# PÖYRY INPUT FOR LIQUID AIR WHITE PAPER

## A note from Pöyry Management Consulting to Liquid Air

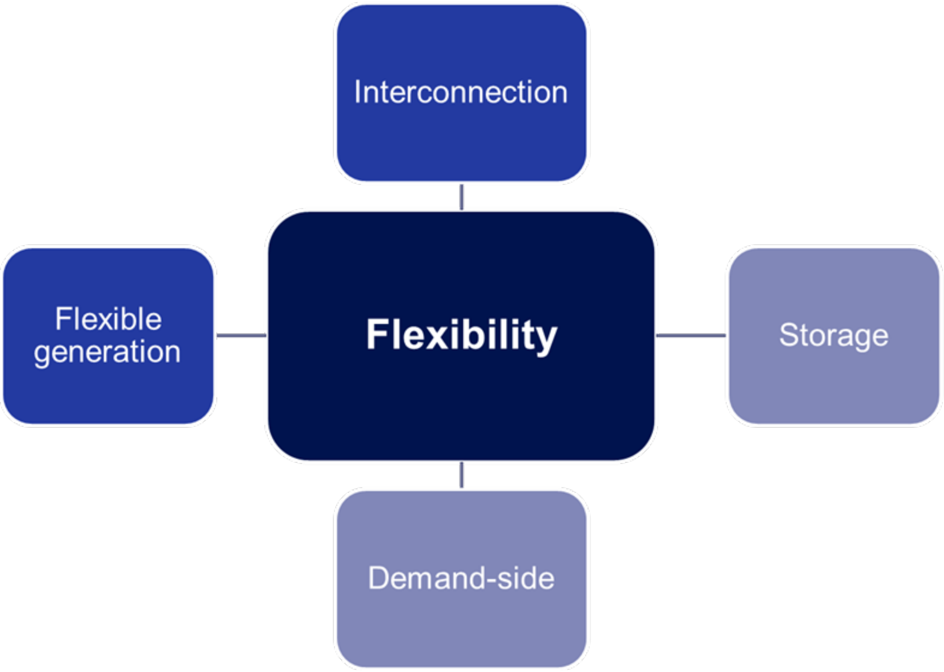
**12 December 2012**

## 1. THE DIFFERENT SOURCES OF FLEXIBILITY AND THEIR RELATIVE MERITS

There are four major sources of flexibility. This section introduces each source of flexibility in turn and presents:

- A brief overview of the different forms of flexibility;
- The role that each form of flexibility provides in the current electricity system and could be expected to perform in the future.
- The strengths and weaknesses of the different forms of flexibility. It is useful to layout the relative merits different forms of flexibility have compared to one another. It is not the objective to argue that one source of flexibility should be chosen in preference to another.  In reality most if not all forms of flexibility will be deployed at some point in the future depending on local circumstances and conditions.

**Figure 1 – The four providers of flexibility**



## 1.1 Flexible generation

In the context of this chapter flexible generation refers to thermal generation that has been specifically designed to respond almost immediately to increase or decrease output over short timescales. Examples of flexible generation in this context include open cycle gas turbines or gas engines and are sometimes classified under peaking generation. It should be noted that all thermal power plants are flexible to some extent i.e. they can increase or decrease output over a certain period but the ability of the plant to alter output under different constraints (e.g. the time taken for a plant to achieve full power output when it is off) varies significantly - see (IEA, 2011) or (Eurelectric, 2011).

In the future, flexible generation could perform the same role as today (i.e. providing reserve and response) and to help incorporate renewable generation by:

- providing electricity during low wind periods or
- provide flexible generation at wind sites to balance output.

Advantages of flexible generation include the fact that it is a reliable, mature, well proven technology. Disadvantages mainly relate to the expectation of difficulties in financing these types of plant in the future market environment and the associated $CO_2$ emissions of running such plants (CCS is an option but this would make the plant more expensive).

## 1.2 Interconnection

Interconnectors are cables that physically link electricity markets (e.g. GB and France). As a result of a physical link, electricity is traded across interconnectors, usually on the principle of price differentials between markets i.e. interconnectors transfer electricity from low price market areas to higher price market areas and hence share flexibility between markets in a cost effective manner.

