Innovative business models making use of the flexibility of the industrial electricity demand for integrating wind energy

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***Abstract*— Wind energy has some drawbacks for its integration in power systems and markets like variability, restricted predictability and firmness that impose extra requirements and costs. The flexibility of the industrial electricity demand has been identified as a potential that - through innovative business models - can facilitate the integration of variable renewable energy, while reducing electricity costs for the industry. As a starting point, this paper provides a basic outline of the different possible business models for supplying variable renewable electricity to industrial users with a potential for flexibility in their demand. It then assesses how the current market and regulatory framework affects the models' applicability in the industrial sector of Belgium, France, Germany, Italy, Spain and the UK.**

***Index Terms*— Variable renewable energy (VRE), flexible industrial demand (FID), wind energy, grid integration, flexibility, industry, cost of electricity**

I. INTRODUCTION

Currently energy policy in Europe is in a transition and faces fundamental choices. Among other topics, the cost-effective integration of variable renewable electricity into the European power system as well as the rising cost of electricity and its effects on the competitiveness of the European Industry have been at the top of the agenda [1]. The EC Guidelines on State aid for environmental protection and energy 2014-2020 [2] define that increased market exposure and balancing responsibilities for renewable energy plants will be introduced by 2016 at the latest. In this context, the IndustRE project aims to support variable renewable energy (VRE) operators to be prepared for this transition, by helping them identify the most cost-effective way to deal with this challenge.

The flexibility potential of the industrial electricity demand has been identified as an opportunity that - through innovative business models - can facilitate further growth and integration of variable renewable energy, while reducing the industrial electricity costs. Large, energy-intensive industrial consumers could have flexibility in their demand arising through a combination of 1) a number of process specific properties such as 'direct' and 'indirect' storage of energy, 2) storage of semi-finished products and 3) a certain amount of over-capacity in the production or installation.

The IndustRE project aims to create win-win situations between the European industry and the renewable energy generators. The renewable energy generators can minimise balancing costs and optimise their generation profile and resulting overall profit. The industry can benefit by using in various ways the value their flexibility has for the power system. Work within the project is separated in three phases: First, business models that bring benefits to all involved parties are outlined. In the second phase of the project, tools and methodologies are developed to bring the business models one step closer to implementation and case studies are selected. During the last phase of the project the benefits for all involved actors are quantified and improvements in the market and regulatory framework are proposed and promoted.

This paper presents the work conducted within the first phase of the project on outlining the different business models [3] as well as provides a first evaluation of these models for commercial exploitation of flexibility in industrial electricity demand in Belgium, France, Germany, Italy, Spain and the UK after screening the regulatory and market frameworks of these countries [4]. This work does

not present definite conclusions and recommendations, but rather defines a common starting point and provides the basis for a stakeholder's consultation that follows in the coming months aiming to identify the main barriers to exploitation of the business models that lead to win-win situations between the European industry and the renewable energy generators.

In section II, the paper provides an overview of the different possible business models in which the current regulatory and market conditions are not taken into account. The business models have been grouped in two categories - those that are based on the reduction of electricity payments (models A) by shifting consumption to lower-cost periods, and those concerned with offering services to the power system (models B). In section III, the paper tries to identify the key elements of regulatory frameworks that potentially influence the applicability of the defined business models. This covers current and future structure of generation and demand, industrial consumer pricing as well as the current participation of flexible industrial demand (FID) and variable renewable energy (VRE) generation in wholesale energy markets and their responsibilities and options in relation to the provision of network and system services. Based on a characterisation of the aforementioned countries' regulatory framework, an evaluation of the business models' applicability in each of them is presented in section IV.

II. Business Models

Any flexibility in industrial demand can be used to provide services to the power system as a response to external signals, for example signals from the system operator. In this section all possible services are listed without examining what rewards they offer, if any, in different countries. The business models below are defined from the perspective of flexible industrial consumers benefitting from their flexibility, interacting directly or not with variable renewable energy generation. The business models are classified into:

A. Reduced energy bills

By shifting consumption to time-periods where the electricity costs are lower, the industrial user can reduce its energy bill. Assuming that the low costs are reflecting real needs in a well operating market, shifting industrial consumption will bring benefits also to the network operator, especially at areas and regions where the grid capacity is close to its limits. In such areas, FID could also bring indirect benefits to VRE plant operators, who might face lower curtailments levels. In case FID is used to reduce peak demand, there are also benefits for the system operator; for example it could indirectly contribute to balancing and lowering the pressure for future increases in generation capacity.

