Wind Energy Integration in the Urban Environment

WINEUR

Grid-Connection Report

January 2006

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Intelligent Energy
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1 INTRODUCTION

Up until recently, the main renewable energy technologies utilised in urban surroundings were solar thermal, solar photovoltaics and heat pumps. In the last few years, small wind turbines have started to become available and are also being installed in urban areas. Similarly to photovoltaics, urban wind turbines generate electricity on site, preventing transport losses and enabling individuals and organisations to visibly express their commitment to sustainable energy sources.

However, small wind turbines for the urban environment are a fairly new product. The market is underdeveloped and there is limited experience with installation and grid-connection of these products. Consequently, the need for information related to the existing technologies, the economics, the regulations, procedures and guidelines specifically related to urban wind turbines is fundamental to encourage market and product development.

The major objective of the WINEUR study is therefore to identify the conditions necessary for the greater integration of small wind turbines in the urban environment and to promote the emergence of this technology as a real option for electricity supply in towns and cities across Europe.

The first Work Package (WP1) of WINEUR, titled “State of art and Experiences gained” consisted of a comprehensive review of the existing technologies in the small and medium range of wind turbines which are suitable for installation in an urban environment. WP1 produced a comprehensive catalogue of small wind turbines available in Europe suitable for urban installation with an accompanying guide to small wind energy, and a report on the current wind energy situation in a selection of countries in Europe and worldwide.

The second Work Package (WP2), titled: “Techno-economic and grid connection aspects” examines two areas: 1) the cost of installation of the different technologies identified in WP1 and their economic viability and 2) the technical and economic aspects of grid connection of small wind turbines.

This report focuses on the second of these two areas and corresponds to deliverable 2.2 of WP2. The report covers the following areas for the three main project countries, France, the United Kingdom and the Netherlands:

- the regulatory framework
- the standards and regulations currently in place
- metering arrangements for small-scale distributed generation
- distribution network operator incentives and disincentives to support small-scale distributed generation, including small wind turbines
- conditions required and difficulties regarding connection to public grid
- identification of any technical barriers / constraints arising from grid connection

Further information on the WINEUR project, published documents and a brief outline of activities under work packages 3 to 6 are available from the project website at www.urbanwind.org .
2 FRANCE

2.1 Grid connection procedure

2.1.1 Legal framework and feed-in tariff conditions

Article 10 of the law n°2000-108 of year 2000 relating to the modernization and the development of the public electricity service provides that various installations can receive a feed-in tariff from Électricité de France (EDF), or other grid operators, for the electricity which they produce. This Article includes wind energy installations of a power capacity lower than 12 MW are included.

Under this legal framework, EDF and other grid operators, are obliged to conclude a contract for the purchase of electricity, if the interested producers make such a request, and subject to the following conditions:

- The limits of nominal power capacity are fixed at 12 MW per site of production by decree n°2000-1196 of the 6th December 2000.
- Decrees n°2001-410 and n°2003-282 of the 27th March 2003 set out the obligations which are binding to the producers profiting from the feed in tariff. Specifically, the electricity producer must obtain a certificate confirming the right to receive the feed-in tariff before being able to conclude their contract with EDF or other grid operators. To obtain the certificate, they must address a request to the ‘Prefet’ of the department where their generator is located and include the following elements:
  - If it regards a private individual, surname, first name and residence or if regards a legal entity, denomination or corporate name, legal form, address of the registered office, as well as the position of the signatory of the file
  - Location of the generating station concerned
  - Energy type and technique of production used
  - Nominal power capacity, electricity output of the installation and the estimated number of hours of annual production

Within two months of reception of the request containing all of the information elements mentioned above, the Mayor delivers a certificate opening up the right to receive the feed-in tariff.

2.1.2 Tariff definition

If the connected power is higher than 36 kVa, the applicable tariff is that defined by the decree of the 8th June 2001. This tariff depends on the number of operating hours in full power (energy produced annually divided by the nominal output). The fixed price of 8.38 eurocents / kWh has been established for the first five years. For year 6 to year 15 different prices are applied as a function of the number of operating hours at full power.

If the connected power is lower than 36 kVa, the producer has the choice between the tariff conditions defined above and the tariff conditions defined by the decree of March 2002 fixing the specific conditions of purchase of the electricity produced by the installations of a power lower than 36kVA.
In the later case, the purchase tariff depends on the existing bond or not between the producer and the purchaser:

- If the producer is related to the purchaser by supply agreement for his consumption of electricity, the tariff of purchase of energy applicable to the installation and appearing in the contract of purchase, net of tax, is equal to the tariff of sale (excepting subscription) over the whole duration of the contract.

- The most favourable tariff for the sale of electricity is 10.4 eurocents/kWh for a contractual demand lower than 3 kW and 8.8 eurocents/kWh for a contractual demand between 3 kW and 36 kW.

The installation of the producer is described in the contract of purchase which specifies:

- Number and type of generators
- Maximum power installed
- Maximum active power of supply
- Average annual production
- Delivery voltage

2.1.3 Technical grid connection conditions

The texts relating to the technical rules of connection for generating stations are as follows:

The conditions schedule defined by EDF stipulates that the voltage and the point of connection will have to be selected in order not to create unacceptable disturbance on the network.

The EDF schedule specifies the relations between the purchaser and the producer for the connection and the monitoring of the generating stations.

