Networked Business Model for Dynamic Pricing in the Electricity Market

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***Abstract*—In a liberalized electricity market, the introduction of dynamic pricing for residential consumers has consequences on the whole network structure. This structure consists out of all market participants and their interactions. To assess the impact of dynamic pricing, an accessible representation of the network structure is implemented in a networked business model applying the e^{3}value methodology. The focus of the model is on the interaction and value exchanges between market participants. Hereby, an economic analysis for all market participants is performed. Using the networked business model reveals the shifts of economic values triggered by dynamic pricing and the resulting demand response for all market participants throughout the network. An indication for the feasibility of dynamic pricing can be given.**

***Index Terms*—Demand Response, Dynamic Pricing, Economic Value, e^{3}value Methodology, Networked Business Model**

I. INTRODUCTION

Over the last years the liberalization of the electricity market has changed the structure of the electricity market significantly. Before the start of the liberalization process, the market was determined by one vertically integrated energy utility. This utility was responsible for the complete supply chain of electricity. It processed all steps from production over transmission to distribution of electricity to the end consumer. However, the unbundling has established a market wherein multiple market players participate. The market has developed from a monopoly to a system of interacting actors, e.g. power generators, system operators and retailers. This process has come along with a change of the structure. The predominant linear supply chain has been replaced by a network formed by emerging market participants and their interactions. As a result, the network is not as predictable as the situation before the unbundling. The network is subject to steady changes such as the market entrance of new players, the establishment of new interactions among them and the introduction of new market places and trading schemes.

For further research of the electricity market, it is important to have a model which represents and visualizes the market participants and their interactions in a simplified and accessible way. Such an accessible model allows the user to easily adapt settings and parameters in the model. In this way emerging market participants, new interactions and business opportunities can be researched. Although, existing models represent the electricity market and its participants, these models typically focused on a specific topic. One example is the EMCAS model [1]. This model uses agent-based modeling and focuses mainly on the transmission system and the market clearing. Another alternative is the HAIKU model which includes all market participants and allows for a detailed setting of parameters for the modeled market participants [2].

In this paper a model of the electricity market using the e^{3}value methodology introduced by Gordijn and Akermans [3] is proposed. This methodology results in a networked business model. Such a model gives a simplified representation of the network structure of the electricity market. Thereby, it puts a strong focus on visualizing and understanding interactions between participants. Above that, it is possible to quantify the impacts of new market participants, shifts in the interactions and changes in the valuation of exchanged values. The model also allows following cause-effect chains through the network. It is highly adaptable in form and scale in order to represent new adjustments in the market. As a result, this model enables to assess new market opportunities [4].

One of the market opportunities for the future is the supply of electricity for residential consumers applying dynamic pricing (DP). Dynamic prices are electricity prices which vary over time and incentivize consumers to shift their consumption from high-priced periods to lower-priced periods [5]. Subsequently, dynamic pricing for electricity is one way to accomplish demand response. Demand response is the change of consumption patterns of electricity triggered by market incentives [6]. This consumption shifting has influence on all market participants including system operators and electricity generators. As the offering of dynamic pricing is initiated by electricity retailer, dynamic pricing is seen as a new business case for them.

In this paper, the economic value of introducing dynamic pricing into a liberalized electricity market is assessed. This assessment is done based on a networked business model representing all involved market participants. In Section II, this paper outlines the objectives and terminology of a networked business model. Section III outlines the concept of dynamic pricing and the resulting effect on the networked business model. Section IV describes the adaptations made in the model to integrate dynamic pricing in a case study. Afterwards, the results of the model calculations are outlined in Section V. Finally, Section VI gives some general conclusions.

II. NETWORKED BUSINESS MODEL

A. *Objective of the Model*

The objective of the networked business model is to represent the liberalized energy market in an accessible way. The model is used as a tool to do an economic analysis. This economic analysis serves as indicator for the feasibility of new business cases such as the introduction of dynamic pricing by the retailer. As a result, the model helps to detect and adapt infeasible configurations of a business case in order to reach a feasible and sustainable system for all participants.

