CINELDI og Skagerak Energilab.** SINTEF Energi - CINELDI 2019. ENERGISINT
5. **Sæle, Hanne. SINTEF - Hanne Sæle. enerWe Vimeo 2019.** ENERGISINT
6. **Vefsnmo, Hanne. CINELDI selvhelende strømnett.** SINTEF Energi - CINELDI 2019. ENERGISINT
7. **Vefsnmo, Hanne; Kjølle, Gerd Hovin. Self-healing distribution Grids.** SINTEF Energi - CINELDI 2019. ENERGISINT

## Dissemination and communication 2018

### Peer reviewed Journal publications

*From:* 2018 *To:* 2018 *sub-category:* Academic article *sub-category:* Academic literature review *sub-category:* Short communication *All publishing channels*

1. **Bobinaite, Viktorija; Obushevs, Artjoms; Oleinkova, Irina; Morch, Andrei Z.** Economically Efficient Design of Market for System Services under the Web-of-Cells Architecture. *Energies* 2018 ;Volum 11.(4). ENERGISINT
2. **Lüth, Alexandra Rebecca; Zepter, Jan Martin Wilhelm; Crespo del Granado, Pedro; Egging, Ruud.** Local electricity market designs for peer-to-peer trading: The role of battery flexibility. *Applied Energy* 2018 ;Volum 229. s. 1233-1243. NTNU
3. **Oostenbrink, Jorik; Kuipers, Fernando; Heegaard, Poul Einar; Helvik, Bjarne Emil.** Evaluating Local Disaster Recovery Strategies. *Performance Evaluation Review* 2018 ;Volum 46.(2) s. - NTNU
4. **Sasan, Pirouzi; Aghaei, Jamshid; Niknam, Taher; Farahmand, Hossein; Korpås, Magnus.** Exploring prospective benefits of electric vehicles for optimal energy conditioning in distribution networks. *Energy* 2018 ;Volum. 157. s. 679-689. NTNU
5. **Skjølsvold, Tomas Moe; Throndsen, William; Ryghaug, Marianne; Fjellså, Ingvild Firman; Koksvik, Gitte.** Orchestrating households as collectives of participation in the distributed energy transition: New empirical and conceptual insights. *Energy Research & Social Science* 2018 ;Volum 46. s. 252-261. NTNU
6. **Zepter, Jan Martin Wilhelm; Lüth, Alexandra Rebecca; Crespo del Granado, Pedro; Egging, Ruud.** Prosumer integration in wholesale electricity markets: Synergies of peer-to-peer trade and residential storage. *Energy and Buildings.* 2018 ;Volum 184. s. 163-176. NTNU
7. **Adrah, C. M.; Yellajosula, J. K.; Kure; Palma, D.; Heegaard, P.E.** *An IP Multicast Framework for Routable Sample Value Communication in Transmission Grids,* Journal of Communications (ISSN: 1796-2021 (Online); 2374-4367 (Print)*
8. **Černivec, Aleš; Erdogan, Gencer; Gonzalez, Alejandra; Refsdal, Atle; Romero, Antonio Alvarez.,** Employing *Graphical Risk Models to Facilitate Cyber-Risk Monitoring - the WISER Approach.,* Lecture Notes in Computer Science 2018 ;Volum 10744. s. 127-146*

**Peer-reviewed papers**

*From:* 2018 *To:* 2018 *sub-category:* Academic chapter/article/ Conference paper *All publishing channels*

