PACE

Pathway to a Competitive European Fuel Cell micro-CHP Market

REPORT

European Grid Service Markets Symposium 2020

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Contents

1 Executive summary

In its World Energy Outlook 2020, the International Energy Agency predicts that renewable energy will more than double by 2030 for achieving global net zero emissions by 2050. Renewable energy is about to replace a significant proportion of fossil fuels, which are expected to decline by more than 35% compared to 2019. Under the same scenario, it is expected that 58% of car and light truck sales will be electric- and fuel cell-driven by 2030. Such developments would represent a significant reduction in CO2 emissions, while at the same time easily stored carriers become replaced with inflexible and geographically as well as temporally unevenly available alternatives. Such a transformation puts the existing electrical energy system under stress and requires an increasing degree of capacity and flexibility, both short-term and seasonal, at regional, national and international levels.

From October 19 to 20 2020, 78 experts from industry, administration and academia discussed for the fourth time the effects, prospects and solutions of grid services for a transforming electricity system. With 15 scientific papers and 17 invited presentations, the symposium dealt with market developments, international cooperation, operation and enabling technologies, virtual power plants and flexibility providing technologies. The European perspective on energy transition and the flexibility roadmap were delved into along with national perspectives for the implementation of harmonized grid service markets, where their orientation and implementation also took account of national circumstances. Expanding flexibility products, digitalization, risk hedging and advanced market design were pointed out as ways of increasing market liquidity. Crucially as important, improved weather and load forecasting algorithms for reducing the balancing gap was covered. In his welcome speech, Stefan Oberholzer from the Swiss Federal Office of Energy (SFOE) emphasized the urgency of the transition of the energy system as well as the Swiss national situation and initiatives towards a sustainable energy future.

With Corona influencing the way people met, the symposium had to be transferred to a virtual space at short notice. The discussions between the participants took place in break-out sessions, where personal contacts could be made. Despite travel restrictions, a very diverse and valuable exchange between experts from industry, administration and science could ultimately still take place.

The fourth edition of the international Grid Service Markets symposium was supported by

- the Swiss Federal Office of Energy SFOE, www.bfe.admin.ch/bfe/en/home.html,
- the Fuel Cells and Hydrogen 2 Joint Undertaking under agreements No 700339,
- the Lucerne University of Applied Sciences and Arts UAS HSLU, www.HSLU.ch,
- European Fuel Cell Forum AG, www.EFCF.com,

and an international advisory board consisting of

- Davor Bošnjak, HEP,
- Prof. K. Andreas Friedrich, Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR),
- Prof. Nikos Hatziargyriou, National Technical University of Athens (NTUA),

- Prof. Christoph Imboden, Lucerne University,
- Dr. Ivana Kockar, University of Strathclyde,
- Thomas Kudela, Ørsted A/S,
- Prof. Carlo Alberto Nucci, Uni Bologna,
- Dr. Bastian Schwark, Swissgrid AG,
- Andreas Svendstrup-Bjerre, Vestas Wind Systems A/S,
- Sebastian Ziegler, 50 Hertz.

Presentations can be found at the GSM website (https://gridservicemarket.com/memberzone/). The proceedings of the scientific papers presented at the GSM are published in LORY, the Lucerne open repository (doi.org/10.5281/zenodo.4284324).

2 Impact

Like no other event in the domain of grid service markets, the GSM establishes a platform of exchange where industry and academia meet and exchange. The mix of invited presentations from industry and scientific paper presentations establishes a place where experts from different fields exchange on market developments and technological advancements, present and test their ideas, as the following statements from participants express:

"The GSM20 was a great opportunity for Energinet to present our proposed solution on local markets for flexibility and thoughts on procuring capacity reserves from variable renewables. The inputs from experts having different roles in the electricity markets and from different parts of the supple chain gave us valuable insight and helped us further develop our solutions." Thomas Dalgas Fechtenburg, Engineer, Flexibility and System Services, Energinet, DK.

"The GSM20 was a great forum for us to present latest developments in grid operation and flexibility management. I am happy to have been part of it." Michael Merz, PONTON GmbH.

With its international audience the GSM additionally provides a great opportunity for industry and academia to establish contacts with national experts:

"Regulation is driving harmonization of grid services markets across Europe; this is supported by the work of international bodies such as ENTSO-E. However, important differences remain between member states. Researchers and industry representatives therefore need good contacts with local representatives. An event such as the GSM helps us to establish such contacts and build relationships. This year, the GSM opened doors for us to experts in national markets relevant to our research, and directly impacted our ability to deliver our research activities within international projects such as PACE (https://pace-energy.eu/." Ben Bowler, Researcher, Lucerne University, CH.

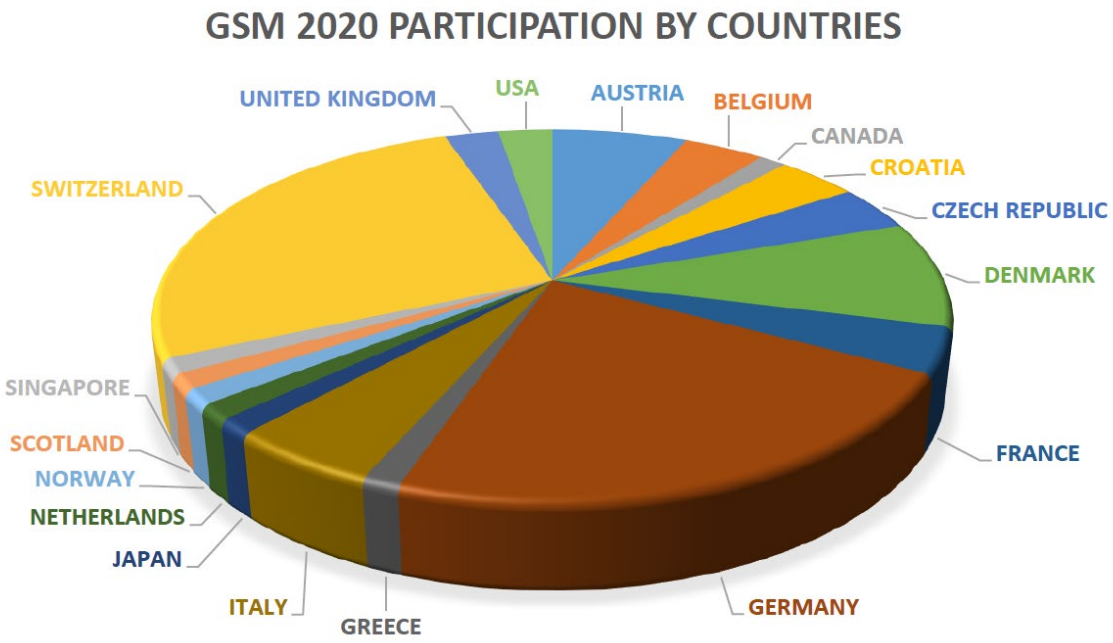
The GSM 2020 took place shortly before the European Fuel Cell Forum, EFCF, which especially motivated technology experts to get into contact with topics and specialists from the electricity markets, supporting the integration of advanced technologies into the overall energy system:

