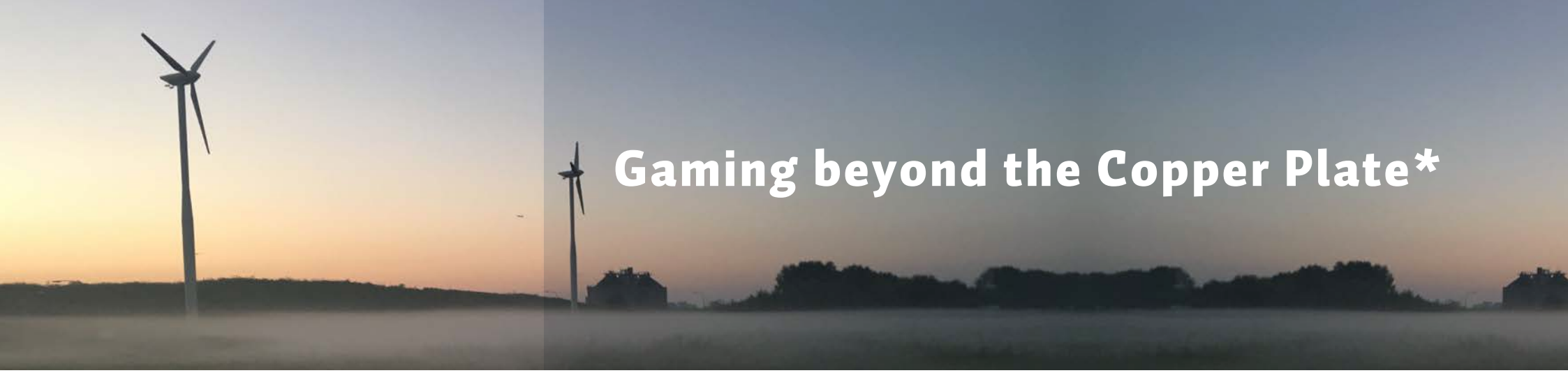

Gaming beyond the Copper Plate*

Team

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Partners

Delft University of Technology ▪ Stedin ▪ GPX ▪ Bellamy BV ▪ E-bridge ▪ Croonwolter&dros ▪ Alliander

Period

1 October 2014 – 30 September 2018

* **Full title:**
Gaming beyond the Copper Plate: scheduling flexible consumption and decentralised generation within distribution constraints

Smart planning for flexible consumption of electricity

Societal costs will be significantly lower if a combination of efficient planning and scheduling algorithms and appropriate market mechanisms are used.

* **Smart energy management algorithms and market design options**
The project has made contributions to planning, auction design and unit commitment under uncertainty, developing better ways to deal with congestion in capacity-constrained distribution grids.

Insights & recommendations

[1] In capacity-constrained distribution grids the network constraint needs to be met by all usage of the grid combined. A complicating factor is that the usage of the agents in the network is not exactly known. Fortunately, temporarily violations of such constraints are acceptable in practice. These constraint violation probabilities can be bounded, and a new algorithm has been designed which can adaptively tune these bounds to improve the quality of the allocation of available resource (network) capacity. Experiments show that this adaptive bound is able to efficiently trade off network capacity violation probability with expected quality, outperforming state-of-the-art planners. This approach is thus the best method to coordinate the network capacity for uncertain but flexible loads.

[2] Resource-constrained planning problems in distribution grids can be modeled using a Constrained Partially Observable Markov Decision Process. A new approximation algorithm has been developed to solve such planning problems more efficiently. Furthermore, realistic

Read more

1 F. de Nijs, E. Walraven, M. de Weerdt, M. Spaan (2017). *Bounding the probability of resource constraint violations in multi-agent MDPs*. In *Proceedings of the 31st AAAI Conference on Artificial Intelligence*

2 M. Spaan, E. Walraven (2018): *Column Generation Algorithms for Constrained POMDPs*, *Journal of Artificial Intelligence Research*

3 A. Lorca, M. de Weerdt, G. Morales-España (2018): *Robust unit commitment with dispatchable wind power*, *Electric Power Systems Research*

4 R. Philipsen, G. Morales-España, M. de Weerdt, L. de Vries (2019): *Trading power instead of energy in day-ahead electricity markets*, *Applied Energy*

Project website

www.tudelft.nl/ewi/over-de-faculteit/afdelingen/software-technology/algorithmics/projects/gcp-gaming-beyond-the-copper-plate/

The research programme Uncertainty Reduction in Smart Energy Systems (URSES) aims to make a quick transition to a reliable, affordable and sustainable energy system possible. It is a joint initiative of several departments of NWO, Shell, AMS and the TKI Urban Energy.

distribution grid constraints have been included in the model, which enables the planner to take grid constraints into account. Preliminary experiments show that the model can be used to control flexible electric vehicles in a distribution grid.

[3] It is possible to solve the unit commitment (UC) problem: Which power plants need to be active? This is one of the most critical tasks in power systems operations. The research has shown that, by considering dispatchable wind and a box uncertainty set for wind availability, a fully adaptive two-stage robust UC formulation, which is typically a bi-level problem with outer mixed-integer program (MIP) and inner bilinear program, can be translated into an equivalent single-level MIP. Experiments on the IEEE 118-bus test system show that computation time, wind curtailment, and operational costs can be significantly reduced in the proposed unified stochastic–robust approach compared to both a pure stochastic approach and a pure robust approach including budget of uncertainty.

[4] Day-ahead electricity markets are inefficient due to their coarse discretisation of time and their representation of electricity production and consumption in energy per time interval. This causes market-clearing results to create infeasible schedules and excessive costs to recover from these. Some real-world systems have increased market resolution to improve accuracy, but this comes at a high computational cost. The researchers have developed an alternative, based on using linear power trajectories in the day-ahead scheduling process, which represent the momentary electricity production. Changing from a traditional energy-based to such a power-based formulation of the scheduling method can reduce cost by several percentage points, leading to a cost reduction of millions of euros in real-world systems on a yearly basis. Furthermore, the researchers provide market design options to implement power-based bidding and pricing in day-ahead electricity markets, showing that pricing and market rules which encompass existing markets are readily available for implementation, and illustrate these with examples.

NWO Netherlands Organisation for Scientific Research

AMS AMSTERDAM INSTITUTE FOR ADVANCED METROPOLITAN SOLUTIONS

TKI URBAN ENERGY Topsector Energie