

# PhD Title: Markets for maximising value from wind energy

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# PhD Title: Markets for maximising value from wind energy

- Research question: *‘Can the penetration and value of wind generation be increased in existing national markets and with future distributed markets?’*
- Motivation:
  - Network capacity limits being exceeded resulting in curtailment of renewables.
  - With closure of dispatchable fossil fuel plant there is increased need for ancillary services from intermittent renewables
  - ➔ **Increasing need for markets to adapt to access flexibility from renewables rather than favouring incumbent dispatchable generation.**
- Talk Focus: *Wind in reserve markets in GB and Spain*

# What is Reserve?

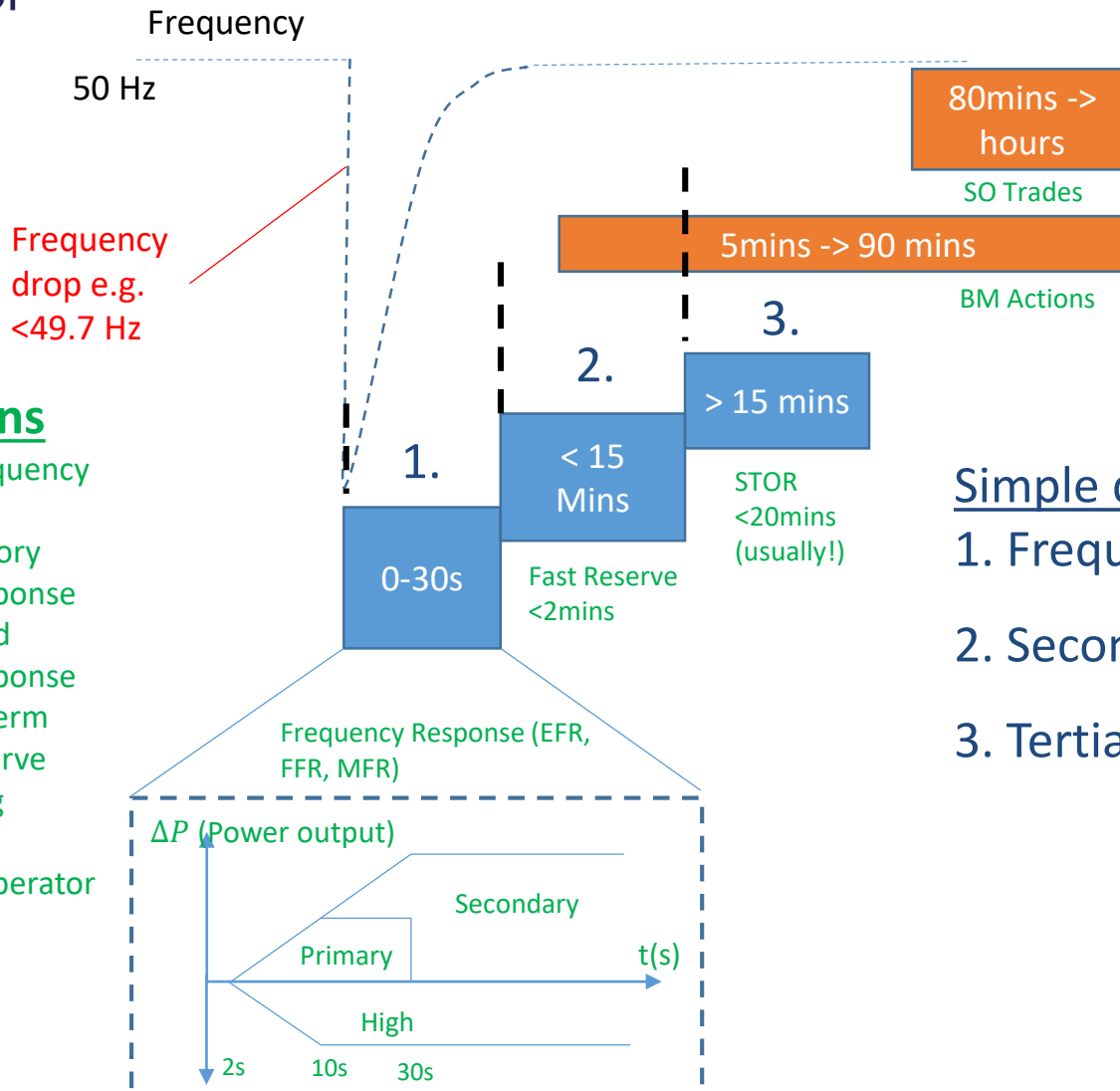


Fig. 1 – Reserve Timeline with GB definitions

Ancillary  
Service

Balancing  
Mechanism

## Simple definitions

1. Frequency Response

2. Secondary

3. Tertiary

## Why GB and Spain?

- Similarities

|                                      | SPAIN  | GB  |
|--------------------------------------|--|---|
| 1) Low Interconnection               | 2.8 GW to France<br>(1.4 GW HVDC)  | 4 GW HVDC links   |
| 2) High wind penetration             | 23 GW (22% of capacity)  | 20.7GW (20.6% of capacity)  |
| 3) Congestion leading to curtailment | 1.1 TWh (2.14%) curtailment in 2013<br>(~240,000 Homes or output of ~420 MW Wind Farm) | 1.5 TWh (3.9%) curtailment in 2018<br>(~326,000 Homes or output of ~570 MW Wind Farm) |

