Capacity value of interconnection

What it is, how to compute it and how to use it

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Risk Day, 5 March 2019
Peterhouse Theatre, Cambridge, UK

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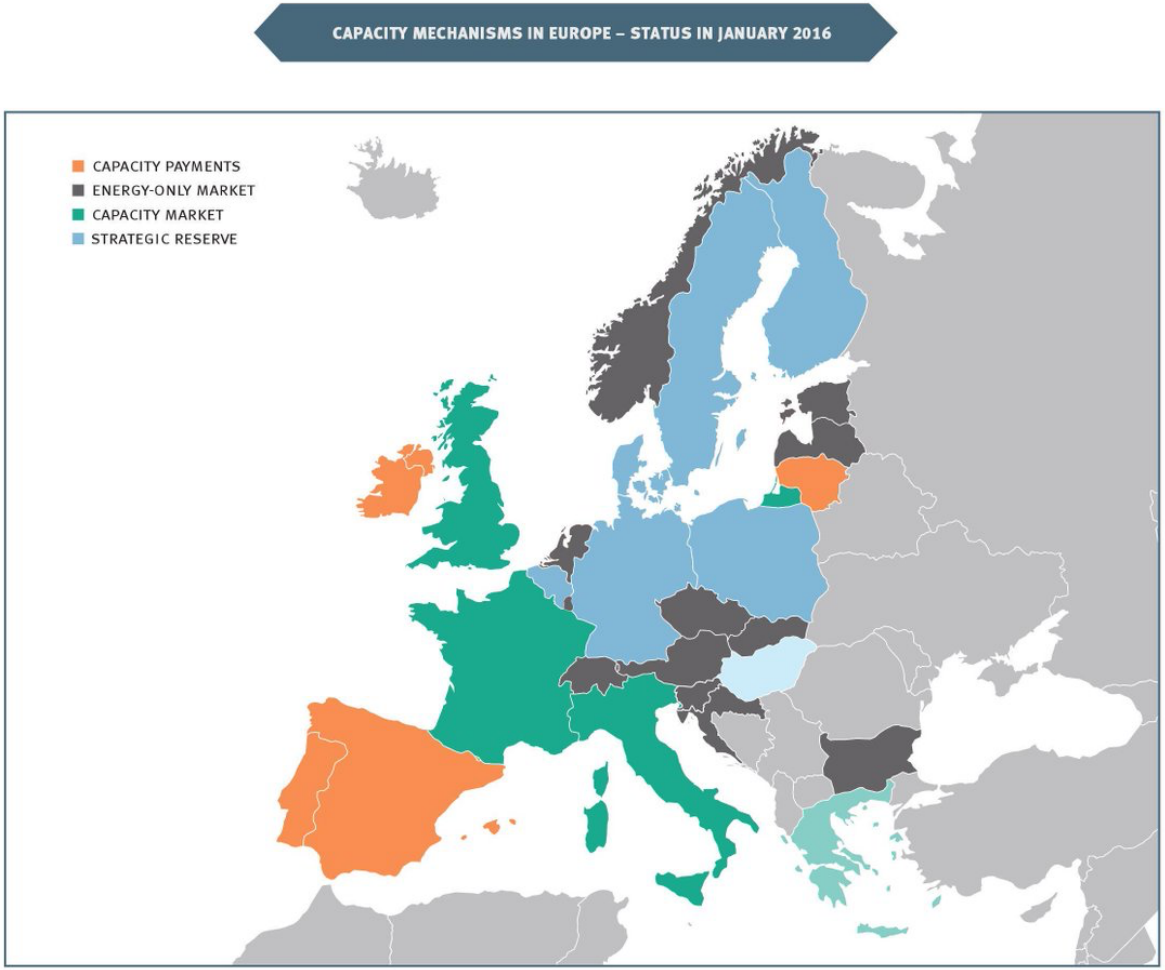


Eurelectric, 2016

Interconnected Europe

"(...) the European Commission proposes to extend the current 10% interconnection target to 15% by 2030 (...)"

- European Commission, COM(2014) 330

National Grid Future Energy Scenarios

Capacity GW	2019/20	2020/21	2021/22	2022/23	2025/26	2030/31
Base Case	4.8	5.8	6.7	8.4	11.2	15.1
Community Renewables	4.8	6.8	6.7	8.4	13.7	16.5
Two Degrees	4.8	6.8	8.1	9.8	16.5	19.8
Steady Progression	4.8	5.8	6.7	8.4	11.2	15.1
Consumer Evolution	3.8	4.8	6.7	7.0	9.8	9.8

National Grid EMR Electricity Capacity Report 2018

Interconnectors and the GB capacity auction

- Interconnectors participate in the GB capacity auction
- Paid according to **de-rated** capacity, based on country factor, computed using European market model.