The model follows the definition of a networked business model given in [7]. Thereby, this model captures the inter-organizational relationships which are established for exchanging (economic) values between market participants. Therefore, it is also named as value network. In the context of this paper, a network describes the interactions of participants and does not refer to the electricity grid. The value network perspective applied on a network ensures the complete assessment of a business case. The focus is on the constellation of market participants, the established value transaction and the creation of an economic (sustainable) system [8]. Consequently, the extent of the network reaches from a starting stimulus, e.g. the demand to consume electricity, to the very last step of creating the demanded value, e.g. the power generation.

The first step towards an economic analysis is the visualization of the network. In order to oversee the network structure, the relevant market participants as well as their interactions are distinguished. As a second step, value flows between market participants in the form of products, services and information are determined. Afterwards the value flows have to be quantified. The valuation of exchanged value forms the baseline for the economic analysis. However, this valuation is independent from the modeling. Subsequently, individual valuations, such as different price schemes can be analyzed and compared. During the modeling, the goal is to find a trade-off between detailed representation and keeping the model adaptable.

B. *Terminology and Modeling*

The model uses the e^{3}value methodology. This methodology is a lightweight ontology-based modeling approach [3]. It is developed to visualize business cases using a simple terminology that gets along with few concepts such as actors & market segments, value activities, value flows and scenario paths. These concepts cover the essential components of a networked business model. The e^{3}value methodology especially focuses on the flows of economic values following a scenario path within the modeled network [9].