- But very different market structures for Reserve
  - Affects Winds ability/incentive to participate

# Wind output and curtailment

**Table 1 – Spain**

|      | Generation | Curtailment | Cost  |
|------|------------|-------------|-------|
|      | TWh        | TWh         | €/MWh |
| 2012 | 48.1       | 0.12        | 26.9  |
| 2013 | 54.3       | 1.16        | 6.2   |
| 2014 | 50.6       | 0.52        | 5.3   |
| 2015 | 48.1       | 0.05        | 28.9  |
| 2016 | 47.7       | 0.09        | 12.7  |
| 2017 | 46.9       | 0.05        | 39.0  |
| 2018 | 49.1       | 0.02        | 42.1  |

**Table 2 – GB**

|      | Generation | Curtailment | Cost  |
|------|------------|-------------|-------|
|      | TWh        | TWh         | £/MWh |
| 2014 | 21.1       | 0.6         | 85.4  |
| 2015 | 29.4       | 1.2         | 72.6  |
| 2016 | 27.3       | 1.1         | 73.6  |
| 2017 | 36.8       | 1.48        | 71.0  |
| 2018 | 39.2       | 1.52        | 72.5  |

## 1. Wind generation

- Spain cut energy based subsidies in 2012
- New capacity since 2012
  - 0.9 GW in Spain vs 10 GW in GB

## 3. Curtailment cost £/MWh

- GB: paid as bid
- Spain: 85% of day-ahead auction price

## 2. Curtailment

- Spain decreasing: Wind now providing downward Tertiary Reserve
- GB Increasing: Network upgrades required (e.g. Western Link)

**EPSRC**

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# Wind farms with subsidies in GB