"I attended the GSM partially as a side event for the Fuel Cell Symposium. I very much appreciated the opportunity to follow the presentations and discussions in this to me less familiar field. With the emerge and scale-up of electrolysers and reversible systems the link between grid markets and fuel cell technologies becomes increasingly important. I hope the two symposiums will go together also in the future. I also very much appreciated the opportunity to participate remotely, enabling more attendance whilst avoiding travel and hope this opportunity will remain as an option also after lifting of the covid-restrictions." Kim Åström, CTO and co-founder, Convion Ltd, SF.

The GSM with its fourth implementation attracts presenters and representatives from many of the key players in the field, such as ETIP SNET (BE), Entso-E (BE), Tennet (NL), 50Hertz Transmission (D), Amprion (D), Consentec (D), Politecnico di Milano (I), Danish Intelligent Energy Alliance (DK), HEP (CR), University of Strathclyde (UK), Austrian Power Grid APG (A), TU Vienna (A), Austrian Institute of Technololgy AIT (A), IBM, Fraunhofer Institute (D), Forschung Burgenland (A), Delta-EE (UK), Next Kraftwerke (D), Energinet (DK), EPFL Swiss Federal Inst. of Technology Lausanne (CH), CEA Liten (F), DENA (D), German Aerospace Center (D) and TU Braunschweig (D). The interest shown by these high-profile representatives of the industry demonstrates the value that the GSM has already achieved as an information hub.

27 presentations are made available to the participants through the GSM repository (*https://gridservicemarket.com/memberzone/*). In addition, 13 scientific papers are published as proceedings in the Zenodo open repository (doi.org/10.5281/zenodo.4284324). 78 experts, mostly from Europe, attended the event (see the next section).

3 Participants



78 experts from 18 countries (14 European countries) participated in the event, where Switzerland (18) and Germany (17) were the countries with the most participants. The target of the int. advisory board to exceed 100 participants could not be met, which is understood to be due to the uncertain Corona situation and travelling restrictions – the event was planned to take place physically until one week before, when an official ban prevented an on-site event.

35% of the participants came from academia (2019: 54%), 29% from industry (2019: 24%), 24% from TSOs/DSOs (2019: 24%) and 12% from administration and associations (2019: 11%).

4 Presentations

The following sections list the abstracts of the presentations given.

4.1 G02 Market developments and international collaborations I

Session chair: Christoph Imboden, Lucerne University, Switzerland

(G0201) EU energy transition – the ETIP SNET roadmap for flexibility
Active demand, flexible generation, conversion and storage of energy carriers, network technologies

Guido Guida, ETIP SNET and Entso-E, Belgium

The ETIP SNET R&I roadmap 2020-2030 is based on a consolidated and balanced stakeholders' view for the future R&I needs of the Integrated Energy System with electricity as its backbone. It considers the encompassing interaction among the different energy vectors (i.e. electricity, gas, heating and cooling, transport, water, communication etc.), addressing the flexibility needs and the related conversion and storage technologies and solutions towards integration and decarbonisation.

(G0202) DSO TSO cooperation: field report from the GOPACS project

Klaas Hommes, Tennet, Nederland

GOPACS - Grid Operators Platform for Congestion Solutions - is a unique cooperation between Dutch TSO and DSO's to solve congestions in the electricity grid. GOPACS is an important step to mitigate capacity shortages in the electricity grid(congestion) and thus contribute to keeping the Dutch grid reliable and affordable.
The energy transition and economic growth require capacity increase of the electricity grid. The grid operators are working hard on increasing this electricity grid capacity to be able to meet the growing demand. However, this cannot be realised overnight. Making use of flexible power from the market can contribute to solving (expected) congestion in the electricity grid. This is where the new GOPACS platform comes in.

4.2 G03 Market developments and international collaborations II

Session chair: Bastian Schwark, Swissgrid, Switzerland

(G0301) Renewables and their financial risk landscape

Thomas Kammann, Energy Risk Solutions, Switzerland

Financing renewable investments is often highly leveraged and thus depending on predictable cash flows. Cash flows are a product of energy price and produced volume. In the past price was a quite predictable component and volume could be hedged with weather derivatives. This stable constellation granted also investment security for grid infrastructure. Meanwhile on the price side mandatory auctioning systems, cannibalization effects and currently overloaded grids present a challenge for renewable investors whom however are required to reach ambitious European targets. A more stringent alignment of generation and grid investments is absolutely necessary.

(G0302) Future-proofing the EU energy system towards 2030

Johannes Henkel, 50Hertz Transmission, Germany

In the presentation, a new amendment for market design is presented. The development is based on market simulations for 2030. The simulation also allows for investigating the impacts of this new market design amendment.

(G0303) Update on the implementation of the European balancing platforms

David Steber, Amprion, Germany

The presentation provides a detailed view of the target model for European balancing markets. In particular, it focuses on the different balancing processes and briefly describes the legal framework of the European balancing target model. The presentation gives an overview of the implementation of the EB Regulation with regard to the European Balancing Platforms and report on the progress made

concerning the integration of balancing markets in Europe.

(G0304) Loop-flows, redispatch and bidding-zone splits: What's the part of German Energiewende in it?

Thaddäus Kreisig, Consentec, Germany

Germanys Energiewende increases necessary electricity transmission in the power system, which leads to additional loop flows through neighboring bidding zones. Loop flows also effect market-based and physical flows on neighboring interconnectors, thus, raising the question of which flows should be allocated. European regulation addresses the conflict of priority access of RES electricity on the one hand and non-discrimination of international trade on the other hand within the Clean Energy Package (CEP). Mr. Kreisig will discuss instruments of the CEP relevant in this context, such as minRAM, cross-border redispatch and bidding zone configuration.

