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How to purchase a hazardous volume in a just-in time system ? The case of wind power

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Abstract
The integration of wind power into competitive electricity markets has been accompanied by economic support mechanisms that could be either price-based (feed-in tariff) or quantity-based (quota, green certificates). These support mechanisms are collective contracts where a group of agents is obliged to purchase either energy or certificates from beneficiaries of support mechanisms. In most countries, the development of wind power leans on the price-based mechanisms which binds down all residential consumers to buy all the production generated by windmills at a fixed price [CE, 2006]. The feed-in mechanism corresponds to a regulated contract ([Goldberg, 1976], [Langniss, 2004], [Finon, et al, 2006]) inducing a contractual relationship binding the beneficiaries of the feed-in tariff – here the wind power producers – and the obligated party – the consumers. We focus on this paper solely on the contractual relationship between producers and consumers. Our aim is to analyse how this collective contract could be enforced between the wind power producers and the consumers in case of hazardous volume of production in the electricity system.
First, we demonstrate that this contract can not be enforced by the contractors themselves since it is incomplete and constrained by the measurement problem of the electricity system. Second, we show that the enforcement of the feed-in contract implies a trilateral governance structure where the third party designs the rules for enforcing it. After the analysis of the tasks of the third party and of the functioning of electricity system, we explain that the third party is the system operator -the centralised authority of electric flows. Finally, we determine how the system operator enforces the contract by ensuring both the delivery of a hazardous volume and the individual settlement warranty of the collective contract. By doing that, the system operator manages the individual and collective enforcement of the purchase agreement.

1. Introduction

The development of wind power capacity into electricity system is basically attractive since this renewable energy reduces the greenhouse gas emissions of the sector. Since this technology can not compete with conventional production units, the integration of wind power has been pushed by a

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contractual framework through economic mechanisms that could be either price-based or quantity-based. Both types of mechanims are collective contract where a group of agents is obliged to purchase either energy or certificates from the beneficiairies of the support mechanisms. In most european countries, the development of wind power leans actually on the price-based mechanisms which binds down all residential consumers to buy all the production generated by windmills at a fixed price. This feed-in tariff could be interpreted as an administred contract between the legislative branch of government, the producers and the consumers ([Langniss, 2004], [Finon, et al. 2007]).To ensure that all the production will be purchased, the regulatory framework that decides the terms of mechanism involves a priority injection on the network. But the wind power is special since the output depends directly from a variable primary resource that could not be accurately forecasted. Wind power is a hazardous production directly injected in a just-in time markets. The objective of this paper is therefore to analyse how this collective contract could be enforced between the obligated party – here the wind power producers – and the obligated party – the residential consumers in the just-in time system.

In this paper, we focus solely on the contractual relationship between producers and consumers. The regulatory nature of this contract concerns political economics and the comparison of support mechanisms deals with the reasons for promoting such technologies. Our aim here is to analyse how it could be possible to integrate such production once it is supported through economic mechanisms. To analyse how this contract could be enforced, we analyse its terms. First, we demonstrate that this contract can not be enforced by the contractors themselves since it is incomplete and the electricity system is strongly constrained. Second, we show that the enforcement of the feed-in contract implies a trilateral governance that individualizes the collective contract. The third party designs the rules that allow it to enforce it. After the analysis of the tasks of this third party and of the functioning ot the electricity system, we explain that the system operator of the electricity system is the third party of the governance structure. Finally, we determine how the system operator enforces the contract by ensuring both the delivery of a hazardous volume and the individual settlement warranty of the collective contract. By doing that, the system operator manages the individual and collective enforcement of the contract.

2. The problem of individualization of the collective contract of wind power purchase

The feed-in tariff is a support mechanisms implemented to incite investments in renewable

energies. It stipulates that the produced renewable energy has to be purchased by obligated parties at a fixed price. The feed-in tariff induces a double contractual relationship. It could be interpreted firstly as a regulated contract ([Goldberg, 1976], [Langniss, 2003], Finon,et al. 2006]) that binds the regulator or the legislative branch of government, the wind power producers and the consumers. In order to fight against the climate change, citizens have mandated public authorities to stimulate the investment in renewable energy sources [Finon,et al. 2006]. Because the fight against the climate change and the positive environmental externalities generated by windmills, all support mechanisms are based on electricity demand [Langniss, 2003]. Secondly, the feed-in tariff could be interpreted as a collective contract between the producers and the consumers directly. The electricity production has to be consumed in electricity market where competitive mechanisms have been implemented. To assure that, a second contractual relationship binding the producers and consumers appears. We focus only on this second contractual relationship. This relationship has to ensure the delivery and the settlement of the hazardous electricity production of windmills.

