NTS Exit Regime: Nodal and Zonal Models

A paper by NGT

Introduction

The proposed reform of exit arrangements from the NTS could be based on either a nodal or a zonal model. The nodal model has the advantage of providing NGT with complete information as to where the capacity is required, but can only be traded on a one for one basis where two parties share the same offtake or alternatively where NGT facilitates a trade via the use of "exchange rates" between offtakes. Conversely, a zonal model will provide greater opportunities for trading, but at the price of the network being designed and operated on the basis of aggregated information. There is a trade off between these factors, ranging from a model with one node per zone where there is complete information but very limited trading, to a single zone, where all parties can trade but NGT has no locational knowledge of where the demand will be taken. This paper explores whether a set of zones can be identified such that there is significant ability for participants to trade whilst giving NGT sufficient information to be confident of meeting its "1 in 20" obligation.

Designing a Set of Zones

A starting point was to look at the table in the Seven-Year Statement in electricity that defines 11 boundaries on the transmission system. Whilst this was used as the starting point for similar analysis in electricity, the SYS contains the following warning. "However, it should be noted that such an approach is only shorthand and cannot provide the complete picture – other needs for reinforcement or constraint of generation may arise that are not shown by particular boundaries."

The translation from electricity to gas must consider the differences between the two networks. Unlike the gas system, the electricity network suffers a significant number of transmission faults. For this reason the electricity grid is operated as a "mesh" to provide alternative paths in event of a fault and a zonal boundary seeks to represent the aggregate capacity of these parallel paths following the most onerous secured fault. Building on this characteristic the NGC system is designed to maintain security against a range of generation and outage scenarios. Accordingly, constraints arise where generation and outage patterns differ from that for which the system has been planned, and these tend to occur across particular 'pinch points' or boundaries, which are resolved by constraining generation. As the NTS network is virtually immune from the failure of pipes, the redundancy of a "mesh" network is not justified and the system operates predominantly in a "radial" fashion. In the unlikely event of the failure of a major pipeline there could be a very widespread loss of gas supplies i.e. there is no concept of parallel paths maintaining supplies following the most onerous secured fault. In addition the gas network is sized to meet peak demand conditions which represents a case in which sources of supply are largely fixed and consequently constraint boundaries do no not arise to the same extent because of the more limited scope for supply to move around (compared to the location of generation in use).

It follows that, if large zones for exit capacity can be identified on the NTS, then they must be based around these radial flows i.e. a zone will be defined as those offtakes supplied by a common radial feeder. (There is some ability to transfer gas from one feeder to another but, compared to electricity, this is very marginal.)

As might be imagined, this leads to a series of cigar shaped zones each associated with a main feeder. These zones are typically over 100 miles long: quite different from the proposals in electricity.

The concept of exit reform is that the quantities and associated prices participants are prepared to pay for exit capacity will inform NGT's future investment in exit capacity. For capacity applications on a zonal basis to provide an accurate signal requires that the impact of any increase in zonal demand on the NTS is largely insensitive to where the gas is extracted within a zone. The ability to swap gas flows within a zone reduces dramatically as the utilisation of the network increases towards its maximum transmission capability at which point reinforcement will be necessary to satisfy any increased demand. When the network's capability is being fully utilised, the pressure at the remote end will be at the lowest acceptable level. Hence any transfer of load in a "downstream" direction will tend to increase the pressure loss on the system causing a loss of supply *with no increase in zonal demand*. It follows that the purchase of zonal capacity cannot, of itself, define the need for reinforcement. Equally, the reinforcement required for an increase in zonal demand will depend upon where the capacity is required.

This theoretical approach is illustrated below by considering one possible set of zones: the existing LDZ zones.

Potential Zoning with Large Zones

The nearest proxies for zones that are used in management of the NTS are the LDZ zones (see Figure 1). If demand is placed as per these zones, and assuming that demand is consistent with our peak planning assumptions then we can expect to see system wide demand growth of around 25 mcmd for 2008 when compared to peak day expectations for the winter of 2005 (total 555 mcmd).