4.3 G05 Market developments and international collaborations III

Session chair: Thomas Kudela, Denmark

(G0501) Balancing markets and DERs in the Italian regulatory framework: Insights on the UVAM case study

Arianna Rossi (1), F. Bovera (1), G. Rancilio (1), D. Falabretti (1), A. Galliani (2), M. Merlo (1); (1) Dept. of Energy, Politecnico di Milano; (2) ARERA, Italy

With the progressive decarbonization, a large part of thermoelectric units risks to be out of the market due to their high marginal costs and environmental impact; hence new flexible resources are required. Moreover, the unpredictability of renewables (mainly wind and solar based) and lack of observability of distributed generators are causing an increasing volume of capacity reserve needs and of the amount of energy moved for balancing purposes

(G0502) Flexibility aggregation for ancillary services in the Czech Republic

Petr Rokůsek, Stanislav Chvala, Nanoenergies, Czechia.

Nano Energies together with Czech TSO, Czech Technical University and municipality of Prague are building a framework for flexibility aggregation for ancillary services in the Czech Republic. The concept is tested on the demand-response type of flexibility providers, both industrial and public.

(G0503) Implementing better framework conditions for new players in the flexibility market

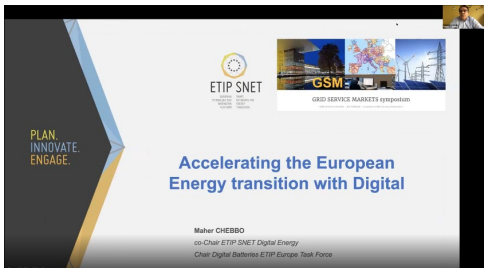
Helle Juhler-Verdoner; Danish Intelligent Energy Alliance, Denmark

Implementing the EU Clean Energy Package (CEP) enhances the role of the independent aggregator. In the Danish context we have developed models for aggregators to improve framework conditions for commercial players including the independent aggregators, beginning before the CEP. The CEP is speeding up implementation of the Danish models which also includes other elements that will influence the value stream of demand side flexibility in the flexibility business case. Hence, the presentation will focus on implementing the independent aggregator in the Danish market models, but also address impact of Danish development of time-of-use tariffs and development of local flexibility markets.

4.4 G06 Operation and enabling technologies I

Session chair: Davor Bošnjak

(G0601) Accelerating the European energy transition with digital



Maher Chebbo; ETIP SNET, Belgium

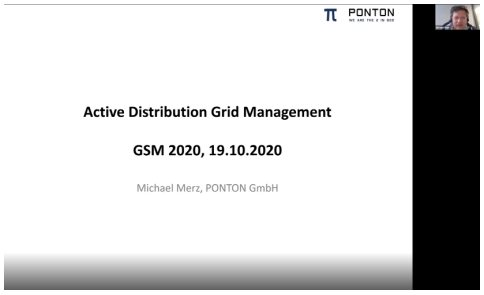
- Role of the Digitalization in accelerating the Energy transition roadmap towards a decarbonized EU 2050
- Digital technologies required and use cases across the energy value chain, generation, grid, retail and customers.
- Role of Digital platforms in the democratic, simple & usable access to Energy for all customers.

(G0602) Impacts of peer-to-peer trading on wind energy curtailment in constrained distribution networks

Ivana Kockar, Mark Jenkins; University of Strathclyde, United Kingdom

The work presented here demonstrates the need for management strategies which analyse P2P trading in a holistic manner that include 'vulnerable' legacy DGs under a PoA agreement. An extension to the standard full AC OPF is used, which includes a set of inequality constraints to enforce bilateral contracts (the mechanisms of which the P2P trades are modelled) alongside a pseudo multivariate piecewise function that enforces LIFO curtailment principles. Simulations are carried out to highlight the potential for significant voltage congestion in low voltage networks, and thus additional levels of curtailments, when exchanges from P2P energy trading are allowed without conventional intermediaries (i.e. network operator). Following this, a new Technical Best - LIFO tool was developed that uses ANM solutions to facilitate P2P trades and decreased levels of DG curtailment simultaneously.

(G0603) Active distribution grid management: A decentralized approach for the management of flexibility options



Michael Merz; PONTON, Germany

Facing the energy transition, decentralized renewable sources of energy as well as decentralized consumers can lead to congestion situations both horizontally at the transmission grid level and vertically within the areas of distribution grids. Grid-supportive flexibility is a solution to mitigate such congestions. In order to roll-out a standardized process for congestion management, Austrian DSOs (distribution system operators) conducted the project Active Distribution Grid Management (ADGM) in early 2020 in order to test if the existing data communication infrastructure can be re-used to offer and activate flexibility, to simulate typical congestion scenarios, and finally to visualize the impact on involved asset managers and grid operators. This paper presents the ADGM project results and how it is applied to a distribution grid congestion scenario. It specifically shows how a distributed flexibility management process is implemented.

(G0604) Simple and efficient implementation of local energy markets

Thomas Walter; Easy Smart Grid, Germany

Short Energy flexibility of prosumer equipment like CHP, heat pumps and electric vehicles can provide low cost storage (virtual batteries) to compensate for growing RE volatility and reduce grid congestion. Combining the well-known principles of the Walrasian Auctioneer (Economics) and Georg Kirchhoff (Physics) enables dynamic tariffs that are both economically efficient and reflect grid needs. We will report on first results of a pilot project and other areas of application.

4.5 G07 Operation and enabling technologies II

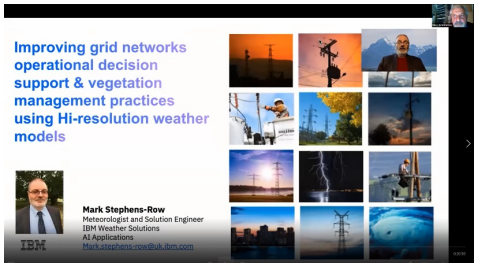
Session chair: Nikos Hatziargyriou

(G0701) Options for the implementation of fast control reserves in the Continental European power system

Alexander Stimmer, Marin Lenz, Manuel Froschauer, M. Leonhardt (1), W. Gawlik, C. Alacs, C. Corinaldesi, G. Lettner (2), A. Anta (3), K. Oberhauser (4); (1) Austrian Power Grid; (2) Technical University Vienna; (3) Austrian Institute of Technololgy; (4) Verbund Hydro Power, Austria

This paper investigates options for the implementation of fast control reserves in the Continental European (CE) power system, which are being developed and examined within the frame of the R&I project Advanced Balancing Services for Transmission System Operators (ABS4TSO). In the first part of this paper, the fast control reserve concepts FCR+, Enhanced Frequency Response (EFR), Synthetic Inertia (SI) and Fast Active Power Injection (FAPI) are described. Furthermore, their impact on the frequency stability is evaluated based on a simulation model of the CE power system, considering a reference incident (imbalance) equal to 3 GW as defined in the System Operation Guideline. In the second part of this paper, the fast control reserve concepts are evaluated with regard to market and regulatory aspects. The pros and cons of the different implementation options are presented and a possible implementation roadmap is shown, based on current observations, future scenarios and simulation results of the CE power system.