1. Bjarghov, Sigurd; Korpås, Magnus; Zaferanlouei, Salman. Value Comparison of EV and House Batteries at End-user Level under Different Grid Tariffs. I: *2018 IEEE International Energy Conference - ENERGYCON 2018, Limassol, Cyprus, 3-7 June, 2018.* IEEE conference proceedings 2018 ISBN 978-1-5386-3669-5. s. - NTNU
2. Blom, Fredrik; Farahmand, Hossein. On the Scalability of Blockchain-Supported Local Energy Markets. I: *2018 International Conference on Smart Energy Systems and Technologies - SEST.* IEEE conference proceedings 2018 ISBN 978-1-5386-5326-5. s. - NTNU
3. Degefa, Merkebu Zenebe; Sæle, Hanne; Petersen, Idar; Ahcin, Peter. Data-driven Household Load Flexibility Modelling: Shiftable Atomic Load. I: *2018 IEEE PES Innovative Smart Grid Technologies Conference Europe (ISGT-Europe)*. IEEE Press 2018 ISBN 978-1-5386-4505-5. ENERGISINT
4. Esposito, Christian; Gouglidis, Antonios; Hutchison, David; Gurtov, Andrei; Helvik, Bjarne Emil; Heegaard, Poul Einar; Rizzo, Gianluca; Rak, Jacek. On the Disaster Resiliency within the Context of 5G Networks: The RECODIS Experience. I: *2018 European Conference on Networks and Communications (EuCNC).* IEEE Press 2018 ISBN 978-1-5386-1478-5. s. - NTNU
5. Føyen, Sjur; Kvammen, Mads-Emil B.; Fosso, Olav B. Prony's method as a tool for power system identification in Smart Grids. I: *24th IEEE International Symposium on Power Electronics, Electrical Drives, Automation and Motion, SPEEDAM 2018.* IEEE conference proceedings 2018 ISBN 978-1-5386-4942-8. NTNU
6. Göthner, Fredrik T. B. W.; Midtgård, Ole-Morten; Torres Olguin, Raymundo E.; D'Arco, Salvatore. Effect of Including Transient Virtual Impedance in Droop-Controlled Microgrids. I: *2018 IEEE International Conference on Environment and Electrical Engineering and 2018 IEEE Industrial and Commercial Power Systems Europe - EE-EIC/I&CPS Europe*. IEEE International Conference on Smart Grid Communications (SmartGridComm) 2018 ISBN 978-1-5386-5186-5. ENERGISINT NTNU
7. Harbo, Sondre; Zaferanlouei, Salman; Korpås, Magnus. Agent Based Modelling and Simulation of Plug-In Electric Vehicles Adoption in Norway. I: *2018 Power Systems Computation Conference PSCC.* IEEE conference proceedings 2018 ISBN 978-1-910963-09-8. s. 1-7 NTNU
8. Sæle, Hanne; Morch, Andrei Z; Rikos, Evangelos J.; Canevese Silva Maria, Silva M.; Kosmecki, Michal. Utilization of distributed energy resources' flexibility in power system operation – Evaluation of today's status and description of a future concept. I: *2018 53rd International Universities Power Engineering Conference (UPEC).* IEEE conference proceedings 2018 ISBN 978-1-5386-2910-9. ENERGISINT
9. Sæle, Hanne; Petersen, Idar. Electric vehicles in Norway and the potential for demand response. I: *2018 53rd International Universities Power Engineering Conference (UPEC).* IEEE conference proceedings 2018 ISBN 978-1-5386-2910-9. ENERGISINT
10. Tveita, Elise; Löschenbrand, Markus; Bjarghov, Sigurd; Farahmand, Hossein. Comparison of Cost Allocation Strategies among Prosumers and Consumers in a Cooperative Game. I: *2018 International Conference on Smart Energy Systems and Technologies - SEST.* IEEE conference proceedings 2018 ISBN 978-1-5386-5326-5. s. - NTNU
11. Zaferanlouei, Salman; Korpås, Magnus; Aghaei, Jamshid; Farahmand, Hossein; Hashemipour, Naser. Computational Efficiency Assessment of Multi-Period AC Optimal Power Flow including Energy Storage Systems. I: *2018 International Conference on Smart Energy Systems and Technologies - SEST.* IEEE conference proceedings 2018 ISBN 978-1-5386-5326-5. s. 1-6. NTNU