Decree n°2003-229 of March 2003 defines the technical principles of connection in the public networks for autonomous generating stations, the acceptable diagrams of connection and the performances to be satisfied by these installations.

Any request for connection of a generating station results in a study whose objectives are to define the technical and financial conditions of the connection itself and to define the works necessitated by the installation to be built.

A new procedure of connection has come into force since June 2004. This procedure defines the various requests for connection which a producer is authorised to carry out as follows.

2.1.4 Installations under 2.5 MW

The applicant has to request near the operator of the network (EDF) information for the estimate of feasibility of the connection of the installation. This first technical feasibility conclusions are defined by EDF and delivered to the applicant free of charges.

Further to this first technical approach applicant may choose to request to EDF a precise financial information regarding connection works to be undertaken.

After agreement of the parts on the Technical and Financial Proposal (PTF) issued by EDF, a connection agreement is established by the manager of the network. This PTF engages the manager of the network in term of costs and time.

2.1.5 Installations of power under or equal to 36 kVA

These installations are connected to the low voltage (LV) distribution network. They remain subject to the consequences of the constraints generated on LV networks and medium voltage (MV) and LV sub-stations.
2.1.6 Connection process schedule for a small wind turbine installation

Figure 1 below gives a typical connection process schedule for a small wind turbine installation (under 2.5 MW). The whole process will take at least 10 months.

![Connection process schedule diagram]

2.2 Conclusion

Within the framework of his public mission of the network maintenance the historical operator (EDF) set up a particularly demanding procedure for grid connection. These requirements result, with final, in long administrative times to obtain a connection agreement.

However it should be noted that EDF launched a phase of reflexion in order to reduce the procedures, considering that the majority of the small wind turbines can be connected directly to the LV distribution network, and that it is thus not necessary to lead important technical studies on the upstream impact of these machines on the MV network.

This new approach aiming to reduce administrative connection procedures specifically devoted to the small wind turbines will thus make it possible to encourage the initiatives for new installations and it will realize the willingness of public authorities to support this technology.

3 UNITED KINGDOM

3.1 Methodology

The effect of increased renewable energy on the economic national distribution of electricity is a widely discussed topic. Issues pertinent to and affecting small wind installations are more associated with the local distribution network than the extra costs and issues, i.e. balancing, cycling and redundancy, on the transmission system. Therefore the work concentrated on contact with the Distribution Network Operators (DNOs).

A questionnaire was designed for issue to DNOs so an overall picture of the concerns and perceptions of industry professionals regarding micro-generation on the distribution network could be assessed and evaluated.
The difficulty with circulating a questionnaire of this specific nature is ensuring that it reaches someone with knowledge and experience in the topic. To facilitate this, each DNO was contacted by telephone to find the most suitable recipient. Upon finding the relevant person, the questionnaire topic generated much interest and discussion and in most cases a telephone interview was conducted. This approach lead to a 100% response rate.

The information collected through the questionnaire was complimented by a literature and website review, which included reports on the standards and regulations currently in place for connection of small scale wind systems on the electricity network.

3.2 Regulatory framework

Ofgem is the Office of the Gas and Electricity Markets which regulates the electricity (and gas) industries in Great Britain. Its main activities are to protect and ensure a fair deal for the consumer and generate a competitive market for suppliers.

Key terms

- **Generation** is the process of producing electricity from various sources, e.g. coal, oil, nuclear, gas and wind to produce electricity from power stations.

- **Transmission** is the process of carrying electricity at high voltages from power stations either by overhead or underground cables.

- **Distribution** is the process of delivering electricity from the high voltage transmission systems to the low voltage regional distribution system, by using the local wires, transformers and substations, to customers.

- **Supply** is the process of buying electricity in bulk and selling it on to customers. Therefore supply is the retail activity in which businesses compete for customers\(^1\).

3.2.1 Transmission networks

There are four transmission systems in the UK, each separately owned and operated; in England and Wales the transmission system is owned and operated by The National Grid Company (NGC); in the south of Scotland by Scottish Power; in the north of Scotland by Scottish and Southern Energy; and in Northern Ireland by Northern Ireland Electricity. All these companies operate under a transmission license granted by Ofgem.

Transmission networks play a central role in the electricity system. Maintaining the balance between supply and demand is a vital task which touches every aspect of electricity supply. The transmission companies are required to develop, maintain and operate an efficient and economical system of electricity and to facilitate competition in generation and supply\(^2\).

3.2.2 Distribution Networks

In England and Wales there are nine distribution companies operating twelve licensed distribution areas. In Scotland distribution is operated by two vertically integrated energy companies who in addition to operating their respective distribution businesses they are also responsible for generation and transmission throughout the Scotland\(^3\).

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\(^1\) [www.energynetworks.org](http://www.energynetworks.org)

\(^2\) ibid

\(^3\) [http://energylinx.co.uk/distribution_network_operators.htm](http://energylinx.co.uk/distribution_network_operators.htm)
Each distribution company holds a separate license for each area they cover and they are strictly governed by the terms of that license. They have a statutory duty to connect any customer requiring electricity within their area and to thereafter maintain the supply to them. They must maintain an efficient cost effective and coordinated system to distribute electricity.

3.2.3 Price regulation

In electricity the transmission and distribution systems are monopoly businesses and are regulated by price controls set by Ofgem. The intention of price control is to protect customers where there is a lack of competition, and to encourage efficiency by determining inflation-limited price caps.