LDZ	Incremental demand	Components
Scotland	-3.52 mcmd	LDZ + 1.98 mcmd (across 18 offtakes) Moffat interconnector –5.5 mcmd
Northern	1.13 mcmd	LDZ +1.13 mcmd (across 14 offtakes)
North West	2.64 mcmd	LDZ +2.42 mcmd (across 13 offtakes) Shellstar +0.22 mcmd
North East	0.86 mcmd	LDZ +0.86 mcmd (10 offtakes)
East Midlands	5.56 mcmd	LDZ +1.83 mcmd (across 14 oftakes) British sugar +0.44 mcmd Staythorpe +3.73 mcmd
West Midlands	1.88 mcmd	LDZ +1.88 mcmd (across 11 offtakes)
Wales North	0.29 mcmd	LDZ +0.29 mcmd (at 1 offtake)
Wales South	0.80 mcmd	LDZ + 0.80 mcmd (across 3 offtakes)
Eastern	2.30 mcmd	LDZ +1.86 mcmd (across 11 offtakes)
North Thames	1.30 mcmd	LDZ + 1.30 (across 4 offtakes)
South East	0.99 mcmd	LDZ +0.99 mcmd (across 5 offtakes)
Southern	2.19 mcmd	LDZ +2.19 mcmd (across 6 offtakes)
South West	8.95 mcmd	LDZ +1.61 mcmd (across 13 offtakes) Marchwood +3.56 mcmd Langage +3.58 mcmd
Total	25.36 mcmd	

The challenge presented by zones defined as above is that a single demand figure leaves considerable uncertainty about how that incremental demand might be distributed between offtakes within each zone. For example, in Scotland, an aggregate reduction in demand masks an expectation that demand will be growing, by varying degrees across 14 offtakes and that a single Offtake is expecting a considerable reduction in demand. The size and topology of the network, with around 1,600 km of NTS pipelines, means that an aggregate reduction in demand cannot necessarily mean that no reinforcement would be required to satisfy demand at the 14 offtakes. The zonal demand is not providing the necessary information to plan the development of the system.

Similarly the South West LDZ is expected to see an incremental demand of 8.95 mcmd, but how should that demand be satisfied? An even distribution of the incremental demand across all 13 existing offtakes would produce a different investment plan to the expected scenario that will focus much of the growth at two new offtakes.

Uncertainties about location and size of demand could be addressed by building a bigger pipeline system to address all the expected scenarios or through the provision of a large demand management fund to buy back in instances where demand cannot be met. The second solution does not sit very well with our security of supply obligations because it will be difficult to declare that we have satisfactorily sized the NTS in advance of learning where the demand will turn up and then having bought back capacity to an appropriate level. Indeed, theoretically, NGT could only be confident of its ability to meet demand if each offtake within a zone was able to supply all exit rights sold within that zone.

Trading within and across zones

A proposition is that trading within a zone should be on an unaffiliated basis, that is a one for one exchange rate with no verification required by the System Operator. The effect of this is to increase uncertainty about the pattern of demand within a zone that once again could potentially lead to a demand pattern that cannot be supported by the installed pipeline infrastructure. An example of this could be that Eastern LDZ agrees to sell some of its firm capability to Little Barford and Kings Lynn power stations (both interruptible at present) with an option for the LDZ to take the capacity back should a colder than expected winter drive its own demand up to very high levels. In this instance the NTS does not know the nature of the deal that has been agreed between the LDZ and the power station operators/shippers and it may well be driven to treat the power stations as firm load and provide the necessary infrastructure. This position has arisen because trading could enable the market to structure its own interruptible deals, which is acceptable in principle but the NTS SO is faced with a situation where all loads need to be treated as potentially firm.