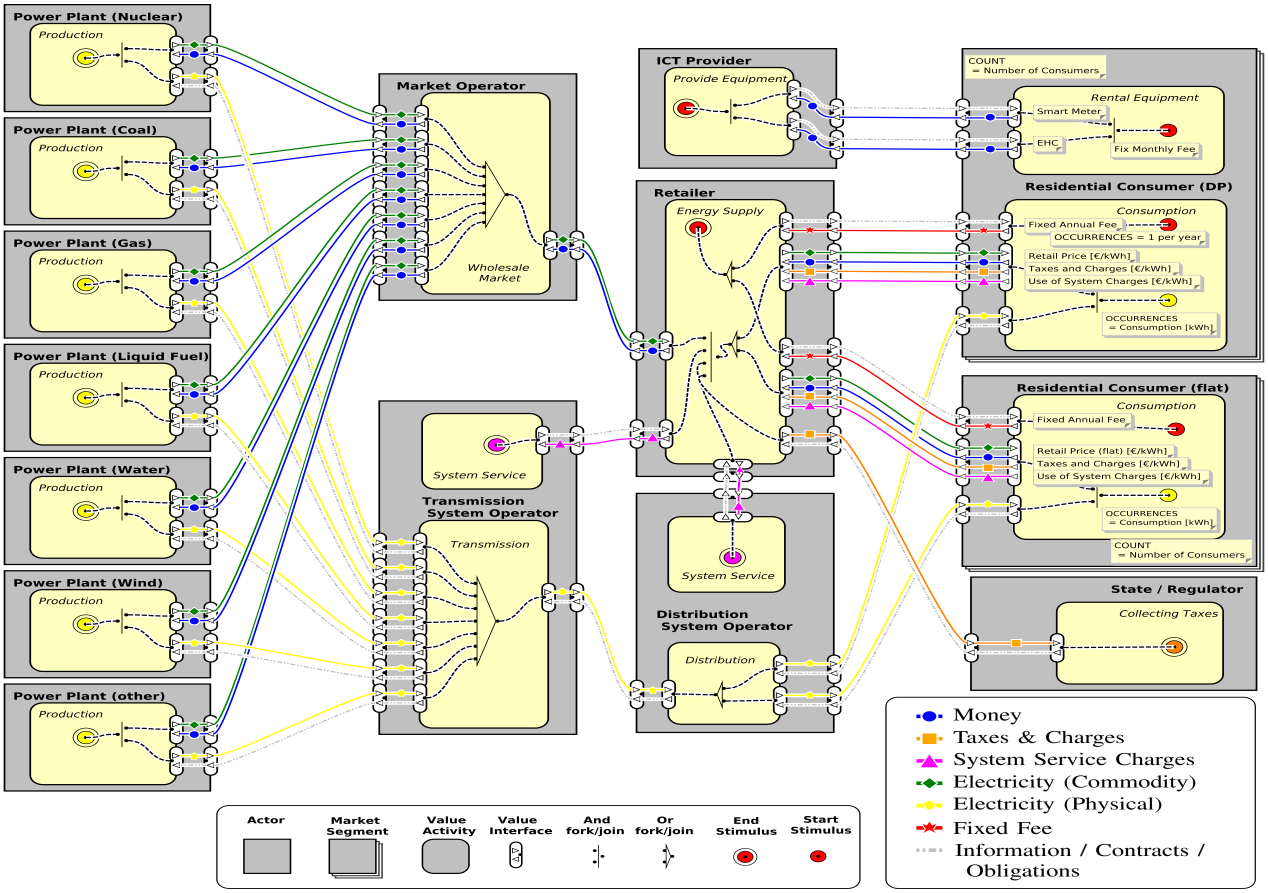

Fig. 1. e^{3}value model for an electricity market with dynamic pricing

A detailed and complete description of the ontology is given in [10]. In what follows the most important concepts for the model in this paper are covered in detail.

1) Actors & Market Segments: Actors and market segments represent the economically independent entities in the network. In the model shown in Fig. 1 the actors are diagrammed as rectangular boxes. One example is the retailer in the center of the figure. The model builds up around one retailer entity offering dynamic prices.

Above that, individual actors may also represent definite business units such as accounting or production within one entity (also shown as rectangular boxes). It might be possible for example that the ICT Provider represents a legal entity or alternatively a business unit within the retailer.

Actors are characterized by their value activities as well as their connections with other actors. Multiple actors with the same characteristics are grouped to a market segment. The market segments have the same meaning as actors, but they can vary in their count and parameter settings. The market segments are depicted as a stack of rectangles. At the right side of Fig. 1, residential consumers are modeled as market segment. All residential consumers purchase their electricity from the same retailer. Therefore, all their activities and interactions follow the same characteristics.

2) Value Activities: Value activities are activities that are conducted by an actor or market segment. Each value activity is performed with the goal to generate economic value in the form of profit or utility. A utility gain can be for example the consumption of electricity while the realization of profit is monetary. A value activity can also include several smaller value activities sharing the same goal. Value activities are shown in Fig. 1 as a rectangular with rounded corners. An exemplary value activity is the consumption of electricity of a residential consumer. Hereby, the goal of a residential consumer is to increase its utility through consuming electricity in its household.

3) Value Flows: Value flows connect actors and market segments with each other. They represent the interaction and exchange of value among them. These value flows include all economic values that are created within the network. They are diagrammed in Fig. 1 as lines between the actors and market segments. The value that is transported via a value flow is represented by its color and symbol (see key bottom right). For example, the electricity (-⬟-) is transferred from the power plants on the left side via the Transmission System Operator (TSO) and Distribution System Operator (DSO) to the residential consumers. In return, the payment (-●-) is forwarded from the residential consumer via the retailer and the market operator back to the power plants. Furthermore, each value flow may be valuated with a certain valuation, e.g. the price for electricity. Later on, this valuation is the baseline for the economic analysis wherein the values of all incoming and outgoing flows of an actor or value activity are summed up.

4) Scenario Paths: Scenario paths are the underlying backbone of the model. A scenario path is the succession of one or more value flows deduced from one or more starting stimuli. It is composed by several objects in the diagram. A scenario path always consists of a start stimulus, one or more connection elements including value flows, and end stimuli. Moreover, scenario paths can be split and merged using join and fork elements. A fork and a join element can be expressed as an AND or OR decision. One example for a scenario path in Fig. 1 is the supply of residential consumers with ICT equipment (top right). The path starts at the start stimulus, the demand of residential consumers to be equipped with the ICT equipment. This includes both the usage of a smart meter and an energy home control (EHC) unit. The scenario path splits up at the AND fork into two sub paths. The two sub paths visualize the exchange of a smart meter and an EHC in return for a monthly fee. Within the ICT provider the scenario paths merge again. The AND elements ensure the fact that both elements have to be available at same ratio in order to make use of dynamic pricing to its full extent. Finally, the merged scenario path ends at the end stimulus. Other scenario paths form the supply of residential consumers with electricity and system service. The wholesale market at the upper left of the model serves as an example for the application of an OR element. The amount of the flow leaving the wholesale market towards the retailer is equal to the amount coming from the power plants. However the share of each power plant may vary.