The basis of Ofgem’s price controls is an RPI-X formula that controls the average revenue earned by the regulated businesses. The RPI-X price control takes the retail price index (RPI) – the rate of inflation – as its benchmark and subtracts X – an efficiency factor – from it. The X factor is used to reflect expected efficiency gains and investment requirements. For example, when RPI is running at 3% and X is 2%, a company would be allowed to increase prices by no more than 1% per annum.

The scope of the price control has developed over time in response to changes within the industry and the development of competition. Transmission and distribution price reviews are carried out usually every five years.

3.2.4 Cost components of the electricity bill

The average annual electricity bill for a typical domestic customer on standard credit tariff, including VAT, is £250. The breakdown of this bill is:

- £105 – Generation
- £10 – Transmission
- £60 – Distribution including metering
- £75 – Supply

3.3 Standards and Regulations

Grid connection of small wind power systems fall into two categories, those which supply up to 16 amps per phase and must comply with Engineering Recommendation G83/1 and those which supply over 16 amps per phase and must comply with G59/1. The 16A/ph limit was set because it agrees with European standards for connection. The power quality control elements required once a generator has a current above 16 amps per phase make the equipment necessary for grid connection much more expensive.

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4 ibid
5 www.energynetworks.org
6 ibid
7 ibid
3.3.1 Engineering recommendation G83/1

The G83/1 regulation was introduced in September 2003 to simplify the conditions required for connection of small-scale electricity generators (SSEGs) to the grid.

G83/1 enables many small generators to connect to the distribution network by introducing a simplified approach and positive statements, such as “The DNO may not refuse to accept the connection...”, supporting connection against objections that could be raised from the DNO. It also gives the DNO discretion to “use this engineering recommendation if it is considered more appropriate than G59/1”\(^8\). Many DNOs do indeed allow turbines such as the 6kW Proven which potentially supply marginally in excess of 16A per phase to connect under the G83/1 regulation.

For single installations the recommendation and DNOs recognise that there will be a negligible impact on the network and the installer need only supply the DNO with the necessary installation information within 30 days of the commissioning of the Small Scale Embedded Generator (SSEG).

For multiple installations in a close geographical area i.e. as part of a housing development, the DNO will need to be consulted in advance, as the effect on the network may need a more detailed assessment. In this case, there may be an additional cost from the DNO to carry out the assessment.

3.3.2 Engineering recommendation G59/1

Under the G59/1 regulation micro generators with an output of over 16A/ph must comply with the technical standards of generators up to 5MW in size. This type of connection is significantly more expensive and burdensome than a G83/1 connection as it requires additional work such as network analysis, potential network alterations, additional protection equipment and technical data submission, which can significantly hinder small scale installations.

In conclusion, regarding connection of small wind systems to the electricity distribution network:

- G83/1 has effectively removed all barriers for single connections below 16A/ph and significantly eases multiple connections
- A new connection standard for small schemes that are over 16A/ph is needed to reduce the complexity and cost of connection

3.4 Metering Arrangements

3.4.1 Domestic Metering\(^9\)

To produce domestic electricity billing, annual meter advances are converted into half-hourly supplier takes, by use of standard profiles (one for single register domestic customers and one for Economy 7 customers). Profiles describe a typical pattern of half-hourly consumption over business and non-business days – adjusted for temperature and daylight hours. The profile is scaled by the customer’s annual consumption and the supplier’s take is then the aggregate consumption of all its customers in each half-hour.

SSEG will undermine the accuracy of profiling; new profiling classes may be required to accurately predict the behaviour of demand where onsite generation exists.

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\(^8\) Engineering recommendation G83/1, p.6

3.4.2 Meter types

3.4.2.1 Single Direction Meter

This is the most widely used metering arrangement in the UK which is designed to run forward (i.e. advance the meter register) when electricity is imported, but does not run backwards if electricity is exported. This may be a single register or dual register (i.e. Economy 7) meter. It may also be a card operated meter10.

Export issues – If on site generation never exceeds demand then electricity imported is simply offset by that generated. However, if reverse flow of power occurs through the meter depending on meter type, it may run backwards, not be affected or malfunction. A site visit from the DNO or meter operator may be required to ascertain characteristics of the meter under reverse flow conditions. In most cases electricity exported will not be metered, this undermines the economics of micro generation.

3.4.2.2 Bi-directional meter

Also called ‘two way’ or ‘net’ metering. This meter will run forward when electricity is imported, and backwards when it is exported. The register records the ‘net’ result11.

Export issues – Provides attractive rates as exported electricity as it charged at imported rate. Does not take into account distribution costs of exported electricity therefore is not popular with electricity suppliers.

3.4.2.3 Import-export meter

This type of meter records both imported electricity and exported electricity on two separate registers.

Export issues - Separate prices may be applied to import and export, depending on the commercial arrangements agreed between the consumer and the supplier. This system can be accommodated by wiring standard single direction meters reverse (~£15) or using bespoke import-export meter (~£30). Multi-rate meters may be used which permit the timing of import and export to be accounted for, facilitating more accurate settlement and cost reflective pricing.

3.4.2.4 Generator production meter

A meter (single register) is directly connected to the generating set and would record the generation output irrespective of consumption on site.

