# Managing Flexibility on the Electricity System

# FINAL SUMMARY

## IN ADVANCE OF PUBLICATION

**14th January 2015**

# Delivering a secure low carbon system

1. **A system with weather dependent renewables needs companion low carbon technologies to provide firm capacity**

**Cannot achieve decarbonisation targets (or get close) with just wind, PV and marine. Need nuclear or biomass or CCS.**

2. **Policy makers and system operators need to value services that ensure grid stability so new providers feel a market pull**

**Currently some necessary services (e.g. inertia/ frequency response) are provided free or as a mandatory service. These providers are disappearing, and the need is growing, but new providers can't develop in the absence of a market signal.**

3. **A holistic approach to system cost would better recognise the importance of firm low carbon technologies and the cost of balancing the system.**

**The value to the system of a technology is dependent on the existing generation mix and the services which that technology can provide.**

# ERP Modelling

ERP modelling stacked generation to meet demand exploring different mixes of low carbon technologies on the system. It met the following criteria on an hourly basis:

- Energy balancing – nearly all modelling does this, at least on an annual basis
- Sufficient firm capacity – some high level models do not ensure peak demand is met
- Sufficient flexibility – the model ensures there's sufficient reserve, response and inertia at all times. Some models deal with reserve, but not all three.

There does not appear to be any other modelling that balances energy on an annual basis whilst ensuring electricity system has sufficient flexibility and firm capacity to be operable on a second by second basis.

# Modelling Assumptions

Demand and wind data from 2012 outturn scaled appropriately.

New sources of flexibility (new storage, demand side response and interconnectors) were not modelled.
Existing storage was modelled as hydro with limited availability.

2030 is modelled “stand alone” and not as a step on the way to 2050

Only effect on total system cost and emissions was considered and not wider benefits or implications of reducing imports of fossil fuels or improving long term security

# Conclusion 1

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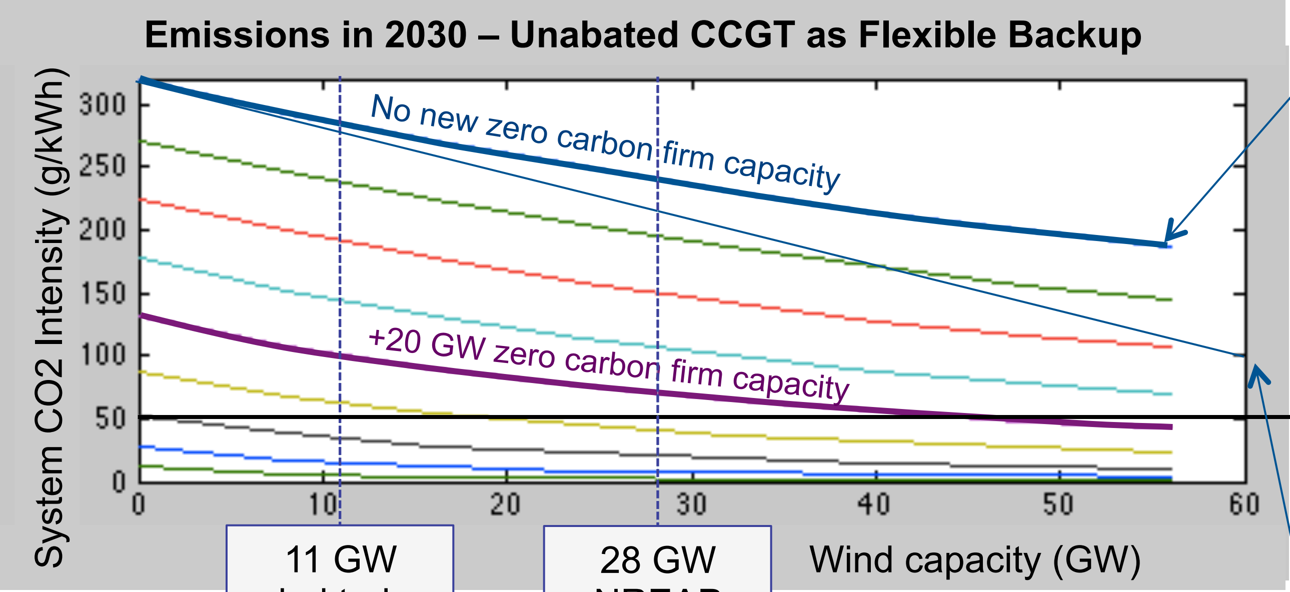
# 1) Achieving 50g/kWh