We firstly analyse the feed-in tariff as a collective contract. The terms of this contract, decided by the regulator, brings credibility to the commitment for the producers only. But, this contract is also incomplete since the obligated party does not know *ex ante* the quantity they have to buy. Secondly we show that a measurement problem appears which hinders the self-enforcement of the collective contract. This measurement issue comes from the impossibility to originate the electrical flow. This measurement issue hinders the individualization of the collective contract.

1. The feed-in tariff is a collective contract

The feed-in tariff stipulates that all the electricity generated by windmills has to be purchased by the residential consumers at a fixed price. Even if the terms of contract have been deciced by the regulator or the legislative branch of government, a contractual framework may allow the enforcement of this support mechanism on the electricity system. This contractual framework binds all the wind power producers to all residential consumers since the latter are obliged to buy the electricity at the fixed price. In that case the feed-in tariff is a collective contract between all producers and all consumers. The aim of this contract is to warranty the enforcement of the regulatory contract on competitive electricity markets. Two major dimensions of the collective contract shed the light on the credibility of this commitment: the price and the volume dimension.

In the feed-in tariff, the price is fixed for all the produced electricity. This price is defined *ex ante* by the regulator. That means that all the electricity produced by windmills and injected on the electricity

network is remunerated at a fixed price. Depending on the country, the parameters to determine the tariff could be different. Most of time, the feed-in tariff corresponds to the production costs plus an environmental premium. This environmental premium could be an assessment of the stranded cost of conventional units[1]. In France, the feed-in tariff has been fixed at 82,6 €/MWh. This is higher than the french spot price [Powernext, 2007] and than the production costs of wind power ([RAENG, 2004], [DGEMP, 2005]). The feed-in tariff is a warranty for the wind power producer since he knows that each time he will produce electricity, he will receive the fixed price. Furthermore, the regulatory dimension of the feed-in tariff set the duration of the feed-in tariff on the long term between fifteen to twenty years. It generally corresponds to the lifetime of windmills.

The second dimension of the contract is the volume one. In order to warranty the feed-in tariff and because of electricity constraints, the feed-in tariff is always accompanied by an injection priority on the electricity network. This priority obliges the electricity network to always accept it whatever the state of the electricity system. Two reason explicit the priority of injection. First, the feed-in tariff is higher than the spot price; on markets no buyer will buy this electricity. Second, the collective nature of the feed-in tariff implies that all producers should receive fixed price for all electricity injected. To enforce it, the warranty of being accepted on electricity markets has to be set.

Both dimensions of collective contract create two kinds of **guarantees** and **incentives** for the producers. First, the feed-in tariff incite investments in wind power capacity. The fixed price is warranted on long term. The investor could forecast the return on investment since he knows exactly the price he will receive. Nevertheless, since wind power depends on meteorological forecasting of wind, the wind power is hazardous. In assuring a fixed price for all the produced electricity, a part of the uncertainty concerning the investment is raised. The long term guaranteed fixed price erases the price risk and by this way it rubs out the price uncertainty. Even if the volume dimension could remain, the injection priority assure that all the production will be accepted on electricity system. In advance, the investor can not know exactly the amount of power the windmills will generate but he knows that all the production will be remunerated at the fixed price. Since the feed-in tariff is higher than production costs, we could assert that the investment uncertainty is partly raised. The second warranty of this support mechanim is the exploitation incentives. Since the feed-in tariff is guaranteed for all the generated and injected production, the wind power producer has strong incentives to always produce when possible. Since wind power is produced from a variable primary resource and the production is accepted on network, the wind power producer would always capture the maximum of the wind