Export issues - This metering arrangement can be used to allow customer-generators to claim Renewable Obligation Certificates, and/or supply electricity directly into the grid bypassing the ring main.

3.4.2.5 Half-hourly metering

A meter which records imports and exports summated in each half hour period. There are a number of cost/technology options within this general group, for example differing data collection techniques.

Export issues – Half-hourly metering would provide accurate information for settlement and supplier pricing. Cost of meter would not be excessive <£80, but other costs like data collection and analysis maybe high.

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10 DTI/OFGEM Embedded Generation Working Group, Report - Options For Domestic and Other Micro-Scale Generation 08 January 2001

11 ibid
3.4.2.6 Profile Metering

Payments can be made to SSEG based on generation profile, where exported energy is estimated rather than measured. Load profiles of electricity consumption are well known and can be accurately predicted, such profiles for generation are less understood with limited historical data.

3.4.3 Charging Arrangements\(^\text{12}\)

3.4.3.1 Net energy tariff

Also called net metering. Where the price paid to a customer-generator for an exported kWh is equal to the price paid by the customer-generator for an imported kWh. This can be achieved by only charging for the net electricity imported (using a bi-directional meter), or by assigning equal prices for import and export when using an import-export meter. An agreement is required for the payment of net exports in both cases.

Netting period - The netting period is an agreed time period in a net energy tariff during which imports and exports are accounted.

3.4.3.2 Dual energy tariff

Where the price paid to a customer-generator for an exported kWh is different to the price paid by the customer-generator for an imported kWh.

3.5 Distribution Network Operators Perceptions and Attitudes towards Micro Generation

The changes needed in the electricity transmission and distribution systems to facilitate the increasing levels of generation from large scale, micro, predictable, unpredictable and intermittent sources are not yet known. Only time will tell what percentage of the overall mix each source will provide. The current perceptions of DNOs regarding the effects and issues that surround small scale generation <50kW are discussed below. All information was derived from the DNO questionnaires unless otherwise stated.

3.5.1 Incentives

The Distributed Generation (DG) Incentive implemented in April 2005 allows DNOs to recover their generation connection costs by a combination of pass through (80%) and incentive per kW connected (£1.5/kW) plus £1/kW/year for O&M costs.

In addition to the DG incentive Ofgem has introduced the Innovation Funding Incentive and Registered Power Zones incentive mechanisms.

- Innovation Funding Incentive (IFI): The IFI is intended to provide funding for projects focused on the technical development of distribution networks to deliver value (i.e. financial, supply quality, environmental, safety) to end consumers. IFI projects can embrace any aspect of distribution system asset management including connection of distributed generation. A DNO is allowed to spend up to 0.5% of its Combined Distribution Network Revenue on eligible IFI projects and can recover a significant proportion of associated costs from its customers (90% in 2005/2006). DNOs have to openly report their IFI activities on an annual basis.

\(^{12}\) DTI/OFGEM Embedded Generation Working Group, Report - Options For Domestic and Other Micro-Scale Generation 08 January 2001
• Registered Power Zones (RPZ): In contrast to the IFI, RPZs are focused specifically on the connection of generation to distribution systems. RPZs are intended to encourage DNOs to develop and demonstrate new, more cost effective ways of connecting and operating generation that will deliver specific benefits to new distributed generators and broader benefits to consumers generally. If a DNO employs genuine innovation in the way that it connects generation it can seek to register the connection scheme as an RPZ. For registered RPZs, the incentive element of the DG Incentive is increased for the first five years of operation by £3/kW.

Open reporting (i.e. available in the public domain) of IFI and RPZ projects is required. This is intended to stimulate good management and promote sharing of innovation good practice.

In addition to the above measures there is also a £46/MWh incentive to reduce network losses. For loss reduction to occur with SSEGs, the load demand would have to match the supply and profile of the generation. Normally generation will occur independently to loads and the electricity would suffer normal losses in the distribution system.

The information received through the questionnaires indicates that DNOs feel that as far as encouraging SSEG generation onto the network, these incentives are of little significance in terms of assisting the connection of very small systems such as micro wind turbines since it would be a breach of the DNOs licence agreement to refuse any connection under G83/1. DNOs can only give an estimate of costs for the required work to ensure power quality is maintained across the network when a new generator requires connecting. If power quality can be maintained, then the DNO must connect the generator.

### 3.5.2 Technical Concerns

Voltage rise on networks caused by an increasing number of individual G83/1 connections is the main concern of the DNOs. However, there would have to be significantly more micro generators connecting to the grid for these conditions to occur. The DNOs surveyed felt that it is unlikely that this will occur in the foreseeable future as a consequence of small scale wind connections. Domestic CHP units are more likely to lead the micro generation market as they start to make economic sense as people are replacing old boilers.

It is possible to have automatic tap changers on the low voltage network to control the voltage fluctuations. These devices are used on high voltage networks, but they are expensive and require significant maintenance. This would add cost to and reduce the reliability of networks. In future years, if solid state voltage control devices improve and become economic, these could provide an effective solution. Overall, it is unlikely that the fault level contribution from small inverter connected SSEGs will be significant in the short to medium term.

### 3.5.3 Advantages

Advantages, like disadvantages of distributed generation only really exist when large numbers of small generators are installed. The DNO answers indicated that reduced reinforcement of networks may be argued over a countrywide system, but are not relevant in local systems as networks still have to be specified based on the fact that the embedded generation may not be available.