11 GW wind today

28 GW NREAP

Even with 5x today's capacity wind alone will only reduce emissions to around 200 g/kWh

CCC recommended target of 50 g/kWh

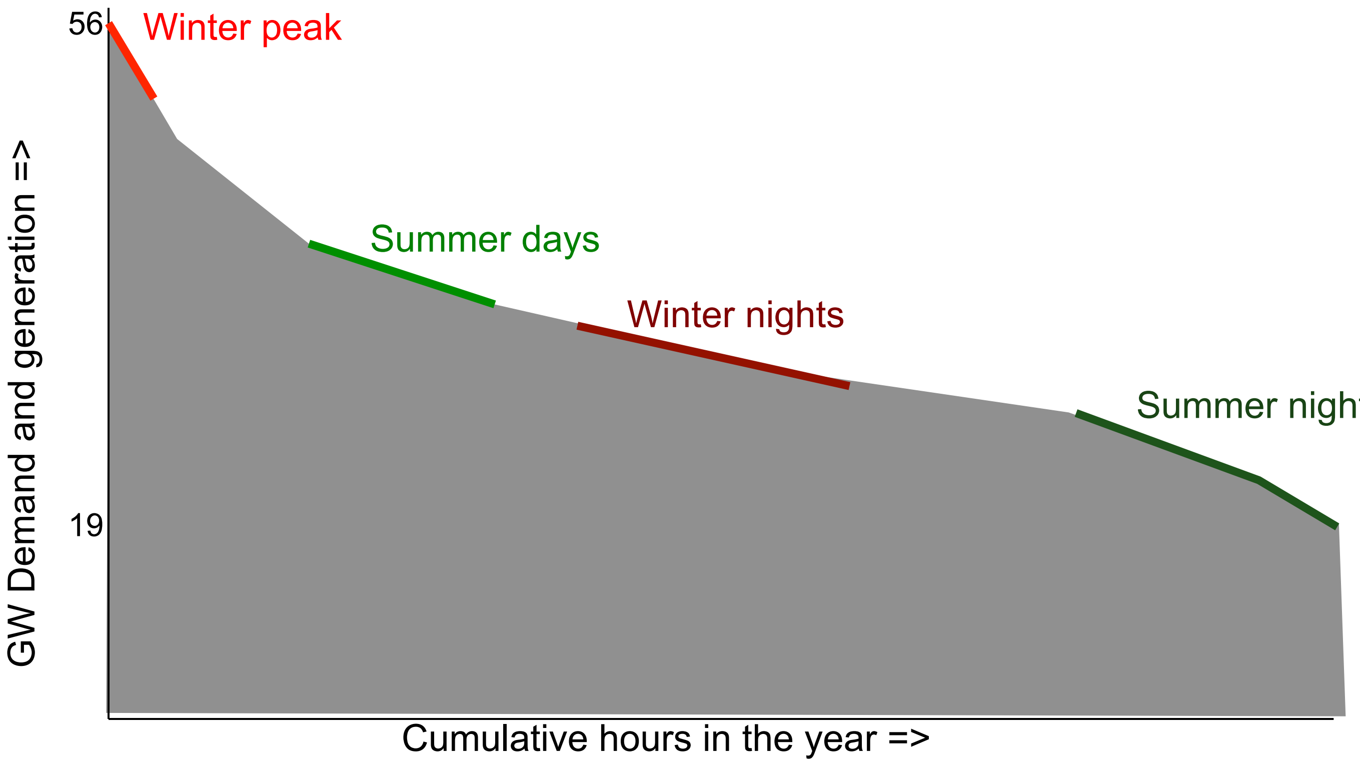
With storage the diminishing returns effect is reduced. Straight line shows theoretical limit with infinite storage available. With this 60GW of wind could achieve 100g/kWh at best.

Even with high levels of wind penetration the grid operator will require a firm backup for low wind periods. If this is left to gas the grid cannot be decarbonised to the level recommended by CCC. This would diminished the abatement potential of a switch to Electric Vehicles and Heat Pumps.