1 The stranded cost of the conventional units of production correspond to the costs that would be generated if a conventional production unit will produce the equivalent production of the windmills. They generally correspond to the fuel cost.

energy. The wind power producer may inject production on network each time it is possible. Furthermore, the long term guaranteed price incite producers to try to minimise costs of production in order to improve profits. The wind technology is not yet mature; and innovations on some components could reduce production costs. By this way, wind power producer would prefer to change some components on the windmills to increase its profit. Concerning the consumer, they have the guarantee to consume a part of "clean" energy and to participate to the efforts for climate change. The climate change and efforts for it could be considered as a public good [Finon, et al. 2006]. Through the feed-in mechanism, all consumers participate to the production of this public good.

Due to the guarantees of the feed-in tariff, this support mechanisms could be interpreted as a **credible commitment**. The regulatory nature of the collective contract and the incentives given by the collective contract define the credibility of the commitment. The credibility of commitment combines flexibility and stability of a commitment ([Perez, 2003], [Williamson, 1985]). The credibility could be interpreted as the stability of *ex ante* incentive rules for coordinating activities and agents [Tchapga, 2002]. For analysing the credibility of the collective contract, we consider four dimensions: 1) the guarantees of the contract, 2) the incentives, 3) the supervision mechanisms of the contract and 4) the coercive dimension [Brousseau, 1997]. The contract brings price and volume guarantees for the producers of wind power since the price is fixed and known *ex ante* and there is no issue of volume for the producers due to the injection priority. These warranties create incentives to invest in wind power capacity and to produce when possible. So the guarantees and incentives related to the contract are well know and defined. The supervision and the coercive mechanisms concern directly the regulatory nature of the contract. The feed-in tariff is a regulatory mechanism that imposes to all consumers to consume and pay for the wind power: the regulatory mechanism holds the coercive dimension since this is a public authorities decisions to be applied. The supervision dimension is assured by the electricity regulator and by the system operator that is the centralised authority specialized in the managemen of electrical flows. The system operator is the sole agent able to know that wind power has been injected in the electricity network since the system operator manages electrical flows on the electricity network. The feed-in tariff appears as a credible commitment of the public authorities favourable of wind power producers.

The feed in tariff is a **collective contract** between all the wind power producers and the residential consumers who have to pay the fixed price for the consumed wind power. The collective contract is particularly credible for the producer. From the consumer point of view, this support mechanism obliges them to pay a fixed price and to consume the wind power. In consideration to the competitive electricity markets, this collective contracts remains quite incomplete and can not be self-enforceable.

2. The collective contract is not self-enforceable

The collective contract binds all the producers and all the residential consumers. This contract is collective and multilateral. The enforcement of the collective and multilateral contract supposes to individualize it. But neither the producer nor the consumer are able to individualize it. Firstly, the electricity system is constrained by physical laws of production and circulation of electrical flows. Second, wind power is highly variable and weakly predictable; wind power is intermittent whereas the electricity system is just in time. A measurement issue appears that can not be managed by both cocontractors.

To enforce the collective contrat the transformation of the collective contrat to bilateral mechanisms between a wind power producer and a electricity retailer could be possible. Consumers don't manage the purchase function: because of their atomicity and the complexity of electricity markets, consumers delegates to electricity retailers their purchase functions [Hunt, 2002]. These retailers can act on electricity markets to ensure the delivery of electricity to its consumers. As demand is hazardous too, electricity retailers act on electricity markets to fulfil their purchase obligations. If demand varies on the day, retailers bears all the risks and costs associated. On electricity markets production may adjust to consumption.

The inability for self-enforcement of a bilateral mechanism comes from firstly its incomplete nature. The contract defines clearly the price but not the volume to be consumed. In a just in time system, this creates huge coordination issues. Electricity is not stockable and travels at light speed on the network. The equilibrium has to be instantaneous: at each second production must equal consumption. But the wind power is hazardous and the electricity demand too. The electricity retailers forecast the consumption of their customers and buy electricity on electricity markets to supply their consumers. The collective contract obliges all the consumers to buy electricity generated from windmills. Therefore, the retailer may know how many wind power energy he has to absorb by this regulatory mechanisms to determine the quantity of electricity he has to buy through market mechanisms. Nevertheless, the collective contract does not stipulate the daily amount of wind power retailers have to buy. No volume dimension is defined through the collective contract for the consumer. Since wind power is hazardous, it is impossible to know accurately in advance how many wind energy will be injected. *Ex ante* it is not possible to allocate wind power. The injected electricity is only known *ex post*. But, all the electricity produced by windmills has to be injected and consumed by all retailers. In advance these retailers can not know the wind energy they have to purchase and so the electricity they have to purchase through market mechanisms. If afterwards it could be possible