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13 Communication with Murray Thomson, Loughborough University
3.5.4 Financial implications

Under the current market conditions, significant levels of SSEG would effect the revenue of the DNOs as they charge electricity suppliers a Distribution Use of Service Charge (DUoS) on every kWh sold, and there is also a Generators’ DUoS but this does not apply to connections on the low voltage network.

However, the market regulator Ofgem is obliged to facilitate an adequate revenue stream for the DNOs and the opinion of the DNOs appeared to be that there are no real financial concerns. Despite user-generators and efficiency improvement initiatives, electricity demand is constantly increasing and networks are constantly being expanded and reinforced to meet new loads; and to facilitate new generation.

3.5.5 Connection constraints for SSEGs

For connections under G83/1 there are no significant constraints. The generator must install and commission the system according to the regulation but this does not add any significant cost. The DNO has to be notified of the connection but cannot refuse it.

For connection under G59/1 the cost of the relevant network analysis and subsequent required work may make the small scale installations uneconomic. The likelihood of a connection charge will be less in urban areas where stronger networks exist compared with those in rural areas.

Until April 2005 whether there is a charge and how much it is was entirely dependent on the DNO of the particular region where the generator is being connected, and therefore charges varied from region to region.

Since April 2005 a common connection boundary was introduced across generation and demand. New generators pay shallower connection charges and will begin to pay use of system charges. In addition there is a requirement for DNOs to publish their charging methodologies and justify their approach to setting tariffs in accordance with the licence objectives.

3.5.6 Metering issues

Many meters exist which can run backwards under export conditions. When this happens the DNO is not fulfilling its legal obligation to accurately monitor electricity consumption. Meter readers, electricity suppliers and DNOs will have to be smarter with their information sharing to keep an accurate account off SSEGs. Under current conditions an export meter can be fitted and a consumer can have a supply and buy back contract with an electricity company without the DNO being aware of generation occurring at the property.

It is also feared that as the home generation market becomes more developed with off the shelf type systems available a small percentage of installations will occur where the DNO is not informed of the connection. This means electricity consumption may not be accurately recorded and an incorrect load profile may be associated with the property.

However, for the time being, these problems remain at a small scale, affecting a very small percentage of the electricity consumption that is monitored by a DNO.

3.6 Conclusion

The introduction of G83/1 has successfully removed all barriers for single small urban wind installations, although a simplified connection standard for small systems supplying more than 16 A/ph would aid in making more installations economic and straightforward to connect. The current process for connecting an urban wind turbine is laid out in Annex 1.
All 12 of the distribution network operators (DNOs) in the UK were surveyed and reported to have no serious problems with the effect of small wind turbines on the electricity network. The increasing penetration of renewables will bring about a time of much change in the system and small wind, like other forms of generation, will be accommodated as renewable energy markets mature.

4 NETHERLANDS

4.1 Legal framework of the electricity market

The liberalisation of energy market, meaning that customers are free to choose their own energy supplier, followed the time planning as shown in Table 1.

<table>
<thead>
<tr>
<th>Year</th>
<th>Market segment</th>
<th>Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>1999</td>
<td>650 largest electricity customers</td>
<td>&gt; 2 MW</td>
</tr>
<tr>
<td></td>
<td>200 largest gas customers</td>
<td>&gt; 10 million m³</td>
</tr>
<tr>
<td>2001</td>
<td>all green electricity customers</td>
<td>all</td>
</tr>
<tr>
<td>2002</td>
<td>60,000 electricity customers</td>
<td>&gt; 3x80 A</td>
</tr>
<tr>
<td></td>
<td>2,000 gas customers</td>
<td>&gt; 1 million m³</td>
</tr>
<tr>
<td>2004</td>
<td>7.5 million electricity customers</td>
<td>* 3x80 A</td>
</tr>
<tr>
<td></td>
<td>6.8 million gas customers</td>
<td>* 1 million m³</td>
</tr>
</tbody>
</table>

The legal framework for the liberalisation of energy market was determined by the Electricity Law from 1998 and the Gas Law from 2000. The electricity market is based on regulated third party access (TPA). Here, the legal framework creates equal opportunities (level playing field) for all market players.

In 2003, 105.3 billion kWh were consumed in The Netherlands. Households used approximately 22% of the electricity, while the largest bulk customers consumed 33%. In total, there were 6.97 million electricity customers in 2003. In December 2005, the number of green electricity consumers was estimated to 2.4 million, about 36% of all electricity customers. A schematic of the organisation of the Dutch Electricity Market is shown in Annex 2.

4.2 Market players

4.2.1 Producers

The electricity producers are the owners of production units with a capacity of more than 5 MW. The total production capacity in 2003 was about 20,000 MW including the large combined heat and power (CHP) units. About 20% of the electricity is imported. There are 5 large electricity producers and a large number of small producers, mostly owners of CHP installations.
4.2.2  **Transport system operator (TSO)**

The national electricity transport grid is since 2001 owned by the national government. The operation and administration of the national electricity transport grids is in hands of the new independent non-commercial organisation TenneT. As a part of that responsibility, TenneT monitors the physical balance of the electricity network and provides connection to international grids. Furthermore, this organisation administers and verifies the so called “green certificates” which play an important role in the trading and supply of green electricity. The transport system operator is entitled to interfere in the commercial process of energy trading, as for example switching on/of the back-up capacity, in urgent situations.