(G0702) Improving grid networks operational decision support & vegetation management practices using Hi-resolution weather models



Mark Stephens-Row; The Weather Company, an IBM business, United Kingdom.

IBM/The Weather Company has developed a new hi-resolution forecast model based on the MPAS gridded forecast model to support improved short-range forecasting. This now forms one of the inputs to the Forecast On Demand (FOD) multiple weather model prediction system that drives an operational decision support forecast for Network operators warning of localized weather-related power outages. By matching past severe weather to historical network outages, the system is able to precisely predict when and where outages may occur and using Artificial Learning (AI) techniques offer guidance on the allocation of resources ahead of and during severe weather events. Furthermore, using the Vegetation Management predictions, those outages related to the impact from trees touching or falling on to power lines

can be accurately modelled. Using case studies from around the world, it can be shown that such services offer significant advantages over mobilisations based solely on national or regional severe weather warnings.

4.6 G08 VPP and advanced technologies I

Session chair: Ivana Kockar

(G0801) The European market monitor for demand side flexibility

Phillipa Hardy; Delta-EE, Scotland

The European Market Monitor for Demand Side Flexibility, published in 2019 in association with SmartEn, provides a holistic and independent view of the progress of Demand Side Flexibility across 21 European markets. The findings from our primary research in each market provides a high-level summary of the current market activity. This will enable industry to benchmark disparate markets against each other and track their progress on demand side flexibility.

(G0802) How virtual power plants enable renewable grid integration

Aleksandra Radwanska, Felix Jedamzik, Felix Lober, Jan Aengenvoort; Next Kraftwerke, Germany

The energy sector demands a new way for managing the growing number of distributed power producers of renewable energy. For this purpose, Virtual Power Plants (VPP) and Power-to-Gas (P2G) are two important technologies to ensure the stability of the power grid. On one hand, VPPs can help controlling and monitoring distributed assets to ensure the stabilization of the grid. On the other hand, P2G plants may contribute to enhance the power system's flexibility, to balance generation and consumption in real time. This paper provides a case study that outlines the possibilities and complexity of monitoring and controlling a P2G plant through a VPP. Greenpeace Energy runs the project in collaboration with Next Kraftwerke GmbH and the municipal utility Stadtwerke Haßfurt GmbH of the city of Haßfurt, Germany.

(G0803) Trade with local flexibility to resolve transmission bottlenecks in Denmark

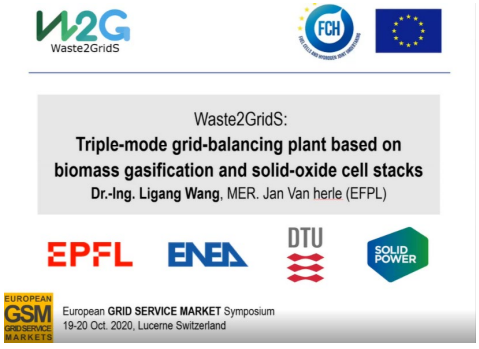
Thomas Dalgas Rasmussen; Energinet, Denmark

The Danish TSO Energinet must be able to handle the expansion of new renewable capacity and electrification of consumption. In 2019 the wind-share of the share of the electricity consumption must be 100 %. RE on market conditions makes it difficult to predict and plan the development of the energy system. Currently, grid efficient internal congestion management. Energinet is working towards enabling trade with local flexibility to enable short term congestion management to resolve local bottlenecks and give longer term incentives to invest in controllability and optimal grid locations for new production and consumption units. The concept for trade with local flexibility in Denmark is currently being tested in a pilot project.

4.7 G09 VPP and advanced technologies II

Session chair: Carlo Alberto Nucci

(G0901) Converting wastes efficiently and flexibly for grid-balancing services and sector coupling



Ligang Wang (1), Mar Perez-Fortes (1), Yi Zong (2), Vincenzo Motola (3), Stefan Diethelm (4), Alessandro Agostini (3), Olivier Bucheli (4), Jan Van Herle (1); (1) EPFL Swiss Federal Inst. of Technology Lausanne, Switzerland; (2) Technical Uni of Denmark, Denmark; (3) ENEA, Italy; (4) SOLIDpower, Italy

Biomass-to-electricity or -chemical via power-to-x can be potential flexibility means for future electrical grid with high penetration of variable renewable power in future. However, biomass-to-electricity will not be dispatched frequently due to the high operating costs. The economic benefit of biomass-to-energy might also be limited by low annual operating hours. This issue can be addressed by integrating biomass-to-electricity and -chemical in one single plant with the solid-oxide cell stack, which can work either as fuel cell or electrolyzer with the same stack. Therefore, a triple-mode grid-balancing plant with flexible switch among power generation, power storage and power neutral (with chemical production) modes is proposed to realize high annual operating hours. Its economic potential relies on grid-flexibility needs, biomass supply, and plant design and operation.

(G0902) SOFC's, fuel flexible, easy to modulate, reversible and future proof!

Jan-Willem Tolkamp; SOLIDpower, Italy.

Buildings account for 30% of total carbon emissions. Electrification is thought to be one of the best ways to tackle this, but will we have enough renewable power to pull this off? With about 1000 hours of sun and 3000 to 4000 hours of wind we can only cover half of year, renewable power needs to come from storage. Batteries are a partial solution, but Hydrogen is likely to be the best answers to this large seasonal challenge and can be stored in our already available, slightly adapted, gas-infrastructure. To make this all happen, we will need the most efficient conversion technologies available. Solid Oxide Fuel cells will play a major role in this cycle of renewable storage in Hydrogen, and turning it back to power again the moment we need it. At the same time this will allow power grid-operators to manage congestion and imbalance issues, whilst gas-grid operators will keep their high value to society and their jobs. In this presentation all benefits of SOFC technology will be elaborated with practical examples taken from the challenges described above.

(G0903) Opportunities and challenges for water electrolysers to participate in grid services

Stéphanie Crevon, Valérie Seguin; CEA Liten, France

This study conducted in the scope of European project QualyGridS analyses the potential economic opportunity for Water Electrolyzers to participate in grid services market. A business case located in Germany considering the possibility to participate in 2 grid services has been modelled and analyzed. A study of potential future evolutions has underlined some important uncertainties WE have to face regarding the interest of this participation.