An approach to managing the uncertainties and potential investment inefficiencies arising from trading is to limit trading such that it cannot lead to an accumulation of capacity that is in excess of a baseline capability at each location. Baselines would then need to reflect physical capability with an implication that interruptible loads would start with a baseline of zero. This mitigation would be effective on a nodal basis but it is not clear how such control could be applied in a zonal model.

Operations

Information, when received on an aggregate basis is likely to be insufficient to understanding how individual offtakes are to be supplied. It is therefore difficult to conceive of an aggregate only information flow without further supporting information about how the information should be broken down to individual Offtake level. As a consequence operational intentions, by DNOs and shippers will need to be expressed on an Offtake specific basis if the NTS SO is to be able to efficiently manage the NTS network. It should however be possible to reduce the level of data transfer to a level akin to a nodal model if the NTS SO can agree with DNOs that nodal commitments should be made about the distribution of demands on a periodic basis and that within period the zonal demand is then provided on an aggregate basis. This type of arrangement replicates the present transfer of information between area and national operations staff and is easier to conceive of in a nodal model but might be harder to gain agreement in a zonal model.

Demand management on a zonal basis could involve tenders for demand reduction within a zone, in which case, when called the NTSSO could not be certain of the Offtake at which the demand reduction would occur. This could conceivably lead to an inefficient contracting process where contracts keep being called until some are invoked at the desired location. In effect the NTSSO has to buy through a large amount of unuseful capacity before it can get to the volume that produces the desired physical effect, which implies that a larger volume must be contracted for. An alternative is that the terms of demand management are those where a counter party owns a number of offtakes then all must be turned down equally. This approach runs the risk of being perceived as discriminatory and the limiting nature of the contract could drive up prices.

The nodal approach is intended to better enable the NTS SO to choose the granularity that it requires. Clearly agreements could be reached for demand management at individual offtakes. In addition it should be possible to construct tenders that would enable DNOs to respond by naming the distribution of offtakes and rates at which they would reduce demand.

Regulation

Assuming that DNOs and direct connect shippers can compete for NTS SO services then the level of potential competition could be gauged by taking the size of individual loads supplied by the NTS SO as a proxy for competing players. In this case each DNO counts as a single player. The Herfindahl Hirschman indices and market share of the largest three loads are listed below for each LDZ. This table suggests that even with the proposed large zones the benefits of competition are likely to be local and limited.

Zones	HHI	Top Three Market Share
Scotland	3,110	81%
Northern	5,424	93%
North West	7,660	95%
North East	7,172	100%
East Midlands	4,573	81%
West Midlands	10,000	100%
Wales North	6,834	100%
Wales South	7,449	100%
Eastern	6,039	92%
North Thames	8,719	100%
South East	10,000	100%
Southern	6,950	100%
South West	6,818	64%

The generally high levels of concentration raise concerns that low levels of competition, even in a thirteen-zone model, would limit the potential for efficient pricing signals to be generated for either capacity release or for demand management products. In almost any zonal construction there will be a dominant DNO, which in turn may well have behavioural characteristics that are driven by its security of supply obligations. Hence while there are clear disbenefits from loss of locational planning information resulting from a zonal model, there appears to be little evidence that this would be offset by better pricing signals resulting from zonal capacity release or trading.

Having identified that using large zones will not provide sufficient information to allow NGT to invest or operate the network efficiently, consideration is now given to whether smaller zones might provide a better balance between trading opportunity and provision of information.

Potential Zoning with Small Zones

NGT has developed a methodology that could be used to derive estimates of substitutability between offtake points. The approach derives estimates of the substitutability loss, in % per km, for each diameter pipe in the NTS.

The substitutability is derived taking account of the Panhandle equation. This equation takes account of the fluid dynamics associated with gas transmission and specifically that, because of the frictional effects, the capability of a pipeline is a function of the distance the gas has to travel. Put simply the longer the transmission distance the smaller the pipeline's ability to be able to transport gas.

The exchange rate represents the extent to which capability might be expected to be transferred from the upstream to the downstream offtake. By way of illustration a 0.95 exchange rate would imply that each unit of capability transferred from the upstream offtake would only generate an extra 0.95 of capability at the downstream offtake.

