

Cross Border Electricity Trading and Market Design: The England-France Interconnector

The England-France Interconnector (Interconnexion France-Angleterre, or IFA) is a powerful high-voltage DC transmission cable that stretches between England and France. In 2002, it was jointly owned by the National Grid Company (NGC) and the Réseau de Transport d'Electricité (RTE). The IFA serves to enable 2,000 MW of electricity to travel in either direction between the two countries' national electricity grids.

Interconnectors such as the IFA were initially built to provide an emergency backup for existing systems during shortages or plant outages. By 2002 however, new opportunities for using the IFA had arisen. EU directive 96/92EC, adopted in 1997, launched the single European market in energy. As member states began liberalising their electricity sectors, a new inter-European market for electricity began to develop and transmission capacity on the IFA became a valuable commodity.

Originally contracted exclusively to Electricité de France (EdF), the IFA was opened to third parties in April 2001. With energy prices and demand varying in each market, requests for IFA capacity had increased. Access rules for allocating capacity had been drawn up in preparation for April 2001. Now, 18 months later, those managing the IFA were wondering if the auction system they had in place best served their needs and those of the market.

Overview of the Electricity Market

The electricity industry is made up of four functions: generation, transmission, distribution and supply. Both generation and transmission are highly capital intensive and transmission is a natural monopoly. Also, unlike other commodities, electricity cannot be stored. Once produced, it travels along the transmission grid according to Kirchoff's law, i.e., following the path of least resistance, and at the speed of light. The further electricity is transmitted, the greater the loss in efficiency. These characteristics, combined with the requirement of guaranteeing universal access to the electrical grid, led most European governments to nationalise their electricity utilities after the Second World War.

Demand for electricity also varies on a near constant basis. Factors such as weather and popular television programmes can cause sharp spikes in the demand curve. The difficulty of foreseeing these and balancing electricity supply and demand meant that technical considerations long dominated how the industry was run.

Unless supply and demand were perfectly matched either wastage or blackouts could occur. This affected how electricity was calculated and sold. While average electricity needs over a day

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would be covered by a 'base' load, an additional 'peak' supply was necessary to top up when demand increased.

Over time however, technological advances made the task of predicting demand easier. By the late 1980s computerised systems were capable of delivering minute-by-minute demand measurements. These developments led proponents of liberalisation to begin highlighting the efficiency and cost gains that a freer market would bring.

The UK Electricity Market

Prior to 1990, the key player in the UK market was the vertically integrated monopoly, the Central Electricity Generating Board (CEGB). As a nationalised company, the CEGB was responsible for generating, transmitting, distributing and selling electricity to the entire UK market. Like its European counterparts, the CEGB had been nationalised in the post-war period, as the government acknowledged the strategic importance of the energy sector in rebuilding the nation's infrastructure.

With the 1989 Electricity Act, a schedule for dismantling the CEGB and setting up a wholesale market in electricity was laid out. The CEGB's generation, transmission, supply and distribution functions were unbundled: nuclear generators remained under state ownership, and two companies were created to run the country's other generating plant: PowerGen and National Power. The transmission network was allocated to the National Grid Company (NGC), which, though private, was subject to regulatory oversight. Distribution was split among the 12 former regional electricity boards, which were also privatised.

The wholesale market operated through an Electricity Pool into which generators sold electricity and out of which suppliers purchased capacity. The Pool's role was to facilitate the competitive bidding process between the generators that would set the wholesale price for electricity for each half hour period of each day. The day before trading, generators indicated the level of output available and the price parameters for each 30-minute block. Likewise, the 12 regional distribution operators produced a forecast of demand (including a required reserve) that took into account factors such as weather and past usage. The Pool matched these components to establish the marginal cost of generating which was then used to determine the wholesale price. National Grid, after adding a safety margin, indicated to generators how much capacity to produce and in which order each generator would be used.

The objectives in establishing the Pool had been to facilitate the introduction of competition in the market. It was largely successful in doing so. The Pool also assisted new generators in entering the market and made it possible to introduce competition among suppliers. Between 1990 and 2001, the number of customers able to choose their electricity supplier expanded from just 60,000 to over 23 million.