4.8 G11 Advanced technologies providing flexibility

Session chair: Andreas Svendstrup-Bjerre

(G1101) Perspectives for flexibility in the German electricity system

Stefan Mischinger; DENA, Germany

Flexibility is a key to reach the climate goals. The presentation will give an overview why Energy Transition needs flexibility, where flexibility potentials in the electricity grid arise due to Energy Transition, why grid-friendly flexibility use makes economic sense and where the regulatory framework in Germany need to be adapted in order to motivate grid-friendly flexibility use.

(G1102) Water electrolysers for electricity grid services – dynamics, advantages and disadvantages of different types of electrolysers

K. Andreas Friedrich, Regine Reissner, Syed Asif Ansar; German Aerospace Center, Instit. of Engineering Thermodynamics, Electrochemical Energy Technology, Germany

Grid services as supplied to TSO (transmission system operators) and DSO (distribution system operators) were investigated in the project QualyGridS and transferred into testing protocols for electrolysers performing grid services. In this application the electrolyser offers its operational flexibility as a power consuming load to achieve improved revenues. The properties of the different electrolyser technologies are reviewed in this contribution. Modern alkaline electrolysers show their suitability even for fast grid services. They as well as PEM electrolysers need an update in their control system to adapt them to grid services requirements. Based on the lessons learned from QualyGridS this contribution will discuss also the suitability of high temperature SOEC technology for grid service based on present knowledge and technology.

(G1103) Frequency control by run-of-river hydropower: a case study on energetic and economic potentials

Bastian Hase (1), Christian Seidel (2); (1) Technische Universität Braunschweig, Germany; (2) AG Regenerative Energien, Institut für Statik, Germany

We developed an operation strategy that enables run-of-river hydroelectric (ROR) plants to deliver both constant load and balancing energy at the same time. Therefore we made use of the fact that upstream reservoir levels of most plants can, to a certain extent, be flexible, without making further impacts. This reveals significant short term storage potentials. This operation strategy was successfully validated by simulations on a projected research power plant in northern Germany. When upscaling the balancing energy potentials of this research plant to the whole German non-swelling ROR-capacities, considerable amounts of the yearly national demand for balancing energy can theoretically be covered. These potentials vary with the type of balancing energy produced and the chose lead value for the upstream water level within the minimum and the maximum possible level.

(G1104) Hydro storage as enabler of energy transition

Peter Bauhofer, Michael Zoglauer; TIWAG-Tiroler Wasserkraft, Austria

Extreme high shares of highly intermittent generation of wind-power and PV will disproportionately increase Austria's flexibility needs in all timeframes up to seasonal dimensions, when system stability and security of supply shall be kept at today's level. The given study analyses residual load parameters of Austria's electricity system up to 2050, estimates flexibility demand and discusses the central role of highly efficient hydropower to meet these challenges. Further on it discusses how reliable imported flexibility could be, when neighbouring countries implement thermal drop off. With it's ambitious decarbonisation targets Austria develops a field test for flexibility needs at times of highly intermittent RESE shares. Basic conclusions on residual load development as well as the role of hydropower to match ramping needs may be generalised for other regions. The ability of modern hydropower designs in the Alps to provide also seasonal flexibility is underlined.

(G1105) Opportunities for CHP plants providing flexibility

Filippo Bovera; Politecnico di Milano, Dipartimento di Energia, Italy

Assessing the economic opportunities coming from the Ancillary Service Market (ASM) participation for Distributed Energy Resources (DERs) is a key aspect to orientate private investments in an economically and environmentally sustainable way within the future energy framework. The presentation will highlight the influence that the Italian dispatching reform currently in place could have on the sizing and operation phases of a Combined Cooling, Heat and Power plant in an industrial context. It will be shown how operators can give a value to flexibility services through market data analysis and which is the technical and economic impact on power plants operations.

(G1106) The key role of distributed generation in system and grids efficiency

Alexandra Tudoroiu, COGEN Europe

The energy system transformation in Europe relies on energy efficiency increase, system wide electrification, green molecules, and an increased share of variable renewables, requiring for new flexibility means along the whole electricity supply chain. Thereby, heat plays a key role in the energy sector. A simple exchange of heat by electricity would be too much a challenge for the existing power system. Managing peak demand by maximising the use of the existing gas infrastructure, together with highest efficiency generation, and multi-energy system integration is a reasonable solution. There, cogeneration has a key role to play, as it links electricity, heat and gas, improves system efficiency, minimises waste, boosts flexibility, lowers energy systems cost, brings value at the local level and reduces investment in the distribution grid.

5 Panel discussion

The panel discussed the future position of hydrogen technologies in the grid service markets domain. The panel was moderated by Carlo Alberto Nucci, Uni Bologna. Panelists were Phillipa Hardy (DELTA-EE), Jan Aengenvoort (Next Kraftwerke), Thomas Dalgas Rasmussen (Energinet), Jan-Willem Tolkamp (SOLIDpower).

It started with the perspective of Gigawatt scale sustainable hydrogen technologies, which is expected for the next 10 to 20 years to be implemented, mainly driven by the market demand for high volumes of low-cost sustainable hydrogen.

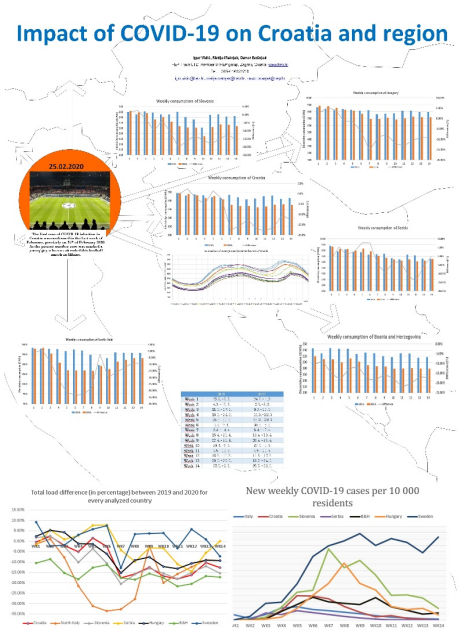
Furthermore, the impact of COVID-19 on flexibility and resilience demand was discussed, which is mainly seen in the distribution grid. Though a ramp-up of sales in mCHPs in the PACE project could not be seen thus far, an increased demand for more resilience can be expected in countries with a week grid infrastructure. In some places, due to higher uncertainties, an increase in traded flexibility volumes could be seen.

For the integration of distributed flexible power devices into flexibility markets, the big issue is the monitoring and control connection of the devices. Compared to the ICT cost of centralized units, connecting decentralized units is far less cost efficient. At the same time, for the time being the big central flexible power units provide sufficient volumes of flexibility, such that the market for decentralized flexibility cannot easily take off.