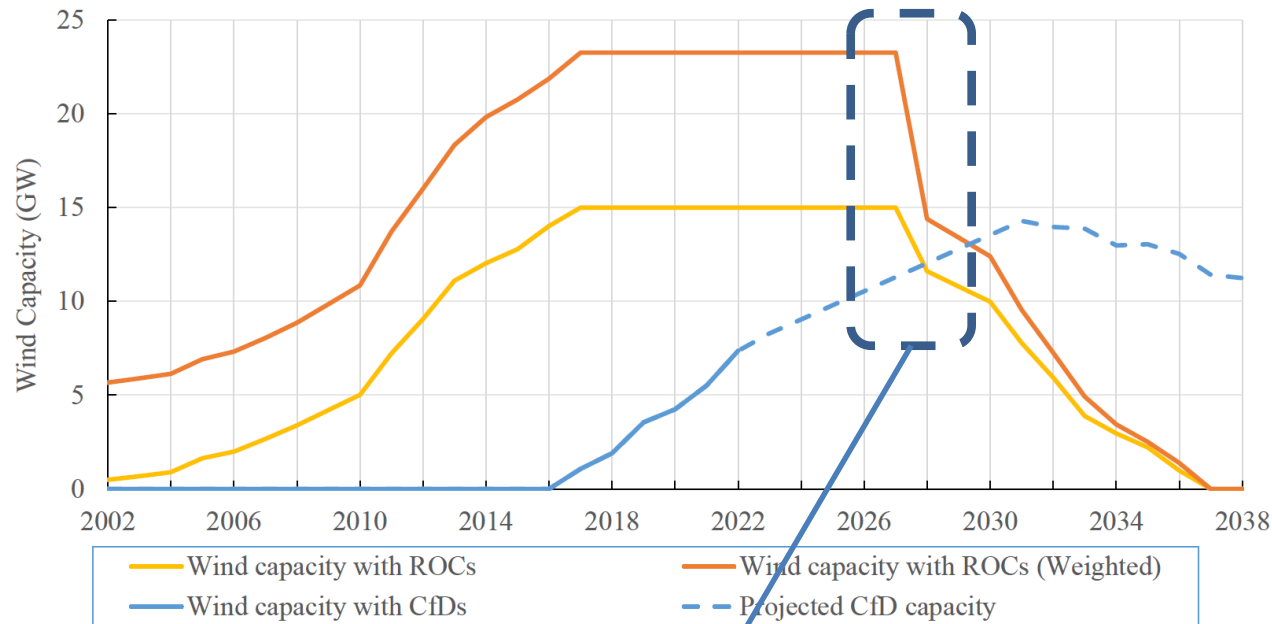


Fig. 2 – GB Wind capacity with ROC and CfD subsidies.

- Energy based subsidies discourage wind from providing reserve (upward or downward)
- ROC subsidy contracts expiring post 2027 => large increase in subsidy free wind
- Subsidy free wind has better incentive to provide reserve  
⇒ Spanish example....

# Spanish success story: Tertiary reserve

- Increasing provision of Tertiary Reserve from wind in Spain after removal of energy based subsidy

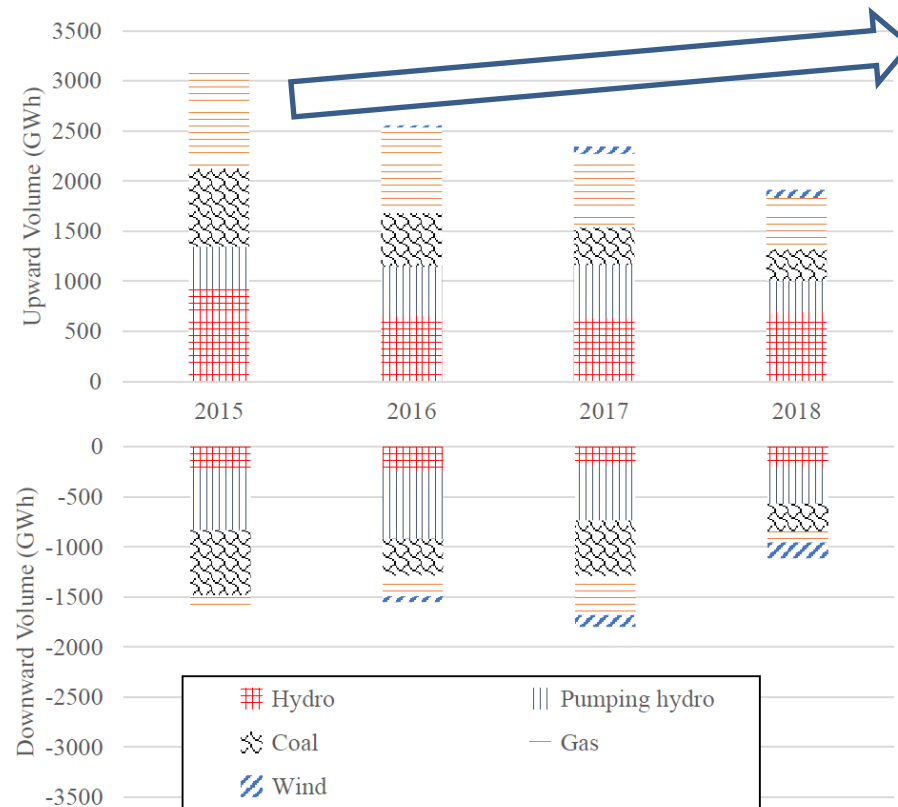


Fig. 3 – Spain: Tertiary Reserve volumes 2015 – 2018. Credit: Sergio M. Martinez

## GB Success Story: MFR from wind

- All large wind farms must have Mandatory Frequency Response capability
- Operators submitting more competitive bids (with help from Strathclyde researchers!) since April 18'