There were several problems with the Pool system however. Traders complained that the Pool's complex and non-transparent pricing mechanisms impeded the growth of a derivatives market. Buyers of electricity complained that prices were too high and that they varied too much; that they could not participate directly in the Pool; and that the Pool did not respond to their concerns. The Pool had operated well when the CEGB accounted for the majority of electricity generated (over 90% of supply in England and Wales when the Pool was established). As the number of generators increased, and their motivations became more varied, the arguments for greater freedom became more vociferous.

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In March 2001, the New Electricity Trading Arrangements (NETA) came into effect. NETA introduced several reforms. First among them was that energy could be traded bilaterally among generators and suppliers. In addition, non-physical traders could also participate in the market and capacity could be sold in advance, in not just daily, but also weekly, monthly or yearly forward contracts.

While market forces were responsible for ensuring that supply and demand were matched, a Balancing Mechanism was also established. The purpose of the Balancing Mechanism was to enable the System Operator (National Grid) to increase or decrease generation to match the minute-by-minute fluctuations in supply and demand that occur as mundane things such as lights and kettles are switched on and off. Such increases or decreases in generation are bought or sold by the System Operator. The cost of these transactions contribute towards the setting of the imbalance price which is charged to the market specifically to those parties who have not matched their contracted demand with output or vice versa. The System Operator is, however, incentivised to minimise the cost of these transactions to the market. The Balancing Mechanism accounts for approximately 2% of energy supply.

The implications of the system were several. Generators could now determine how much electricity to produce. They could also sell capacity in forward contracts, up to three years in advance, thereby reducing exposure to price volatility or funding long-term capital projects. The trade-off was that having committed to forward contracts, generators had to produce sufficient capacity. If a generator miscalculated output, it used the market mechanisms such as Power Exchanges to sell excess or to buy additional capacity from traders, financial institutions or other electricity companies (prior to Gate Closure) to fine tune their positions.

The impact of NETA on wholesale electricity prices in the UK was significant. From April 2001 to February 2002, base load prices fell by 20% and peak prices by 27%. With a new market for energy traders and greater liquidity, the UK energy market was finally fully liberalised...quite unlike in France.

The French Electricity Market

The pace of liberalisation in France was much slower than in the UK, but some progress had been made.

For decades the French electricity market had been the domain of EdF, the national electricity monopoly. Created in the post-war period, EdF and the French government had invested heavily in building nuclear-powered generators during the 1950s. By the 1990s, 57 nuclear stations accounted for 75% of the country's power.

Nuclear power, at the time, was thought to offer several long-term advantages over oil or coal-powered plants. Though the capital investment required to build a nuclear plant was huge, its generating capacity outstripped that of an oil or coal plant many times over. In addition, nuclear power was considered cleaner than oil or coal, despite safety concerns and future decommissioning costs. Once operational, nuclear power had significantly lower production costs than either coal or oil (both of which required the purchase and transport of inputs). However, unlike other types of generator, it was totally inflexible. While combined-cycle gas turbines (CCGT) could be turned on and off easily (making them ideal for coping with peak demand), safety concerns made it next to impossible to switch off nuclear generators.

EdF's nuclear plants gave it a distinct competitive advantage. Pre-liberalisation energy prices for both industry and household customers in France were cheaper than the European average

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(see Exhibit 1). At 93.8%, the company's market share was also huge. It also had capacity to spare; when its nuclear facilities were constructed, future demand for energy had been overestimated. Even operating at reduced rates, the company produced sufficient energy to make it the world's largest electricity exporter, selling 12% of its output, mainly to the UK.

Despite EdF's market power, there were some opportunities for importing energy into France. As concerns about clean power grew and regulatory changes began to favour alternate and renewable sources of energy, a market for trading hydro- and wind-generated electricity developed. Moreover, while France's existing nuclear facilities typically led to baseload prices that were lower than in England and Wales, that price differential could be reversed at peak times (see Exhibit 2).

Steps towards dismantling EdF's grip on the French market had already been taken. In February 2000, in order to comply with EU regulations, an Electricity Act had created an independent transmission system operator (TSO) charged with operating the French grid. Though legally part of EdF, the Réseau de Transport d'Electricité (RTE) was an independently managed entity. It was responsible for the continuity and quality of EdF's transmission services and for providing equal access for all users to the power transmission network. All high and extra high voltage power lines, and transforming substations, in addition to all interconnectors in France — including the IFA — became the operational responsibility of RTE.

