Stochastic Evaluation of Aggregator Business Models - Optimizing Wind Power Integration in Distribution Networks

Quentin Lambert, Claes Sandels, and Lars Nordström

Abstract—In order to limit the environmental impact of electricity production, renewable energy sources are expected to expand significantly. The current grid and production structure are not designed to absorb such quantities of intermittent power output and smart grids can provide promising solutions, like demand response. This paper presents the technical advantages of managing flexible demand through Aggregators in a centralized fashion.

An optimization model is developed to evaluate the economic benefits induced by adapting instantaneous electricity consumption to renewable generation. The model presented can easily be adapted in a more general context, and tested for different scenarios. Further, a use case related to the Smart Grids project on the Swedish island of Gotland is simulated. The simulation results show that the Aggregator solution is technically feasible, but that the current market design is a barrier for a successful implementation.

Keywords—Aggregators, Demand Side Management, Distribution Networks, Wind Power Integration, Local Supply/Demand Matching

I. INTRODUCTION

In a continuously changing context, utilities must keep a watchful eye on opportunities that appear in the electric landscape. Most private end-users currently have a passive attitude towards their electricity consumption. Tariff structures provide too limited incentives to adapt one’s behavior towards a smarter and more flexible consumption pattern. Although the introduction of hourly metering opens for more flexible pricing, the reluctance of private consumers to actively modify their habits remains.

The development of reliable wireless communication and improved steering equipment [1] has paved the way for Demand Response (DR), centrally managed by Aggregators. End-users would give their consent to third part entities to steer their consumption. A cluster of customers would be optimally managed by an Aggregator and would react to market and grid signals to eventually influence the production systems planning. Instead of meeting demand peaks with extra power capacity, load reduction is an interesting alternative if proven reliable in large scale. An Aggregator can optimize the power dispatch in the grid, matching Renewable Energy Sources (RES) production to the consumers needs in order to exploit the grid under the best conditions.

Lambert, Sandels and Nordström are with the Department of Industrial Information and Control Systems, Royal Institute of Technology, Stockholm, Sweden, e-mail: quentinl@kth.se, {claess, larsn}@ics.kth.se.

A. Scope of the paper

The aim of this paper is two folded. The first aim is to give an overview of the benefits that Aggregator DR services can provide to the different actors in the electricity market chain. The second aim is to develop a quantitative simulation model that can assess the economic and technical performance of a Aggregator DR service scheme on the electricity market. Subsequently, a number of simulations will be performed for a delimited use case. The use case concerns power congestion problems related to RES integration for the distribution network on the Swedish island of Gotland [2].

B. Outline

Firstly, in section II, a literature review in the research field of DR Aggregators is conducted. A description of possible DR services is given in section III to help the reader understand both the mechanisms and benefits associated to these. Then, an extensive assessment of the business cases offered to an Aggregator, classified by service provider, type of service and final beneficiary is elaborated in section IV. This is followed by the mathematical simulation model that aims to capture the essential properties of the Aggregator DR service (section V). Subsequently, simulation results for the use case are handled in section VI. Finally, some concluding remarks are given in section VII.

II. RELATED WORK

In the ADDRESS project [3], the Aggregator is defined as a “deregulated player whose main role is to be the mediators between the consumers who provide their flexibilities and the markets where the Aggregators offer these flexibilities for the use of the other electricity system players”. In other words, the Aggregator’s main purpose is to construct different products from the flexibilities of consumers, in order to increase the efficiency on various markets. Furthermore, in [4], the Aggregator is thought to be responsible for (i) grouping customers and participating on the wholesale market to get the lowest possible prices, (ii) planning the usage of distributed generation units with respect to energy prices, and (iii) shifting and manage the controllable loads of the consumers to a time of low energy costs. It is stipulated that the Aggregator is an entity who empowers the customers to manage their energy use and save money without inflicting their comfort and needs.

An overall literature review of different approaches to aggregate small Controllable Distributed Energy (CDE) units is
available in [5] (CDEs can control its output of active and reactive power). Here, Smart Grid concepts such as Virtual Power Plants (VPPs), Microgrids, and Cells are thoroughly described from, among other things, an information exchange, and organizational structure point of view. For each aggregation approach a list of its advantages, e.g., in which situation is it more favorable to aggregate in a specific way, is depicted. Furthermore, a clear description of what that can be aggregated, and which actors that are affected by these aggregations, is made. An overall conclusion by the authors is that a consistent description of aggregation approaches does not exist today.

