Supporting Energy Communities - Operational Research and Energy Analytics

Paula Carroll[1,3], Cristian Aguayo[5,6], Sandeep Araveti[1,3], Luce Brotcorne[6], Imre Drovtar[4], Bernard Fortz[5,6], Evita Kairiša[4], Tarmo Korõtko[4], Anna Mutule[4], and Conor Sweeney[2,3]

[1]School of Business, University College Dublin, Ireland, ✉ paula.carroll@ucd.ie
[2]School of Mathematics and Statistics, University College Dublin, Ireland, ✉ conor.sweeney@ucd.ie
[3]Energy Institute, University College Dublin, Ireland
[4]SmaA, Institute of Physical Energetics, Riga, Latvia
[5]Computer Science Department, Université libre de Bruxelles, Belgium
[6]INRIA, France

We present an overview of the Supporting Energy Communities - Operational Research and Energy Analytics (SEC-OREA) project which enables local energy communities (LECs) to participate in the decarbonisation of the energy sector by developing advanced efficient algorithms and analytics technologies.

LECs require accurate information on renewable energy generation to develop their full potential at both planning and operational stages. SEC-OREA is an open data driven project. As part of the project, we plan to go through the path of creating an energy community modelling framework, simulating different energy community load profiles in four countries, considering each country's low voltage network restrictions and average annual household consumption. At the same time, the emphasis is placed on the accuracy of the data and the assessment of real world conditions. Generated load profiles will be validated, comparing the communities' load profiles with their county's typical load curve and average households' electricity consumption.

Climate reanalysis combine past observations with models to generate consistent time series of multiple climate variables. Reanalysis datasets are widely used for simulating renewable energy availability such as assessing the potential of solar photovoltaic, and wind power generation. There is growing demand from industry, research and other sectors for high quality and long-term gridded climate datasets with high temporal and spatial resolution.

We explore available climate services to gather energy-relevant pan-European indicators of climate trends and variability. We assess these open data sources against meteorological observations to determine the best suited climate data sources for particular use cases such as the location where an LEC may decide to locate. The climate data is used to estimate renewable energy scenarios at high time and geographic resolution by converting weather variables such as wind speed to estimates of wind power for different wind turbine technologies. We use better data to model renewable energy generation, to understand and create dynamic scenarios of electricity consumption. We create better ensemble models of climate dependent electricity generation from renewable energy sources, and consumer electricity demand.

We create a set of mathematical optimization models to efficiently solve the multilateral economic dispatch decisions of the LEC Renewable Energy Sources in a fair manner. More precisely we explicitly model the interactions among the stakeholders by relying on Nash and Stackelberg equilibriums. These problems result in bilevel optimisation problems involving possibly muti-leader or multi follower.

In particular, we extend the classical Unit Commitment (UC) problem to take into account the specific characteristics of LECs. We develop methods to solve realistic size instances of these UC deterministic optimisation problems, and extend these methods to address uncertainty given by the different electricity consumption and generation scenarios.

For the evaluation of mathematical optimisation models, an LEC power system model is used. The LEC power system is modelled using a universal prosumer model as shown in Fig 1. This enables us to simulate power flows in various grid topologies using a single modelling object. The prosumer modelling object enables to incorporate customised control blocks, to simulate individual asset controllers but also to execute internal optimisation and aggregation logic of the LEC, and provides an interface for integration with external utilities, e.g higher-level mathematical optimisation models or data sources for forecasts.

This approach provides a simple and flexible way to model power flow in LEC power systems, thus reducing the required resources for object modelling and control system integration.

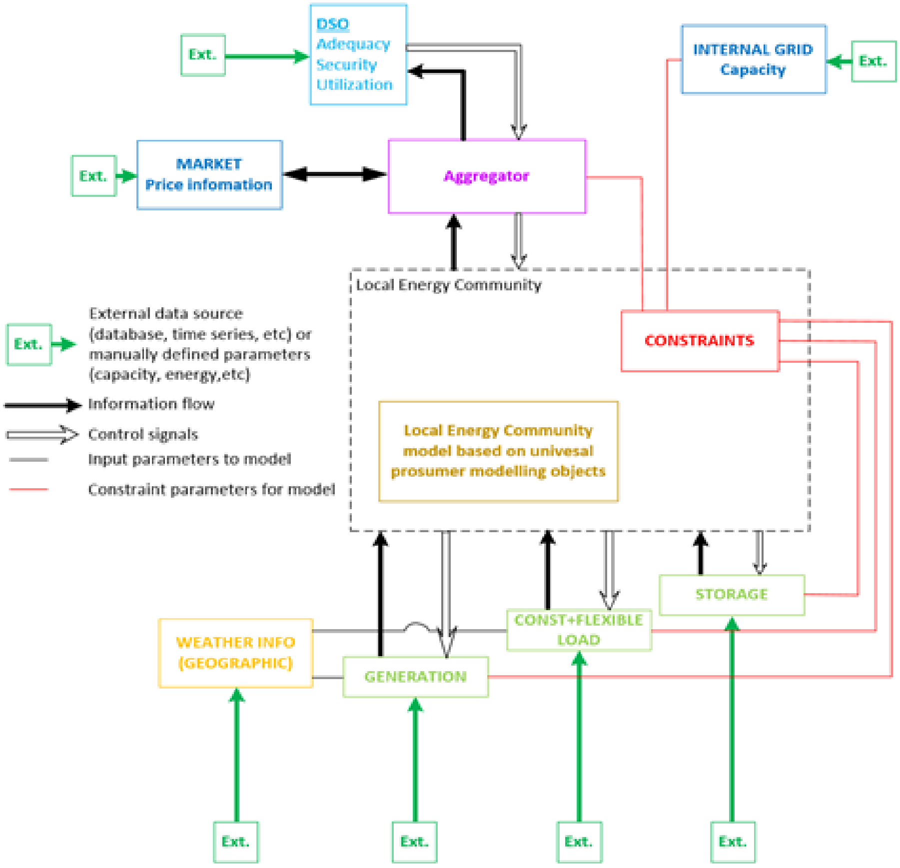

Figure 1: LEC Modelling Framework

We evaluate the implications of the LEC activity and net demand on sample grid topologies. The model provides support to the Distribution System Operator (DSO) in understanding the impacts of, and requirements for LECs on the low voltage distribution network. Different optimisation models are investigated on their performance to meet objectives of different LEC parties but also provide benefits for the DSO. This understanding supports better LEC and DSO decisions on asset reinforcement, network power flow and congestion management.

We address challenges in operation and planning of the grid, studying various climate, energy and dispatch optimisation scenarios useful in understanding of LEC impact on distribution systems. The scenarios will cover operation of different technologies (either individually or in combination). Concerns will be addressed for operation, short-term planning and investment planning from the perspective of different stakeholders. Thus, solutions will address adequacy, security, utilisation and investment decisions, developing solutions to enhance economy and sustainability of grid development.

We provide recommendations for an overarching LEC enabling framework to ensure safe reliable efficient sustainable operation of the LEC and low voltage network. Our framework will allow LEC members to take ownership of the energy transition, benefit from the new technologies we develop and so reduce their bills and their carbon footprint. We provide business model analyses, efficient scalable multilateral economic dispatch and energy analytics algorithms, and integrated climate/LEC/Low Voltage models to support our climatology, meteorological services, smart city, municipality and energy agencies stakeholder decision makers.

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