C. Advantages and Disadvantages

Applying the e^3value methodology on the liberalized energy market shows certain advantages and disadvantages. As already stated before, the model is a trade-off. The complexity and attention of detail on one side must be weighed against adaptability and visual accessibility on the other. This paper gives preference to the latter.

As a result, the drawback is the simplification of the modeled actors. That is done for example for the modeling of the wholesale market. While existing models are able to simulate the market clearing in detail, in this model a simplified division of the produced electricity among the power plant types is done according to historical data. This especially diminishes the effect of demand response reducing the operating hours of peak power plants. A combination with e.g. an unit commitment model reveals these shifts between different generation technologies. The reduction and grouping of individual entities to market segments simplifies the model as well. This is done for example for residential consumers which leads to the assumption of aggregated behavior.

Using the e^3value methodology results in a very accessible and communicative model. Because of the graphical representation, see Fig. 1, the model can be easily communicated to market experts and used as baseline for further discussion on new market opportunities. Moreover, the model creates an economic analysis on several levels, thus for the holistic network or each actor or value activity. Both, visualization and economic analysis give insights in the market structure. Furthermore, the increased traceability of value flows through

TABLE I
BENEFITS OF DYNAMIC PRICING FOR MARKET PARTICIPANTS

Time Horizon	Consumers (DP)	Consumers (flat)	Retailer	DSO / TSO	Power Plants	State / Society
Short Term	Reduction of electricity bill	-	New market opportunity	Improved reliability Efficient operation	Efficient operation	Reduction of CO_2 emissions
Long Term	Reduction of electricity bill Lower prices for electricity	Lower prices for electricity	Attraction of new consumers	Fewer investments in infrastructure	Fewer investments in peak power plants	Reduced market power

the network allows examining cause-effect chains. Because of the simple graphical representation, value activities and actors can easily be inserted or allocated to new actors or market segments. The model can graphically be adapted to new market situation. As a result, the effect on the economic analysis is clear and comprehensible. It is also noteworthy that because of the ontology-based approach, each model is also represented in a machine-readable language and can be extended with further models, like a unit commitment model. This can help to overcome the simplification drawback stated above.

III. CONTEXT OF DYNAMIC PRICING

Dynamic pricing implies a time-varying tariff scheme which reflects the retail prices for the peak and off-peak periods of demand throughout a day. This incentivizes consumers to shift their electricity consumption from peak periods (high price) to off-peak periods (lower price) [5]. This means that consumers adapt their demand to a price signal given by the retailer. Implementations are time of use pricing (ToU), critical peak pricing (CPP) and real time pricing (RTP). Therefore, dynamic pricing is one way to achieve demand response by the consumer [6].

Demand response in general is defined as the change of consumption patterns of electricity. The change can be achieved in several ways. The incentives to change consumption are mostly economic, including incentive-based and price-based programs. Price-based programs concern the price of electricity that has to be paid by the consumer. The incentive to change consumption patterns is based on the price signal that is sent to consumers [11]. The characteristics of the incentives include different prices for periods with high and low consumption, thus dynamic pricing.

Applying dynamic pricing schemes leads to four different types of benefits: financial consumer benefits, financial market-wide benefits, reliability benefits and market performance benefits. Above that, benefits can be separated into short-term and long-term benefits and allocated to the different market participants (see Table I).