to measure the part of wind power really consumed by consumer, one could measure it and pay for it. This is not the case of electricity system.

It is impossible, secondly, to originate the electrical flow. This create a strong measurement issue that hinders the individualisation of the collective contract. Electricity is a flow; it is impossible to originate it. Once injected, the electricity is a normalized and standardized product. The consumer can not know if the electricity he consumed comes from a nuclear power plant or from windmills. Moreover, it is not possible to know exactly the path the electricity takes on the network. Electricity takes the path of least resistance. From one part, it is impossible to originate the flow of electricity and from another part, it is impossible to know the path it takes along the network. It is therefore impossible to determine the part of the wind energy in the total consumption of a consumer. This fact explains clearly the measurement issue of the collective contract.

Consumers are not able to measure the wind power they have consumed. The measure is impossible *ex-post*. But, they have to pay for all the electricity injected on the electricity system. A bilateral contract is not able to enforce the collective contract since neither the producer nor the consumer can say how many wind power they have consumed. By doing so, the consumer are not able to pay the feed-in tariff since it is not possible to know the volume. Each producer can measure the electricity fed into the electricity grid. If, *ex post*, it is not possible to measure the wind energy consumed by the consumer, the contract could not be enforced since no producer could receive the feed-in tariff. A governance structure may enforce the collective contract and individualize it. The individualisation of the collective contract means the delivery of a hazardous volume, the measurement of this volume and the settlement of consumed energy.

3. A trilateral governance to enforce the purchase agreement

We have explained that the collective contract that binds the wind power producers and consumers is incomplete since it defines clearly the price but not the volume dimension. This volume dimension create a huge measurement issue on electricity markets where it is impossible to originate the electrical flow. In that case, the collective contract can not be self-enforceable since neither the producer nor the consumer can manage this measurement issue. First, the wind power is hazardous and can not be accurately forecasted. The wind power injected in the network can only be measured *ex post*. Electricity being a flow, it is impossible to measure the wind electricity consumed by obligated consumer. No payment could be made.

The enforcement of the collective contract involves the measurement of the electricity produced and consumed by each producer and consumer. The governance structure that will pilot this transaction has to 1) manage the measurement issue et 2) assure the settlement of energy. We show in this section that the governance structure is trilateral, and that the third party is the system operator. The trilateral governance manages the individualisation of the collective contract.

1. The trilateral governance to enforce the contract

The collective contract concerning the wind power purchase can not be enforced by parties of the contracts. Neither the wind power producer nor the consumer are able to manage the measurement issue. In the new-institutional economics, the third parties could refer to the judge who may decide when contracts are not well enforced [Williamson, 1985]. This judge may solve conflict when appearing during the execution of the contract. Another role of the third party is to act as an arbiter or a referee. An arbiter is a neutral agent who may interpret the terms of contract. Concerning the execution of the feed-in tariff, the third party is kindly different. The third party may assure the execution of the regulatory contract by individualising the collective contract. In the electricity sector, a trilateral governance exist and the third party is an "expert". This trilateral governance corresponds to a "permanent delegation to a third party of the assessment capacity and decision rights on a kind of events" [Glachant, 2002]. This expert on the electricity system is not chosen by agents but determined by public authorities. With the collective contract, the third party has to individualize and enforce the collective contract.

The trilateral governance allow the enforcement of the collective contract due to the specificity of the electricity system. Because all producers can inject their electricity on the network and all consumers have to buy it and because electricity systems are now competitive, the centralisation of the electricity generated by windmills and its allocation to all retailers representing all consumers is the only means to individualise the collective contract. By this way, the third party manage two kinds of issues. Firstly, the third party assure the individualization of the contract. Secondly, the third party manages measurement tools that ensure the settlement of energy. By doing that, the third party enforces the collective contract.