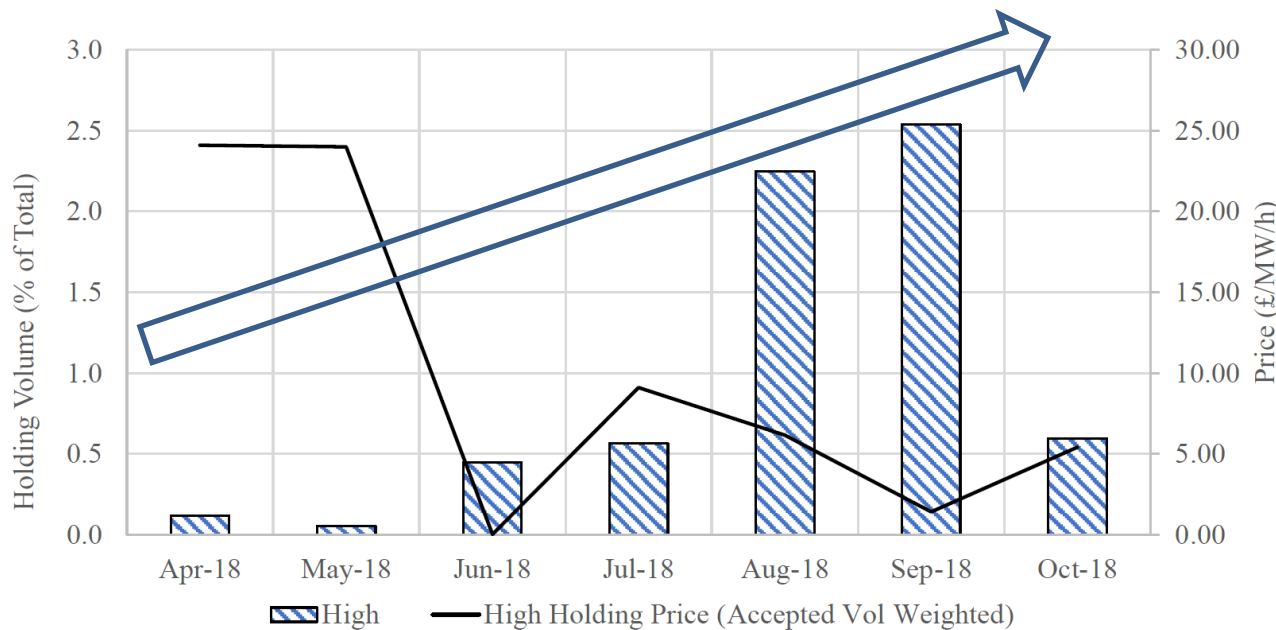


Fig. 4 – GB: MFR Holding Volumes and volume weighted price wind farms providing mandatory high frequency response in GB