Financial consumer benefits include the direct reduction of electricity bills for consumers with dynamic pricing on both short and long-term. However, also consumers without dynamic pricing benefit as generation costs are reduced due to peak load reduction. This results in a benefit for both consumers with and without a dynamic pricing tariff [12]. Next to the financial benefits for consumers, market-wide benefits, increased reliability and market performance have to be valued as well. Because of the expected shifting of consumption from the peak hours towards the off-peak hours and a resulting smoothed and steadier load curve, the system can be operated more efficiently [6]. The efficiency gain results in fewer necessary cost-intensive investments into the grid infrastructure. These investments include replacing obsolete components and adjusting the grid to an increasing peak demand and enhanced distributed generation [13]. Furthermore, dynamic pricing facilitates reduced investments in capital intensive and hardly used power plants for peak demand in the future. Through the smoothing of the total load curve and the avoidance of peaks a reduced usage of conventional peak power plants is necessary. Via the linkage of the retail price, the usage of renewable energy sources is further facilitated. This results in less CO_2-emission intensive power generation.

The dynamic pricing scheme applied in this model is a price based on the day-ahead price with a time period of one hour. Hereby, the consumer is aware of all prices for the following periods one day ahead.

IV. CASE STUDY: DYNAMIC PRICING

The case study in this paper is done in the framework of the Linear project. The Linear project implements a field test in order to achieve demand response of residential consumers in Flanders [14]. Amongst others, dynamic prices are introduced as incentive for consumers in the field test. In this paper, the goal of the case study is to show the effect of dynamic pricing on all market participants. The starting point of the case study is the retailer that offers both a dynamic pricing tariff and a flat tariff to its residential consumers. The retailer is therefore the center of the model (see Fig. 1) and the model is adjusted to its viewpoint. An overview of all actors, activities, flows involved in the model is given in Table II.

A. Adjusting Model to Case Study

On the demand side, the retailer sells electricity as a commodity (-◆-) to its customers, the residential consumers. In return, consumers pay for electricity. The price includes the retail price (-●-), taxes & charges (-■-) and use of system charges (-▲-). The different tariff schemes are represented in the valuation of these flows. Next to the price depending

TABLE II
ELEMENTS OF NETWORK BUSINESS MODEL

Actors & Market Segments	Value Activities	Value Flows In (←); Out (→)
Residential Consumers	Consumption	→ Payments Electricity
		Energy Component
		Taxes & Charges
		Use of System Charges
		Contracting
		← Electricity$^{(\diamond)}$
	Smart Grid Equipment$^{\triangleleft}$	→ Payment (Rental Fee)
		← Equipment
Retailer	Energy Supply	↔ Electricity$^{\diamond}$
		← Payments Electricity
		← Obligations
		→ Taxes & Charges
		← System Service
		→ Use of System Charges
Distribution System Operator	System Service	→ System Service
		← Use of System Charges
	Distribution	↔ Electricity
Transmission System Operator	System Service	→ System Service
		← Use of System Charges
	Transmission	↔ Electricity
Market Operator	Wholesale Market	↔ Electricity$^{\diamond}$
		→ Payment Power Producers
		← Payment Supplier
State / Regulator	Collecting Taxes	→ Obligations
		← Taxes & Charges
Power Producers	Production	→ Electricity (TSO)
		→ Electricity$^{\diamond}$(Market)
		← Payment from Market
ICT Provider	Smart Grid Equipment	→ Equipment
		← Payment (Rental Fee)

$^{\diamond}$: Electricity traded as commodity
$^{\triangleleft}$: Only for consumers with dynamic pricing

on consumption, an annual fee for the contract is paid by the consumers to the retailer (-★-). The earnings for the retailer arise as a surcharge on the price of electricity from the wholesale market.

Apart from this, residential consumers with dynamic pricing need to rent the necessary ICT equipment (Smart Meter and EHC) from an ICT provider (top right of Fig. 1). The billing for the consumed electricity is also handled by the retailer. This implies that taxes & charges and use of system charges are transferred via the retailer. The taxes & charges are forwarded to the state and partly transferred to the electricity market regulator. The use of system charges are divided among the DSO and TSO.

On the supply side, electricity is produced by the power generators. The power generators are divided into seven different actors representing the installed capacity per fuel type (see left side of Fig. 1). The power plant types are nuclear, coal, gas, liquid fuel, water, wind and others.

