## 1) What is your definition of dispersed or embedded generation?

| Country | REPLY |
|---|---|
| Australia | Connected to the distribution network (up to 132 kV) which is capable of supplying customer load directly |
| Austria | Usually up to 10 MW, connected to MV network |
| Belgium | Not included in national co-ordinated production |
| Czech Republic | Connected to the distribution network (up to 110 kV) and up to a limited power rating. |
| Denmark | Not subordinated to the regional load despatch centres |
| Finland | By voltage level (20 kV and 0.4 kV) |
| France | Connected to the distribution network capable of supplying customer loads directly. Generation connected to the following voltage levels (0.4 kV, 15 kV, 20 kV) |
| Germany | No strict definition, mainly sun, wind and small hydro (connection up to 20 kV, 110 kV for wind parks) |
| Greece | Connected to the distribution system, not centrally planned or despatched |
| India | New renewable energy sources (connection up to 11 kV) |
| Italy | Connected to the distribution system (0.4 kV up to 150 kV) |
| Netherlands | Owned by utilities, industry or combination but not active in national production optimisation (up to 150 kV) |
| Poland | Not despatched and connected at up to 110 kV |
| Portugal | Power limit 10 MW (except CHP)<br>Co-gen or renewable energy source<br>Any voltage level. |
| Spain | Connected to the distribution system, |
| UK | Connected to the distribution system (up to 132 kV) - may be despatched. |

**Notes**

There appears to be no strict definition. A number of descriptions were proposed by members of the working party.

The definition given by Working Group 37-23 of CIGRE is

- not centrally planned
- today not centrally despatched
- usually connected to the distribution network
- smaller than 50-100 MW

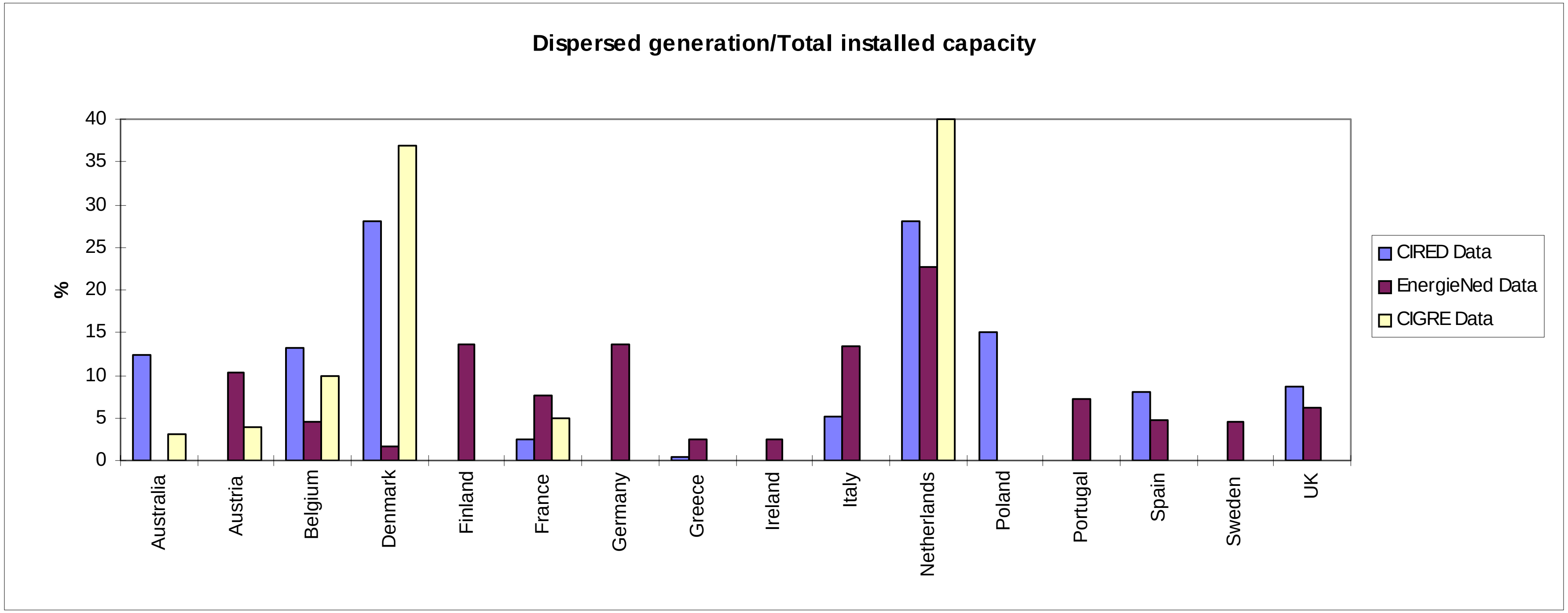
Not centrally planned or dispatched means that major influences such as unit commitment or reactive power generation are out of control of the system operator.