4.2.3  **Regional grid operators (RGO)**

The regional grid operators are the cornerstones of the energy market in The Netherlands. They maintain the network, provide connections to the grid, take care of the physical distribution of the electricity and administer the electricity exchange through their grids. The RGO’s are responsible for providing all necessary information regarding the distribution of energy through their network. This includes all billing and balance control information for suppliers and system operators respectively. Per connection point the grid operators register: the unique connection number, name and address of the customer, supplier, program responsible party or shipper, metering company, metering data and the transport capacity.

4.2.4  **Metering companies**

Metering companies install and maintain meters (kWh, m³, GJ). Metering is a part of the open energy market. At this moment there are still very few companies providing the metering services. In the past, the energy meter was a part of the installation of the regional grid operator who also has been responsible for the device maintenance. In the free market, the consumer is responsible for having a correctly working, calibrated electricity meter.

4.2.5  **Program responsible parties**

Program (or balance) responsible parties ensure that the electricity demand matches the electricity supply. This matching takes place one day ahead on hourly basis (forecasted balanced system). This mechanism prevents overloading or insufficient utilisation of the electricity grid and ensures the balance in the energy supply system. The parties who cause unbalance must pay penalties. The program responsible parties can be: energy suppliers, traders or producers.

4.2.6  **Suppliers**

The suppliers have the commercial and administrative relationship with the energy consumers: they supply the energy and do the billing. In the energy market, the suppliers are responsible for the commercial balance: the sold volume must be equal to the purchased volume.

The supplies may delegate the responsibility for the associated physical system balance (demand matches supply) to a ‘Program responsible party’, typically a major supplier. This is a commercial service offered at a free market.

Most of the traditional suppliers are still owned by provincial governments and municipal councils. The electricity suppliers, green as well as conventional, compete for the new customers by TV advertising and telemarketing.

There were 18 electricity suppliers in the Dutch market in 2003.
4.2.7 Energy traders

Traders are intermediaries that try to buy and sell the electricity at the most advantageous prices. Most of the large energy suppliers have their own trading department.

On the APX (Amsterdam Power Exchange Spotmarket b.v.) the producers, suppliers and traders can buy and sell electricity for the following day. In 2003, about 11.3% of the total electricity consumption was traded via APX. The biggest portion of the electricity supply is acquired by long term contracts.

Brokers are intermediaries between the market players, trying to bring together supply and demand.

4.2.8 Dienst Uitvoering en Toezicht Energie (DTe)

In order to insure that the parties respect and follow the regulations and agreements regarding the open market, Dutch Government established an oversight and regulatory institutuion, ‘Dienst Uitvoering en Toezicht Energie’, DTe, (Dutch Electricity Regulatory Service). New suppliers who want to enter the electricity market must obtain the permit from DTe.

DTe is responsible for the implementation and supervision of the Electricity Act of 1998 and other regulations and agreements regarding the free energy market. The organisation may impose financial or other penalties on parties not complying with these Acts.

DTe has also been included as a chamber within the Netherlands Competition Authority (NMa) which bears responsibility for the implementation of the Competition Act. NMa enforces the prohibition on cartels and on the abuse of a dominant position and assesses mergers and acquisitions.

4.2.9 Role of the government

The market players agreed that the government have the important role of creating the market conditions needed for open energy market. These conditions can be highlighted as follows:

- Stable investment climate
- Transparent market
- Stable political situation
- Stable, predictable and non discriminatory laws and rules
- European level playing field

4.3 Technical preconditions

One of the major preconditions for the opening of the electricity market was that the reliability of the energy supply systems may not be compromised with the introduction of the open market. This translates to the fundamental requirements: the physical system must be safe and large enough to cope with the consumers’ needs. This means enough production capacity and a good working transport and measuring systems.

The prerequisite for the control of the suitability of the production and transport capacity is the continuous monitoring of these systems. This role in the Dutch electricity market has been assigned to Tennet. In this matter, the reserve capacity has an important role, but it is difficult to create it. In a free market situation, parties are not willing to invest in new installations if they can not be sure of making profit. In order to ensure enough production volume for the future, the Ministry of Economic Affairs has introduced a three-step plan
consisting of: monitoring, energy saving and demand side management and incentives for creating a capacity market.

To ensure a good functioning physical system, three important documents have been developed, called Technical codes: Grid Code, Metering Code and System Code. These documents describe the functioning of grid operators, and metering companies: the way they operate their systems, their relation to each other, and to consumers.

4.4 Measures for quality control and consumer protection

Next to a good functioning physical system, it is important to guarantee the quality of this system and protect the customer. The government has introduced a number of additional regulations on this matter:

- Grid operators and suppliers are obliged to follow the proscribed switch procedure including the proscribed time schedule.
- In order to be able to provide independent grid services, the regional grid operators must become economically independent from the supplying companies.
- Each grid operator must provide a two-yearly quality and maintenance programme. This programme must include the measurable goals to be reached.
- Interruptions in supply are monitored on a national level. There is one national telephone number to report interruptions. An overview of supply interruptions is published yearly.
- A new tariff system is introduced for grid operators. Operators with many interruptions are penalized with lower transport tariffs. Those who provide a good service without interruptions are permitted to charge a higher grid tariffs.
- A special law regulation is introduced for financial compensation of supply interruptions.
- DTe is entitled to impose fines on companies that do not comply with rules. The fines can grow up to 10% of the yearly turnover.
- In case of a serious mismanagement, the minister of Economic Affairs may decide to (temporary) transfer the rights for grid operation to some other grid operator or put the grid operator under supervision.
- Suppliers must give information to their customers about the energy sources (fuel mix) which are used to generate the electricity they are selling.