# GB Wind farm output (FPN) forecasting: could be better?

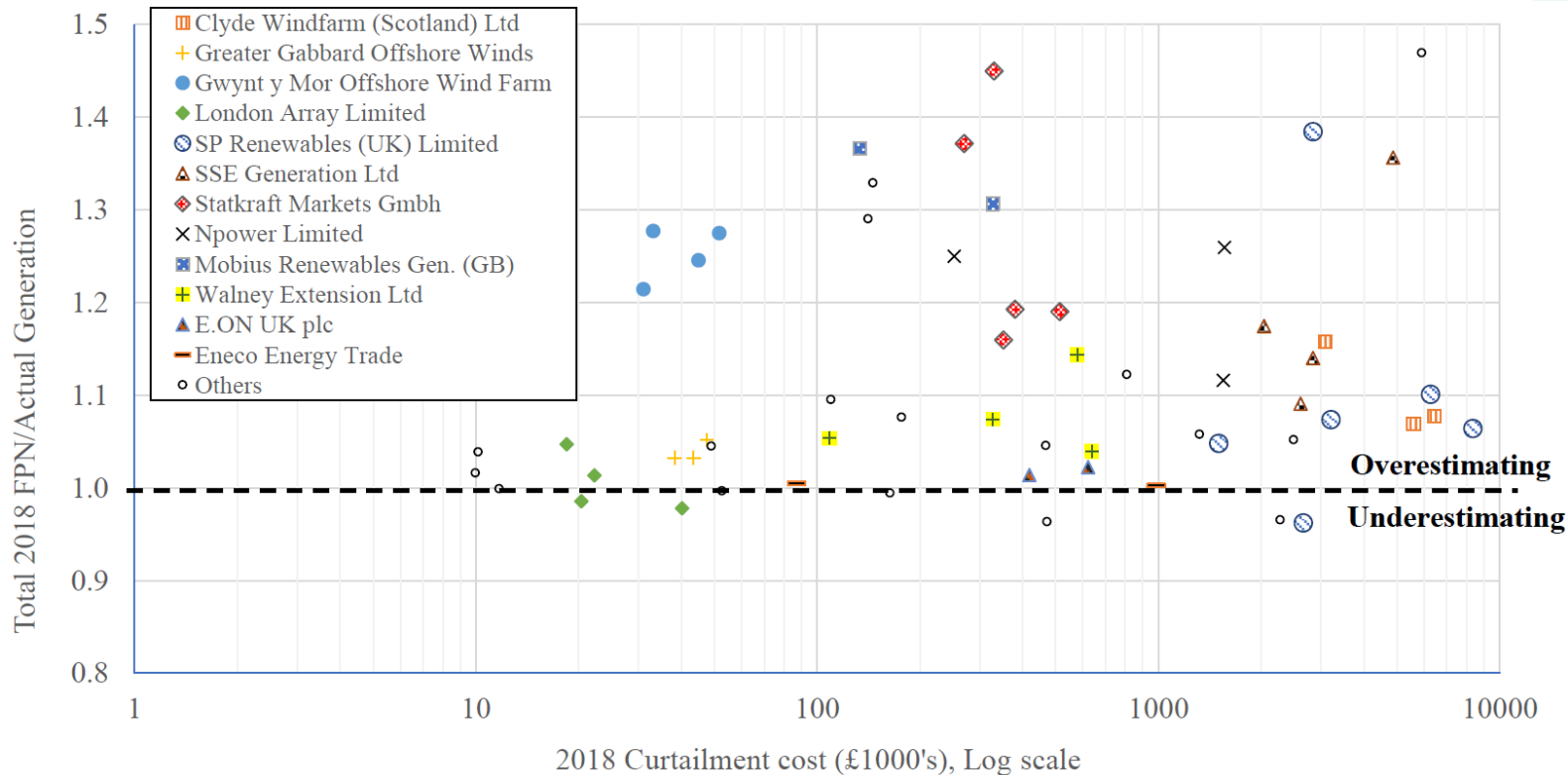


Fig. 7 – GB: FPN (Final Physical Notification)s / Actual generation (for times without curtailment) against Curtailment cost by operator 2018

- Subsidy payments for curtailment are paid based on difference between Final Physical Notifications (FPNs) and reduced output.

## How are Spain and GB performing?

- Wind participation in reserve markets

|                                | SPAIN  | GB   |
|--------------------------------|--|--|
| 1) Frequency Response(<30s)    | No information published. Mandatory with no market mechanisms.                                       | Wind providing up to 2.5% of monthly MFR volume since Sept 2018. Work done at Strathclyde on bids!   |
| 2) Secondary Reserve (<15mins) | Procured Day ahead. Limited (<20 MWh/day) wind provision.  | Procured 1 month in advance. No provision of Fast Reserve.   |
| 3) Tertiary Reserve (>15mins)  | Procured Day Ahead and bids updated intraday. Wind provided 4.2% of upward and 14% downward in 2018. | STOR procured 3 months in advance. Effect of subsidies on bids/offers prevent wind providing Tertiary reserve in BM. No Provision of STOR. |

# Policy Recommendations and Conclusions

- Recommendation for Spanish Frequency Response market
  1. Publish information on frequency response and consider a competitive market to widen access
- Recommendation for GB BM
  2. Revise policy of curtailment payments based on FPNs to incentivise accuracy rather than overestimation
- Both GB and Spain for all markets:
  3. Move markets as close to delivery as possible
  4. Enable portfolio/aggregated bids and stacked offerings.
  5. For future subsidy mechanisms consider capacity based subsidy rather than energy based.