**2) What is the peak electrical output of dispersed generation in your country? How much of the electrical output is despatched, how much of the electrical output is determined by heat demand (or process demand), how much of the electrical output is determined by new renewable energy sources?**

| MW | Despatched. Diesel and GT. | Cogen Not desp. | Wind | Steam | Hydro | PV | Other ( inc. waste) | Total of dispersed generation | System Installed Capacity | System Maximum demand | % Dispersed generation/Installed capacity |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Australia | 718 | 1747 | 5 | 2754 | | | | 5224 | 42437 | 29841 | 12.3 |
| Austria | | 70 | 13.3 | | 616 | 0.7 | | 700 | | | 4 |
| Belgium | 214 | 1174 | 5 | | 97 | | 1938 | 1938 | 14693 | 11972 | 13.2 |
| China | 17269 | 16640 | 167 | 20470 | 25000 | | | | | | |
| Czech Republic | 977 | | | | | | | 1913 | | | |
| Denmark | | 2000 | 1450 | | | | | 3450 | 12150 | 6400 | 28.0 |
| Finland | | | | | | | | | | | |
| France | 610 | 435 | 8 | | 450 | | 250 | 1753 | 114500 | 68900 | 2.5 |
| Germany | | 2800 | 1545 | | 3333 | 17 | 904 | 8599 | | | |
| Greece | | 3 | 40 | | | | | 43 | 9859 | 6705 | 0.4 |
| India | | | 970 | | 155 | 32 | | 1300 | | | |
| Italy | 492 (not desp.) | 766 | 34 | | 2159 | 5 | 252 | 3708 | 70641 | 43774 | 5.2 |
| Netherlands | | 4736 | 427 | | 37 | | 80 | 5280 | 18981 | 12000 | 28 |
| Poland | | 3000 | | | 2008 | | | 5008 | 33400 | 23500 | 15.0 |
| Portugal | | | | | | | | | | | |
| Spain | | 2500 | | | 1500 (all renew) | | | 4000 | 50311 | 27251 | 8.0 |
| UK | | 3732 | 330 | | 1494 | | 421 | 5977 | 68340 | 56965 | 8.7 |

## Notes

Comparison of data from Question 2 with other sources is shown. The chart compares the data collected in response to Q2 (the CIRED data) with that given by the 1997 EnergieNed report and the report of the CIGRE Working Group WG 37-23. Although it may be seen that general trends coincide, the agreement between the three data sets is quite poor. This is probably due, at least in part, to different definitions of dispersed generation.



**3) What are the main policy drivers in your country which are leading to dispersed generation?**

| Country | Reply |
|---|---|
| Australia | Competition policy, energy efficiency policy. |
| Austria | 3% of distributed energy to be by new renewable sources by 2005, Co-gen suspended (except biomass) |
| Belgium | Rational use of energy, reduction of $CO_2$ |
| Czech Republic | Support for small hydro |
| Denmark | Energy efficiency and $CO_2$ reduction. Government targets: 2200 MW Co-gen, 1500 MW wind by 2005. By 2030 government targets of 5500 MW of wind of which 4000 MW to be offshore. |
| Finland | Private interest, deregulation |
| France | Diversification of energy sources and use of Co-gen |
| Germany | Law which encourages solar, wind and hydro generation at agreed tariffs |
| Greece | $CO_2$ reduction and promotion of renewables |
| India | Encouragement of development of new renewable energy sources |
| Italy | Reduction of gaseous emissions, improvement of energy efficiency |
| Netherlands | $CO_2$ reduction by sustainable energy and improved efficiency |
| Poland | High efficiency of generation, use of gas for generation |
| Portugal | $CO_2$ reduction |
| Spain | Energy savings, reduction in foreign currency expenditure. 12% of total generation of energy must be renewable by 2010 |
| UK | $CO_2$ reduction, energy efficiency, deregulation |

**Notes**

A number of policy drivers were quoted as being responsible for the encouragement of dispersed generation. Although environmental issues were clearly important they were not the only policy driver. The CIGRE WG 37-23 report quotes a similar large number of reasons, twelve in total, to explain why dispersed generation is increasing.

**4) What are the national technical rules or regulations for connecting dispersed generation? Are there simple rules for the maximum power which may be connected by a generator at a particular voltage level?**

| Country | Reply |
|---|---|
| Australia | No national rules but various guidance in the NEC: design limits:<br>415V 290 kVA<br>11kV 8 MVA<br>33 kV 35 MVA (underground)-69 MVA (overhead)<br>132 kV 300 (underground)-600 (overhead)<br>(In practice the largest installation so far considered has been 130 MW with considerable local load). |
| Austria | No simple rules but various guidance |
| Belgium | No simple rules: detailed guidance for evaluating connections<br>LV busbars 200 kVA<br>inside MV network<br>6 kV 1.7 MVA<br>11.5 kV 5 MVA<br>15 kV 6.5 MVA |
| China | No simple rules but various guidance |
| Czech Republic | Some utilities have simple rules e.g. 60 kW into LV<br>2.5-4 MW into HV |
| Denmark | There are national guidelines and 3 sets of operational requirements in the Jutland-Funen area depending on rating:<br><2 MW, 2-50 MW, >50 MW.<br>The utility decides the voltage level of connection. |
| Finland | Technical recommendations from electricity association and local guidance |
| France | Considerable technical documentation and government decree (which can be relaxed following studies) of<br>LV 400V <250 kVA<br>MV 15/20 kV <10 MW<br>HV 63/90 kW 10-40 MW<br>EHV 225 kV >40 MW |
| Germany | No simple rules but recommendations from VDEW |
| Greece | No simple rules but various guidance. Studies performed by PPC. |
| India | No special rules or guidance is available |
| Italy | Current criteria:<br>LV 5 kVA single phase<br>LV 50 kW 3 phase<br>MV 8 MW (over 3 MW should be at MV busbar) |
| Netherlands | No simple national rules but various guidance - local utility rules |
| Poland | No simple rules but various guidance |
| Portugal | No simple rules but various guidance in national guide |
| Spain | Simple rules are not published. Dispersed generation cannot exceed 50% of line capacity |
| UK | No simple rules but various guidance |