The collective contract adresses two distinct groups quite independant: all the wind power producers and all the consumers. The third party has to assure the individualisation of this collective contract: all the producers have to receive the payment of generated electricity and all consumers have to pay for consumed wind power. Since consumers are not able to manage their purchase

function, they delegates it to the retailers[2]. Therefore the collective contract binds the wind power producers and the retailers. In that case, the trilateral governance may develop mechanisms to transfer energy from each wind power producer to each retailer and to realise the settlement of that transfer. Each retailer has to support a part of the wind power in proportion to its customers so that the obligation is supported by all the consumers. These mechanisms have to be determined *ex ante* to be sure that all the wind power will be allocated to the consumers. Nevertheless, the execution of the contract supposes that retailers do not bear the volume risk associated to the hazardous volume. The retailers act on the electricity markets to assure the supply of their consumers. For doing that, each retailer estimates the demand of electricity and buys the electricity required *ex ante*. If retailers have to add a hazardous volume of production, they have to balance it with demand in real-time. To avoid retailers to support balancing costs from the hazard of the wind power, the third party determines *ex ante* the quantity of wind power the retailer should absorb. Therefore, the first task of the third party is the delivery of a hazardous volume of wind power.

The third party may develop mechanisms to assure the measurement system in the individual and collective contract of wind power purchase. Neither the wind power producer nor the consumer are able to coordinate themselves and to manage the measurement issue. Neither of them is not able to tell in advance the quantity the producer will inject on the electricity grid or the quantity the consumer will withdraw. By assuring the individualization of the contract, the third party assures the measurement. This measurement issue appears on two stages: 1) the delivery of the hazardous volume of wind power in a just-in time system and 2) the settlement of the energy. The wind power has a priority for the injection. If injected, a counterparty may be found: the wind power has to be insered in the purchase portfolio of a retailer. The measurement issue for the retailer concerns the lack of information *ex ante* on the quantity he will absorb. To support the volume risk, the third party measure *ex ante* the quantity to be delivered at each retailer. Concerning the settlement of the wind energy, the measurement of the injected energy could be done at the exit of each power stations. This is done *ex post*. The third party manages *ex post* the measurement of the electricity generated by windmills and allocates *ex post* the true costs to be paid by the obligated consumers. The third party manages the individualisation of the collective contract by defining *ex ante* the quantity to absord by retailer and measuring *ex post* the electricity generated and consumed. By doing that, the third party manages the delivery of the hazardous volume of wind power and the settlement of the wind energy.

2 Firstly, consumers don't really know their own consumption. Secondly, they don't have skills to manage their purchase of complex electricity markets. Thirstly, the competitive mechanims of the electricity markets can't accept a lot of participants ([Hunt, 2002], [Stoft, 2002])

2. The system operator as the third-party

To assure the role of the third party, certain skills have to be developed. The third party may know how the electricity markets function. First, the third party may be able to measure the electricity injected on the grid. The installation at the exit of each wind farms of a metering device could be enough. Since the contract is collective and concerns all the producers, this kind of devices has to be installed for each producer. Second, the third party may act on the electricity market as a middlemen. In determining *ex ante* the volume of wind power to be absorbed, the third party may act on the electricity market to absorb the wind intermittency. Since the volume to be absorbed is determined in advance, all deviation involve a balancing on the spot market. Thirdly, the third party may have skills on the electrical flows on the network. In that sense, the third party can not be external of the electric activities.

In the electricity system, the third party of this collective contract is the system operator. The system operator has all the necessary skills to manage the hazard of wind power and the measurement issues. On the electricity system level, the system operator manages all the measurement issues, the externalities due to the circulation of electrical flows and the ancillary services related to the supply of electricity. The system operator is the centralised authority for the flows [Glachant, 2004]. The system operator coordinates in real time all the activities of the supply of electricity [Saguan, 2007]. Through the balancing market, the system operator knows exactly the amount of electricity injected by the power stations and the contractual position on the forward electricity markets. In real-time, he manages the balancing of the production and the consumption. In case of events, he has asymetric decision rights to balance the system. That's why the public authorities have delegated to the system operator the role of the third party of the collective contract.