A.1 Often industrial users adapt their production to programmes where certain pre-defined time periods are charged at a reduced tariff; a common example is the night rate.

A.2 As we are moving to a power system where the time-period of low-cost energy cannot be so easily foreseen, the fixed programmes (see A.1) become less relevant and more elaborate options start emerging, involving signals from the supplier to the user indicating the time periods of high, normal and low energy prices.

A.2.1 By reacting to these signals, the industrial user can adapt its consumption profile, minimising its energy bill, while not necessarily affecting its overall production.

A.2.2 An interesting case is when the electricity supplier is also an operator of VRE plants. This can be for example a utility that owns also VRE plants and can benefit from FID to balance their generation portfolio. We can also envisage in the future the case where the supplier is a small independent power producer, selling their electricity directly to flexible industrial users.

A.2.3 In the case of on-site renewable energy there are more options opening within the option A.2. There can be emphasis in shifting consumption to time periods when electricity is available from the on-site VRE plant, as the flexible user will be able to maximise the share of the overall demand covered by own production. This would lead to reduced energy costs, depending on the relation between the tariffs at any given moment and the on-site generation costs. Here, there can also be the option of feeding electricity back into the grid and being rewarded based on the agreement with the supplier, for example a "net-metering" scheme.

A.3 Another option is to procure electricity from the wholesale/spot market, either directly or through an aggregator. That case is similar to A2.1, with the difference being that there are more opportunities to benefit from fluctuating prices. Especially in the case of an on-site VRE system, when participating to the wholesale market the industry could sell the excess generated electricity and use its flexibility to maximise the related revenue.

A.4 The flexibility can result in lower peak demand, which will result in lower requirements from the grid and reduced associated charges. The application of this option might be restricted by the industrial production capacity and the production requirements, unless there is on-site VRE or other generation capacity that could allow reducing peak-demand while maintaining full operation close to the peak production capacity, when necessary.

B. Offering flexibility services to the power system

Industrial electricity demand flexibility can also offer other services to the power system, contributing to lowering the costs of maintaining the required power quality and helping to defer investments in the transmission and distribution networks. These could also benefit indirectly the VRE plant operators by potentially lowering their grid related tariffs.

B.1 FID can be used to contribute in containing the frequency variations by offering reserve capacity, either directly or through an aggregator. The details on how this could work in practice vary between countries, regarding minimum thresholds, time periods, rewards and requirements for automatic activation, etc. Usually, reserve capacity is offered through the markets for primary, secondary and tertiary control managed by the network operator.

B.2 The use of FID in containing the frequency variations can also happen through the signals sent by the Balancing Responsible Party (BRP), either directly to the industrial user or through an aggregator. These signals aim to activate the flexibility of the industrial user in order to support the balancing of the BRP portfolio.

B.3 FID can also be used to offer other services to the system, such as long-term generation investment deferral (e.g. capacity markets), network congestion management, reactive power control as well as distribution system services (e.g. peak demand shaving, active and reactive power control, voltage support and contribution to distribution network security). For most of these services, there have been no markets established yet in most countries, at least no markets where consumers can participate.

III. MARKET AND REGULATORY FRAMEWORKS

This section tries to identify the key elements of regulatory frameworks that potentially influence the applicability of the defined business models. This covers current and future structure of generation and demand, industrial consumer pricing as well as the current participation of FID and VRE generation in wholesale energy markets and their responsibilities and options in relation to the provision of network and system services.

A. Structure of generation and demand

The structure of the power generation mix and the adequacy of the installed capacity are relevant for identifying the need for flexibility and the potential significance of variable renewable energy in the system. The categorization of consumers into different groups of activity, size and connection voltage level is necessary to discover the FID target group in each country. Both elements of the characterization give us a sense of the magnitude of the potential impact of the proposed business models for demand response from FID integrating variable renewable energy provided these models where applicable.

The European electricity system is made up of a variety of interconnected regional and national systems, each of which presents its particular generation mix. Even though there are common EU policy guidelines and key directives, the implementation at MS level differs from country to country, leading to a variety of foreseeable investment scenarios especially in view of renewable energy sources and their market development and integration.

B. Electricity prices for industrial consumers

The final prices paid by industrial consumers is a key determinant in the applicability of the business models of type A, related to the management of flexible demand in response to price signals that incentivise changes in the consumption pattern. These signals can have two sources: a) variability of the energy price in the market; and b) the structure of the network tariffs and other regulated charges.