**Notes**

In some countries (e.g. France and Italy) simple rules are applied which define the voltage level to which dispersed generation may be connected depending on its rated output. It is generally recognised that, although this approach saves engineering effort, it may be possible to relax these simple rules in some cases after suitable studies have been done. The alternative approach is to evaluate the impact of the dispersed generation on other users of the network by undertaking engineering studies of various complexity.

**5) What do you see as the main technical connection issues at each power/voltage level?**

| Country | Reply |
|---|---|
| Australia | Safety, system security and quality and reliability of supply - inverter islanding - guidelines have recently been introduced for inverter fed generators (PV) |
| Austria | LV - voltage rise, cost effective anti-islanding protection and isolation<br>MV- voltage rise, increase in fault level, power quality, cost effective protection |
| Belgium | LV - operational difficulties and low cost protection<br>MV - mal-operation of protection<br>Multiple embedded generators on a feeder. |
| Czech Republic | LV - voltage limits, power factor limits, islanding, reduction in ripple control signal |
| Denmark | LV - cost effective islanding protection and isolation<br>MV (10-60 kV) balance between loss of generation and sensitive protection against auto-reclosing.<br>Voltage rise at both voltage levels is an issue |
| Finland | MV and LV<br>- Lack of rules for despatching<br>- Protection of MV network<br>- Lack of clear contract procedures for connection<br>- Harmonics and VAr compensation<br>110 kV<br>- Power flow on the relatively weak 110 kV grid<br>- Short circuit levels<br>- Reactive power<br>- Dispatching |
| France | Voltage control during low load<br>Fault level contributions<br>Protection mal-operation<br>Ripple control signal strength |
| Germany | 400 V voltage rise, cost effective anti-islanding protection and isolation<br>10 kV overvoltage, fault level, harmonic voltages<br>20 kV voltage and thermal limits |
| Greece | For wind turbines connected to the 15 kV or 20 kV networks - voltage rise, power quality and cost-effective islanding protection |
| India | Reactive power demand of induction generators |
| Italy | Generally islanding,<br>for solar and wind generation power quality<br>for large installations fault current contribution |
| Netherlands | Absolute voltage level and voltage rise, flicker, fault level contribution, protection, islanding protection |
| Poland | Voltage rise and difficulties on circuits with auto-reclose |

| | |
|---|---|
| Portugal | Main issue is minimum 3 phase short circuit level at point of connection |
| Spain | LV - anti-islanding, voltage rise<br>MV- transfer tripping is required which is expensive<br>MV, HV - voltage rise, especially with multiple generators |
| UK | LV - voltage rise, cost effective anti-islanding protection and isolation<br>MV- voltage rise, increase in fault level, power quality, cost effective protection |

**Notes**

There appears to be a reasonable consensus concerning the important technical issues of the impact of dispersed generation on distribution networks:

- Voltage rise
- Islanded operation (and cost-effective anti-islanding protection)
- Increase in short circuit level
- Impact on power quality

In addition some concern was expressed over operational issues including voltage control and central dispatching.

**6) When connecting dispersed generation do you use general guidelines or carry out system studies**

| Country | Reply |
|---|---|
| Australia | Generally specific studies are undertaken |
| Austria | Generally specific studies are undertaken |
| Belgium | Specific studies are undertaken (no simple national guidelines exist) |
| Czech Republic | Studies not generally required, some utilities require studies for asynchronous generators |
| Denmark | Studies are only required for larger installations. Guidance referred to in Answer 4 is usually adequate |
| Finland | Specific studies are always required |
| France | Specific studies are carried and computer tools are available |
| Germany | Specific studies are carried out |
| Greece | Individual studies are performed |
| India | No system studies required |
| Italy | General ENEL guidelines are used. Only special cases (e.g. high power schemes) require studies |
| Netherlands | Studies required for larger installations. For smaller installations simple guidelines are being used. Rules described in Answer 4 are applied. |
| Poland | Specific studies are performed |
| Portugal | Simple evaluation of short circuit level of connection point, which is then used to define max. generation capacity |
| Spain | Specific studies apart from small generators |
| UK | Specific studies are undertaken |