The European Electricity Market

The European national electricity grids had begun to be connected as early as 1951. Part of the post-war reconstruction plan of the Organisation for European Economic Co-operation (the predecessor of the European Union) focused on interconnecting electricity systems in order to better exploit energy resources. The organisation put in charge of facilitating this move was the Union for the Co-ordination of Electricity Generation and Transmission (UCTE).

From an initial eight members, by 2000 the UCTE had expanded its membership to 20 transmission system operators (TSOs). Through them almost 450 million people were supplied with 2,300 TW of electricity in 23 countries annually. Prior to the introduction of the Internal Electricity Market (IEM) in the European Union, cross-border exchanges were negotiated between the incumbent producers and suppliers. Each contract was negotiated separately and tended to be for long-term capacity.

The initial role of interconnectors (supplying emergency electricity) changed radically with the start of the EU Internal Electricity Market as market liquidity was determined by interconnector capacity. With 8% of European electricity trade carried on interconnectors in 2001, some were becoming heavily congested (particularly the France/Spain, Germany/Netherlands, Germany/Denmark and France/Italy interconnectors). With capacity ranging from 1,000 to 7,000 MW, between 5 and 30% of electricity demand could potentially have been imported. However, 40 to 60% of capacity was reserved under long-term import contracts by former monopolists. At the time of market opening, the European Commission ruled that transmission capacity should be allocated in a fair, non-discriminatory and transparent way and that it would closely monitor the allocation of capacity on congested interconnectors.

The IFA

When it was first built in 1961, the England-France Interconnector was the largest electrical link in the world. Laid on the seabed of the English Channel, the DC cable was capable of carrying 160 MW of electricity on two single conductor cables – one carrying current to the UK and the

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other providing the return loop. Though initially a success, the pioneer link suffered from frequent disruptions. Because it was laid on the seabed, ships' anchors and the heavier fishing trawls which began to appear in the 1970s often damaged the cable, resulting in frequent interruptions.

The first link was taken out of service in 1982. After some initial studies by its joint owners (EdF and the CEGB) and the two governments, it was decided to lay a new and much more powerful 2,000 MW cable. To avoid the problems of damage, the new link would be buried into the seabed in four trenches (each carrying a pair of positive and negative cables to prevent their magnetic fields from disrupting marine navigation) and spaced 1 km apart. Each party took responsibility for the construction of the converter station required to transform the current from AC to DC and back to AC in their home territory, and each was responsible for laying two pairs of the cables.

The project was extremely challenging, demanding innovations in hydrographic surveying as well as in drilling and cable laying technology. A 45 km submarine route avoiding steep gradients and hard rock conditions was eventually identified between Sangatte, near Calais, and Folkestone. National Grid used a huge submarine robot, guided and operated by umbilical cord from a barge on the surface to cut into the deep seabed, excavating over 200,000 tonnes of chalk, rock and clay as the 600 mm wide and 1.5 m deep trenches were carved. Behind it, another specially designed cable-laying undersea robot hauled itself along the steel hawser deposited by the digging machine, using high-pressure jets to clear the trench of silt and debris. In July 1985, three months after the cable-laying vessel *Venturer* set out from the English coast, the two British cables were ready to be landed on French soil and transported to the converter station at Les Mandarins.

The first exchange of power took place in January 1986 and by October of that year the full 2,000 MW capacity was commercially available in either the France-England or England-France direction. At a total cost of £700 million at 1981 price levels, the operation represented just half of the cost of constructing an equivalent power station. Energy consumption and demand were also highest in the South East of the UK...much closer to the nuclear generators in the North of France than to the power stations in the North of the UK. It was less costly and more efficient to source energy from France than to transport it the entire length of the UK.

Though in theory transmission capacity was commercially available in either direction of the IFA, a long-term access contract gave EdF exclusive rights over exports to the UK. This long-term contract expired in March 2001 and it was decided to open up access to the interconnector without any particular company having a preferential reservation. There were several ways to allocate capacity: by straightforward 'first-come, first-served' reservations; by linking the market for transmission rights directly to the spot market for electricity; or by an auction system. Options were considered by the joint operators of IFA (National Grid and RTE).