Next to these governmental measures, the consumer can find a lot of comparative information about electricity suppliers, conditions and prices on independent web sites.

4.5 Effects of the liberalization

The liberalisation process in The Netherlands started in 1998 and was completed in 2004. So far it resulted in more suppliers and slightly lower energy prices. However, the energy costs have increased due to higher energy taxes. About 30% of business customers and about 12% of consumers have changed the energy supplier. On the production side, two of four large power plants were taken over by foreign companies, one by E.On and the other by Electrabel.
4.5.1 Electricity tariffs

The figure below illustrates the price development for households (red), large industry (green) and small industry (blue) during the last 35 years. (source: ECN).

The electricity tariff consists of three components: transport, supply and taxes. The transport fees are determined by DTe. These costs are independent of the supplier. Supply rates depend on contractual conditions agreed with the supplier. Taxes make a significant part of electricity costs. The electricity bill of a household with an average consumption of 3.402 kWh/a, consists for almost 50% of taxes: fuel tax, regulatory energy tax and VAT. The average electricity price for consumers was 0.18 €/kWh in 2002 and 0.20 €/kWh in 2003. In the last two years the price continued to grow due to higher fuel prices.

4.6 Grid connection issues

The liberalisation of the energy market has caused drastic strategy changes by all Dutch utilities. In the first place the utilities are split into production companies, energy traders and grid operators. These parties are, due to the expected competition, focused on lowering the energy prices which can only be reached by large production volumes. This strategy is also followed for renewable energy sources. There are few energy traders who believe that individual renewable energy installations are useful.

ENECO, one of three largest energy companies in The Netherlands has responded to our questionnaire for energy traders and grid operators. We have summarized the responses as follows:

- Eneco is willing to use urban turbines under condition that the turbines are reliable and safe and supplied by reliable parties
- Urban turbines are viable on the renewable energy market only if they will be supported by financial incentives
- The most important reasons for ENECO to use urban turbines are: their durability, tangibility and innovation
- The main weakness of urban turbines is the bad image which comes from large wind turbines: low safety and high noise level
• The main bottleneck at this moment is the lack of national policy and the lack of financial incentives regarding urban turbines

• The energy traders are not going to develop any incentives for urban turbines. They have no clear vision about the value of green electricity and/or green certificates for the electricity generated by urban turbines

• Grid operators have no policy regarding connection of urban turbines to the public grid at the moment

4.6.1 Standards and requirements regarding the grid connection

Small de-centralised energy producing units connected to the low voltage grid must comply with a certain number of standards and directives. In the Netherlands these directives are determined by the Nederlands Normalisatie Instituut (NNI). The general requirements regarding the connection to the low voltage grid are defined in the following documents:

NEN1010 safety of low voltage electricity installations
NEN11000-3-2 grid connection
NEN11000-3-3 electromagnetic compatibility (flickering curve)
NEN1014 lightening protection
NEN 3173 harmonics
NEN 10038 electrical systems
NEN 10555 1 and 2 sine disturbances
NEN 3173 rotating electrical machines

It is certain that a number of dedicated standards must be developed for the electrical and mechanical safety of urban turbines. Most probably these standards will be different from the existing standards for large wind installations.

The experience from the past learns that it is usual practice that new regulations come at the moment that the number of the installations needing these standards becomes more significant.

4.7 Governmental grants and feed-in tariffs

There are no special incentives for urban turbines in the Netherlands, but the investors can use incentives which are applicable to all renewable energy installations. These are summarised below:

4.7.1 Energy investment deduction

The EIA (energie investerings aftrek = energy investment deduction) is a tax relief measure which gives a direct financial advantage to Dutch companies that invest in energy-saving equipment and sustainable energy. 44 percent of the annual investment costs of such equipment (purchase costs and production costs) are deductible from the fiscal profit over the calendar year in which the equipment was procured. At a tax rate of 31.5% one can save up to 14% (0.44 x 0.315%) of the investment costs. Only companies which generate profit and pay tax can make use of this incentive. This means that NGOs, governmental organisations and large housing corporations can not make use of these incentives, as they do not pay tax.
**4.7.2 Green mortgage**

Green mortgage offers about 1.5% lower rate of interest than the standard mortgage. This financing can be applied when a private person invests in energy saving and renewable energy measures a minimum amount of € 34,000.

**4.7.3 Environmental quality of electricity production**

The MEP (milieukwaliteit elektriciteitsproductie = environmental quality of electricity production) is the feed-in tariff for renewable electricity. The tariff is different for different renewable sources. Onshore wind installations receive 0.077 €/kWh. The photovoltaic and offshore wind installations receive 0.097 €/kWh. For urban turbines applies the same tariff as for onshore wind. The ministry of Economic Affairs decides each year on the MEP tariff. Once the owner of a renewable installation has a contract for an MEP subsidy, the tariff stays on the same level for 10 years. In order to get the MEP subsidy the owner of urban turbine is required to:

- place the producers kWh meter (€ 500)
- register with the producers databank (€ 25 to subscribe + € 25 a year)

This implies that MEP subsidy is bound to certain minimum electricity production to be economically justifiable for the owner. Currently, the break-even point is the generation of at least 1010 kWh/year.