**Notes**

In most countries specific system studies are undertaken to examine the impact of connecting dispersed generation on the quality of power provided to other customers

**7) At present do the utilities in your country consider that dispersed generation makes any contribution to system security?**

| Country | Reply |
|---|---|
| Australia | Probably not |
| Austria | No |
| Belgium | No definite position yet. Not in LV and MV networks maybe in a reduced manner in HV networks |
| Czech Republic | Not generally |
| Denmark | No due to sensitive loss-of-mains protection and low inertia of. dispersed generation reduces system security. “The high share of dispersed generation is considered to have a negative influence on system security” |
| Finland | No allowance is made in terms of generation or transmission security |
| France | No dispersed generation does not contribute to system security |
| Germany | No |
| Greece | No |
| India | No |
| Italy | No - but the subject is under discussion |
| Netherlands | For the customer - yes as a no-break system<br>For the distribution system - studies are in progress<br>For the transmission system one company includes dispersed generation |
| Poland | No<br>Operators of fossil fuelled dispersed generators. must pay up to 10% of energy price for the costs of additional spinning reserve |
| Portugal | No, number of dispersed generators in Portugal is small |
| Spain | No, because it is not integrated with the utility SCADA system |
| UK | Only marginally |

**Notes**

There was a clear majority view that dispersed generation does not make any contribution to system security. This was partly due to the essential characteristic of the prime movers of the dispersed generation and partly due to the administrative and protection arrangements which have been adopted.

A recurring theme was the problem that dispersed generation was not integrated into the utilities control and SCADA system.

The Netherlands, with a very large percentage of dispersed generation, was addressing this issue actively.

**8) Do you foresee any mechanism or arrangements for dispersed generation to be able to contribute to system security in the future.**

| Country | Reply |
|---|---|
| Australia | Cannot answer at present |
| Austria | Yes but further investigations required |
| Belgium | Depends on evolution of protection, CHP is heat driven |
| Czech Republic | May improve voltage drop |
| Denmark | A possibility of some infrequent control (connecting/disconnecting) of larger groups of dispersed generation would contribute to higher system security |
| Finland | As UK answer |
| France | Yes this may be possible but only with significant conditions concerning availability and control of dispersed generation |
| Germany | Not at present |
| Greece | Generally no |
| India | Difficult to predict at this stage |
| Italy | Some allowance could be made if dispersed generators were controllable or despatchable. Progress is required in prediction of the output of new-renewable generation |
| Netherlands | Yes if a statistical approach is adopted based on a large number of units |
| Poland | Perhaps if the energy market develops |
| Portugal | Not at present |
| Spain | It will be necessary in the future to consider suitable mechanisms and avoid the present situation where it makes a negative contribution |
| UK | Under present deterministic arrangements dispatched dispersed generation can make a limited contribution to system security and ad-hoc arrangements are possible. Non-dispatched dispersed generation can make no contribution unless probabilistic security assessment techniques are introduced. |

**Notes**

This was a rather speculative question but not much serious work on this topic appears to be in progress.

**9) Do electrical power utilities in your country consider installing dispersed generation when planning to supply new loads or reinforce the network?**

| Country | Reply |
|---|---|
| Australia | Would be considered for remote area power supplies |
| Austria | No, dispersed generation requires additional investment in rural distribution networks |
| Belgium | Not in LV and MV networks |
| Czech Republic | No |
| Denmark | No, dispersed generation usually requires network reinforcement |
| Finland | No, the contribution of dispersed generation is not considered during network planning |
| France | Yes for peak shaving only and not for "full backup of the grid" |
| Germany | Yes if they are in the network already |
| Greece | For remote area power supplies |
| India | No |
| Italy | Not generally considered |
| Netherlands | Not at present, perhaps in the near future |
| Poland | Yes when local heat consumption is large and gas is available |
| Portugal | No |
| Spain | Not generally |
| UK | Only if overhead circuits cannot be built |

**Notes**

As might be expected, distribution utilities do not consider dispersed generation a substitute for network capacity. The degree to which existing dispersed generation was considered during planning varied.

**10) What are the requirements for controlling the reactive power output or busbar voltage of dispersed generation? Is there a particular power level at which a voltage regulator scheme is required?**