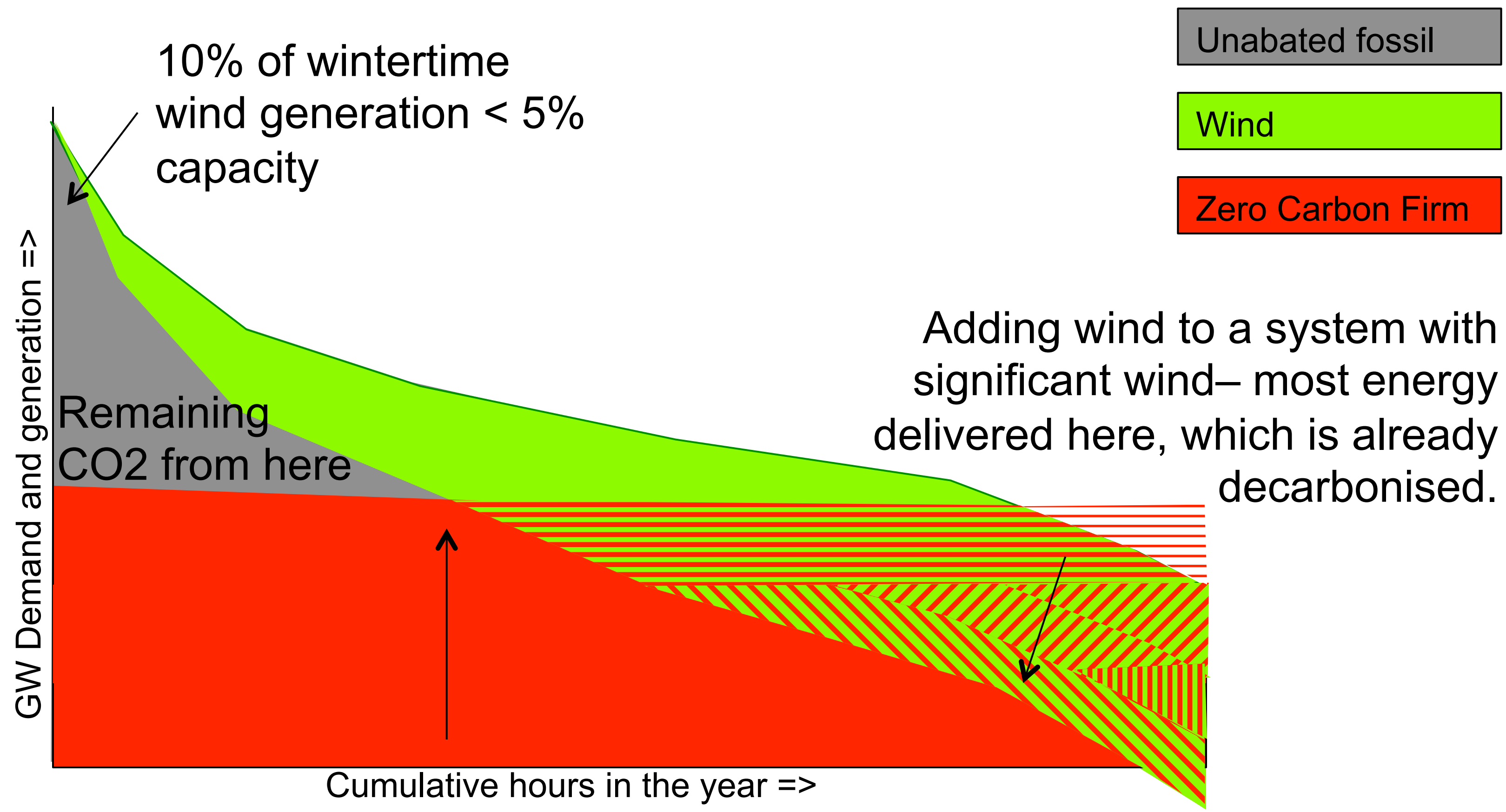
The National Renewable Energy Action Plan's 28GW of wind would need 20-25 GW of nuclear (or other zero carbon firm capacity) to achieve 50g/kWh

# Effectiveness of Low Carbon Technologies

## The Demand Duration Curve Schematic



# Effectiveness of Low Carbon Technologies




Adding firm zero carbon technology (nuclear, biomass or CCS). Energy delivered evenly across the load duration curve

# Conclusion 2

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ERP Energy Research Partnership

# Energy Balancing at Work


**Short Term Operating Reserve (STOR) is available within 5-20 minutes of instruction, although some can be as long as 4 hours. This provides a longer term replacement for the lost generation**

**Unforeseen**
Generator loss incident
1000MW is lost at 13:43. Frequency drops to 49.6 Hz before recovery begins. Statutory limit is 49.5 Hz.