6 Poster presentations

The following sections list the abstracts of the posters presented.

(G0504) Impact of COVID-19 on the demand curves of Croatia and region

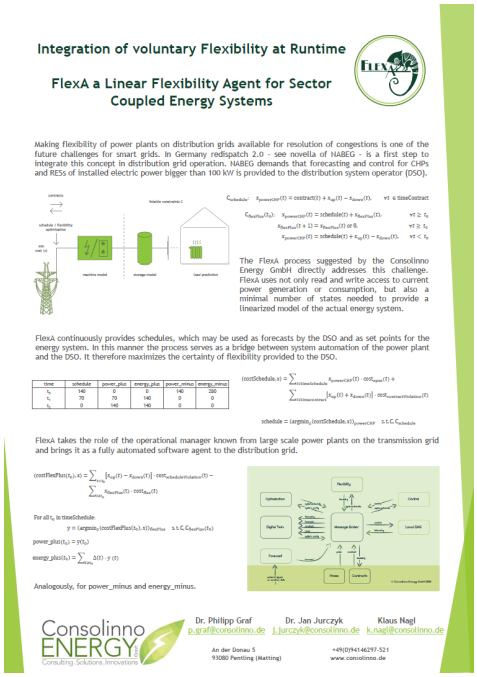


Igor Vidić, Matija Melnjak, Davor Bošnjak; HEP Trade, Croatia

Electrical energy plays a vital role in our everyday lives. Modern lives are unimaginable without a reliable and secure power supply. As electricity generation and consumption have to be always in a balance, the task of planning an accurate day-ahead electricity consumption and generation is of the utmost importance. Electricity consumption forecast is a challenging task, especially in countries with a poor industrial development where the households take the majority of share in the total load. This paper analyzes some of these cases with very variable electricity load, due to volatile household behavior, on cases of Croatia and countries in the region. Additionally, results are compared with the electricity load of North Italy whose economy and industry are far better developed. Electricity consumption is an ever changing curve that is very sensitive to a variety of external factors. Thus, even minor change can drastically change its shape and volume. The main part of this paper focuses on the analysis of the COVID-19 impact on the demand curves of Croatia, but a brief overview of the countries in the region was presented as well. A variety of restrictive, governmental, and epidemiological measures have been gradually introduced and this paper attempts to detect how they affected the total load and the shape of the demand curve in each analyzed country. Historical electricity load data has been gathered for Croatia and five other neighboring countries and the analysis of COVID-19 impact has been carried out. External conditions such as weather and social impact have been taken into account for the analysis in the case of Croatia, but since the category of consumers that contribute in total load (industry, households, entrepreneurship, etc.) were unfortunately unavailable, it is hard to find out whose consumption habits have been changed the most during the

lockdown. Some unpredictable, stochastic parameters influenced the demand curve, hence, sometimes it's behavior cannot be easily explained. Results have shown the severe impact of the COVID-19 on the demand curves of every analyzed country. The highest electricity load decrease, in all of the examined countries, has been during the lockdown measures. Moreover, analysis shows that the regions with more significant industry share in total load and more developed economies are starting to recover faster (e.g., North Italy) in terms of electricity load, while the countries with a lower share of industry (in the total load) struggle with such a recovery. The results of this paper highlight the sensitivity of electricity consumption, the significance of COVID-19, and any future possible pandemics in electricity consumption forecast as well as the correlation between countries' economic development and their electricity consumption.

(G0505) Integration of voluntary flexibility at runtime



Philipp Graf, Jan Jurczyk, Klaus Nagl; Consolinno Energy, Germany

Making flexibility of power plants on distribution grids available for resolution of congestions is one of the future challenges for smart grids. There is a development of understanding flexibility as a prognosis-based quantity ([1] 4.2). In Germany redispatch 2.0 (see novella of NABEG [2]) is a first step to integrate this concept in distribution grid operation. NABEG demands that forecasting and control for CHPs (KWK-Anlagen) and RESs (EEG-Anlagen) of installed electric power bigger than 100 kW is provided to the distribution system operator (DSO). In this non voluntary sense, the knowledge about future flexibility is of highly statistical nature. This seems to be a controllable problem with big powerplant portfolios. Nevertheless, flexibility on distribution grids is of highly local nature. In many cases only a small number of power plants can provide flexibility and the accuracy of forecasted values underlies a higher uncertainty.

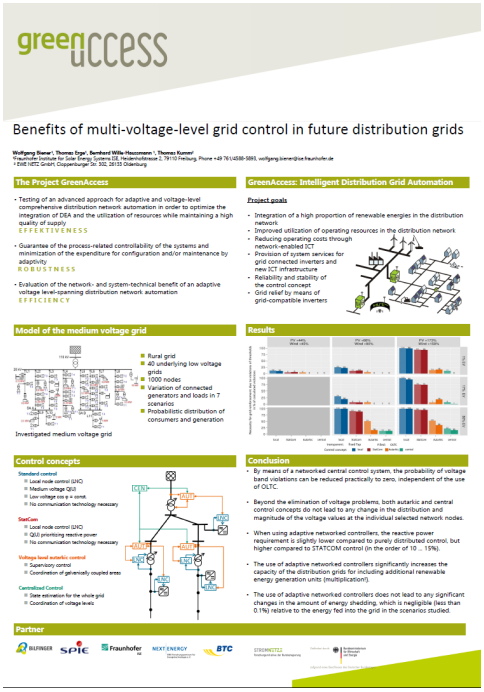
The FlexA process suggested by the Consolinno Energy GmbH directly addresses this challenge. FlexA uses not only read and write access to current power

generation or consumption, but also a minimal number of states needed to provide a linearized model of the actual energy system. It continuously provides schedules, which may be used as forecasts by the DSO and as set points for the energy system. In this manner the process serves as a bridge between system automation of the power plant and the DSO. It therefore maximizes the certainty of flexibility provided to the DSO. FlexA takes the role of the operational manager (Einsatzverantwortlicher) known from large scale power plants on the transmission grid and brings it as a fully automated software agent to the distribution grid.

FlexA models sector coupled energy systems based on electric, thermal and fuel energy flows connected to controllable and statistical prosumers and storage systems. There are two ways to integrate flexibility in the FlexA runtime process: Contracts and price signals. Runtime contracts ensure that FlexA keeps schedules stable in near future. This mechanism considers that energy suppliers may only sell energy at certain times of the day and therefore must assume schedules being stable in the meantime. External contracts allow partners to post preferred schedules and price signals allow for example spot price optimization or own consumption maximization.