| Country | Reply |
|---|---|
| Australia | Generally, distributed generation is operated close to upf . Some voltage control is arranged on an ad-hoc basis with monitoring to disconnect generator if network voltage limits are exceeded. |
| Austria | A pf of 0.9 inductive is required |
| Belgium | Reactive power in excess of 33% of real power attracts penalties. Voltage protection relays disconnect the generator when the limits are exceeded. |
| Czech Republic | Reactive power should be 1/3 of active power, but for new large sources the utilities require adjustment of the power factor |
| Denmark | Most synchronous generators inject reactive power and take part in controlling the voltage. They are designed to operate with a tan $\phi$ between 0.4 and -0.1. New wind turbines installed today should be designed with automatic reactive power compensation in order to operate with tan $\phi = 0$ from zero to full load. As an alternative the owner of the wind turbine can pay the utility an amount to install reactive power compensation somewhere in the network. |
| Finland | No guidance is available |
| France | LV units must operate at upf. MV units must operate between 1 and 0.928 (injecting VArs). New Ministerial Orders are that large units (say over a few MWs) must contribute to voltage control by a reactive power capability of 0.1-0.6 their rated capacity |
| Germany | At 10-20 kV a voltage regulator is required |
| Greece | No |
| India | No, difficulties with induction generators have been identified |
| Italy | A pf of 0.9 lagging at high network loads and 0.95 leading at low network loads is required. For induction generators, average monthly power factor must be above 0.9. These rules apply only for generators with rated power greater than 10 MVA. No general mechanism for voltage control |
| Netherlands | The pf is mainly set between 1 and 0.9 inductive. Dispersed generation plays no part in voltage control of the distribution network |
| Poland | The connection agreement defines the pf within which the generator must operate (at no extra charge) and the voltage limit at which the generator will be disconnected |
| Portugal | At peak times reactive power injected must be at least 40% of active power, outside peak times the dispersed generation should not inject reactive power into the network |
| | |

| | |
|---|---|
| Spain | For asynchronous generators, the pf must be greater than 0.86. For synchronous generators on the MV or HV a pf range of between 0.8-1 (leading and lagging) and a voltage regulator are required Voltage relays are also required to disconnect the generator. |
| UK | Generally, all dispersed generation will prefer to operate at unity pf to minimise the charges for reactive power. |

**Notes**

The answer to this question revealed considerable diversity. Many utilities placed some sort of requirement on the reactive power capability of (large) dispersed synchronous generators and some specified an operating requirement in terms of power factor or VAr flow. There was little evidence of the integration of dispersed generation in voltage control of distribution networks.

**11) What rules are used for studying the effect of the generator on the system voltage?**

| Country | Reply |
|---|---|
| Australia | - |
| Austria | For power quality considerations the maximum voltage change permitted is +/- 3% on MV networks and +/- 6% on LV networks. Under no circumstances may the supply voltage variation to other customers exceed +/- 6%. |
| Belgium | Dips of 6% are permitted on connection but the generator must not cause flicker nuisance |
| Czech Republic | Maximum voltage changes permitted<br>LV network 3%, HV network 2%, for induction machines in LV network 6% |
| Denmark | Main consideration is to maintain LV limits of +6/-10% on 400/230V system |
| Finland | Voltage changes based on standards |
| France | The voltage change at each customer supply point is considered +/-5% for MV and +6/-10% for 400/230V system.<br>Calculations are carried out for each customer supply point with Min/max. loads and min/max. generation. |
| Germany | The maximum transient change which a generator may cause on a network is +/- 3% (from power quality considerations). A calculation is also required to ensure that the supply voltage variation seen by other customers (+/- 6%) is not exceeded. In addition connection/disconnection events are considered. |
| Greece | EN 50160 is used to evaluate voltage quality indices (with and without dispersed generation) Flicker is evaluated to IEC standards |
| India | Indian electricity rules are applied |
| Italy | The maximum voltage change which a generator may cause is +/-4%. For generators at MV the maximum contribution to short-circuit level may not exceed 600 Amp. |
| Netherlands | Dispersed generation may cause a voltage rise of 3-5%, provided the original rules on customers voltage are still regarded |
| Poland | |
| Portugal | A dispersed generator may cause a maximum voltage change of +/-7%. The limits if NPEN 50160 (+/-10%) must not be exceeded |
| Spain | Starting of asynchronous generators, -5%. For operating wind turbines +/-2%. Max. power of wind generators must be less than 1/20 of short circuit level. The generator operation must be stable dynamically and after transients |
| UK | The maximum transient change which a generator may cause on a network is +/- 3% (from power quality considerations). A calculation is also required to ensure that the supply voltage variation seen by other customers (+/- 6%) is not exceeded. |

**Notes**

There was considerable divergence in the answers to this question. Some countries considered only the effect of dispersed generation on other customers while others had intermediate regulation to try to maintain voltage variations at particular voltage levels. In addition to steady state voltage effects this question also elicited answers concerning power quality. It was noticeable that EN 50160 was not applied in a number of countries (as noted in the CIGRE WG 37-23 report).

**12) What arrangements are made for the change in distribution network losses caused by dispersed generation?**

| Country | Reply |
|---|---|
| Australia | - |
| Austria | No arrangements at present |
| Belgium | Tariff changes according to location of dispersed generation |
| Czech Republic | No arrangements |
| Denmark | Energy is traded at the point of connection whit the utility network and so this has not been an issue so far, but some types of arrangements are now being discussed. |
| Finland | There is no guidance |
| France | Energy is traded at the point of connection with the public utility system. Losses in any dedicated feeder are paid for by the generator (metering is located at the utility end of any dedicated circuit) |
| Germany | This is under discussion |
| Greece | Losses in any dedicated feeder are paid for by the generator (metering is located at the utility end of any dedicated circuit) |
| India | |
| Italy | No arrangements |
| Netherlands | No arrangements but this may change when the industry is split into supply and network companies |
| Poland | To be considered in local contracts for power purchase. No general rules exist |
| Portugal | Arrangements are made through network optimisation |
| Spain | Losses in any dedicated feeder are paid for by the generator (metering is located at the utility end of any dedicated circuit) |
| UK | Loss adjustment factors are calculated and used to scale (up or down) the energy traded at the interface between the distribution system and the transmission system |

**Notes**

This was clearly not yet a major issue in most countries. However, this may change as distribution utilities are split into energy supply and network businesses.