In this sense, it is equally important to look into the structure of the network tariffs as well as into the relative importance of each of the components of the final price. Sometimes, industrial consumers are charged more complex tariff structures, with time differentiation and incentives to reduce peak demand. Also, industrial consumers are generally charged lower regulated costs than residential and other small consumers, often through direct allowances or exemptions to the regular tariff. In addition, large industrial consumers are more easily exposed to the real time market prices, or other dynamic structures, through advanced retail contracts. When the energy purchase component has a relevant weight in the final price, the business models A.1 - A.3 will make more sense, while the business model A.4 will be very dependent on the available tariff options and the extent to which the tariff structure sends a sufficiently sound signal that incentivises peak reductions.

Incentives to self-consumption

The possibility of netting demand with self-consumption or even the subsidies for the surplus energy produced, encourage the combination of business models type A for FID with on-site VRE (business models A.2.2 and A.2.3).

C. Wholesale energy markets

Energy transactions between generation and load parties are organized in a sequence of successive markets with different time scales, covering from months to years before the trade is to be implemented, day-ahead, intraday, gate closure, real time and post-transaction settlement.

Generators compete in the wholesale energy market to sell electricity to large consumers and suppliers in different time horizons. Until gate closure, market agents are allowed to balance their positions (of generation or demand) and correct any deviations without the intervention of the Transmission System Operator (TSO) in the day-ahead and intraday markets.

The type of participation of VRE and FID in the wholesale energy market is relevant for the applicability of the business models type A. The role of VRE operators in the market, which is very related to the existing support schemes, will be indicative of their incentives to selling energy bilaterally or in the market. In addition, the form of having access to electricity in the market by FID will be a key determinant in their exposure to real-time market prices.

VRE support schemes & participation in the market

The extent to which VRE operators are allowed to participate in the market depends mainly on the current regulation on support schemes for renewable energy. In so far as the expected profitability of VRE is based on regulatory subsidies, VRE operators will be decoupled from actual market conditions and therefore will be less incentivized to be competitive in the market or develop innovative contractual arrangements with FID. Only if certain market mechanism exists for the allocation of subsidies for renewable energy, some incentives for efficient market behaviour in the VRE operators are introduced.

FID access to electricity supply & participation in the market

Regulated prices for industrial consumers are generally being phased out so they are forced to go to the free market to purchase their electricity. Additionally, they always have to pay for the use of system or network tariff that corresponds to their level of voltage and power consumed. In this context, FID connected to the medium or high voltage grid with an average peak demand of some MW and consuming in the range of some GWh per year, has two possibilities to buy electricity: a) purchasing energy directly through bilateral contracts with generators and from the wholesale market, and b) signing a contract with a supplier in the free retail market with certain price structure conditions (from flat rates to final prices indexed to the real time, going through other forms of time-of-use dynamic pricing).

D. Network and system services

After market gate closure, the responsibility for generation scheduling and dispatching is transferred to the TSO, who is in charge of maintaining system security and provide an adequate quality of supply. The TSO is supported in its task of maintaining the balance within its area of control by different grid users. Each TSO acquires ancillary services from network users, mostly contracted ahead of real time from selected grid users that qualify for providing these services. The main elements of ancillary services include active and reactive power reserves for balancing power and voltage control. In particular, active power reserves are used for frequency control and system balancing, i.e. ensuring the instantaneous physical balance between supply and demand, among other system operation needs. These power capacities can be contracted and activated by the TSO with an associate payment for their availability and/or activation, or made available without payment. Closer to real time, operating reserves can be automatically or manually activated, turning these balancing resources into effective Balancing Energy. In addition to the regulation and balancing reserves, and mechanisms to manage congestions in real time, the TSO may count on additional emergency services by which, in case of necessity, the TSO could ask for adjustments in the dispatch of generation groups or ask for demand interruptions.

Business models belonging to type B are directly related to the possibilities of FID, alone or in combination with VRE, to provide flexibility services to the system, mostly to the TSO. In this sense, it is necessary to identify the responsibilities and possibilities of participating in the provision of active power reserves and energy for balancing, congestion management and other ancillary services by VRE and FID.

IV. Applicability of the Business Models

In this section, the applicability of each business model presented in more detail in section II is evaluated in the light of the present regulatory and market frameworks of Belgium, France, Germany, Italy, Spain and the UK. An overview of the country by country analysis conducted in relation to the existing barriers to the applicability of those business models is presented and then summarised in TABLE I. . More details can be found in the original report [4]. It is highlighted that this analysis does not present definite results, conclusions or recommendations, but rather provides a basis for a stakeholder consultation that aims to identify the main barriers to exploitation of the defined business models.