**4.8 Electricity metering**

The monitoring of energy yield of urban turbines in the Netherlands can be accomplished in three different ways:

- on-line monitoring via PC
- kWh meter for the registration of total electricity generation (the ‘producers meter’)
- kWh meter for the registration of the electricity surplus which is being fed into the grid.

The on-line monitoring of the electricity generation can be used for the private registration of the owner and to control the working of the turbine. On request, the turbine manufacturers can offer software and hardware for on-line monitoring.

The second, ‘producers kWh meter’ registers the total electricity generation. This meter is required if the owner wants to make use of the national feed-in tariff for urban turbines (MEP) of 0.077 €/kWh.

If the owner of urban turbine wants to sell the electricity generated by his installation and fed into the grid, than this electricity must be measured on one of the calibrated kWh meters listed by the regional grid operator. The kWh meters must be purchased from the energy company. They cost about € 500 including the placement. This requirement applies for all owners of small generation units in the Netherlands.
4.9 Conclusion

An open energy market makes possible that everyone can become electricity supplier. The small scale producers of renewable energy are free to feed the surplus of their electricity into the grid.

The regulations and incentives regarding the grid connection, monitoring and pricing of feed-in electricity from urban turbines already exist. The specific technical standards regarding safety of urban turbines are not yet available.

The capacity of the Dutch urban turbines is lower then the capacity of the grid connection which makes these turbines suitable for connecting on the consumer’s side of the grid. The major part of the generated electricity is consumed on the premises and incidentally some surplus is fed into the grid.

Technically, as long as the manufacturers keep to the existing standards and guarantee the safety of their products, no problems are expected with the grid integration of urban turbines.

The grid operators are not concerned about urban turbines because they expect that the amount of installations and the production capacity will stay rather low.

The energy suppliers are focused on large scale options and have no clear policy regarding urban turbines. Nevertheless, some of them are interested in urban turbines because of the possibility to build on the innovative and environmentally friendly image and enable their customers to make their ‘green’ strategy visible.

The electricity prices have been increasing for the last few years. This will have a positive impact on the feasibility of urban turbines.

Because the reliable yield data are not yet available, it is still not clear whether urban turbines would need any extra financial incentives. If it turns out that the pay-back time is shorter or equal to ten years, than the existing incentives would be sufficient. In that case it would be valuable to develop a financing concept for avoiding the obstacle of high initial investment.

If the pay-back time would turn out to be longer than 10 years, the extra incentives should be proposed. In that case the manufacturers would have to develop a model that would prove that the manufacturing costs would go down to the “break-even” point with a certain larger production volume.
5 REFERENCES

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6 ANNEX 1: PROCESS MAP FOR GRID CONNECTED URBAN TURBINE, UK

**Process**

- Site Selection
  - Wind Resource Data

- Turbine Selection
  - Energy Requirement
  - Budget
  - Cost analysis and payback period
  - Environment

- Grid Connection
  - Engineering standards must be complied with before a connection to the UK electricity network is made.
  - Grants for community and households using approved products and installers, available from Clear Skies scheme (England, NI & Wales)
  - Household - £1000 per kW installed up to a maximum of £5000
  - Communities - 50% of total capital and installation costs, or £100,000, which ever is smaller.
  - Grants applied for via application form procedure.
  - Limited number of grant available which are distributed in rounds.**

- Planning Permission
  - Apply for planning permission (£135 - Charnwood Council)**

- Grant Application
  - Building mounted turbines must comply with building regs
  - Apply for planning permission (£135 - Charnwood Council)**

- Grid Connection
  - G83 (up to 16 amps per phase)
  - If 3 phase connection is required and not present, contact DNO for connection cost.
  - Install and commission SSEG Complying with G83, submit commissioning pro-forma to DNO

- Power Purchase Agreement
  - Establish contract with electricity supplier for purchase of exported power
  - If necessary contact DNO for installation of appropriate meter. ~(£40 + £100 installation)*

- Claiming ROCs
  - Electricity generated from Renewable sources may be eligible ROCs which have a monetary value
  - 1-Where generator uses some of its own generation 'sell-and-buy-back' contract with a licensed supplier must be obtained.
  - 2-Register with Ofgem as a generator (application questionnaire)
  - 3-Receive ROC per 1MWh (part MWhs rounded) generated per annum for SSEG <50kW, or pcm for generator >50kW (ROC register)
  - 4-Agree price and sell ROC to a trader

- Installation

* list of approved meters
**http://www.charnwoodmuseum.co.uk/uploads/1424d26d957345172919683.pdf
***www.clear-skies.org

**Abbreviations**

ROC: Renewable obligation certificate
DNO: District Network Operator
SSEG: Small Scale Electricity Generator
Organisation of the Dutch Electricity Market

- Electricity Generation
- National Transport Grid
- Balance
- Regional Grids
- Metering Companies
- Brokers
- APX
- Trade
- Customers

Direction of demand for traded energy
Physical transport of electricity
Exchange of meter readings
Exchange of data
Intermediary role of broker