**Reports**

*(not registered in Cristin)*

1. Sondre Harbo. Tackling Variability in Renewable Energy *Production and Electric Vehicle Consumption with Stochastic Optimization - The Benefits of Using the Stochastic Quasi-Gradient Method compared with Exact Methods and Machine Learning.* MSc thesis NTNU 2018
2. Fredrik Blom. *A Feasibility Study of Blockchain Technology As Local Energy Market Infrastructure.* MSc thesis NTNU 2018
3. Sjur Føyen, Mads-Emil Kvammen. *A signal analysis toolbox for power system identification in Smart Grids.* MSc thesis NTNU 2018
4. Håkon Edøy Hanssen. *Data acquisition and analysis of acquired data from geographically distributed sensors connected by 2G / 4G technology.* MSc thesis NTNU 2018
5. Erlend Grande. *Data gathering and -assembling from several smart meter HAN ports.* MSc thesis NTNU 2018
6. Thea Øverlie. *Forbrukerfleksibilitet som en ressurs i fremtidens kraftsystem.* MSc thesis NTNU 2018
7. Ruben Buchmann. *Harmonic Sharing in Microgrid Applications - Modeling, Developing and Evaluating a Microgrid Control System With Harmonic Sharing. Capability*. MSc thesis NTNU 2018
8. Martin Lillebo. *Impact of EV Integration and Fast Chargers in a Norwegian LV Grid - An analysis based on data from a residential grid in Steinkjer.* MSc thesis NTNU 2018

9. **Jarand Hole.** *Integrasjon av distribuert fornybar energi i Trøndelag.* MSc thesis NTNU 2018
10. **Signe Gjørven.** *Integrasjon av sol i det norske kraftsystemet.* MSc thesis NTNU 2018
11. **Elise Tveita.** *Methods for Cost Allocation Among Prosumers and Consumers Using Cooperative Game Theory.* MSc thesis NTNU 2018
12. **Kasper Thorvaldsen.** *Multi-Market Optimization of Energy Storage Taking Into Account Uncertainty.* MSc thesis NTNU 2018
13. **Lene Marie Rognan.** *Photovoltaic Power Prediction and Control Strategies of the Local Storage Unit at Campus Evenstad.* MSc thesis NTNU 2018
14. **Henrik Willett.** *Security evaluation of communication interfaces on smart meters.* MSc thesis NTNU 2018
15. **Edem Avevor.** *Smart Grid security in the IoT world.* MSc thesis NTNU 2018
16. **Ingrid Andersen.** *Stochastic Optimization of Zero Emission Buildings.* MSc thesis NTNU 2018
17. **Marit Tundal.** *Utilizing Blockchain Technology for Settlement in a Microgrid.* MSc thesis NTNU 2018
18. **Anders Holvik.** *Virtual Impedance Techniques for Power Sharing Control in AC Islanded Microgrids.* MSc thesis NTNU 2018

### Presentations

*Main category:* Conference lecture and academic presentation
*All publishing channels*

1. **Fjellså, Ingvild Firman.** Det fleksible mennesket 2.0: om sosiale relasjoner i det digitale elektrisitetssystemet. Sosiologisk Vinterseminar; 2018-02-02 - 2018-02-04. NTNU
2. **Fjellså, Ingvild Firman.** Energy practices, reflections and flexibility: Stories from end-users. CenSES Scientific Conference; 2018-11-22 - 2018-11-22. NTNU
3. **Fjellså, Ingvild Firman.** Understand mechanisms and incentives for motivating user flexibility- a PhD prosjekt. Demand Side Management: Empowering the end user in the energy transition; 2018-04-16 - 2018-04-16. NTNU
4. **Føyen, Sjur; Kvammen, Mads-Emil B.; Fosso, Olav B.** Prony's method as a tool for power system identification in Smart Grids. 24th IEEE International Symposium on Power Electronics, Electrical Drives, Automation and Motion - SPEEDAM 2018; 2018-06-20 - 2018-06-22. NTNU
5. **Jaatun, Martin Gilje.** Incident Response & Business Continuity in the Grid. 5th Cyber & SCADA Security for Power and Utilities Industry 2018; 2018-09-26 - 2018-09-28. SINTEF
6. **Korpås, Magnus.** Small-scale vs large-scale flexibility options in high-RES power systems. The MIT Energy Initiative Electric Power Systems Center Fall. Workshop; 2018-11-14 - 2018-11-14. NTNU
7. **Steenstrup-Duch, Anne.** SmartGrid konferansen 2018 - kommunisere SmartGrid i CINELDI. Konferanse; 2018-09-12. ENERGISINT
8. **Sæle, Hanne.** Research on the future intelligent, flexible and robust distribution grid –with special focus on potential for demand response from household customers. Demand Side Management: Empowering the end user in the energy transition - IEA DSM; 2018-04-16 - 2018-04-16. ENERGISINT