A.1 Time-of-use tariff or price rates

Time-of-use tariff or price rates are feasible in Belgium, Germany, Italy and Spain. In France this option is rather limited for large electro-intensive consumers who are strongly incentivised to contract energy with suppliers at regulated fixed price for their baseload, benefiting from the ARENH ('Accès Régulé à l'Electricité Nucléaire Historique') scheme. However, industrial consumers may be offered time varying prices by suppliers by the end of 2015 when they stop being under an integral regulated tariff ("Tarif Vert"). In the UK this model is very limited because around 80% of trading activity occurs in the bilateral market through over-the-counter (OTC) and forward trades.

A.2.1 FID shifting consumption in response to dynamic pricing signals from the supplier

FID shifting consumption in response to dynamic pricing signals from the supplier is applicable in Belgium, Germany and Spain. In Italy electricity suppliers can offer dynamic prices to industrial entities, but only on the energy sales component of the electricity bill (excluding taxes and network and general system charges). In France and the UK the present circumstances limit the full realisation of this business model for the same reason as A.1.

A.2.2 A supplier owning VRE plants benefitting from the FID to balance

This business model is applicable only in Belgium and Germany. In France it is possible to establish such bilateral contracts, however, due to the feed-in tariff support scheme still present suppliers with VRE are encouraged to sell their renewable production in the wholesale market where there is an obligation of purchasing it, instead of arranging a bilateral contract with FID. In Italy the majority of VRE so far has not been installed by traditional electricity suppliers. Alternatively, direct bilateral sell of energy from VRE operators to FID is possible but not usual. In Spain a supplier owning VRE plants benefitting from the FID to balance their generation portfolio is not possible, due to the fact that offers/bids in the wholesale energy market and the balancing markets are separate for generation and consumption. Alternatively, direct bilateral sell of energy from VRE to FID are possible but not usual. This model is very unlikely also in the UK where VRE require long-term power-purchase-agreements (PPAs) from credit-worthy parties.

A.2.3 On-site renewable energy and the possibility of netting demand

In Belgium and Germany on-site renewable energy and the possibility of netting demand with self-generation, or net metering is applicable. The "direct line" option allows users to avoid distribution and transmission costs and accede to cheaper energy. Self-consumption is possible also in France, with no additional taxes. In Italy a mechanism for on-site renewable energy and the possibility of netting demand with self-generation exists but only for a capacity of up to 500 kWe. In Spain and the UK on-site renewable energy is possible but without netting demand with self-generation.

A.3 Manage consumption in response to wholesale electricity prices by acceding directly to the market or through a supplier/aggregator

This model is applicable in Belgium and Germany. Direct access to the market requires the acknowledgement of the FID that owns the VRE plant as BRP, otherwise the only possibility is being exposed to retail prices based on the wholesale market. French and Italian large consumers are allowed to net their demand with self-consumption and participate in the wholesale market but the low regulated price may disincentive this option even if it is possible. Specialized suppliers for large consumers in Spain may directly pass through the market price plus a fixed or market-indexed component to recover imbalances and management costs. With on-site VRE, "excess" energy being sold in the market is not directly applicable because all (not only the excess) injected energy would be measured separately from consumption and would be subject to the renewable energy remuneration scheme. Very little

experience has been reported on applying this business model in the UK.

A.4 Reduced network charges by lowering peak demand

Reduced network charges by lowering peak demand is possible only for large grid users in Belgium, given that they have a capacity measurement and a capacity charge. With on-site VRE, peak 'net demand' can be compensated with self-generation. In France the transmission tariff for HV consumers has a capacity charge and time differentiation for the volumetric charge but it is unlikely that it provides a sound incentive for peak load reduction given that it accounts for a small share of the final electricity price for this consumer group. In Germany network operators can provide reductions in network tariffs for large industries according to their consumption behaviour. The individual tariff can't be lower than20 % of the published regular tariff. A part of the network charges for Italian consumers is fixed and a part is variable with no charges directly related to installed or contracted capacity. Industries with on-site generation pay the whole amount of the fixed part they purchase from the grid but only 5% of the variable part of network charges. This model is generally applicable in Spain as the access tariff includes a capacity charge that is relatively low for industrial consumers. In addition, even if contracted power can be lowered to reduce the capacity charge, it cannot be done with self-consumption from own VRE. This model is applicable and feasible in the British context because of the high value of avoided transmission costs if peak demand is reduced, which is reflected in the locational part of the transmission network use of system (TNUoS) tariffs. The capacity that is used to calculate transmission charges (for injection or withdrawal) is based on each parties position during peak demand period which gives industrial consumers a strong incentive to forecast peak demand periods and manage their injection/withdrawals during those hours either by using on site generation or by reducing their consumption.