The system operator balances the entire electricity system in real-time. He is used to deal with the hazard of the demand, since it is hazardous too. As the wind power is hazardous too, the system operator is the "first best" agent to manage the collective contract. The system operator may individualize the collective contract and assure its enforcement. The system operator manages the network infrastructure too. The operation of system is considered as a natural monopoly since the system won't work with different system operators. The system operator is thereforce still regulated. Since the feed-in tariff is a regulated contract, it seems to be normal to let the enforcement of the feed in tariff to a regulated actor. In some case, the legislation of the feed-in tariff stipulates clearly the role of the system operator for enforcing the contract. That was the case in Denmark before the reform of 2005 [Eltra, 2004].

4. The enforcement by the system operator

The enforcement by the system operator of the collective contract imposes to manage the delivery of a hazardous volume of production and to assure the individual and collective settlement of the wind power. In the first time, the system operator creates "firm blocks" of energy to be delivered at the retailers. In the second time, the system operator warrants the measurement and the settlement of the produced wind power.

1. The delivery of a hazardous volume

To deliver a hazardous volume of production, the system operator determines new arrangments in order to suppress the volume risk for the retailers. The system operator transforms *ex ante* the hazardous wind power into firm blocks of energy. These firm blocks of energy allow the individualization of the collective contract and therefore the settlement of energy.

A day before the delivery time, exchanges are made on the day-ahead market. This is a forward contract market [Hunt, 2002]. Another forward market is the intraday market, where generators could realise some fine adjustments (if some parameters change over time). The gate closure determines the time from which the nominations of production exchange schedules made to the system operator can no longer be changed. After the gate closure, the transactions are considered as firm and the system operator has to coordinate the production scheduling to the network constraints. If, for a reason, the production scheduling could not be respected, two main means are possible for balancing the production with consumption: (1) a real-time market, namely the Balancing Market, and (2) an adjustment mechanism[3].

Concerning the wind power, it is really difficult to know one day before the delivery time what will be the realised production. The tools developed by the system operator to deliver wind power output without penalizing neither the electricity retailer nor the wind power have to make it certain: the system operator as a "wizard" of the electricity market should transform a variable input into a firm one. For doing that, the TSO has to ensure that:

(1) Electricity retailer have to fulfil their requirements of wind power output in accepting firm blocks of energy. The firm blocks of energy are defined as “Exchange Schedule of Wind Power” between the system operator and the electricity retailer

3 For further information on electricity market designs, see [Saguan, 2007]

(2) The system operator is financially responsible for the supply of energy defined in the firm blocks. If the electricity quantity defined in the firm block is different from the realised wind power energy, he would have to purchase/sell electricity on the electricity market.

The firm block is a tool which enables the system operator to organize the contractual relationships between the wind power producer and the electricity retailers. Three main missions of these firm blocks are determined:

(1) the firm block leaves the suppliers only partially influenced by the uncertainty of wind power generation

(2) the firm block should contain on average an amount of energy equal to the amount of energy effectively produced by wind mills

(3) it should be non-discriminatory towards energy supplier

Electricity retailers are responsible for the balance between the consumption of their customers and the supply contracts resulting from both transactions on electricity markets and purchase requirement of wind power output. By delivering a firm block of wind energy through the Exchange Schedule of Wind power in advance, the electricity supplier can realise the exact amount of electricity transactions he needs to balance his supply contract with the customer consumption. The second mission depends on the tools deployed by the system operator to approximate the yearly wind power production and redistribute it on average to all electricity retailers. In the case where more wind power production is realised than the one set on the firm block, the system operator has to refund the electricity supplier for having too much purchased compared to the average of the firm block. To fulfil the mission (3), the most natural means is to forward the firm block proportionally to their consumption [Hiroux, et al. 2006]. In fact, the system operator have the right to choose independently the design of the formulae to change a variable output into a firm proxy. Diverse ways to design it are possible. [Hiroux et al., 2006] explained that what is important is the daily shape of the Exchange Schedule of Wind Power whose form depends on three kind of parameters: the reference period defined as the period during which the exchange should contain an amount of energy equal to the estimation of wind power output for the same period and the delivery period defined as the period during which the amount of energy sold should be proportional to the consumption of the supplier. Three study cases in [Hiroux, et al. 2006] show that the reference

period in Germany is one month and is decided by VDN (the association of German System Operator) whereas in Denmark it was from 2000 to 2003 a period of 3 months. In fact, the determination of the blocks design depends on the choice of the system operator. [Hiroux, et al. 2006] shows that the way the system operator determines the rules of the exchange schedule of wind power, have an impact on the gains and losses of the block determination.