*There might be some discrepancies between the numbers in figure and numbers registered in Cristin, mainly due to FME partners that do not have a university or research institute affiliation or because the FME projectcode has not yet been registered in the post.*

### Op-eds

*sub-category:* Feature article *sub-category:* Editorial
*All publishing channels*

1. **Sæle, Hanne; Kjølle, Gerd Hovin.** Folk vil dele på strømmen. *Dagens næringsliv* 2018. ENERGISINT

### Media contributions

*Main category:* Media contribution *sub-category:* Popular scientific article *sub-category:* Interview Journal *sub-category:* Article in business/trade/industry journal *sub-category:* Sound material *All publishing channels*

1. **Kjølle, Gerd Hovin.** Gir «digitalisering» av nettet innhold. KS Bedrift [Internet] 2018-02-15. ENERGISINT
2. **Kjølle, Gerd Hovin; Korpås, Magnus.** Batterier blir en del av strømnettet. Energiteknikk [Business/trade/industry journal] 2018-06-25. ENERGISINT NTNU
3. **Kjølle, Gerd Hovin; Korpås, Magnus.** Batterier kan bli en del av strømnettet ved høyt strømforbruk. Itbaktuelt [Business/trade/industry journal] 2018-07-25. ENERGISINT NTNU
4. **Kjølle, Gerd Hovin; Sæle, Hanne.** Folk vil dele på strømmen. Gemini [Business/trade/industry journal] 2018-09-23. ENERGISINT
5. **Kjølle, Gerd Hovin; Sæle, Hanne.** Folk vil dele på strømmen - KS bedrift. www.ksbedrift.no [Internet] 2018-09-28. ENERGISINT
6. **Korpås, Magnus.** Slik kan batterier brukes i det norske strømnettet - energiteknikk. Energiteknikk [Business/trade/industry journal] 2018-08-31. NTNU

7. **Olsen, Claude R.; Korpås, Magnus; Kjølle, Gerd Hovin.** Batterier blir en del av strømnettet. gemini.no [Business/trade/industry journal] 2018-06-25. NTNU
8. **Sæle, Hanne.** En digital dugnadsånd med strømdeling kan redusere milliardutbygginger i strømnettet. enerWE [Internet] 2018-10-24. ENERGISINT
9. **Sæle, Hanne.** PODCAST: ENERGIBRANSJENS UKESLUTT – Dette spår ekspertene om Norges strømmarked. enerWE [Radio] 2018-10-26. ENERGISINT

### Blogs and information material

*Main category:* Information material(s) *All publishing channels*

1. **Hermansen, Tonje Skoglund.** CINELDI partnersamling: planlegging og asset management i fremtidens distribusjonsnett. ENERGISINT
2. **Hermansen, Tonje Skoglund.** CINELDI-dagene 2018 var en suksess. ENERGISINT
3. **Hermansen, Tonje Skoglund.** CINELDI-prisen delt ut til et «nytt vernkonsept» – et pilotprosjekt av Hafslund nett. ENERGISINT
4. **Hermansen, Tonje Skoglund.** Digitizing grid data for a future-proof SmartGrid. ENERGISINT
5. **Istad, Maren Kristine.** Smartere og sikker nettdrift – hvordan skal vi få til dette?. ENERGISINT
6. **Kjølle, Gerd Hovin.** CINELDI Annual Report 2017. ENERGISINT
7. **Kjølle, Gerd Hovin.** CINELDI pilot projects, PhDs, deliverables and milestones are well under way. ENERGISINT
8. **Kjølle, Gerd Hovin.** Hafslund Nett – Månedens brukerpartner i CINELDI. ENERGISINT
9. **Korpås, Magnus.** Batterier blir en del av strømnettet. NTNU
10. **Korpås, Magnus.** Energy Modelling workshop and 5th Pyomofest. NTNU
11. **Mathisen, Geir.** Using home area network to extract information about the grid. NTNU
12. **Mendis, Handunneththi V. Kalpanie.** 5G enabling digitalization of the distribution grid. NTNU
13. **Moore, Richard.** Drones protecting the grid – UAS Norway Fagdag. SINTEF
14. **Sæle, Hanne.** CINELDI WP3 og 5 hadde felles workshop 12. juni. ENERGISINT
15. **Torsæter, Bendik Nybakk.** Workshop i CINELDI WP4: Mikronett i fremtidens distribusjonsnett. ENERGISINT
16. **Vefsnmo, Hanne.** CINELDI partnermøte: Utvikle scenarier for fremtidens distribusjonsnett. ENERGISINT

