Energy-Open workshop, University of Groningen, November 7-8, 2019

Final Program

Thursday morning (Energy Academy building, Zernike Campus)

8.45 - 9.15 registration + coffee

9.15 - 10.00 John Simpson (UWaterloo)
'Feedback optimization of uncertain dynamic systems with application to energy systems'

coffee break

10.30 -11.15 Bert Zwart (CWI/TUEindhoven)
'Why are blackouts in power grids heavy-tailed?'

break

11.30 - 11.55 Gerwin Hoogsteen (UTwente)
'Optimizing hybrid-energy system operation using profile steering'
11.55 - 12.20 Victor Reijnders (UTwente)
'KPI's for battery sizing in a neighbourhood'
12.20 - 12.45 Jorrit Nutma (TNO)
'Evaluation of energy flexibility from hybrid heat pumps'

Thursday afternoon (Smitsborg, Zernike Campus)

Lunch 13.00 -14.00

14.00 - 14.45 Johannes Schiffer (Brandenburg UTechnology)
'On multivariable cell structures and Leonov functions for global synchronization analysis in power systems'

coffee break

15.15 - 15.40
Stephan Trenn (UGroningen)
'Switch induced instabilities for stable power system DAE models'
15.40 - 16.05
Michele Cuccuzella (UGroningen)
'Nonlinear loads, electric vehicles and social welfare in DC grids'
16.05 - 16.30
Mark Jeeninga (UGroningen)
'Plug-and-play solvability of the power flow equations for interconnected DC microgrids with constant power loads'
16.30 - 16.55
Krishna Kosaraju (UGroningen)
'Distributed and decentralized voltage regulation in DC microgrids'

break

17.10 - 17.50 Sergio Grammatico (TUDelft)
'Equilibrium seeking in electricity markets'

19.30 workshop dinner (Land van Kokanje, city center)

Friday (Smitsborg, Zernike Campus)

9.00 - 9.45 Ioannis Lestas (UCambridge)
'Stability and control in power grids: from local conditions to global properties and choice of reference frame'

coffee break

10.15 -11.00 George Weiss (Tel Aviv U)
‘A stability theorem for networks containing synchronous generators'

break

11.15 - 11.40
Esther van der Waal (UGroningen) & Tineke van der Schoor (Hanzehogeschool Groningen)
‘Participatory experimentation with energy law: digging in a “regulatory sandbox” for energy cooperatives and homeowners’ associations in The Netherlands’
11.40 - 12.05
Steph Johnson-Zawadzki (UGroningen)
‘How climate beliefs translate into action in a changing political landscape’
12.05 - 12.30
Ashish Cherukuri (UGroningen)
‘Iterative bidding in electricity markets: rationality and robustness’
12.30 - 12.55
Marieke Kootte (TUDelft)
‘Comparison of numerical methods to solve the steady-state integrated transmission-distribution power flow problem’

Lunch 13.00 - 14.00

14.00 - 14.45 Maria Prandini (Politechnico Milano)
‘Multi-agent decision making with application to energy systems'

Discussion + Closing remarks + Drinks

The Energy-Open workshop is sponsored by 4TU-AMI and the Bernoulli institute UGroningen.

Abstracts of Contributed Talks (in order of program)

Gerwin Hoogsteen: Optimizing hybrid-energy system operation using profile steering

Abstract:
The work builds on top of the previous work on the Profile Steering heuristic to optimize the use of flexibility to shape the energy profile. Recent extensions to this algorithm also allow us to schedule the operation of converting devices in a scalable manner, such that Hybrid Energy Systems can be controlled. The ideas and extensions to the heuristic will be presented. Additionally, in an example, we will demonstrate the use of a Heat Pump, CHP and hot water storage to balance a district heating system, while flattening the electricity profile.