The analysis does not take account of the impact of transfers across compressors (which would be expected to reduce the transferability and hence inflate the requirement for distinct zones).

Definition of Zonal boundaries

The analysis has been applied to actual pipeline data within the network. Specifically pipeline diameters and offtake separation distances have been used to derive expect capacity transfer losses between offtakes.

The derived data has then been used to define which offtake points might be included in multi-node zones.

To perform this analysis a series of thresholds (0.9, 0.8, 0.7, 0.6) have been defined. A 0.9 zone is one where the shifting of load from any upstream node to a node downstream would result in the ability to transfer at least 90% of the upstream node load without a requirement for a larger system within the zone.

The analysis has been summarised in the following table to illustrate the potential impact of different exchange rate limitations on the potential number of zones.

The analysis can be summarised as follows:

Exchange rate to be at least:	Number of multi-node zones	Implied number of zones
.90	30	140
.80	43	117
.70	43	103
.60	43	97

The zones for an exchange rate of 0.9 and 0.6 are illustrated in figures 2 and 3.

Implications of Zonal Regime

Zonal capacity release would dilute the value of the investment signals by creating uncertainty about where capacity might be demanded. For example a larger system would be required to meet current system security standards (assuming no buy-back to mitigate the risks). Thus effectively we would require the system to be upsized more than 5% in a .90 zone if the current demand is equally distributed across the nodes to be able to satisfy all potential offtake demand patterns consistent with expected aggregate load.

NGT has therefore developed approaches to derive indicative capital investment costs associated with the upsizing of the system that might be appropriate to support zones defined at each of the threshold levels. These approaches have been based upon proportional increases in the relevant zones based upon current NTS regulatory asset value as well as another approach based on consideration of investment costs based on current UCAs.

Additionally NGT has completed extensive analysis to determine the alternative costs that might arise from demand management (buy-back). This approach seeks to determine the demand that could not be supported under peak conditions should demand transfer downstream within a zone. The modelling then uses load duration curves to measure the extent and number of days on which buy-backs within the zones might be required. The approach then applies the series of unit costs associated with buy-backs included in the Ofgem

Interruptions RIA to derive estimates of these costs. These costs have been converted into an equivalent capital cost to facilitate comparison with the alternative investment costs.

This analysis is summarised as follows:

Exchange rate to be least:	Investment costs £m	Demand management buy-back costs (£m capital equivalent)
.90	54-65	9-53
.80	139-169	42-251
.70	250-302	121-727
.60	357-433	270-1622

This analysis illustrates that tolerating lower exchange rates causes the cost of investment and/or buy-back rises sharply. More importantly, it also demonstrates that significant costs are incurred in order to achieve even a small number of zones containing more than one node. Given that most of these zones are within a Distribution Network, even here there is likely to be only one counter party to trade with.

Conclusions

1. Any zones for gas exit are likely to be associated the route of a main gas pipeline.
2. The use of large zones will not provide the information required by NGT to efficiently develop and operate the NTS.
3. The use of small zones incurs significant buy-back/investment costs for even a modest number of multi-node zones.

We have been unable to identify a zonal model that provides significant opportunity for trading of exit rights combined with sufficient information for NGT to develop/operate the NTS securely without incurring large costs in buy-back/investment. Unless a compelling case can be made for the benefits of trading in a zonal model, we conclude that a nodal model should be implemented with NGT facilitating trading between nodes.