The electricity system to supply the residential consumers can be divided into two subsystems, the physical subsystem and the economic subsystem [15]. The physical subsystem involves all hardware that physically produces and transports electricity [16]. In the model this system is represented by the value flows of electricity (-⬟-, bottom of model) from the power plants via the TSO and the DSO to the consumer. The TSO collects all electricity from the power plants and forwards it to the DSO. This represents the injection of electricity into the transmission grid and the transport to the distribution grids. From the distribution grids the electricity is delivered to the residential consumer by the DSO.

The economic subsystem involves all administrative and economic transactions of electricity as a commodity (-◆-, top of the model). The market operator handles all electricity in the form of a commodity. This represents the electricity market where the demand and supply are cleared. The two subsystems depend on each other. The split into two subsystems gives more scope for development while modeling. Transferring changes within the electricity system into the model are simplified. These changes include for example the modeling of new markets (e.g. capacity mechanisms), new transmission schemes (e.g. HVDC, import/export of electricity), balancing mechanisms or distributed generation.

Certain simplifications are taken without curtailing the model. This affects the demand side where industrial consumers are excluded. Also distributed generation at the residential consumer level is excluded. Furthermore, it is assumed that all electricity is traded via the wholesale market. This means that there are no over the counter market between retailer and power producer. For future models, trading of electricity has to be enhanced with additional market places. This also refers to balancing mechanisms and ancillary services. For the supply side, technical constraints and grid topologies are omitted. However, in the future this can be included via e.g. a unit commitment model or power flow calculations.

B. *Scenarios*

Three different scenarios are applied to make an economic analysis of the model described above. In line with the model, these scenarios are based on the framework of the Linear project [14]. A base, mid and full scenario are used whereby the difference refers to the amount of consumers with a dynamic pricing tariff. The total number of consumers is set to 2000 for all three scenarios. In order to quantify the effects of dynamic pricing the number of consumers with dynamic pricing is increased from 0 (Base) to 2000 (Full). The mid scenario shows the situation wherein the retailer offers two different price schemes. This represents the introduction stage of dynamic pricing. An overview of the scenarios and parameters is given in Table III.

The consumers consume according to an initial and optimized consumption pattern derived from applying a short-term consumer benefit model for dynamic pricing presented in [17]. Hereby, only the shifting of consumption from white goods (dish washer, washing machine) is taken into account. Consistent with [17], consumption data refers to measurements from the field test within the Linear project. However, the total consumption of all consumers does not change with the change

TABLE III
PARAMETERS FOR SIMULATION

Scenario		Base	Mid	Full
Flat tariff consumers	#	2000	1000	0
DP tariff consumers	#	0	1000	2000
Fixed Annual Fee	€/a	40	40	40
Retail Price (Flat)	€/kWh	0.1983	0.1983	-
Retail Price (DP)	€/kWh	-	0.12-0.29	0.12-0.29
including				
Taxes & Charges	€/kWh	*0.033*	*0.033*	*0.033*
TSO tariff	€/kWh	*0.013*	*0.013*	*0.013*
DSO tariff (basic)	€/kWh	*0.039*	*0.039*	*0.039*
+ DSO tariff (7h-22h)	€/kWh	*0.049*	*0.049*	*0.049*
+ DSO tariff (22h-7h)	€/kWh	*0.022*	*0.022*	*0.022*
Rental ICT Equipment	€/a	-	30	30
Total Consumption	MWh/a	13.543	13.543	13.543

of the pricing scheme as the demand is only shifted but not reduced.

Dynamic prices for electricity are derived from the Belpex price, the Belgian Power Exchange. These prices are adjusted in order to take into account the availability of renewable energy sources to a large extent. Thus, lower prices represent more power injection from renewable energy sources. The complete formation of the price is described in [11]. Taxes and charges are adapted to the situation in Flanders [18]. The use of system charges also follow the legal situation in Flanders and are appropriately divided among the DSO and TSO [19].

V. RESULTS

Results of the model derive from the calculated economic values. These economic values are calculated for each market participant and each value activity. The economic value of each value activity is the sum of the valuation of each incoming and outgoing value. Consequently, the economic value of a market participant is the sum of the economic values of each its value activities. A positive economic value shows a benefit for the participant. As an exception, consumers end up with a negative economic value. The absolute value of this represents the economic value which is needed to attain a certain level of utility. If the absolute value goes down, it is assumed that the same level of utility can be attained at a lower cost. For consumers a reduction of this absolute value at the same level of consumption shows an improvement of their situation.

