Economics of pooling small electricity prosumers – prosumer vs business as usual approach

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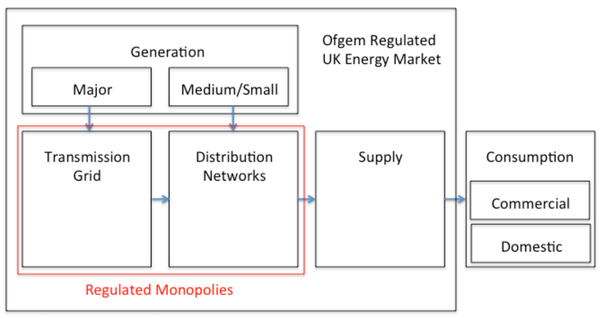
Introduction

An earlier paper of the Authors focused on the modeling of levelized cost of electricity (LCOE) and self-consumption levels for wind and photovoltaic (PV) installations for six UK sites[1]. This presentation will look at the economic feasibility of pooling local prosumers with connection to the main grid vs a business as usual (BAU) scenario. A three-tiered model has been developed and a hierarchical consumption/production logic was suggested, which looked at single prosumer level, local prosumer pool level and national grid level to ensure a balanced electricity supply and demand. The aim of the research was to provide a better understanding of the relevant factors influencing the economics of prosumer models and examine their role in the context to the UK and its energy market framework.

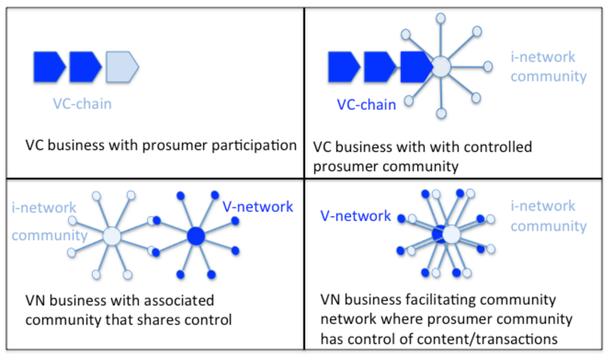
Background

The **UK energy market** is heavily regulated and is subject to political decisions. Such regulation is not only motivated by consumer protection but is also desired by utilities and investors to have a stable commercial framework for investments. Political and regulatory frameworks influence market structures, hence guide economic activity. The current regulatory and technical framework is challenged with the emergence of renewable energy (RE) and its specific characteristics, e.g. capital intensity and low running cost, intermittent nature, decentralized application, natural resource dependent site selection criteria etc.



UK electricity market structure.

Prosumers are a relatively new concept in energy markets but have been present in a wide range of other markets for a long time. The common part is that prosumers produce and consume a product/service at the same time. At which stage and to what extend that happens can be quite different. Bremdal[2] identified value chains (VC) and value networks (VN) in which a prosumer will take on a specific role. In a value chain the consumer is engaged at the end of a production process and only finishes the product. In a value network the process is much more interactive and the network itself is the market; and its participants may produce for and consume from the network in real-time, e.g. social networks.



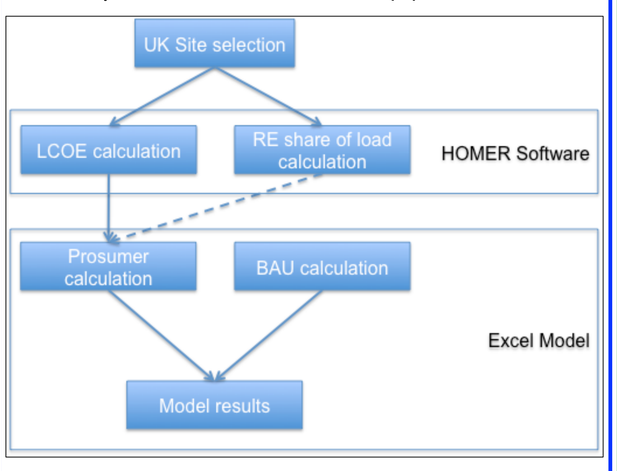
Archetypes of prosumer business models (Bremdal[2])

A decisive differentiator between those concepts is management and control of the product design and production process, with the value network representing the part of the spectrum with lesser centralized functions. The internet would typically be the infrastructure base on which prosumer activity is enabled.