FlexA continuously provides flexibility tables for external partners containing schedules together with positive and negative power and energy, which describe how much the system may deviate from the schedule at each time and for how long. In this way voluntary flexibility can be offered on platforms ([1] 4.2.2, [3] 1.2.2, [4] p.38/39). As a service for DSOs and TSOs these platforms aggregate flexibility and call the demands from system operators. Such calls are integrated by FlexA as external contracts. FlexA enables a fully automated communication between system operators and platforms. A similar approach could be realized with energy suppliers trading flexibility intra-day.

(G0703) Benefits of multi-voltage-level grid control in future distribution grids



Wolfgang Biener (1), Thomas Erge (1), Thomas Kumm (2), Bernhard Wille-Haussmann (1); (1) Fraunhofer Institute for Solar Energy Systems ISE, Germany; (2) EWE NETZ, Germany

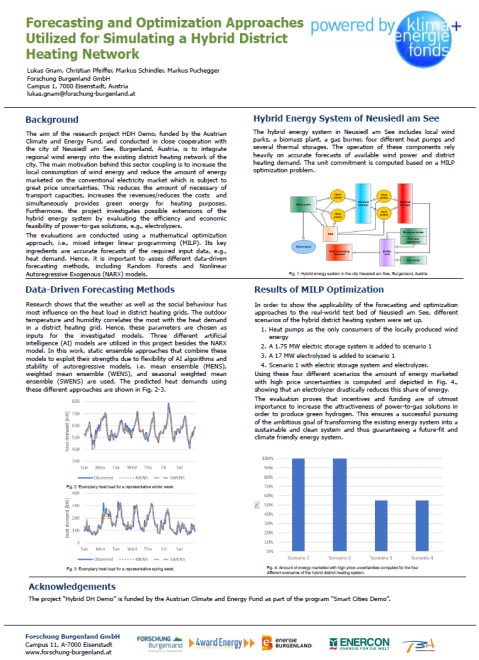
Operators of distribution grids will be confronted with new challenges caused by a high share of distributed fluctuating generators (PV, wind) together with new load profiles of a fleet of electric vehicles (EV), decentralized storage systems or electricity-heat-converters (like heat-pumps or direct heaters). Conventional grid reinforcement is an expensive and inflexible way to handle upcoming grid problems like the violation of voltage limits or the thermal overloading of operating equipment. By controlling flexible components (like on-load tap changers or reactive power generation from inverters) grid operators can counteract violations of operational limits.

A grid simulation study has been performed to compare benefits of intelligent multi-voltage-level grid control with single-voltage-level control solutions and conventional grid control methods. The starting point for this work was a number of scenarios for the future grid penetration by PV, wind and EV. Representative type grids consisting of interconnected grid segments for rural and municipal distribution grids were modelled within a probabilistic load flow calculation framework. To quantify the probability of voltage violations or thermal overload situations, a probabilistic assignment of grid components (PV, wind, EV) to grid nodes was implemented. Four grid control approaches have been studied by use of the simulation, representing different distributed and centralized control methods.

The results of the investigation show the benefits of multi-voltage-level grid control for distribution grids with a high share of distributed wind, PV and EV. While conventional grid operation solutions might be able to counteract local voltage problems, a combined control algorithm for the LV and MV grid segments is able to prevent the violation of given voltage and current limits in many cases quite effectively. The effectiveness of using transformers with variable on-load tap changers (OLTC) might improve significantly if communication based multi-voltage-level grid control concepts are applied. Overloading of cables resulting

from solving local voltage maintenance problems by means of reactive power injection can be avoided. Multi-voltage-level grid control avoids or delays grid extension and increases grid capacity towards the installation of additional PV, wind or EV-charging units.

(G0704) Forecasting and optimization approaches utilized for simulating a hybrid district heating network


Forecasting and Optimization Approaches Utilized for Simulating a Hybrid District Heating Network

powered by klima+ energie fonds

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Background

The aim of the research project HDH Demo, funded by the Austrian Climate and Energy Fund, and conducted in close cooperation with the city of Neusiedl am See, Burgenland, Austria, is to integrate regional wind energy into the existing district heating network of the city. The main motivation behind this sector coupling is to increase the local consumption of wind energy and reduce the amount of energy marketed on the conventional electricity market which is subject to great price uncertainties. This reduces the amount of necessary of transport capacities, increases the revenues/reduces the costs and simultaneously provides green energy for heating purposes. Furthermore, the project investigates possible extensions of the hybrid energy system by evaluating the efficiency and economic feasibility of power-to-gas solutions, e.g., electrolyzers.

The evaluations are conducted using a mathematical optimization approach, i.e., mixed integer linear programming (MILP). Its key ingredients are accurate forecasts of the required input data, e.g., heat demand. Hence, it is important to asses different data-driven forecasting methods, including Random Forests and Nonlinear Autoregressive Exogenous (NARX) models.

Hybrid Energy System of Neusiedl am See

The hybrid energy system in Neusiedl am See includes local wind parks, a biomass plant, a gas burner, four different heat pumps and several thermal storages. The operation of these components rely heavily on accurate forecasts of available wind power and district heating demand. The unit commitment is computed based on a MILP optimization problem.

Data-Driven Forecasting Methods

Research shows that the weather as well as the social behaviour has most influence on the heat load in district heating grids. The outdoor temperature and humidity correlates the most with the heat demand in a district heating grid. Hence, these parameters are chosen as inputs for the investigated models. Three different artificial intelligence (AI) models are utilized in this project besides the NARX model. In this work, static ensemble approaches that combine these models to exploit their strengths due to flexibility of AI algorithms and stability of autoregressive models, i.e., mean ensemble (MENS), weighted mean ensemble (WENS), and seasonal weighted mean ensemble (SWENS) are used. The predicted heat demands using these different approaches are shown in Fig. 2-3.

Results of MILP Optimization

In order to show the applicability of the forecasting and optimization approaches to the real-world test bed of Neusiedl am See, different scenarios of the hybrid district heating system were set up.

1. Heat pumps as the only consumers of the locally produced wind energy
2. A 1.75 MW electric storage system is added to scenario 1
3. A 17 MW electrolyzed is added to scenario 1
4. Scenario 1 with electric storage system and electrolyzer.

Using these four different scenarios the amount of energy marketed with high price uncertainties is computed and depicted in Fig. 4., showing that an electrolyzer drastically reduces this share of energy.

The evaluation proves that incentives and funding are of utmost importance to increase the attractiveness of power-to-gas solutions in order to produce green hydrogen. This ensures a successful pursuing of the ambitious goal of transforming the existing energy system into a sustainable and clean system and thus guaranteeing a future-fit and climate friendly energy system.