Victor Reijnders: KPI's for battery sizing in a neighbourhood

Abstract:
In project proposals, estimates are often made on sizes of batteries that are needed without knowing exact details of the energy profiles of a neighbourhood. After acquiring data for some time, we can evaluate how reasonable these estimates were. However, when is the capacity and power of batteries in the neighbourhood sufficient?
In the GridFlex Heeten project, this question arose as well. Since the focus of the project is on reducing the stress on the network, measures for reducing peaks in the energy profile were vital to decide if a battery was sufficient. To quantify this, four key performance indicators were chosen: Gini coefficient, MAD, PAR, and SD. The Gini coefficient is used in economics as a measure of statistical dispersion of a countries wealth. However, as it essentially measures inequality, it can also be used to indicate the unevenness in an energy profile. Secondly, MAD (or median absolute deviation) is a robust statistic that gives the median deviation of all values in a set to the median of that set, where the median is the value separating the lower half from the higher half of a set. The PAR (peak-to-average ratio) takes the maximum total load of a neighbourhood and divides it by the average load of this neighbourhood. This gives a measure of how unbalanced the grid is used. Lastly, the SD is simply the standard deviation of the dataset. Some assumptions were made to evaluate these indicators; firstly, the battery was assumed to be ideal, with only a constant loss over time. Secondly, we assumed we have perfect predictions on the energy consumption of the neighbourhood. We do this to eliminate the effect of wrong predictions and only focus on the effect of the battery. To simulate the effect of the different battery setups on the indicators, we used DEMkit (decentralized energy management toolkit) with profile steering algorithm. The data comes from the GridFlex Heeten project in the spring and summer of 2019. We simulated batteries with total capacity between 60 and 240 kWh and total power between 6 to 60 kW. In general, we found that increasing the capacity or power both significantly decreases the indicator values. Especially when going from 20 kW to 30 kW power, the PAR value decreased by up to 35%. This is mainly due to the production peaks that otherwise cannot be substantially captured by the battery. It led us to conclude that a minimum power of 30 kW is necessary for this neighbourhood. When increasing the battery capacity, we see that all indicators decrease. However, the decrease becomes asymptotically smaller. Therefore, selecting an exact capacity based solely on the indicators proves difficult. After 120 kWh, there is no significant decrease in the PAR (though the SD still decreases substantially). This could be taken as an estimate for the ideal capacity. Future research on these indicators could result in a decision scheme for the capacity and power needed in a neighbourhood, which would be a helpful tool for smart grid planners.

Jorrit Nutma: Evaluation of energy flexibility from hybrid heat pumps

Abstract:
Hybrid heat pumps can play an important role in the transition to a low-carbon energy system. In particular for homes that are not insulated that well, high efficiency gas boilers can assist heat pumps in case of a large heating demand, e.g. on a cold winter day. In addition, hybrid heat pumps can offer flexibility for DSO's because those systems could use the gas boiler at moments of a congested electricity grid. At TNO, we have investigated this potential in both

theoretical and practical sense. Theoretical, in the sense that we have designed an architecture, on basis of existing standards and technologies, that provides the whole communication chain from DSO down to the device without relying on proprietary protocols and solutions. In the architecture, that features the necessary separation of concerns, there is a place for an aggregator as well. To validate the concept, we have tested five Hybrid Heat pumps, which are currently on the market, on their capabilities to provide the flexibility. It turns out that all five systems have capabilities to provide the flexibility in a more or less standardized way and thus are a fit in the architecture. More advanced use of flexibility cannot be unlocked easily in most cases.

Stephan Trenn: Switch induced instabilities for stable power system DAE models

Abstract:
It is well known that for switched systems the overall dynamics can be unstable despite stability of all individual modes. We show that this phenomenon can indeed occur for a linearized DAE model of power grids. By making certain topological assumptions on the power grid, we can ensure stability under arbitrary switching for the linearized DAE model.

Michele Cuccuzella: Nonlinear loads, electric vehicles and social welfare in DC grids

Abstract:
The most relevant challenge in power grids deals with the transition of traditional power generation and transmission systems towards the large scale introduction of smaller and environmental friendly distributed generation units, posing significant challenges to the planning and operation of the existing power networks. In this talk we show theoretical properties of DC grids including nonlinear loads, enabling the design of decentralized robust controllers that improve the grid reliability. We will also focus on the charge scheduling of electric vehicles as a mixed-integer aggregative game and on the design of a primal-dual controller to address a (feasible) social welfare problem in DC grids.

Mark Jeeninga: Plug-and-play solvability of the power flow equations for interconnected DC microgrids with constant power loads

Abstract:
We study the DC power flow equations of a purely resistive DC power grid which consists of interconnected DC microgrids with constant-power loads. We present a condition on the power grid which guarantees the existence of a solution to the power flow equations. In addition, we present a condition on any microgrid in island mode to guarantee that the power grid remains feasible upon interconnection. These conditions provide a method to ensure that a power grid remains feasible after the interconnection with a specific microgrid with constant-power loads. Although the presented condition are more conservative than existing conditions in the literature, its novelty lies in its plug-and-play property. That is, the condition gives a restriction on the to-be-connected microgrid, but does not impose more restrictions on the rest of the power grid.

Krishna Kosaraju: Distributed and decentralized voltage regulation in DC microgrids

Abstract:
The recent widespread of renewable energy sources motivates the design and operation of Direct Current (DC) microgrids, which are interconnected clusters of Distributed Generation Units (DGUs), loads and energy storage systems interacting with each other through distribution lines. In order to guarantee a proper and safe functioning on the power network, voltage stabilization is the main goal to achieve in DC microgrids. Additionally, to avoid the over-stressing of a source, it is generally desired that the total demand is (fairly) shared among all the DGUs of the microgrid. However, in order to permit the DGUs to share the generated current or power, voltage differences among the nodes of the microgrid are necessary. As a consequence, it is generally not possible to achieve the aforementioned objectives simultaneously. In this talk, we present some of our new results that achieve distributed and decentralized voltage regulation in DC microgrids.

