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Flexible Plug and Play

Understanding best practice regarding interruptible connections for wind generation: lessons from national and international experience

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Contents

This report

- The Electricity Policy Research Group (EPRG) from University of Cambridge is the project partner responsible for exploring and analysing different case studies of commercial arrangements that involve the allocation of curtailment (‘Principle’ of Access) in response to network constraints.

- The report is part of the SDRC 9.2 (submitted by UK Power Networks in December 2012).

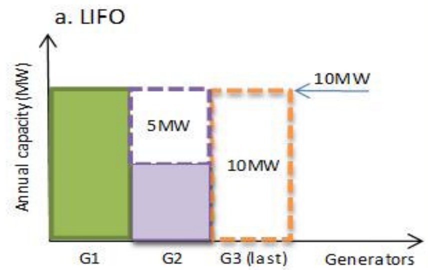
About Curtailment

- Definition:
  - Any limitation that prevents the generator to export its maximum capacity to the distribution or transmission network.
- Allocation rules (most popular):
  - LIFO: Generators are given a specific order for being curtailed (based on a selected parameter such as the connection date).
  - Pro Rata: Curtailment is equally allocated between all generators that contribute to the constraint.
  - Market-Based: Generators compete to be curtailed by offering a price based on market mechanisms.

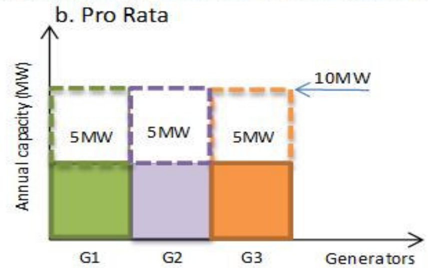
About Curtailment

Figure 1: Example of Risk Allocation

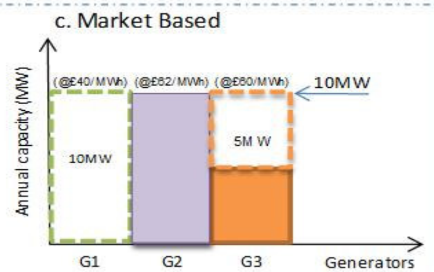
Allocation Rule	Notes



G3 is the first generator to be curtailed up to 10MW then G2 up to 5MW. Maximum level of curtailment is 10MW + 5MW = 15 MW. G1 is not affected.



G1, G2 and G3 are equally curtailed up to complete 15MW. Curtailed energy per generator is equal to: Maximum level of curtailment * Generator Capacity /(Total Capacity) = 15 * (10/30) = 5MW.



G1, G2 and G3 bid for being curtailed. The selection is made on cost order: G1 first @£40/MWh (10MW), G3 second @£60/MWh (5MW). G2 is not selected because the maximum level of curtailment has already been allocated (10MW+5MW=15MW).

Own elaboration.

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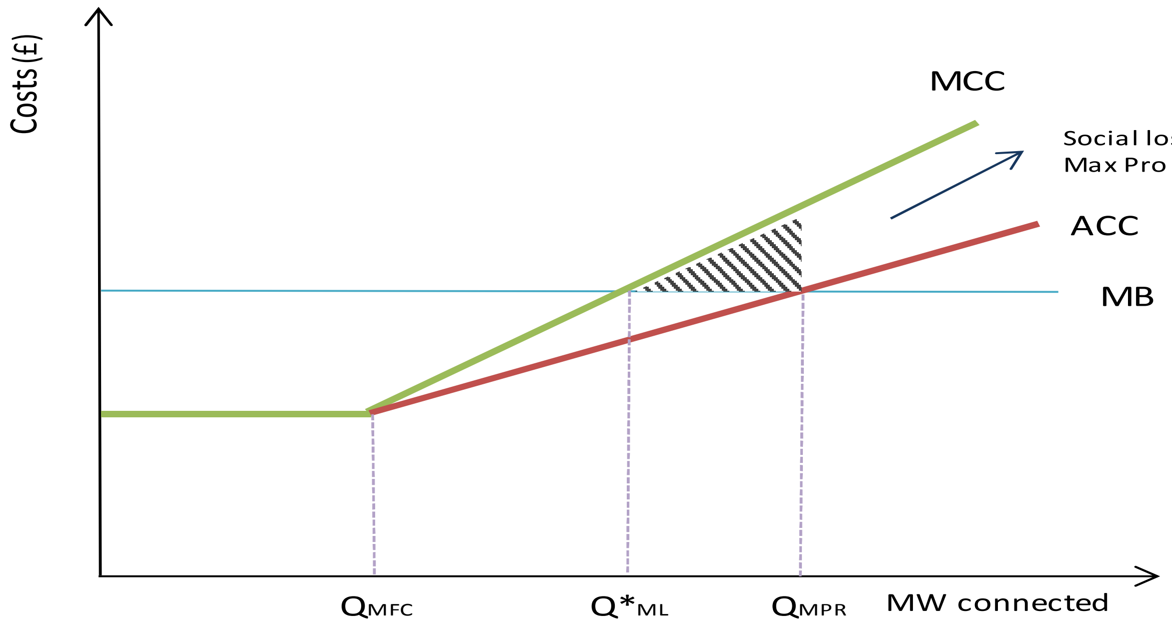
About Curtailment