Several concrete Aggregator business models connected to DR have been proposed by the literature. Firstly, in [6], business models concerning the integration of a future EV fleet in the US with the existing power system are presented. An EV interacting with the power grid is commonly referred as Vehicle to Grid (V2G). It is stated that an EV fleet can provide: (i) base load power, (ii) peak power, (iii) spinning reserves, (iv) regulation, (v) emergency power, and (vi) balancing intermittent production (e.g., wind power), to a power system. However, due to the mobile behavior and limited energy storage of EVs and the inherent properties of the different markets, the authors recommend that EVs should initially focus on providing frequency control. The market potential for EVs acting as frequency control has been assessed in multiple articles, e.g., [7], [8], [9]. The expected profitability varies a lot between different countries due to market rules, energy prices, generation mixes, etc. The Aggregator is a necessary actor for V2G due to, most importantly, capacity constraints on today’s control markets (at the level of MW’s).

Another Aggregator business model is presented in [10]. Here, a cluster of $\mu$-Combined Heat Power (CHP) units is used to reduce the peak demand of a Distribution Network (DN) substation in the Netherlands. This is realized through a market based control scheme of software agents (a.k.a. the PowerMatcher concept). Bids are communicated between the agents to optimize the global welfare (i.e., the system performance and the economical remuneration of the users). By using different operation strategies, it is concluded that the PowerMatcher approach can decrease the peak load by 50%, and in the same time fulfill customer satisfaction. The unintelligent fit and forget strategy implied no mitigating effects on the peak demand of the DN, i.e., accentuating the importance of aggregated control in this case.

A similar study focused on utilizing the flexibility of $\mu$CHPs in DNs with PowerMatcher can be seen in [11]. However, in this case, the control is applied w.r.t. to the local supply/demand energy mismatch caused by wind power generation. The simulation results show good potential for reducing these imbalances. For instance, the export of overproduced wind power is reduced from 90% to 65% if the control concept is applied. Other papers that analyze the potential of managing RES production with DR are observed in [12] and [13].

Clearly, the focus on the Aggregator’s business cases varies between the reviewed references. This paper tries to generically classify the business opportunities of a DR Aggregator. Subsequently, an optimization simulation model is developed that enables quantitative assessment of the technical and economic performance of such an actor on the markets. The optimization model is flexible in such sense that different types of business cases and scenarios can be inputted and simulated. Thus, the model is adaptable for analyzing a wide range of business opportunities of a DR Aggregator.

III. DEMAND RESPONSE

The current electricity systems’ flexibility mostly relies on the use of plants that rapidly adjust their power output. In other words, the current market mechanisms are built upon the assumption that the consumption from small customers lacks elasticity. The load curve is considered unaffected by actual market or grid conditions. When the system is under pressure due to grid problems or mismatch between supply and demand, it is always the production side that is called upon to remedy the situation. It is often a suboptimal solution that is chosen, like subsidizing polluting peak-power plants with a very low utilization factor. This is why DR appears to be promising: it is cheaper, more flexible and besides, promotes energy efficiency.

The main impediment to the development of DR resides in the concept itself: it assumes either an active involvement of the end-users, known as Active Demand (AD) or the technology to remotely manage the final customer’s consumption. This part provides a description of the different mechanisms for DR, its benefits and the potential barriers against its implementation. Finally, a synthesis of the key factors for its success is presented.

A. Mechanisms for Demand Response

DR can be implemented with two different mechanisms: active demand or remote management. For the former, end-users make active choices modifying their consumption and their approach to energy while for the latter customers still behave passively and delegate the responsibility for adjusting their load profile to external entities. Yet, from the system’s viewpoint, the result is the same: higher consumption flexibility. AD has long been present in the electricity landscape, though representing negligible amounts of power. Historically, AD has mostly been triggered by price signals: with the rise of deregulated electricity markets, large industrial clients were interested to reduce their consumption during high-price periods, while retailers encouraged their residential clients to flatten out their consumption profile thanks to time-of-use tariff structures. However, the consumers engagement cannot rely only on price signals. The key factor for success lies in the active involvement of the client in the long run. In order to ease the active engagement from private users, new technological devices have emerged on the market [1] allowing the client to follow his consumption in real time. Coupled to efficiency advice and historical data comparison, the device encourages the end-user to adopt smarter consumption habits.