### Multimedia products

*sub-category:* Multimedia product *All publishing channels*

1. **Kjølle, Gerd Hovin.** CINELDI Prisen 2018 går til Hafslund Nett for "Nytt vern konsept". SINTEF Energi 2018. ENERGISINT
2. **Kjølle, Gerd Hovin.** CINELDI-dagene ble en suksess. SINTEF Energi Facebook 2018. ENERGISINT
3. **Kjølle, Gerd Hovin.** CINELDI-senterleder svært fornøyd med CINELDI dagene 2018. SINTEF Energi 2018. ENERGISINT
4. **Kjølle, Gerd Hovin.** GREETINGS FROM CINELDI CENTRE DIRECTOR GERD KJØLLE. SINTEF Energi Facebook 2018 ENERGISINT
5. **Kjølle, Gerd Hovin.** Hva får Lyse ut av å være med i CINELDI?. SINTEF Energi 2018. ENERGISINT
6. **Kjølle, Gerd Hovin.** Hvordan bidrar og deltar Skagerak Nett i CINELDI?. SINTEF Energi 2018. ENERGISINT
7. **Kjølle, Gerd Hovin.** Hvorfor er Skagerak Nett med i CINELDI ?. SINTEF Energi 2018. ENERGISINT

## Dissemination and communication 2017

### Journal Papers

1. **Zaferanlouei, Salman; Korpås, Magnus; Farahmand, Hossein; Vadlamudi, Vijay Venu,** *Integration of PEV and PV in Norway Using Multi-Period ACOPF - Case study,* IEEE Press 2017. ISBN 978-1-5090-4238-8.

### Published Conference Papers

1. **Zecchino, Antonio; Marinelli, Mattia; Træholt, Chresten; Korpås, Magnus,** *Guidelines for Distribution System Operators on Reactive Power Provision by Electric Vehicles in Low Voltage Grids,* Proceedings of Cired 2017, 2017

### Reports

1. **Jørgen S. Erdal,** *Stochastic Optimisation of Battery System Operation Strategy under different Utility Tariff Structures,* MSc thesis NTNU 2017
2. **Sigurd N. Bjarghov.** *Utilizing EV Batteries as a Flexible Resource at End-user Level,* MSc thesis NTNU 2017
3. **Vegard S. Bjerketvedt,** *Analysis of the Role of Energy Storage in Power Markets with Strategic Players,* MSc thesis. NTNU 2017

Read our digital annual
report for videos and more

**www.cineldi.no** → Annual report 2020

**CINELDI – Centre for intelligent electricity distribution**

CINELDI is a Centre for Environment-friendly Energy Research (FME). The objective of the FME-scheme is to establish time- limited research centres which conduct concentrated, focused and long-term research of high international calibre.

**CONTACTS:**


**Centre Director**
Gerd Kjølle - Gerd.Kjolle@sintef.no

**Administrative Coordinator**
Hanne Sæle - Hanne.Saele@sintef.no



CENTRE FOR ENVIRONMENT-FRIENDLY ENERGY RESEARCH
The Research Council of Norway