IFA Products

It was eventually decided to adopt an auction mechanism without a reserve price and to offer a mix of products, consisting of earmarked bundles of long and short-term capacity in each direction. Thus in the first auction in January 2001, 1,500 MW of capacity was tendered in 50 MW blocks for three years, 350 MW was to be auctioned annually in blocks of 1 MW each, and 150 MW was to be auctioned daily in 1 MW blocks.¹

¹ Rights were sold based on a target level of availability. Downtimes due to technical failures may cause actual available capacity to exceed or fall short of the target. In those instances, rebates were paid by the

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The first three-year auction was a sealed bid tender process. The first annual auction was held in February 2001 for the fiscal year 2001/2 (the UK fiscal year starts in April). Daily auctions began at the end of March for 1 April 2001, while quarterly auctions were introduced in September 2001. Exhibit 3 gives the capacity made available to the bidders in the different long-term auctions and the capacity assigned to the bidders.

IFA products are essentially options: a successful bidder has the right, but not the obligation, to take up his assigned capacity.² Given that flows on the IFA are based on a half-hourly resolution, IFA capacity is essentially a bundle of half-hourly options: for every half hour the owner can decide either to use his right or to forego it.

Quarterly and Longer-term Products

An Internet-based auction mechanism was adopted for both the annual and the quarterly products, with the following rules:

- Bidders were permitted to submit new bids at any time during the auction;
- By entering different prices and quantities, bidders could submit any demand schedule;
- Bidders could see the prices and volumes submitted by all parties;
- Bids were listed in decreasing price order so bidders knew immediately if their bids would win; and
- The bidder's identity was concealed from other bidders.

A new system was introduced on 25 March 2002 for the quarterly auctions, so that the end of the auction was not fixed in time, but rather depended on the bidding activity. Auctions lasted for at least 30 minutes and continued as long as bids were placed every two minutes. For instance, if no bid was received before the 32nd minute the auction would close. A bid submitted before the 32nd minute would instead prolong the auction by two minutes from the point the bid was received. Only when two minutes of inactivity had passed would the auction close.

There was no reserve price, but as the operators of IFA retained the right to reject bids, a *de facto* hidden reserve price existed. All unallocated capacity was added to the lots for the daily auctions, sold with slightly different rules.

Daily Auctions

Daily auctions began on 31 March 2001 for France to England and England to France capacity, sold separately. After some initial experimentation, from October 2001 all auctions had a reserve price of €3 MW/day in either direction.

In addition to the unsold capacity from the longer-term auctions, the capacity offered in daily auctions was 250 MW in the France to England direction, and 500 MW in the England to France direction. Each working day a daily auction was run for the capacity of the following calendar day. On Fridays, six auctions would take place for Saturday, Sunday and Monday in each direction.

interconnector operators or additional capacity payments were made by users depending on the actual availability of capacity.

² Owners of rights for longer-term capacity were also able to resell it, though not much use had been made of this feature.

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As for quarterly and yearly products, daily rights were sold in an ascending screen based auction mechanism. However, in the daily auctions, the bidding time was fixed at 30 minutes and capacity was allocated to the highest bids submitted (any bids below the reserve price were prevented from being entered into the system).

Bidders

Among those participating in the auctions were a range of different companies. Bidders included firms with physical generation capacity, distributors and pure traders.

Generators participated in the wholesale market for several reasons. In order to fund long-term capital projects, generators would sell energy in forward contracts and options. This was also a way to reduce their exposure to price volatility. NETA had exposed over-capacity in the generation industry and generators had sought protection through long-term contracts with energy traders and retailers. However, if generators had over-committed their capacity and were unable to meet their supply obligations, they would look to purchase on the wholesale market, possibly also seeking to import from Continental Europe (principally France and Germany) via the IFA.

Though the Enron collapse in November 2001 affected many energy trading companies, several continued to operate in the French and UK markets. Traders were chiefly interested in the IFA for the arbitrage opportunities that it made possible. By securing electricity supply through contracts with generators, traders could profit from price differences in the respective markets.