Esther van der Waal & Tineke van der Schoor: Participatory experimentation with energy law: digging in a 'regulatory sandbox' for energy cooperatives and homeowners' associations in The Netherlands

Abstract:
To facilitate energy transition, in several countries regulators have devised 'regulatory sandboxes' to create a participatory experimentation environment for exploring revision of energy law. These sandboxes allow for a two-way regulatory dialogue between an experimenter and an approachable regulator to innovate regulation and enable new socio-technical arrangements. We focus on the Dutch Energy Experimentation Decree (EED) that invites homeowners' associations and energy cooperatives to propose projects prohibited by extant regulation. In order to localize, democratize and decentralize energy provision, local experimenters can, for instance, organise peer-to-peer supply and determine their own tariffs for energy transport. However, these experiments do not take place in a vacuum but need to be formulated and implemented in a multi-actor, polycentric decision-making system through collaboration with the regulator but also energy sector incumbents such as the distribution system operator. We are, therefore, especially interested in new roles and power division changes in the energy sector as a result of the Decree. Our central question is: What can be learnt from the EED about the use of regulatory sandboxes for facilitating bottom-up, participatory innovation in the energy system? Theoretically, we rely on Ostrom's concept of "polycentric governance" to study the dynamics between actors involved in and engaging with the participatory experiments. Empirically, we examine 4 approved energy experiments through interviews and document analysis. Our conclusions focus on the potential and limitations of a regulatory sandbox for participatory innovation in a polycentric system, and especially on democratization of legal innovation in the studied context.

Steph Johnson-Zawadzki: How climate beliefs translate into action in a changing political landscape

Abstract:
What happens to public engagement with climate change after a climate skeptic is elected president? Our research explored the psychological process through which climate change beliefs may affect climate-friendly behavior and policy support during the rise of a climate skeptical political leader. Specifically, we assessed how individuals' climate beliefs (i.e., belief in the anthropogenic origins and negative impacts of climate change) were affected during the US Presidential election and earliest administrative days of a climate skeptical political leader, Donald Trump, and how this in turn affects climate-friendly intentions and policy support. We found Trump's supporters' climate beliefs were weaker after the election compared to before the election. Furthermore, we found people's origin and impact climate beliefs interact to influence their climate actions by activating moral sentiments about their own environmental behavior (i.e., guilt, striving to be a better person), with the weakest moral sentiments reported by those low in belief in climate change's anthropogenic origins and its negative impacts. Moral sentiments, in turn, predicted respondents' willingness to save energy to reduce climate change and their support for the Paris Climate Agreement. Our results suggest the election of climate skeptical political leaders does impact the public's climate-related beliefs, which influences their moral sentiments to engage in climate-related actions, and consequently, changes their climate-friendly behavioral intentions and policy support.

Ashish Cherukuri: Iterative bidding in electricity markets: rationality and robustness

Abstract:
This talk will consider an electricity market consisting of an independent system operator (ISO) and a group of generators and explores the possibility of carrying out multiple rounds of bidding per dispatch event instead of the current practice of one-shot dispatch. We will introduce an iterative scheme, termed *bid adjustment algorithm*, which prescribes a way for the generators to adjust their bids in each iteration of bidding based on the previous bid and the allocation provided by the ISO. We will establish that this algorithm takes the generators' bids to any desired neighborhood of the efficient Nash equilibrium at a linear convergence rate. As a consequence, the optimal production of the generators converges to the optimizer of the DC-

OPF problem. We then show using various arguments that the prescribed adjustment policy is a rational one for the generators.

Marieke Kootte: Comparison of numerical methods to solve the steady-state integrated transmission-distribution power flow problem

Abstract:
In this talk, I will compare and review a variety of numerical methods to solve integrated transmission-distribution power flow problems. Currently, transmission and distribution systems are solved separately. However, the outcome of integrated power flow systems differs from the outcome when separated systems are used. Furthermore, the increasing penetration of locally generated PV affects the power flow in transmission networks, which would not be noticed in separated models. Three numerical methods are the object of study: a master-slave splitting, an interconnected method and a full three-phase approach. Comparison has been performed on Matpower test-cases using steady-state Newton-Raphson power flow solvers. Findings regarding modeling complexity, convergence, and speed are discussed. Tests are performed on networks up to a size of thousand buses. Future work will include use-cases in order of million buses to leverage numerical properties.