Interconnectors play an important role in electricity markets at the moment – Denmark is a good example as it has around 4.5GW of interconnection with Sweden and Norway in the North and Germany in the South. Interconnections with Norway and Sweden allow Denmark to take advantage of cheap and plentiful hydro resources to help balance significant volumes of wind in the Danish system. Moreover, in the future there are plans to significantly increase interconnection volumes throughout Europe – the latest ten year development plan of ENTSO-E highlights the need for €104bn of investment in networks (ENTSO-E, 2012).

Interconnectors provide the following advantages:

- Full utilisation of the network e.g. reduce wind curtailment i.e. when inflexible generation is greater than demand, the excess generation can be exported.
- Transmission reinforcement to link variable renewables (e.g. wind) with demand i.e. allow energy to flow to where it is needed.

Interconnection has the following weaknesses:

- If flows across interconnectors are based on price differentials between markets, flows depend on what is happening in the respective market – it is possible that interconnection can exacerbate a problem e.g. if both markets are constrained (short of capacity) power will still flow from the low price area to the higher price area (Pöyry, 2011)

- Weather patterns are highly correlated across much of Europe, so interconnection cannot always be relied upon when needed if you have large amounts of wind (Pöyry, 2011(b)).
- The benefits associated with the use of interconnectors are not symmetric and this could form a significant barrier to interconnector deployment. For example, we found that connecting to Norway may give excellent results for the UK as it will drive "baseline" import but it pushes up Norwegian prices (Pöyry, 2011(b))

## 1.3 Demand side response

At its simplest, demand side response (DSR) refers to the shifting or reduction of demand at one point in time to another point in time. This is typically done in response to a trigger such as electricity price or a network constraint.

Demand side response is currently used in the UK for providing balancing services to National Grid in the form of single large loads or aggregated small loads.

In the future, the volume of demand side response is expected to grow significantly as networks become "smart" and charging patterns of new technologies such as electric vehicles or heat pumps can be altered according to the state of the electricity system.

In summary, demand side response has the following strengths (Pöyry, 2010):

- DSR could significantly reduce of price volatility and eliminate the wastage of wind.
- DSR could reduce peak demand at a certain point in time to accommodate fluctuations in supply or accommodate network constraints.
- DSR can reduce or increase demand to optimise the price exposure of the appliance i.e. charge when it is cheap, discharge when it is expensive.
- DSR can shift demand to ensure baseload plant runs optimally.
- DSR can facilitate demand reduction for balancing services .

The weaknesses of demand side response relate to a number of important questions regarding delivery of demand side response that will define the market impact of the technology. The key questions include:

- Significant infrastructure/delivery costs (DECC estimate smart meter roll out for the domestic sector to be £10.8bn (DECC, 2012)).
- How will demand side response be implemented? New market rules and control models will be required to ensure that DSM is used in the optimum way for the system and to meet the needs of all stakeholders. Previous work has shown that the different stakeholders may have conflicting interests – see (Pöyry, 2011) and (Pöyry, 2011 (c)).
- Even when deployed, there are questions around how DSM will behave in reality i.e. how consumers will allow demand to be moved around.
- Commercial models need to be developed.

## 1.4 Energy storage

Energy storage is probably the most versatile form of flexibility. Storage covers a wide range of technologies that can operate over a variety of different timeframes at a variety of scales (kW to 100MW or more) and can provide a range of system benefits. Examples of storage technology include compressed air storage, pumped hydro storage, liquid air storage. In the future more storage technologies are expected to come to market including heat storage (due to the electrification of heat), electric vehicles and large scale batteries.

In summary, electricity storage has the following strengths:

- Price arbitrage to reduce price volatility i.e. charging (or storing energy) during periods of low electricity prices and discharging (or producing electricity) during periods of high electricity prices;
- Storage to keep base load generation running;
- Storage at point of generation (large or small) to balance output;
- Provision of black start services (i.e. restoring a power station to operation without relying on power from the grid);
- Promote the full use of network to minimise wind curtailment;
- Use to limit impact of network constraints at either the local (distributed) level or the national level; and
- Provision of national or local storage for balancing services

The main disadvantage of some electricity storage technologies (apart from those already established such as pumped storage) is that many technologies (batteries, hydrogen, A-CAES) are relatively immature technologies and hence expensive.