[1] Kästel, P & Gilroy-Scott, B 2015, Economics of pooling small local electricity prosumers – LCOE & self consumption
[2] Bremdal, B.A. 2012. Prosumer oriented business in the energy market

Methodology

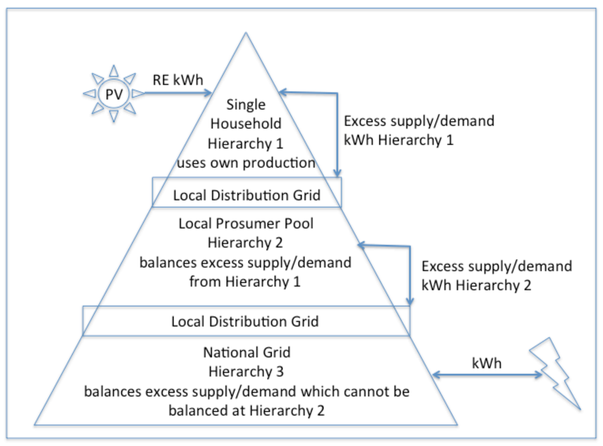
The methodology is designed to analyze the economics of pooling small local electricity prosumers in an actual or virtual micro-grid environment with back-up access to the national grid ('Prosumer-Model'). The Prosumer-Model results are compared to the established electricity supply model or business as usual approach ('BAU-Model'). The economic advantage/disadvantage between the two approaches is measured as difference between annual and lifetime cost for a given electricity consumption in British Pounds (£).



Schematic presentation of methodology approach

The **Prosumer-Model** is an extension to the UK Feed-in-Tariff model by adding another local electricity balancing layer resulting in a three-tiered hierarchical production/consumption model:

- Level-1, prosumers consume their own production;
- Level-2, they share with/provide to excess production, or draw/consume additional demand from, a member-energy-pool; and,
- Level-3, they feed into or take electricity from the national grid.



Prosumer Model diagram

The **BAU-Model** calculates the annual electricity cost by multiplying the consumed energy with a price per kWh as it is the standard approach in today's market.

The **Simulation-Model** allows for various input parameters, which are mainly load and cost related. Parameters were set around current UK market levels and some were varied for the scenario analysis of the six modeled UK sites.

Load related parameters are: 'Annual Production' which equals the 'Annual Consumption' in kWh; 'Hierarchy 1 and 2 Consumption %', which also determines 'Hierarchy 3 Consumption %'; 'Hierarchy Consumption kWh' and 'Sales into Grid' in kWh.

Cost/income related inputs include: 'Cost-of-Capital', 'Inflation Assumption', 'Network Charges', 'Administration Charges', 'Project Life', 'Grid Electricity Prices', 'LCOE', 'Grid Price Electricity', 'Production Credits', 'Back-up Price Electricity' and 'Sellback Price to Grid'.
The unit of all cost/income parameters is £/kWh apart from the inflation and the cost-of-capital parameters, which are denominated in %. LCOEs are based on simulated values from a previous study.

Results

The Simulation-Model produced site-specific Prosumer vs BAU results and a sensitivity analysis based on LCOE break-even calculations.

The P/L (profit/loss) represents the comparison between the Prosumer vs BAU approach. A positive P/L indicates an advantage for the Prosumer-Approach hence a disadvantage for the BAU-Approach.

The tables show **summary results** on how better/worse a prosumer scenario compares to a BAU scenario based on a one year and project lifetime horizon. Only minimum and maximum values are displayed defining the result range. These values coincided with the best and worst-case Model settings.