**13) Are generators treated in the same way as loads in terms of power quality issues e.g. harmonics, unbalance, sags etc.?**

| Country | Reply |
|---|---|
| Australia | - |
| Austria | Yes |
| Belgium | Yes, but for MV connection an intermediate transformer is required with Xt>10%. |
| Czech Republic | Yes |
| Denmark | Yes |
| Finland | Yes |
| France | In general Yes. Standards do not exist for limits to harmonic currents injected into LV networks. |
| Germany | Yes, in a similar manner |
| Greece | Yes, in general |
| India | Yes |
| Italy | Yes, the same regulations apply to loads and dispersed generators |
| Netherlands | Yes |
| Poland | Yes |
| Portugal | Yes |
| Spain | Yes |
| UK | Yes |

**Notes**

There was a very clear consensus that this was the case

**14) Do the distribution utilities in your country specify or provide guidelines for any particular form of generator protection? Is the generator protection too sensitive and subject to nuisance tripping?**

| Country | Reply |
|---|---|
| Australia | Only check to ensure generator protection is adequate for the safe and reliable operation of the distribution system |
| Austria | Generator protection is the responsibility of the generator operator and, as it does not contribute to system security, may be set as sensitively as desired. |
| Belgium | No but the choice of protection lies with generator |
| Czech Republic | A Czech standard is followed |
| Denmark | Guidelines are provided, nuisance tripping is not a big problem |
| Finland | Guidelines are available |
| France | Protection is the responsibility of the generator, However nuisance tripping is becoming a problem and additional guidance from EDF is being developed |
| Germany | - |
| Greece | Protection is specified |
| India | No |
| Italy | Generator protection is the responsibility of generator operator: anyway detailed guidance is given by national standards |
| Netherlands | Guidelines are provided in national documents |
| Poland | Generator protection is the responsibility of the generator operator |
| Portugal | Generator protection is the responsibility of the operator and may be set as sensitively as desired |
| Spain | Generator protection is the responsibility of the operator, in some cases there has been nuisance tripping |
| UK | Generator protection is the responsibility of the generator operator and, as it does not contribute to system security, may be set as sensitively as desired |

**Notes**

There was a clear consensus that the generator protection was the responsibility of the generator operator. As most dispersed generators do not contribute to system security this approach would appear to be entirely reasonable.

**15) What interface protection is required in order to protect the distribution network and other customers from the generator?**

| Country | Reply | | | | | |
|---|---|---|---|---|---|---|
| | over and under Freq. | over and under Volt. | over current and earth fault | pole slip | CB fail | loss of mains | OTHER |
| Australia | Y | Y | Y | Y | Y | | intertripping and SCADA operation on MV |
| Austria | Y | Y | | | | Y | |
| Belgium | Y | Y | Y | | | | zero sequence volts |
| China | | | | | | | |
| Czech Republic | Y | Y | dir. o/c | | | | |
| Denmark (relaxed for induction generators) | Y | Y | Y | | | | +ve sequence under voltage |
| Finland | Protection is the responsibility of generator operator | | | | | | |
| France | Y | Y | | | | | zero sequence volts and transfer tripping |
| Germany | Similar to UK | | | | | | |
| Greece | Y | Y | Y | | | | -ve and zero sequence voltage |
| India | | | | | | | |
| Italy | Y | Y | Y | | | | zero sequence voltage |
| Netherlands | Y | Y | Y | | | | recommended: over/underspeed, phase asymmetry, single phase reverse power mains jump |
| Poland | | Y | Y | | | | directional power |
| Portugal | Y | Y | Y | | | | zero sequence |
| | | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Spain | Y | Y | Y | | | | zero sequence voltage, transfer tripping, synch check |
| UK | Y | Y | Y | | | Y | |

**Notes**

There was a degree of consensus in the main types of interface protection required but considerable differences in practice, particularly for the detection of loss-of-mains. The Danish experience of positive sequence undervoltage relays appeared to be very good while other countries (e.g. Spain and Australia) used transfer trip schemes. Some countries have special rules for small PV inverters

**16) Is specific loss-of-mains protection required? Is auto-reclose of circuit breakers used on the distribution networks to which dispersed generation is connected?**

| Country | Reply | |
|---|---|---|
| | Loss-of-mains protection | Auto-reclose |
| Australia | - | - |
| Austria | Yes | - |
| Belgium | No (but vector shift is optional) | Yes but delay increased to 2.5 seconds if dispersed generation is connected |
| Czech Republic | Yes (vector shift) | Yes |
| Denmark | +ve sequence undervoltage + df/dt or vector shift (optional) | Yes |
| Finland | | |
| France | No but transfer tripping is sometimes used. Islanded operation has been experienced for several minutes | Yes but special precautions are taken |
| Germany | Yes | Yes |
| Greece (issue is under discussion) | Yes | Yes |
| India | No | |
| Italy | No - transfer tripping used in some places | Yes |
| Netherlands | Included in undervoltage relays | Not in underground networks |
| Poland | - | Not on circuits with generators connected |
| Portugal | Producers are warned about auto-reclose | Yes |
| Spain | No - transfer tripping is preferred | Yes |
| UK | Yes - df/dt or vector shift | Yes |