- Social optimality:
  - LIFO: reflects the social optimum (each generator is exposed to their marginal connection/curtailment cost, MCC) to the system) . MCC should be = Marginal Benefit (MB).
  - Pro Rata: does not reflect the social optimum (generator faces the average connection/curtailment costs, ACC). ACC=MB. Social loss = shaded area (figure 2).
  - Shaded area: those incremental system costs above the system benefit (produced by each additional MW of wind generation beyond the point where MCC=MB).
  - It has been assumed that the MB to the system of each additional unit capacity is constant (same subsidy and technology).

About Curtailment

Figure 2: Optimal connection (MW) with fixed constraint (ignoring risk)



Where **MCC** : Marginal connection cost, **ACC** : Average connectio cost, **MB** : Marginal benefits,
Q_{MFC} : Max firm connection, **Q^*_{ML}** : Max LIFO, **Q_{MPR}** : Max Pro Rata. Own elaboration.

Selection of Case Studies

- Selection criteria: (1) level of maturity of regulatory framework for renewable energy (wind) and (2) selection of experiences with some relevance to UK Power Networks (smart solutions, curtailment practices).

Table 1: List of Case Studies

Country	Wind Figures [1/]		Case Study	Type of initiative
	Installed capacity (MW)	Share on electricity generation (%)		
United Kingdom	7,952	4.4%	Orkney ANM	Project
			Connect and Manage	System Operator Regime
Ireland and Northern Ireland	1,998	11.4% (Ireland), 7.2% (Northern Ireland)	Wind curtailment in tie-break situations	System Operator Regime
United States [2/]	4,570	4.1%	Renewable Auction Mechanism	Programme

[1/] For further details see Sections: 4.1.1 (United Kindgdom), 4.2.1 (Ireland and Northern Ireland), 4.3.1 (United States)

[2/] Regarding California

Source: American Wind Energy Association (Wind energy facts: California), DECC (2012c), EirGrid and SONI (2011b).

Case Studies – Orkney ANM Project, GB

- Implemented by SSEPD.
- New connections: only under non-firm generation (NNFG) and subject to ANM and constraint policy.
- Principle of access: LIFO (date of connection offer).
- Maximum level of economic curtailment: 25 MW.
- Capacity connected around 15 MW (>9 generators).
- Capacity contracted > 20 MW.
- Curtailment risk: transferred to generators (no compensation).
- Investment risk: generators pay for network upgrades.
- Smart solutions: ANM saved around £30m in reinforcement costs.
- Commercial innovation: Curtailment: "commercially acceptable".
- Strong stakeholder involvement.
- Issues: High fixed (ANM) costs for small generators, no possibility to curtail them if under 50 KW.

Case Studies – Connect and Manage, GB

- Implemented by National Grid, replaced Invest and Connect (IC) and Interim Connect and Manage (ICM). The aim is to accelerate the number of generators connected.
- New connections: firm access (full access).
- Principle of Access: market-based. High price payments to wind generators under local constraints/low competition.
- Type of generators: renewable and non-renewables, including large and small embedded generation.
- Types of reinforcement works: (1) enabling works, (2) wider works. Enabling works allow early connections. The two-stage approach contribute to mitigating stranding risk for consumers. 805 MW connected by 31 December 2012.
- Curtailment risk: socialisation of all constraint costs (BSUoS).
- Investment risk: transferred to SO users (TNUoS).
- Issues: increase on network congestion, payments to generators (wind generators) do not reflect subsidies, difficult to apply to DNOs.

Case Studies – Wind curtailment in tie break situations, Ireland

- Proposed by the Single Electricity Market Committee (SEMC) from Ireland and Northern Ireland (Oct. 2012).
- Type of generators: only wind generators in tie break situations.
- Type of firmness: firm, non-firm and partially firm generation.
- New Proposal: Pro-Rata with defined curtailment limits:
  - The idea of indefinite compensation is not supported anymore after 2020.
  - Curtailment limit based on a renewable penetration threshold.
  - Gradual reduction of compensation for curtailment reasons.
  - Impact: € 13million saving achievable in 2020, assumption 4% curtailment (638 GWh), with a curtailment value of around €20/MWh.
- Curtailment risk: transferred to customers (dispatch balancing costs, -DBC- gradual reduction), after 2020 risk transferred to generators (no compensation at all).
- Investment risk: transferred to SO users (TUoS).
- Issue: protect consumers from full compensation (DBC) and at the same time promote connection of more wind generation.