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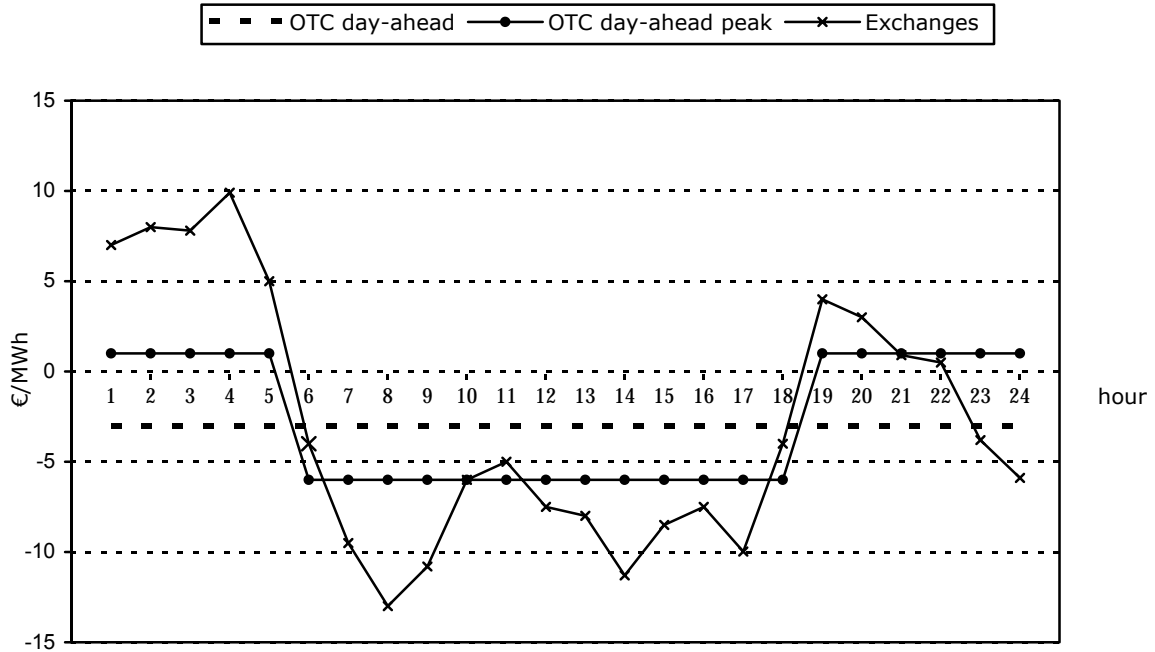
Exhibit 1. Comparative Electricity Prices France and UK

Average Household Electricity Prices (€ per 100 KW/h)						
	1992	1994	1996	1998	2000	2001
UK	10.5	10.1	8.8	10.4	10.6	8.5
France	9.6	10.4	9.6	9.5	9.3	9.1

Average Industry Electricity Prices (€ per 100 KW/h)						
	1992	1994	1996	1998	2000	2001
UK	7.6	7.1	5.4	6.3	6.6	6.6
France	6.0	6.5	6.5	6.0	5.7	5.6

Source: Eurostat

Exhibit 2. Hourly Price Differentials: France to England Direction



Notes: This figure shows a typical daily price pattern at an hourly resolution. Over-the-counter (OTC) prices and exchange prices are provided by UKPX, Powernext and Platts.

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Exhibit 3. Capacity Allocation (in MW) to Different Products

<i>Product</i>	<i>Auction date</i>	<i>Available F2E</i>	<i>Allocated F2E</i>	<i>Available E2F</i>	<i>Allocated E2F</i>
Three years					
2001/2-2003/4	23/01/2001	1500	650		
One year					
2001/2	12-16/2/2001	1000	323	1000	100
2002	18/12/2001	627	627	1000	602
2002/3	19/03/2002	223	223	398	398
One quarter					
Q4 2001	18/09/2001	527	527	0	0
Q1 2002	19/12/2001	250	250	898	102
Q2 2002	20/03/2002	300	300	500	0
Q3 2002	12/06/2002	250	250	500	500
Q4 2002	12/09/2002	250	250	500	500