Acknowledgements

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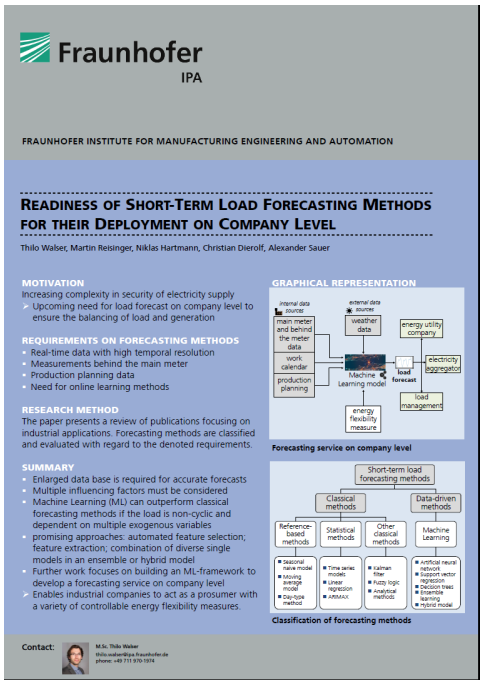
The historically grown centralized energy system is undergoing massive changes due to the transformation from centralized energy production with large assets (e.g. fossil-thermal power plants) towards a sustainable, clean and decentralized energy system. This transformation is based on the inclusion of renewable energy sources (RESs) (e.g., wind and solar) into the classical systems. However, as the energy production stemming from RESs is extremely volatile and thus challenging to predict, new approaches have to be found in order to guarantee a successful integration of RESs into the existing infrastructure.

In the Austrian state of Burgenland approximately 1,000 MW of wind capacity is available. As already mentioned above, the high volatility of wind energy together with forecast uncertainties hinders the optimal integration of this RES into the existing energy system. Furthermore, the successful deployment of wind turbines was based on an attractive but timely limited subsidy scheme with a fixed feed-in tariff. As these subsidies now come to an end for more and more wind turbines and future support systems will rely on market premiums and tendering models, new approaches and business models have to be devised in order to sustain the rapid transformation of the classical energy systems.

In the research project HDH Demo in close cooperation with the city of Neusiedl am See, Burgenland, Austria, the aim is to integrate wind energy into the existing district heating grid of the city. This is realized by utilizing power-to-heat technologies, e.g., heat pumps. However, an economically feasible and successful integration is

based on accurate forecasts for both, wind production and district heating demand as well as the actual energy prices.
Therefore, this work evaluates the applied data-driven forecasting methods. In particular, ensemble approaches that combine autoregressive models with artificial intelligent techniques are used to exploit the strengths of different methods (e.g. stability, flexibility). To compare the model performance, an overview on the accuracy and efficiency of the ensembles by using appropriate score metrics (e.g. RMSE, MAPE, R^2) is given. Furthermore, a mixed integer linear optimization model is presented for computing optimized schedules for the different components (e.g., heat pumps, energy storage units, biomass boiler) of the district heating grid. Together, these two approaches, forecasting and optimization, are used to investigate and evaluate different business models, which help to ensure the future market integration of wind production.

(G0705) Readiness of short-term load forecasting methods for their deployment on company level



Thilo Walser (1), Martin Reisinger (1), Niklas Hartmann (2), Christian Dierolf

Short-term load forecasting (STLF) has been playing a key role in the electricity sector for several decades, due to the need for aligning energy generation with the demand and the financial risk connected with forecasting errors. Following the top-down approach, forecasts are calculated for aggregated load profiles, meaning the sum of singular loads from consumers belonging to a balancing group. Due to the emerging flexible loads, there is an increasing relevance for STLF of individual factories. These load profiles are typically more stochastic compared to aggregated ones, which imposes new requirements to forecasting methods and tools with a bottom-up approach. The increasing digitalization in industry with enhanced data availability as well as smart metering are enablers for improved load forecasts. There is a need for STLF tools processing live data with a high temporal resolution in the minute range. Furthermore, behin-the-meter (BTM) data from various sources like submetering and production planning data should be integrated in the models. In this case, STLF is becoming a big data

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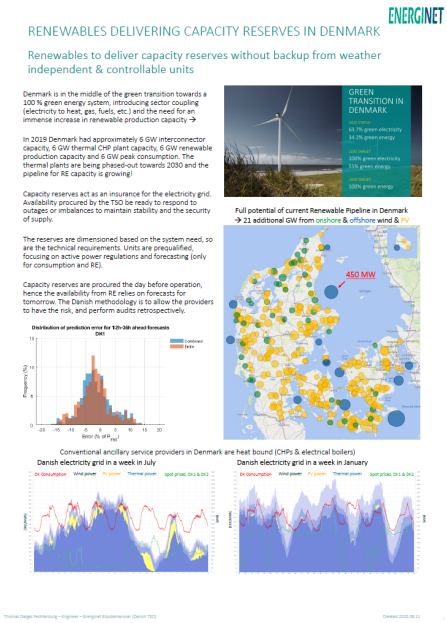
problem so that machine learning (ML) methods are required. The research project “GaIN” investigates the improvement of the STLF quality of an energy utility using BTM data and innovative ML models. This paper describes the project scope, proposes a detailed definition for a benchmark and evaluates the readiness of existing STLF methods to fulfil the described requirements as a reviewing paper.
The review highlights that recent STLF investigations focus on ML methods. Especially hybrid models gain more and more importance. ML can outperform classical methods in terms of automation degree and forecasting accuracy. Nevertheless, the potential for improving forecasting accuracy by the use of ML models depends on the underlying data and the types of input variables. The described methods in the analyzed publications only partially fulfil the tool requirements for STLF on company level. There is still a need to develop suitable ML methods to integrate the expanded data base in order to improve load forecasts on company level.

(G1106) Renewables delivering capacity reserves in Denmark



Thomas Dalgas Rasmussen; Energinet, Denmark

The Danish TSO Energinet procures reserves to be able to handle significant outages and to balance the power system. To ensure balance and stability in the grid at reasonable cost, Energinet is investigating the possibility for RE to deliver capacity reserves on equal terms as i.e. power plants and consumption. In 2019 the wind-share of the total Danish electrici -share of the electricity consumption must be 100 %. Hence, the capacity and hours of operation of the conventional providers, thermal power plants, are rapidly decreasing. Procurement for availability of reserves is performed the day before operation. If RE is to deliver reserves, it will require high quality forecasts to ensure available capacity to the reserve markets. Hence, Energinet is currently testing the regulating functionalities of RE and the certainty of forecasts and developing baselines for audit of the actual reserve delivery.

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