B.1 FID offering reserve capacity, either directly or through an aggregator

FID offering reserve capacity, either directly or through an aggregator is possible in Belgium and France and partly possible in the UK. In Germany demand response and aggregation are allowed in all balancing markets, however, the regulation is very strict around balancing group management which is a clear barrier for new entrants. In Italy and Spain this business model is not applicable. However, a new system of capacity remuneration mechanism will be put in place from next year in Italy in which demand side management (DSM) is allowed to participate.

B.2 FID responding to signals sent by the BRP

In Belgium and France large grid users and aggregators (for smaller ones) can offer services by responding to signals by a BRP via bilateral contracts. In Germany this business model is applicable but limited for the same reason as B.1. In Italy and Spain FID can help BRP reduce demand imbalances through a dual imbalance pricing system that treats generation and demand separately. In the UK this model is possible when the supplier is distribution connected, assuming the role of BRP. FID might have balancing responsibility if transmission connected.

B.3 Other services to the system, e.g. investment deferral, congestion management, etc.

Other services to the system reported vary from country to country. In Belgium there is an interruptibility service for large grid users, whereas voltage control is mandatory and not remunerated. In France load can take part in the capacity market through a certification process contributing to reduce or defer investments in new power plants. Interruptibility programs are implemented by the TSO as well. The German law allows TSOs to take either grid- or market-related measures, whereby the latter may include cutting off installations at peak based on a contractual agreement. DSOs also have the possibility to conclude such contracts with installations connected to their grid, which will normally be awarded reductions in their grid use fees. In Spain large consumers can provide interruptibility services to the TSO for emergency situations. Intensive industrial demand in the UK can participate in the capacity market (even though in practice this has been very limited and already committed for a long period of time), provide supplementary balancing reserves and may be exempted from green levies.

In the following table a first qualitative assessment of the applicability of each business model in each target country is provided. A colour is assigned for each case with the following meaning: green if the business model is compatible with the current regulatory and market framework; amber if the present circumstances limit the full realization of the business model or make it unattractive; and red if significant barriers exist that do not enable the business model.

TABLE I. QUALITATIVE ASSESSMENT OF THE APPLICABILITY OF THE BUSINESS MODELS IN THE TARGET COUNTRIES

Model	*BE*	*FR*	*DE*	*IT*	*ES*	*UK*
A.1	🟢	🟡	🟢	🟢	🟢	🟡
A.2.1	🟢	🟡	🟢	🟢	🟢	🟡
A.2.2	🟢	🟡	🟢	🟡	🟡	🔴
A.2.3	🟢	🟢	🟢	🟡	🔴	🔴
A.3	🟢	🟢	🟢	🟢	🟢	🟡
A.4	🟡	🟡	🟢	🟡	🟡	🟢
B.1	🟢	🟢	🟡	🔴	🔴	🟡
B.2	🟢	🟢	🟡	🟡	🟡	🟢
B.3	🟡	🟢	🟢	🟡	🟡	🟡

V. CONCLUSSIONS

The present paper contributes to the discussion about what the role of flexible industrial demand in accommodating higher shares of variable renewable energy can be. A first assessment of the applicability of business models that could create win-win situations between the European industry and renewable energy generators has been made for Belgium, France, Germany, Italy, Spain and the UK based on the present regulatory and market frameworks in these countries. This analysis will be used by the IndustRE project as a basis for a stakeholder consultation that aims to identify the main barriers to

exploitation of the defined business models in the respective countries and the rest of Europe.

Commitment and action from decision makers would be necessary for improvements in the regulatory and market framework that would make the business models more attractive. More concrete recommendations on how this can be achieved will follow in the next months from the IndustRE project. The input for our recommendations will not be coming from one sector that just promotes its interests. They will represent a wide consensus of the renewable energy community and the large industry in Europe, two sides that have often had opposing views in key energy policy aspects, plus feedback from other key actors like utilities, TSOs, DSOs and regulators will be taken into account.

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