In order to not be imbalanced by the intermittent nature of wind power, the electricity retailer knows in advance each day the amount of wind power he has to purchase so that the imbalance issues disappear. The system operator acts on electricity markets to compensate the imbalances between the scheduling of wind energy and the delivering.

2. The settlement of energy

The delivery of the hazardous wind energy allow the individualization of the collective contract since each retailers knows in advance the quantity of electricity he has to absorb. Nevertheless, the firm blocks do not correspond to the electricity really injected in the grid by windmills. Another step has to be done to enforce completely the collective contract. This is the individual and collective settlement of energy.

The measurement of energy is realised *ex post*, after the delivery of energy to the final consumers. This ex post measurement disposes the transaction in a temporal sequence. Once realised the measurement, the system operator send to the retailer the amount of wind power they have really consumed. For doing that, the system operator collects measures from all the wind farms and then he shares out this quantity in proportion to the retailer business. In general, this measurement and share arrived one month after the delivery of wind power. Afterwards, the retailers charge their consumers for the energy consumed. The consumers do their payment one month later to the retailer. Between the delivery of energy and the settlement there is a period which could be one to two months. One result of this temporal sequence could be a financial imbalance in the short-run. This imbalance is managed by the system operator that is the "pivot" of the temporal sequence.

The wind power producers could receive their payment as soon as the system operator managed the measurement. It depends on the rules decided by the system operator. In Germany, electricity retailers pay in real-time the delivery of the firm block of energy. One month later, consumers pay the amount for the electricity consumed. At this moment, the distribution system operator pay on account the wind power producers connected to the distribution network. At the end of the year, the

system operator realises the measurement of all electricity generated by windmills, and regularizes the payments 1) of the distribution system operators and 2) to the retailers if they purchase more or less than the really produced wind power. One month later, the wind power producer receive all the payment for the year. In that case, financial imbalances appears between 1) the producers and the consumers, 2) the distribution system operators and system operators, 3) between retailers and consumers, et 4) between retailers and system operator [Hiroux, 2007]. In Denmark, all the payments are made one month after the delivery of energy.

The system operator measures ex post the electricity generated by windmills after the delivery of energy to the final consumers. This ex post measure put the wind power transaction into a temporal sequence where the system operator appears as the pivot. He centralises the information and the measurement. He transfers information to the participant in charge of withdrawing the payment. In most of cases, he pays afterwards the wind power producers. By doing that, the system operator assures the individualisation of the collective contract. He firstly manages ex ante the hazardous volume of wind power in creating firm blocks of energy to be delivered to the electricity retailers. He secondly manages ex post the measures of wind power and the settlement of wind power by the consumers. The system operator enforces the individual and collective contract of wind power purchase.

5. Conclusion

In this paper, we have shown that the trilateral governance enforces the collective contract of wind power purchase. The feed-in tariff corresponds to a collective contract binding all the wind power producers and all the consumers. This collective contract takes place in a wider regulatory framework. This contract stipulates that all final consumers are obliged to pay all the electricity generated by the windmills at a fixed price. This contract corresponds to a credible commitment for the producers since the contract brings them guarantees and incentives on long term. In spite of this credibility, this collective contract can not be self-enforceable. The contract does not define clearly the volume dimension whereas the electricity system is physically constrained and needs an instantaneous balancing. As wind power is hazardous, it is impossible to define *ex ante* the volume dimension. Among other, the inability to originate the flow from the unit producing it creates a strong measurement issue since *ex post* the measure is not possible too. The measurement issue hinders the individualization of the collective contract and its enforcement.