AD is a process where the end-user deliberately modifies his consumption behavior in response to external factors. The action taken by the consumer is individual and requires personal involvement. Users optimize their own private welfare, which implies that the same triggering parameter can have
different effects on different people. The global impact of uncoordinated AD on the whole system is therefore hard to forecast. With remote management, end-users let an external entity modify their consumption. The customers do not need to modify their behavior because an external actor, called Aggregator, optimizes the load curve of selected appliances in a large number of households or companies. An Energy box [14], installed in the customer’s premises, communicates with the Aggregator and receives signals from it to turn on or off controllable appliances, e.g. water heaters, electric radiators, heat pumps and air conditioners.

Remote load management gives approximately the same benefits as AD for the end-users without forcing them to consciously adapt their behavior. On a global level however, the coordinated action of an Aggregator can have a positive impact both on the infrastructure by reducing peak-loads and financially by converting part of the inelastic demand into price-sensitive load. Remote management of consumption offers the possibility for end-users to reduce their electricity bill without having to take deliberate actions. The consumption is modified by an external actor, called Aggregator, which optimizes its providers’ load profiles to fulfill its own objectives. Thus, coordinated demand-response can benefit the entire system.

B. Consequences and Benefits

There are many advantages associated to demand response compared to the traditional solutions, and they affect the whole supply chain, from producers to end-users.

Producers will be directly affected by a modification of the market towards a higher flexibility of demand. The main impact for them will be reduced needs for peak-load generation units, which are seldom profitable. Another side-effect of flexible demand is the possibility for the system to accept a higher share of intermittent sources. Indeed, DR allows under specific circumstances a quick modification of the load profile. Thus variations in electricity production from wind and solar power can partly be dampened by an adaptation of consumption.

For the grid, a more flexible consumption will most probably imply a flattened daily load. Part of the total demand will be shaved, but it is likely that most of the load will be shifted from the current peak hours to periods with lower consumption. Lowering the demand during peak periods will reduce the transmission congestion and therefore the risk for outages will be reduced. The operators will therefore improve their availability index while simultaneously getting a higher satisfaction from their customers. Besides, as the losses due to the Joule effect on the transmission lines are proportional to the square of the power flowing into the cables, a flattened power curve will mathematically reduce the losses and the costs associated to them. Demand response also appears as an interesting alternative to grid upgrades since new investments to build stronger networks could be, if not canceled, at least postponed. The current infrastructure coupled to load management enhances the network’s strength, as higher energy consumption will no longer imply higher electricity power needs.

The flexibility of demand can also favor the Balance Responsible Parties (BRP). These market actors are financially responsible for maintaining the balance between power production and consumption. The current market design entails 1-hour balance agreements, meaning that the energy consumed by the BRP’s clients during one hour must correspond to the energy bought by the BRP on the market. If it is not the case, the BRP has to pay proportionally to its imbalance. Remote control over a BRP’s consumption portfolio could ensure a better match between forecasted and actual load and thus substantial profits.

Thanks to price sensitive purchase bids, the inelastic demand curves currently observed on the electricity exchange place would change and the price cross would certainly lie at lower levels than today. Higher demand elasticity is also a way to avoid extreme situations when prices reach very high values. Price-sensitive demand from consumers requires that retailers adapt their offers and propose new types of contracts rewarding active modification of one’s consumption. Beyond the new tariff structure, it also brings extra security for them by limiting their volume and price risk exposure. End-users actively participating in DR will have an increased awareness when it comes to energy consumption. They will turn from passive to active and responsible prosumers with the will and possibility to reduce their electricity bills by adopting new habits.

The benefits from DR for the environment are real. Limited use of pollutant peak power plants will decrease greenhouse gases emissions while a more flexible load will enable higher RES penetration, thus securing the energy supply and limiting the imports of fossil fuels. What is more, a higher awareness among the consumers can contribute to improve the energy efficiency and reduce unnecessary consumption.

C. Potential Barriers

Many obstacles have to be overcome before DR is implemented in a large scale. This section lists the main concerns that can emerge as well as advice to avoid them.

Getting a widespread customer involvement is of a critical importance. The main responsibility to inform the end-users falls to retailers, which have privileged contacts with them. It is only through a better understanding of their own electricity consumption that customers will be able to discern the societal advantages of DR. It is however doubtful that demand response will experience any break-through in the coming years.