**Notes**

Loss of mains detection remains a major issue, mainly associated with auto-reclose and the potential for damage to the generators caused by out-of-phase re-closing. It was interesting that in the Netherlands, with no auto-reclose on the underground distribution network, specific loss-of-mains protection is not required.

**17) Do you consider that the presently available loss-of-mains relays are satisfactory?**

| Country | Reply |
|---|---|
| Australia | Insufficient experience at present |
| Austria | No |
| Belgium | No |
| Czech Republic | No |
| Denmark | +ve sequence undervoltage relay seems to work well |
| Finland | |
| France | No, tests a few years ago on a phase shifting relay led to nuisance tripping |
| Germany | - |
| Greece | Protection integral with wind turbine controllers seems to be acceptable |
| India | Not tried |
| Italy | No experience to date |
| Netherlands | Phase jump relays are recommended. Loss-of-mains relays are not 100% sufficient for preventing islanding. |
| Poland | - |
| Portugal | No, both df/dt and dv/dt relays are subject to nuisance tripping |
| Spain | No, transfer tripping, sometimes extending to two substations is used. Some generators have installed loss-of-mains relays which have been subject to nuisance tripping |
| UK | No - nuisance tripping is fairly common particularly following a frequency excursion caused by loss of a major central power station unit or similar event. |

Notes

The answers to this question merely confirmed the anecdotal evidence that sensitive loss-of-mains protection is subject to nuisance tripping.

**18) What procedures and equipment is required to isolate a dispersed generator for work on the network?**

| Country | Reply |
|---|---|
| Australia | Operating agreement required. The PV installations for Sydney Olympic Village 2000 are a major installation and the arrangements under discussion |
| Austria | All dispersed generation must have an accessible disconnect switch. The network supplying the generator may be taken out of service by the utility subject to 3-4 days notice. |
| Belgium | Accessible switch required |
| Czech Republic | A locked CB accessible only to utility staff is required |
| Denmark | A disconnect switch must be available to utility staff |
| Finland | |
| France | For dead working disconnection is required, for live working protection must be set to instantaneous. The issue of disconnection of very small generators has been recognised |
| Germany | - |
| Greece | A disconnect switch operable by the utility staff is required |
| India | Isolators and circuit breakers are used |
| Italy | A disconnect switch operable by the utility staff is required, this is an issue for very small generators |
| Netherlands | A disconnect switch required. this is an issue for very small generators (<5 kVA) |
| Poland | Negotiated between network and generator operators |
| Portugal | A disconnect switch operable by the utility staff is required |
| Spain | A local disconnect switch operated both automatically and by the local operators is required. Telecontrol is required for larger plants in some areas |
| UK | All dispersed generation must have an accessible disconnect switch. The network supplying the generator may be taken out of service by the utility subject to suitable notice |

**Notes**

There was general consensus on the requirement for a disconnect switch to be available to the utility staff and the replies also emphasised that this had been recognised as an important issue for very small generators.

**19) What level of generation is despatched? What information is exchanged between the generator operator and network operator?**

| Country | Reply |
|---|---|
| Australia | Those with maximum output greater than 30 MW are despatched |
| Austria | Awaiting liberalisation of electricity market in February 1999 |
| Belgium | Only 5 plants presently exist of ratings between 18-54 MW. The network operator has authority over their connection and disconnection |
| Czech Republic | All generators are despatched |
| Denmark | Dispersed generators (as defined in this questionnaire) are not despatched. Plants rated above 2 MW have their outputs monitored while plants rated above 50 MW are obliged to inform the despatch centre of their intentions a day in advance |
| Finland | |
| France | Some units are despatched, some units e.g. Co-gen which only export a small part of their output have to exchange information with the network operator |
| Germany | Level of despatch not defined |
| Greece | All wind parks on island systems are tele-controlled. For dispersed small units there are no fixed rules |
| India | Output is not very significant. Energy from dispersed generation is generally utilised in full |
| Italy | Dispersed generators are not generally despatched. All plants greater than 10 MW must inform ENEL of their weekly production plan |
| Netherlands | Wide range of situations depending on output of dispersed generator and the maximum load of the customers of the specific distribution company |
| Poland | Old regulations set limit at 100 kW, new regulations not issued yet. For generators connected to the MV network the generation schedule must be communicated to the network operator |
| Portugal | No privately owned dispersed generation is despatched. For hydro connected to the 60 kV level an exchange of information with the distribution company is required |
| Spain | Dispersed generators can elect to be “guaranteed power” and receive a premium. This involves an annual scheduled hourly based timetable. Over 1 MVA rated units more then 95% of the generators are considered to be “guaranteed power” |
| UK | Complex situation concerning generation licences and pool membership. This may change in the near future |

**Notes**

The answers to this question indicted considerable diversity. Practice varied from central or regional despatch, to notifying the utility of a power production plan some time ahead, to completely independent operation.