PV Identifier	LCOE £/kWh	Advantage/ Disadvantage yr 1 £/1000kWh/yr	Advantage/ Disadvantage Project Life £/1000kWh/yr	
PV generic IV1	0.580	-£363.16	-£2,783.00	Min
PV generic IV1	0.132	£130.64	£4,507.61	Max
PV generic CA2	0.569	-£352.16	-£2,687.87	Min
PV generic CA2	0.134	£128.64	£4,465.61	Max
PV generic YO24	0.530	-£313.16	-£2,350.57	Min
PV generic YO24	0.115	£147.64	£4,864.61	Max
PV generic KT2	0.491	-£274.16	-£2,013.27	Min
PV generic KT2	0.118	£144.64	£4,801.61	Max
PV generic SY23	0.448	-£231.16	-£1,641.38	Min
PV generic SY23	0.106	£156.64	£5,053.61	Max
PV generic TR14	0.432	-£215.16	-£1,503.00	Min
PV generic TR14	0.105	£157.64	£5,074.61	Max

PV summary Model results. Sites are by UK post code and ordered by increasing irradiation level (IV1 lowest and TR14 highest).

Wind Identifier	LCOE £/kWh	Advantage/ Disadvantage yr 1 £/1000kWh/yr	Advantage/ Disadvantage Project Life £/1000kWh/yr	
Enercon 33 45m KT2	0.215	£47.24	£852.38	Min
Enercon 33 45m KT2	0.031	£277.04	£7,892.44	Max
Enercon 33 45m YO24	0.206	£56.24	£930.22	Min
Enercon 33 45m YO24	0.030	£278.04	£7,913.44	Max
Enercon 33 45m CA2	0.188	£74.24	£1,085.90	Min
Enercon 33 45m CA2	0.028	£280.04	£7,955.45	Max
Enercon 33 45m IV1	0.178	£84.24	£1,172.38	Min
Enercon 33 45m IV1	0.027	£281.04	£7,976.45	Max
Enercon 33 45m SY23	0.154	£108.24	£1,379.95	Min
Enercon 33 45m SY23	0.024	£284.04	£8,039.45	Max
Enercon 33 45m TR14	0.130	£132.24	£1,587.52	Min
Enercon 33 45m TR14	0.021	£287.04	£8,102.44	Max

Wind summary Model results. Sites are ordered by increasing average wind speed (KT2 lowest and TR14 highest).

The **sensitivity analysis** undertaken shows the effect of various input parameters on the P/L.

	LCOE	Production Credit	Inflation assumption	Cost of Capital	Hierarchy 1 consumption %	Hierarchy 2 consumption %	Hierarchy 3 consumption %
Parameter	up	up	up	up	up	up	up
P/L	down	up	up	down	up	up	down

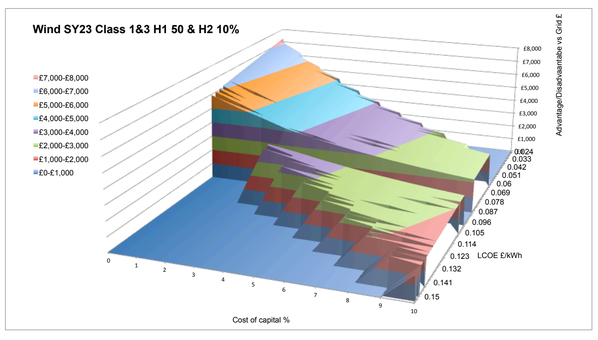
	Hierarchy 1 Network Charge	Hierarchy 2 Network Charge	Hierarchy 1 Admin Charge	Hierarchy 2 Admin Charge	Back up Price Grid Electricity	Sellback Price to Grid	Grid Price Electricity
Parameter	up	up	up	up	up	up	up
P/L	down	down	down	down	down	up	up

Input parameter and Model result sensitivity matrix.