Market design shall also be adapted for this new solution. Otherwise, there is a risk that the potential for DR and its development pace will be slowed down. A rewriting of the rules is therefore advised in order to allow active demand penetrate the market. Requirements on negative consumption bids must be adapted to reality, i.e. low minimal size and a clear definition on how the negative power is determined are of utmost importance. It is indeed a subtle calculation to estimate the impact of a DR measure on the load profile. Another point to take into account is the responsibility agreements for non-delivery. The risks inherent to forecast errors as well as the method used to calculate imbalances shall be specified. Finally, even the best regulatory regime would not be of much
use if no incentives for DR services exist. Traditional, secure solutions will always be preferred to risky new ones. This is why Aggregators must be provided with the right incentives to permit the take-off of DR until the technique is proven and widespread.

D. Key Parameters for Success

After describing the potential advantages and risks linked to DR, it is important to underline that they depend on the conditions in which it is implemented. The success of a demand response program is directly related to a specific set of parameters. This section offers a list of key parameters that are to be compared to the characteristics of any area where DR is planned. The results presented here are mainly adapted from [14] and four factors have been identified as key parameters.

- **Geography**: refers to the climatic conditions and natural resources of the region under study.
- **Consumers**: their density, number and consumption pattern must be identified, as well as their evolution perspectives.
- **Electricity production**: the generation mix and its potential evolution are of interest. Extra attention must be paid to the regulatory context.
- **Technology**: the consumers’ behavior towards new, more flexible forms of using electricity must be predicted, the emergence of new technologies and their success has to be forecasted and the general quality of the grid must be assessed.

Once these four parameters have been identified, a trustworthy scenario based on the current situation and reasonable evolution perspectives has to be built up and mapped against a reasonable business case.

IV. Analysis of Business Opportunities for Aggregators

The services that an Aggregator can deliver are of different nature depending on which actor they are destined to, as shown in Fig. 1. The technical feasibility of each service is evaluated and the economic outcome estimated, based on a comparison with conventional solutions. Potential barriers and risks are also presented.

A. Services to Network Operators

The existence of an Aggregator opens a whole range of new solutions for the network operators to tackle with grid problems. The flexibility offered by the Aggregator will allow a better management of local grids and thus defer investments for upgrades by increasing the lifetime of the current infrastructure. A correctly designed grid shall be able to cope with the maximal expected load. Nevertheless, as distributed generation and load profiles evolve at a higher pace than grid upgrades, load flexibility can postpone new investments through peak-load shaving, i.e. limiting the number of occurrences when the grid is solicited at its top capacity. The Aggregator contributes to reduce the load during sensitive time slots or offers a flexibility that can be called upon at any moment. The benefits of avoiding peak loads are transmission losses and grid maintenance reductions, thus increasing the net present value of grid investments. These services can easily be provided through industrial customers with predictable loads and possibly in-house back-up generators or residential customers (electric heating and cooling) who can adapt their consumption upon short notice. An Aggregator can adapt the consumption curve in a given area to the production of distributed RES. When the share of renewable energy represents a significant percentage of the local load, it can be interesting to adapt the load profile to the actual production in the area. It results in technical benefits such as reduced losses and congestion in the lines. From an economic viewpoint, the network operator would avoid paying for losses and could postpone grid investments both for load and generation expansion thanks to an improved management of its assets. The distribution operator would reward the Aggregator proportionally to its own benefits in proportion of the quality of the service delivered. The demand response should preferably come from private households, with electric vehicles flexible charging potentially involved in the future.

B. Internal Portfolio Balancing

BRP buys electricity on the day-ahead market corresponding to the expected consumption of their clients. There is a systematic volume risk that the actual consumption will not match the predicted (and bought) power on the exchange. In order to hedge against this type of risks and minimize the cost of forecast errors, the BRP may be interested by a service adapting the actual consumption of its consumers to its day-ahead prediction, on an hourly average. This can naturally be offered by an Aggregator under some conditions. In order to perform a good service, the Aggregator would ideally need to be able to control the load of the whole retailers portfolio in a given area. In practice, this would hardly be achievable but it is easy to understand that the more clients participate in its portfolio, the more valuable the service will become. The effectiveness of the Aggregator directly depends on the capacity of the BRP to accurately forecast production, since the amount of power that can be regulated is limited.
C. Day-ahead Optimization