In order to investigate the feasibility of the introduction of dynamic pricing, the resulting economic value of each market participant has to be examined. In order to state the introduction as feasible, each market participant should be better off or at least have no negative result. However in an initial market-wide analysis, individual participants can have a negative result if the overall market value is positive. This shows that the activities or valuations are not allocated and configured properly yet. Shifting value activities to other actors, e.g. a new market participant, or changing the valuation, e.g. remuneration schemes, can take the economic value to a feasible level.

The starting point for the analysis is the shift of consumption at residential consumer level. This is caused by the reaction of consumers to the price signal. Consequently, this results in a reduction of the electricity bill [17]. At the same time consumers spend money for the rental of ICT equipment (see Table III). However, the absolute economic value for consumers declines (see Table IV) in the full scenario. In order to achieve an incentive for more consumers, pricing for ICT equipment should not eat up the bill savings [20].

The provision of the smart meter and EHC for consumers introduces a new value activity in the market. This activity can either be taken by an individual new actor, the ICT provider, or also be incorporated in one of the existing actors, e.g. supplier or DSO. In this model expenses for the development and maintenance of the equipment are covered by the rental fee. The payment of this fee, either only paid by the consumer or partly by the supplier or DSO, depends on the placing of the activity and also the usage of information gained from the ICT equipment, i.e. real time consumption data.

The market operator is not listed in Table IV. In this model it is assumed that the market operator does not create any economic value. This represents that the market operator does not gain additional economic value if the supplier offers dynamic pricing schemes.

For the other market participants the analysis of results is less obvious. Comparing the base and the full scenario, the total volume declines. This corresponds to the decline of the absolute value of consumers. Since the consumers still consume the same amount of electricity, this decline can be seen as an efficiency gain. Fig. 2 visualizes the development between the three scenarios. The share of economic value for each market participant is depicted in Fig. 3. The economic value of consumers is not depicted as the absolute economic value of consumers represents the total volume corresponding to the shares.

The result shows that the economic value for the TSO and state does hardly change. Smaller shifts are related to shifts of consumptions over the end of the considered time frame. The constancy relates to the fact that the transmission tariff and the taxes & charges are not affected by the dynamic pricing. These components of the retail price remain constant in all scenarios. In contrast, the economic value of the DSO declines. The reduction of the economic value refers to the shift of consumption from day to night hours with a lower distribution tariff (see Table III). The difference of day and night distribution reinforces the dynamic pricing based on the energy component. In a feasible system for the DSO the decrease of economic value must be covered with the benefits from a more stable and reliable operation of the system. In order to further reinforce the price signal the transmission tariff and also the taxes & charges can have dynamic characteristics as well. This would lead to larger differences between peak and off-peak prices, more shifts and an even steadier load in the system.

TABLE IV
ECONOMIC VALUES OF ACTORS AND MARKET SEGMENTS

Scenario		Consumers*	Retailer	ICT Provider	DSO	TSO	Power Plants	State
Base	€	-2,765,081	179,335	0	1,055,228	176,053	894,017	460,447
Mid	€	-2,763,356	176,497	30,000	1,051,870	176,057	868,474	460,457
Full	€	-2,761,631	173,659	60,000	1,048,512	176,061	842,931	460,468

*: Negative economic values of consumers because of consumption of electricity ⇒ Economic utility of electricity

The economic value for the supplier goes down as well. In the model, the margin of the supplier is related to the energy component (+10%); the price the supplier pays for buying electricity at the market. With an increased consumption of electricity at periods with lower prices for electricity, subsequently the economic value of the supplier declines.

The model shows that the DSO, supplier and power plant operators are worse off. This can only be a first indication of the feasibility and only considers the short-term financial benefits. In order to come to a holistic assessment the benefits from improving the reliability and postponing investments in the infrastructure have to be included. The savings from the deferring or preventing investments have to cover the reduction of the economic values seen in this model. On the long term, also power plants may benefit from the increased demand response. The shifting of demand has positive effects on the overall load factor of power plants which leads to a higher and more steady utilization. It is to discuss, if without peak consumption enough scarcity prices are created to cover the fixed costs of peak power plants.