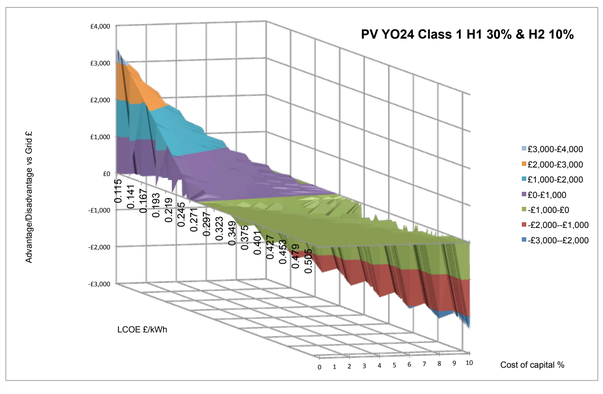
More **site specific results** share similar patterns.

Wind Load Class 1 & 3				
Site	LCOE range £/kWh	lowest avg P/L at 10% cost of capital	highest avg P/L at 0% cost of capital	highest minus lowest
KT2	0.031 – 0.210	£1,088.00	£7,099.00	£6,011.00
YO24	0.030 – 0.206	£1,166.00	£7,120.00	£5,954.00
CA2	0.028 – 0.188	£1,322.00	£7,162.00	£5,840.00
IV1	0.027 – 0.178	£1,408.00	£7,183.00	£5,775.00
SY23	0.024 – 0.154	£1,616.00	£7,246.00	£5,630.00
TR14	0.021 – 0.130	£1,878.00	£7,462.00	£5,584.00

Wind site specific P/L results.



SY23 wind site specific results for 44,500 simulated data points.



YO24 PV site specific results for 49,500 simulated data points.

Discussion

The Model results suggest that a Prosumer-Approach can have its **economic merits** and could already now offer benefits to single consumers and communities. All analyzed sites and technologies indicated the economic attractiveness of the Prosumer-Model under specific assumptions. Yet, there is not a straight linear pattern since the final economics are dependent on a whole set of factors, which can either neutralize or amplify each other.

The **LCOE is a major input factor** into the Model and it is dependent on various assumptions. LCOE effects are applicable to both, the BAU-Approach and the Prosumer-Approach. One of the main RE LCOE differentiators in comparison to conventional energy is that for most RE technologies the LCOE can be considered to be fixed or to have little expected volatility. Hence REs have an in-built hedging mechanism, which protects prosumers from rising energy prices over the project life but also excludes them from the benefits of falling energy prices from other electricity sources. In the BAU-Approach the cost of electricity together with the annual energy consumption are the only input factors. The grid electricity retail price is to over 50% a function of wholesale energy price which itself is not a stable variable. In the context of the need for the renewal of a substantial part of the UK's energy plants, an extensive infrastructure investment program and higher environmental standards upward pressure on LCOEs for new conventional energy plants and energy in general is a plausible scenario.

The **LCOE break-even analysis** was designed to isolate Model inputs, vary them and quantify their impact on the LCOE break-even. The highest impact could be observed in production credits and the grid electricity price. This is specifically relevant since most recent UK energy policies focused on reducing production credits/FiTs and tendencies to externalise some energy and infrastructure cost in order to lower upward pressure on energy cost.

All **Model assumptions** are static or trend based, which may be questioned in a real life scenario. Also correlations of individual parameters have not been considered separately. Lastly qualitative aspects of a Prosumer-Model are worth highlighting, e.g. sociological, economic, technological and regulatory issues . These aspects can present significant limitations to the Prosumer-Model's feasibility and demonstrate the complexity of the subject.

Conclusion

Overall it can be concluded that a Prosumer-Approach could offer significant economic opportunities to the UK. Based on the current conditions such an energy model could bring economic advantages to consumers, yet by doing so it would necessitate/cause changes to market structures over time. The UK electricity market is shaped by a highly concentrated market structure. Its infrastructure is currently based on a centralized energy generation and a bias towards a top-down electricity distribution system. A prosumer system is by design decentralized and more democratic. Hence, the widespread adoption of such a system would impact almost all elements of the market over time.

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