The Aggregator is a new actor on the electricity market. As such, it can trade on the power exchange in order to maximize the economic outcome of its flexible resources. Depending on the structure of its service providers, the Aggregator can act both as a producer and as a consumer as long as it fulfills the size requirements to participate on the power exchange. If it is able to accurately predict the amount of power that it can force its prosumers to consume or disconnect during a given hour on the following day, then it can buy or sell the corresponding power on the exchange. The service is essentially oriented towards flexible industrial customers who already adapt their load according to their own economic optimization. In order to become a valid business case for the Aggregator, the service should bring additional incentives to convince targeted customers to adopt its offer instead. The driving force for price-sensitive load adaptation needs not be exclusively financial. It can also be offered to consumers interested in reducing their impact on the environment. Reducing the amount of peak-load periods would result in a proportional decrease in CO2 emissions, beyond the simple economic consequences.

D. Frequency Control

When there is the slightest variation in the nominal frequency, it must automatically be restored to its original value. A frequency drop can be counteracted either with increased power production or reduced consumption. An Aggregator disposing of remote-controlled, fast-activated DR could easily use its service providers in order to participate in primary control, which is automatically activated. As the market is symmetric, meaning that an actor has to be able to deliver both up and down-regulation, the technical implementation for an Aggregator is challenging. The best solution to provide symmetric control is to possess batteries or alternatively electric vehicles, and adapt the charging phases to the frequency on the grid. This would however cause unpredictable states of charge and would prematurely damage the batteries. This is why primary control is not likely to become profitable in a foreseeable future.

When primary control has been activated and the frequency is stabilized again, it must be brought back to its nominal value. An Aggregator could participate in such services since the technical requirements are less demanding than primary control. This type of service could be made possible through specific contracts with industrial clients that have fast ON/OFF cycles.

V. THE OPTIMIZATION MODEL

In order to perform a given service of DR, an Aggregator has to take into account a set of internal and external constraints based on the availability of its resources and the reliability of forecasts. The Aggregator receives revenues corresponding to the benefits it induces for its counterparts while it must compensate for the discomfort it creates for the customers. Yet, it is not bound to deliver a certain quality of service. If it were to be unable to offer a good quality of service, the only penalty would be reduced incomes. If it were to be carried out in reality, the Aggregator would have to perform an individual assessment of what each and every single one of its providers can deliver under a given period of time, based on both historic-statistical data and real measures collected by a so-called Energy box [14]. Such a box allows remote observation and control over each customer's electricity consumption. Furthermore, as the data used to perform the optimization calculations are only predictions, sensitivity analysis or expected deviations should also be accounted for in the business model.

The mathematical optimization model presented below has been specifically designed to maximize the profit of an Aggregator performing DR with electric-heated private consumers in order to better follow the local wind power production.

A. Assumptions and Simplifications

The model has for objective to determine whether the given current conditions can be considered as economically interesting for an Aggregator. In order to fulfill this goal, it was necessary to model the actual conditions in the object of use case (the Swedish island of Gotland) and simplify them in order to be able to perform numerical simulations. Although the values are site-specific, the model was designed to be adaptive and in principle, consistent data from other areas can also be used as relevant inputs.

Concerning market prices, it has been assumed that the Aggregator is acting as a pure price-taker, i.e. it does not have any influence on spot prices. It has also been assumed that all houses of a given type have the same building characteristics and that all customers behave in the same way, when it comes to temperature discomfort. A list of parameters is given in Table I.

B. Description of the Process

In order to better understand the optimization algorithm it can be useful to describe the reasoning sequence. Concretely, the Aggregator’s role would be to minimize the transmission losses through the distribution network. This is done by optimizing the load profile so as it follows the instantaneous wind production. To do so, the Aggregator can remotely control the electric heating load of private households. Based on day-ahead forecasts and on their variability, the algorithm suggests
TABLE II. THE OPTIMIZATION VARIABLES