For suppliers, the outcome of the model does not incentivize them to introduce dynamic pricing for consumers. In order to generate an increase of economic value for the supplier a higher fixed annual fee can be considered. In the model an increase by 2.85 € is enough to let the supplier be better off in the full scenario without changing the conclusions for consumers significantly. In the long term, it is to determine if the supplier can use the information from the smart meters and the smoothed load curve to better predict the consumption of its consumers and generate additional economic value from this knowledge. Furthermore, the improvement of the outcome for its consumers attracts more consumers.

In addition to the model in this paper, approaches to do a cost-benefit analysis for smart grid projects are presented in [21] and [22]. These approaches can be included in the calculation of the economic value of this model. For further analyses this also involves a longer time period of several years.

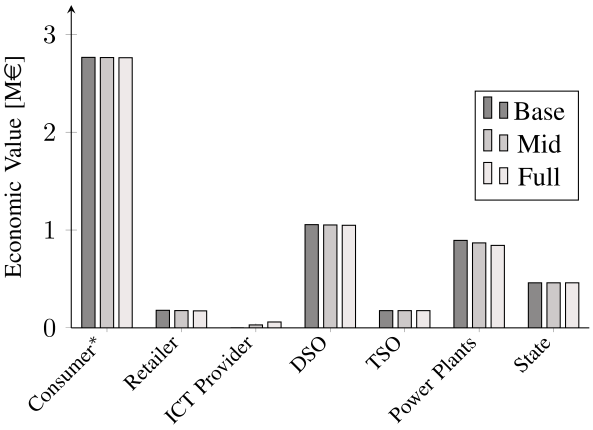

Fig. 2. Absolute economic value of market participants

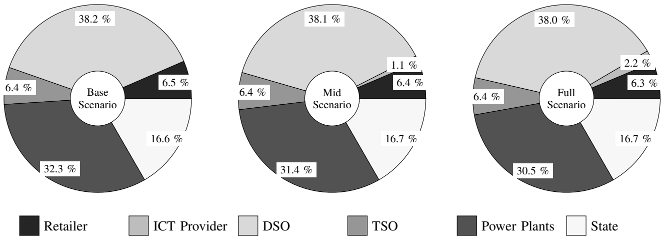

Fig. 3. Share of economic value of each market participant

VI. CONCLUSION

This paper discusses the usage of a networked business model for the analysis of new market opportunities in the liberalized energy market. The objective of the model is to represent the interactions between market participants in an accessible way by using a network structure. The focus of the model is put on the exchange of values resulting from the interactions.

The model in this paper is developed based on the e^{3}value methodology. This lightweight ontology based methodology uses only few concepts. The most used and presented concepts are actors & market segments, value activities, value flows, and scenario paths.

This paper presents an application of the e^{3}value methodology for dynamic pricing. The focus lays on the offering of dynamic pricing to residential consumers by one retailer. A complete model including all relevant market participants and interactions is shown. The model distinguishes between a physical and an economic subsystem of supplying electricity. The advantages and disadvantages of this approach observed while modeling are outlined.

The model is applied within the context of the Linear project in Flanders. Three different scenarios are calculated to show the resulting economic value of introducing dynamic pricing. This shows an improvement of the economic value for consumers despite expenses for additional ICT equipment. The outcome of TSO and state stays unchanged because of revenues independent from the tariff scheme. The economic value for the retailer, DSO and power plants declines. In order to reach a feasible system these reductions have to be covered by savings from improved reliability and postponed investments in the system in the long term.

For further work the model will be enhanced through integrating further business cases within the Linear project such as wind balancing and managing of low voltage load profiles. Together with the data from the field test of the project, more detailed economic analyses can be done. This will include the analysis of the interactions of all business cases within the Linear project [14]. Moreover, this will include the quantification of long-term benefits. This quantification will contribute to the results of this paper and complete the economic analysis. In particular, as a method for communicating results and as baseline for discussion, the e^{3}value model provides valuable contribution.

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