Summary Table

Model	Provides Sufficient Planning/Operating Information	Increased Investment/ Buy Back Costs	Inter Node Trading	Average Herfindahl Hirschman Score
Nodal	Yes	No	Only Facilitated by NGT	10,000
Large Zones	No (Additional mechanism required)	Very Large	Yes, widespread	6,980
Small Zones	No (Additional mechanism required)	Large	Very Local & Limited	10,000

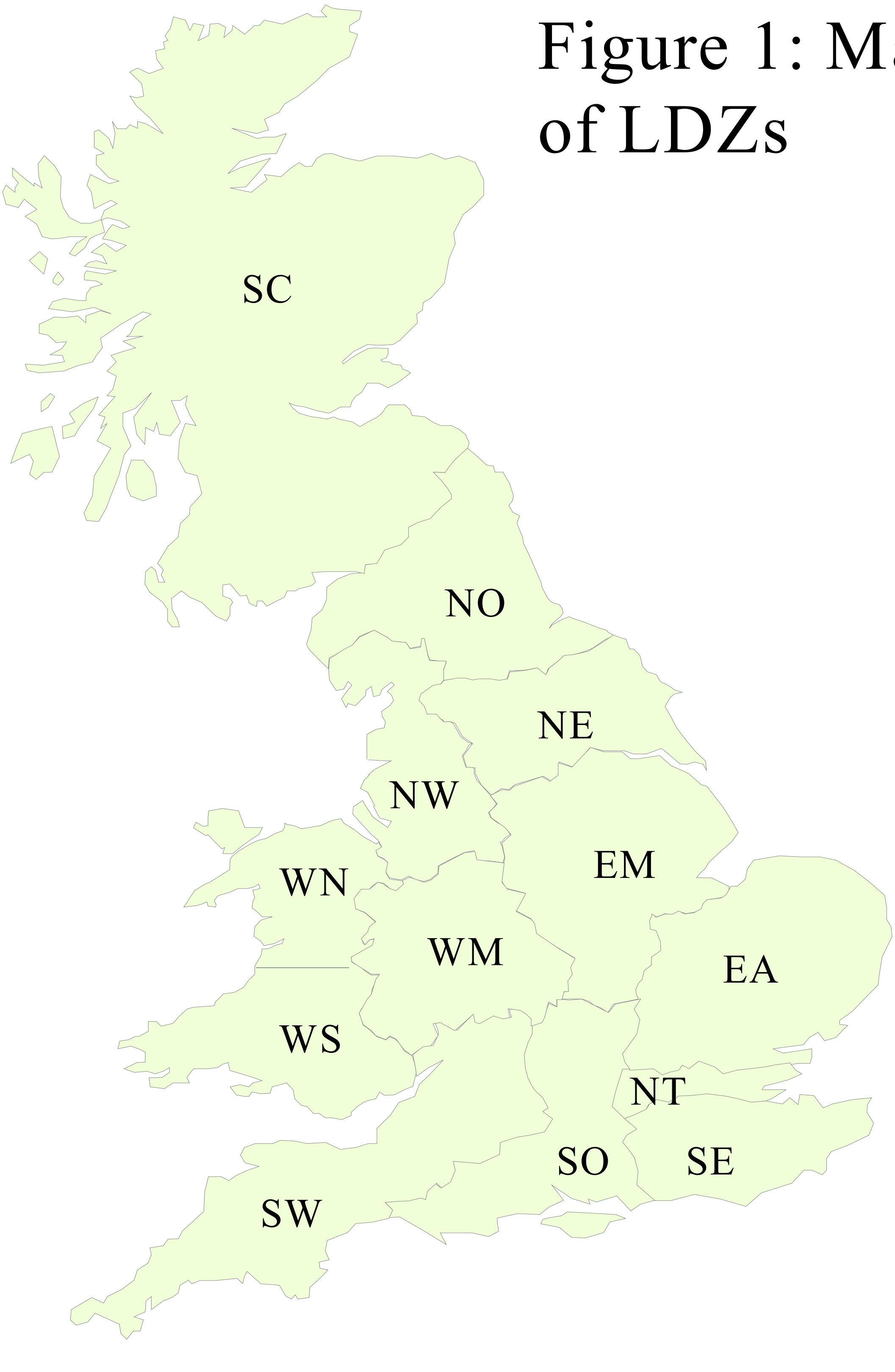

Figure 1: Map of LDZs

Figure 2: Zones > 0.9

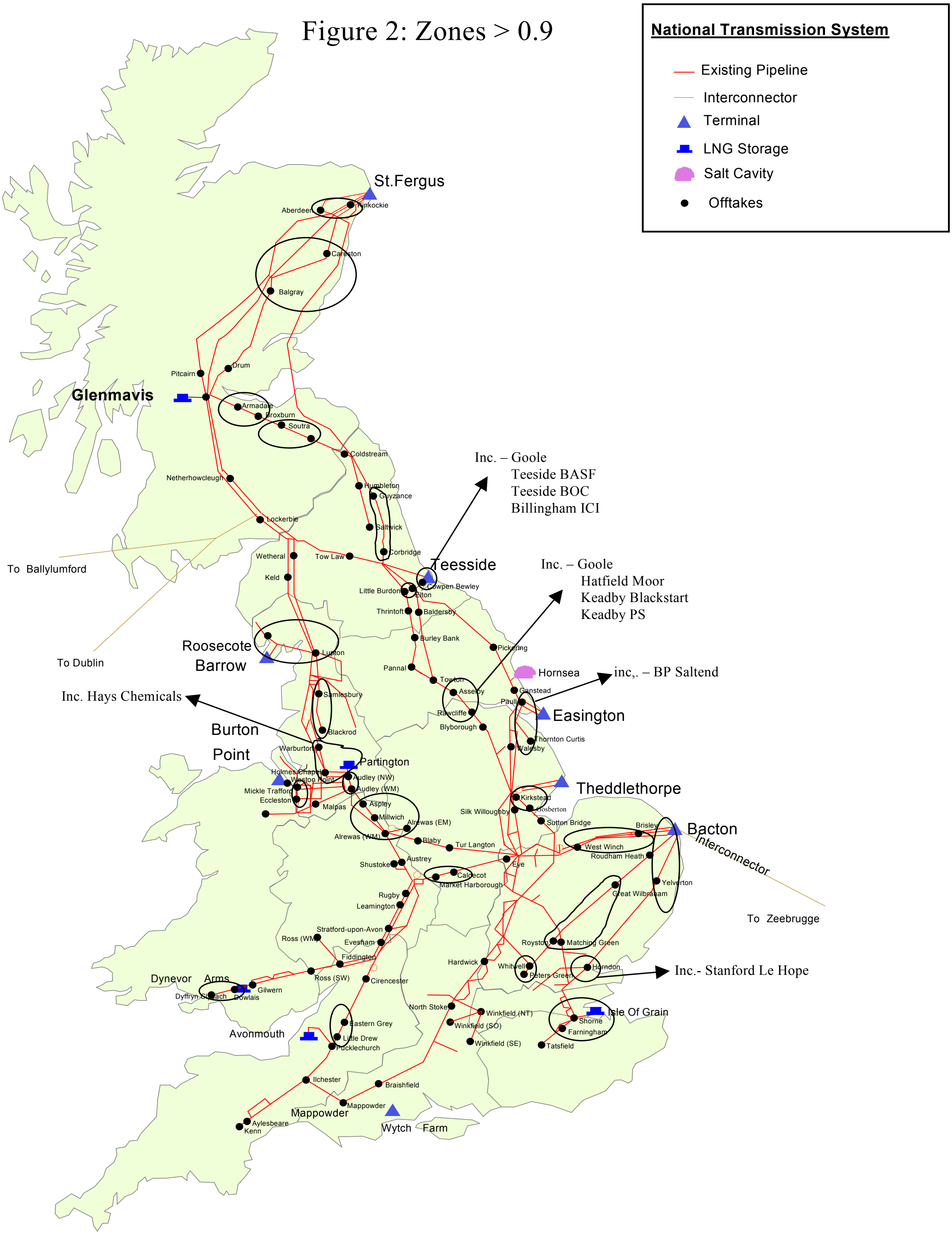

Figure 3: Zones > 0.6