**20) How is the output of dispersed generation sold?**

| Country | Reply |
|---|---|
| Australia | Under open access, sale of energy is possible to any retailer. "Green power" premium schemes are operated by some retailers |
| Austria | Before liberalisation power was sold to local regional utility. Now every dispersed generator may operate as an IPP |
| Belgium | Energy is bought at tariffs set by the Regulatory Commission, there is a temporary premium for renewables |
| Czech Republic | Energy is purchased by the local distribution utility |
| Denmark | Co-gen or wind generation is sold at a premium price and has priority. This power is bought by the local distribution company and the cost of the premium spread over all consumers. Non-utility dispersed generation can obtain grants from the Government. New arrangements are undergoing revision, i.e. a market of renewable energy Certificates |
| Finland | |
| France | By EDF using a calculation based on load tariffs. Main cost of kWh is of the marginal cost of displaced conventional plant. For Co-gen units the price of electrical energy is related to the gas price. |
| Germany | Wind generation is bought at 66% of retail price. Co-gen electrical output is used mainly by the private generator. Very high premiums for PV generated power |
| Greece | Energy is sold to PPC. Price paid is related to retail price (which changes on the islands) |
| India | Output is purchased by utilities which are state owned |
| Italy | A premium price is paid for energy produced by high efficiency plants. |
| Netherlands | By special feed-back tariffs. CHP production costs are lower than for renewables. |
| Poland | Renewables receive approximately 85% of LV tariff. For other dispersed generators the price is related to bulk supply prices |
| Portugal | At a price decided by government legislation |
| Spain | The output of dispersed generation is bought by the distribution company at the price applicable to generation in general, plus a premium. The premium price varies depending on the type and the size of the DG plant. PV has very high premiums. |
| UK | Energy generated by some new renewable sources is sold at a premium price under the Non-Fossil-Fuel Obligation. Other approaches are to sell directly to other customers on the same distribution system or to sell as "Green Electricity". Energy from Co-gen plants is sold either to the local utility or to 3rd party supplies of energy. The arrangements for the sale of electrical energy in the UK are presently under revue. |

**Notes**

There were very diverse answers to this question reflecting the different positions of the market for electrical energy in various countries. Some forms of dispersed generation are very actively encouraged by central government and receive attractive tariffs.

**21) What calculation techniques/standards do you apply to calculate plant short circuit ratings for circuits containing dispersed generation? Is there any special attention paid to the out-of-phase switching capability of existing circuit breakers?**

| Country | Reply |
|---|---|
| Australia | - |
| Austria | IEC 909 - A particular problem was identified of out-of-phase reconnection following circuit breaker operation |
| Belgium | IEC 909 - out-of phase closing is avoided through loss-of-mains protection |
| Czech Republic | Czech standard based on IEC 909. No special consideration to out of phase switching |
| Denmark | IEC 909 or dynamic simulation. Out-of-phase capability not checked on existing switchgear but the utilities are aware of this issue. |
| Finland | Based on IEC 909 |
| France | IEC 909 is applied following EDF guidelines. EDF is investigating if out-of-phase switching will cause any risk |
| Germany | VDE norm |
| Greece | IEC 909, no special check is made for out-of-phase switching |
| India | Not required due to low level of dispersed generation |
| Italy | By software simulation. No special checks are made for out-of-phase switching as it is assumed anti-islanding protection will not allow this condition |
| Netherlands | Calculations are based on IEC 909. There are no special considerations for asymmetric switching |
| Poland | Polish standard PN/E-05002/74 is applied |
| Portugal | IEC 909 and computer based tools used |
| Spain | IEC 909 and software simulation, No special checks for out-of-phase switching as a synchro-check relay is used. |
| UK | IEC 909 and additional UK guidance to allow the use of computer simulation |

**Notes**

There was a general consensus that IEC 909 was followed with no particular consideration given to unusual switching conditions caused by dispersed generation.

**22) Is special attention paid to unusual switching conditions caused by dispersed generation?**

| Country | Reply |
|---|---|
| Australia | - |
| Austria | - |
| Belgium | No |
| Czech Republic | No |
| Denmark | Simulations are carried out for some large (>50 MW) units prior to commissioning, and after any issues arise |
| Finland | |
| France | EDF is investigating this issue |
| Germany | Grid operator decides which studies are required |
| Greece | Normally no - a particular problem has been identified with induction generators and long submarine cables |
| India | No |
| Italy | Not generally |
| Netherlands | This is becoming an issue |
| Poland | “The transient voltage problems have been reported” |
| Portugal | Time delays are imposed on reconnection to avoid this problem |
| Spain | Special operating procedures are written to avoid this problem |
| UK | No but a possible issue has been identified by some utilities |