Case Studies – Wind curtailment in tie break situations, Ireland, Final Decision (March 2013)

- **Pro rata with removal of DBC for curtailment by 1 January 2018:**
  - Pro rata applicable to all wind farms (firm, non-firm).
  - No compensation for curtailment (firm, non-firm) by 1 January 2018.
  - No sliding scale mechanism: costly and complex to develop.
  - 2018 strikes an appropriate balance (between developers/consumers).
  - Encourage only viable wind farms projects to proceed and contribute to meeting renewable targets by 2020 (strong entry signal: short run dispatch efficiency and long run market efficiency).
  - Distinction between curtailment and constraint remains (direct impact on market payments).
  - Required changes to market rules and systems by TSOs and SEMO.

Case Studies – Renewable Auction Mechanism (RAM) by SCE, California

- Adopted by California Public Utility Commission (CPUC) in 2010.
- Implemented by 3 Investor-Owned Utilities (IOUs) in California:
- The RAM Programme:
  - Procuring method: market-based, 2 auctions per year (1,299 MW in 2 years across IOUs). Length of contract:10/15/20years.
  - Size: small generators (up to 20 MW per project).
  - Bidding: project price + upgrade costs (transmission)
  - Results: RAM 1 (IOUs: 140 MW allocated), average price (single value): US$ 89.23 / MWh. SCE: RAM 1 (67MW), RAM 2 (87MW)
  - Use of independent evaluator.
  - Availability of connection maps (Google Earth).
- Curtailment risk: transferred to generators (curtailed energy < 50 hours/year – cap) under specific conditions (negative price, …).
- Investment risk: transferred to generators (distribution upgrades), and to SO users (transmission upgrades).

Conclusions

- **Principle of Access**: LIFO, Pro Rata and market-based represent different alternatives of how the DNOs could address the need for connection of more wind to the existing distribution system.

  – LIFO: makes economically efficient use of the available capacity in the short run, but transfers increasing risk to the last in generator connected. May compromise dynamic efficiency by making it more difficult to get agreement to increase network capacity when this becomes socially valuable.

Conclusions

- Pro Rata: reduces risk to the marginal generator, but at the cost of potentially connecting too much generation behind a constraint. But, it is crucial and difficult to set the right capacity limit, it needs to consider both short run and dynamic efficiency.
- Market-Based: allows generators to optimally turn down their wind farms according to the costs of doing so, dual advantages: encourages generator investment in flexibility and creates the opportunity to have system operator incentives to reduce curtailment. But, problems in deciding who pays generators for curtailment (usually customers), others: lack of competition and high transaction costs (small generators), administrative burden (setting up the bid).

Conclusions

- **Allocation of risks among the parties:**
  - Curtailment risk:

  System operators usually transfer the risk of transmission connected generation being curtailed to final customers (i.e. through DBC-Ireland/NI, BSUoS-UK). However for distribution connected generation, the rules are less homogeneous (SEEPD does not compensate, SCE compensates based on a cap curtailment: 50 hours/year).

Conclusions

- **Allocation of risks among the parties**
  - Investment risk:

  Generally transferred to the generators when an upgrade to the distribution network is required. When a transmission network upgrade is necessary the investment risk is transferred to the users. Thus, regulation allows the socialisation of transmission upgrades but not the socialisation of distribution upgrades.

Conclusions

- **Key lessons relevant to UK Power Networks**
  - Smart solutions versus conventional reinforcement
    Determine the way to optimally increase generation capacity behind a constraint versus the option of making the incremental reinforcement. Identification of the equilibrium condition.
  - Compensation versus no compensation
    Find the best arrangement to optimise curtailment in order to reduce the possibility of compensation. Distribution network reinforcements could be an option for mitigating the risk of curtailment. This will attract the interest of generators.

Conclusions

– Publishing interconnection/connection maps as a way for encouraging connections to less congested points:

Provides more transparency on the status of the network (valuable information for generators for the selection of the most convenient connection points) and accelerates the evaluation process conducted by the DNOs.

– Stakeholder engagement matters:

Promote stakeholder engagement by encouraging active participation of key parties in the development and implementation of the Flexible Plug and Play trial.

Conclusions

– Auction mechanism is an alternative way for procurement of renewables with focus on small generators in which price and connection costs are bid:

Applied by SCE (4.9 million customers). A regional auction mechanism for procurement of small scale renewables can be seen as a potential option to accelerate the connection of the most cost-efficient projects. This option may add more complexity to the energy procurement process in terms of implementation when there is not enough demand.

Next steps

- Publish the report as working paper (EPRG), academic journals (shorter versions): *IEEE Transactions on Power Systems, Energy Policy.*

- Writing new report examining the costs and benefits of different options for connecting non-firm generation to the DNO networks, while taking decisions on when to reinforce into account.

Thank you