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Definition</th>
<th>Boundaries</th>
</tr>
</thead>
<tbody>
<tr>
<td>$P_{\text{need}}$</td>
<td>Needed regulation</td>
<td>-</td>
</tr>
<tr>
<td>$P_{\text{avail}}$</td>
<td>Available extra heating load</td>
<td>$[0, \ p_{\text{max}}]$</td>
</tr>
<tr>
<td>$P_{\text{act}}$</td>
<td>Activated power</td>
<td>$[-Q_{\text{base}}, P_{\text{avail}}]$</td>
</tr>
<tr>
<td>$T$</td>
<td>Home temperature</td>
<td>$[T_{\text{min}}, T_{\text{max}}]$</td>
</tr>
<tr>
<td>$\text{Load}_{\text{agg}}$</td>
<td>Optimized load</td>
<td>$[0, \text{Load}_{\text{max}}]$</td>
</tr>
</tbody>
</table>

The equations are essentially provided to help the reader understand the theory lying behind the whole optimization process. The simulations have been implemented in MATLAB [15], with the help of the optimization toolbox in order to be able to solve the entire problem. The optimization problem is solved by calling fmincon, which minimizes a given function (here the opposite of the objective function) under specific constraints, both linear (load limits) and non-linear (temperature boundaries).

C. Mathematical Formulation

The equations are essentially provided to help the reader understand the theory lying behind the whole optimization objective. It also sets the foundations for possible refinements that can be added. Table II presents the optimization variables calculated according to:

$$P_{\text{act}} = \begin{cases} P_{\text{avail}} & \text{if } P_{\text{need}} \geq P_{\text{avail}} \\ P_{\text{need}} & \text{if } -Q_{\text{base}} \leq P_{\text{need}} \leq 0 \\ -Q_{\text{base}} & \text{if } P_{\text{need}} \leq -Q_{\text{base}} \end{cases}$$

$$P_{\text{need}} = W - \text{Load}_{\text{base}}, \text{Load}_{\text{agg}} = \text{Load}_{\text{base}} + P_{\text{act}}$$

D. The simulation model implementation

Once the whole mathematical problem is correctly defined, numerical simulations were performed with the help of an optimization algorithm. The simulations have been implemented in MATLAB [15], with the help of the optimization toolbox in order to be able to solve the entire problem. The optimization problem is solved by calling fmincon, which minimizes a given function (here the opposite of the objective function) under specific constraints, both linear (load limits) and non-linear (temperature boundaries).

There are several stochastic phenomena on which the Aggregator relies in order to calculate the optimal load response. The factors that have been studied are: spot prices, temperature, load and wind production. It has however been assumed that the totality of the customer base is available at every single instant. Concerning the construction of the stochastic input variables, historical variations have been studied and an average hourly price for each month has been calculated with its corresponding standard deviation. The algorithm then generates a matrix of random hourly values for each day and the optimization is performed. In order to give a more accurate estimate of what the actual outcome would be, the procedure is repeated a certain amount of times in a Monte-Carlo process. Finally, when the optimal solution is found, the algorithm provides an average value for the daily outcome of the Aggregator and the expected deviation.
An interesting observation is that if the service is performed only once every other day (set-back curve in the figure), allowing the home temperature to go back to acceptable levels before turning off the heating again. Since most of the action of DR in this case would consist in load-shaving, retailers would indirectly benefit from the demand-response. Provided that they are informed of the Aggregator’s actions, they would be able to reduce the amount of power purchased on behalf of their consumers, leading to overall savings up to ten times higher than the Aggregator’s profits.

VI. Simulation Results

In Fig. 2, the results of the Monte Carlo simulations is graphically displayed. In essence, the results show strong seasonal variations, with a noticeable increase during the core winter months when the temperatures are low. However, on a annual basis, the average daily expected outcome for the Aggregator is rather low, as it must be taken into account that the service studied only can be performed during the winter season (ca. 6 months in the study). The results of the simulations have highlighted the good quality of the physical delivery. The low benefits for the Aggregator are partly due to the specific conditions prevailing on the study’s object. Provided that there are distribution networks with high penetration of electric heating or cooling and intermittent local RES, the results could be radically different under modified market conditions with higher price volatility. This paper has identified the key parameters for a successful implementation of an Aggregator and the simulation tool developed is versatile and not case-specific so it can be used to test the same or different business model with other scenarios.

This work has just investigated a particular aspect of the vast subject of Aggregators and has paved the way for pursued research in the field. As this concept is still mostly in the research phase, the natural pursuit would be to carry out small-scale pilot projects. Their objective would not be to create a profitable business but rather to put into practice the technical conclusions of this and coming research works.

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