The trilateral governance allow the enforcement of the collective contract in individualizing it. The task of the third party is to enforce the property rights of ensuring the realization of transactions related to the contract. The third party ensures the individualization of the collective contracts and determines the measurement devices assuring the enforcement of both collective and individual contracts. In the electricity system, the system operator is the third party of the collective contract. Since neither the producers nor the consumers bear the volume risk, the system operator individualizes the collective contract by determining ex ante the quantity of wind power each retailer has to absorb. The system operator must ensure the delivery of the hazardous volume of wind power and has to guarantee the individual settlement of the collective contract. For the first step on the delivery of the hazardous volume, the system operator creates firm blocks of electricity to be delivered to suppliers. The blocks must contain on average the wind energy produced on a specified time period. By doing this, the system operator bears the volume risk due to the unpredictable and variable wind power production: he erases the uncertainty of delivery. The need to create firm electricity blocks is imposed by the characteristics of electricity system. Suppliers have to know in advance how much wind power they have to absorb. This operation generates costs that are finally paid by consumers through use-of-system charges. For the second step concerning the settlement of contract, the system operator realises the measurement of the energy really injected *ex post* through mechanic devices. This operation takes place on a temporal sequence where the system operator centralises information and collects payments. Hence, the third party manages and bears contractual hazards.

We conclude that **the trilateral governance structure enforces the collective contract**. The third party designs of rules allowing the enforcement of this collective contracts. In the case of wind power purchase agreement, the system operator is the third party. He ensures the delivery of a hazardous volume and the individual payments by managing the risk volume and the measurement problem. This work opens the path of studying the case when the system operator adopts strategic behaviour. Another further work concerns the possibility that another entity is able to manage the collective feed-in contract.

Bibliographie

Brousseau, E – 1997 - "Théories des contrats, coordination interentreprises et frontières de la firme", in P.Garrouste (sld), *Les Frontières de la Firme,* Economica, 1997, pp. 29-60

DGEMP (Direction Générale de l'Energie et des Matières Premières) – 2005 – *Les couts de références de la production électrique*, Updated 2005

ELTRA. - 2004 – Annual Report, 2004

European Commission – 2005 – *The support of electricity from renewable energy sources*, Communication from the Commission, 07/12/2005

Finon, D & Perez, Y – 2006 - « Transactional Efficiency and Public Promotion of Environmental Technologies: The Case of Renewable Energies in the Electric Industry », Forthcoming in *Ecological Economics*

Glachant, J.-M. - 2002 – « L'approche néo-institutionnelle de la réforme des industries de réseaux », Revue Economique, vol. 53. N°3

Glachant, J.-M. & Brousseau, E. - 2004 – *The economics of contracts: Theories and Applications*, Cambridge University Press, 2004

Goldberg, V – 1976 – « Regulation and Administered Contracts », *Bell Journal of Economics*, Autumn 1976, Vol. 2, Issue 2, pp 426-48

Hiroux, C; Maupas, F; Plumel, S – 2006 – *Management tools for the purchase obligation of priority production: the case of wind power*, Presentation at the European Electricity Market Conference 2006, Poland 2006

Hiroux, C. - 2007 – L'insertion d'une production inflexible dans des marchés concurrentiels: l'énergie éolienne, Dissertation, University Paris XI – To be defenced in July

Hunt, S – 2002 – *Making competition work in electricity*, John Wiley & Sons, 2002

Langniss, O – 2003 – Governance structure for promoting renewable energy sources, Dissertation, Lund University, October 2003

Perez, Y – 2002 – L'analyse néo-institutionnelle des réformes électriques européennes, Dissertation, University Paris I.

Powernext – 2007 – web site: www.powernext.fr

RAENG, Royal Academy of Engineering – 2004 – *Cost of generating electricity*, March 2004

Saguan, M - 2007 – Efficacités comparées des architectures de marchés électriques, Dissertation, University Paris XI

Stoft, S. - 2002 – *Power System Economics, Designing Markets for Electricity*, IEEE - Wiley

Williamson, O – 1985 - *The Economic Institutions of Capitalism: Firms, Markets, Relational Contracting*, The Free Press, New York, 1985