**Fast Reserve is available to replace plant that was on frequency control and aid recovery by increasing generation within 2 minutes of instruction**

**Inertia slows the fall in frequency immediately after an incident, buying time for frequency response services to act**

**Frequency response automatically increases generation or decreases demand to begin recovery. Acts in 10-30s window (primary) or 30s-30m window (secondary)**

*There are 22 ancillary services NG buy, but these four + the need for firm capacity > peak demand are key for energy balancing.*
*Other services are more technical in nature.*

# 2) The Need for Market Pull

## DEMAND

More weather dependent renewables & larger unit sizes drive:

- Greater need for reserve
- Less inertia (stability)
- Greater demand for response
- Response has to be faster

Traditional suppliers are going:

- Closure of coal & …
- closure of auxiliary gas turbines
- Closure of Oil
- AGR end of life
- Poor economics & low load factors of gas

## SUPPLY

## NEW SUPPLY?

- Dynamic use of interconnectors
- Storage
- DSR from: Existing demand + New techs (EV, HP)
- New build (if designed flexibly)
- Existing embedded generation

Some of the services the grid operator needs are not fully valued so potential suppliers are unable to realise the value of the services offered.

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# 4) Holistic Approach

Example: DECC assumptions, unabated gas based system (CCGT at margin) and £100/t$CO_2$

| Tech. | Energy | LCOE (£/MWh) | Flexibility | Firm Cap. | Net Value* to pure gas sys. (£/MWh) | Net Value* to Sys with 30 GW+ wind (£/MWh) |
|---|---|---|---|---|---|---|
| Nuclear | +++ | 87 | + | + | 11 | 8 |
| Wind | + | 81 | - | 0 | -3 | -17 |
| Gas-CCS | +++ | 91 | ++ | ++ | 6 | 4 |

* Net Value is calculated as the reduction in total system cost by the addition of 1 MWh from this technology
+ This is close to National Renewables Energy Action Plan (NREAP)

Wind has the cheapest LCOE, so may mistakenly be considered the cheapest option to decarbonise the system.

However it only delivers energy. It provides no firm capacity and increases need for balancing services.

Holistically adding nuclear delivers value to the system (reduces system cost) by the most.

The value of a technology is dependent on what's there already. So a system with significant wind build reduces the value of all technologies, but the value of further wind wind is reduced the most.

# Important Observations

Hitting 50 g/kWh drives the need to meet the vast majority of residual demand (after allowing for renewable generation) in a low carbon manner.

Even acknowledging the possible contribution of DSR, Interconnectors and storage at a later stage there's a pressing need to make no-regrets decisions today.

Of the issues examined it is rare for lack of inertia to be a biting constraint, the need for response is driven by issues other than the technology mix, but the need for fast reserve and STOR are most critical and dependent on technology choice.

Using DECC's costs* the differences in economic value to the system between the key options examined (nuclear, gas-CCS and onshore wind) are much smaller than the margin of error estimating those costs.

A minimum of 13 GW of new nuclear was required to meet 50 g/kWh.

Technologies like DSR/ flexible interconnectors and new storage will help optimise the system but probably not fundamental bring changes to the ultimate solution.

The implication of valuing firm capacity and ancillary services is that the retail market pricing structure (based on energy only) will need to change to make it reflective of actual costs.

* Parsons Brinkerhoff 2013

# Further Work

ERP is unlikely to have much more time to develop the model or undertake the further analysis.

However it may be worth others exploring the effect of these:

- The addition of new storage
- Allowing interconnectors to operate fully flexibly
- The availability of DSR

Members will be given access to the model, the detailed results and any help they might need in getting started in modelling.