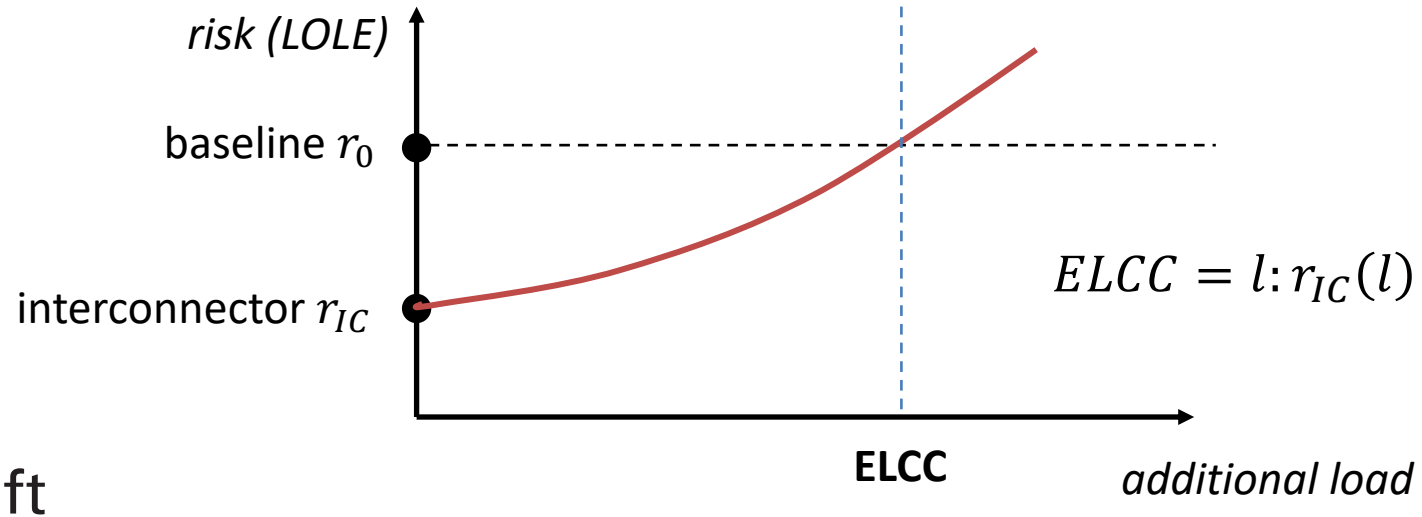
Country	Delivery Year	Historical	Low	High
Ireland	2019/20	5	35	54
	2022/23		24	42
France	2019/20	55	61	92
	2022/23		59	86
Belgium	2019/20	67	65	78
	2022/23		35	67
Netherlands	2022/23	70	27	62
Norway	2022/23	96	90	100

National Grid EMR Electricity Capacity Report 2018

Capacity value – a 1 minute primer

Acts as a **common currency** for capacity markets.

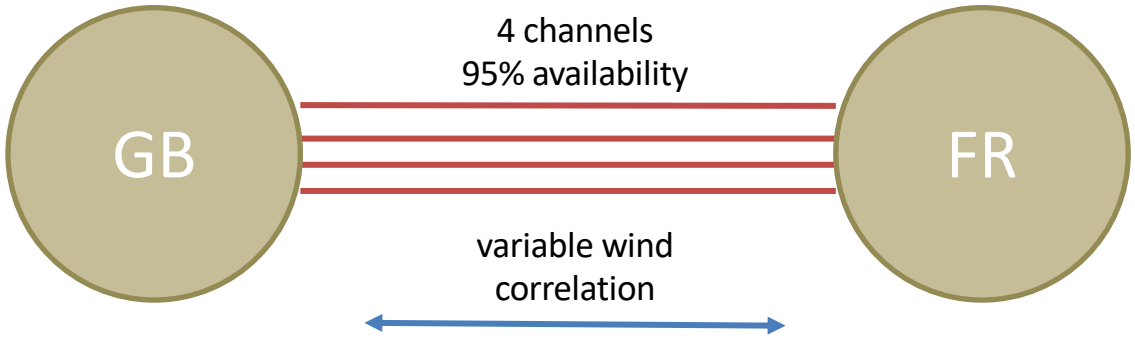
For this talk: **equivalent load carrying capacity (ELCC).**



$$ELCC = l: r_{IC}(l) = r_0$$

Demonstration system

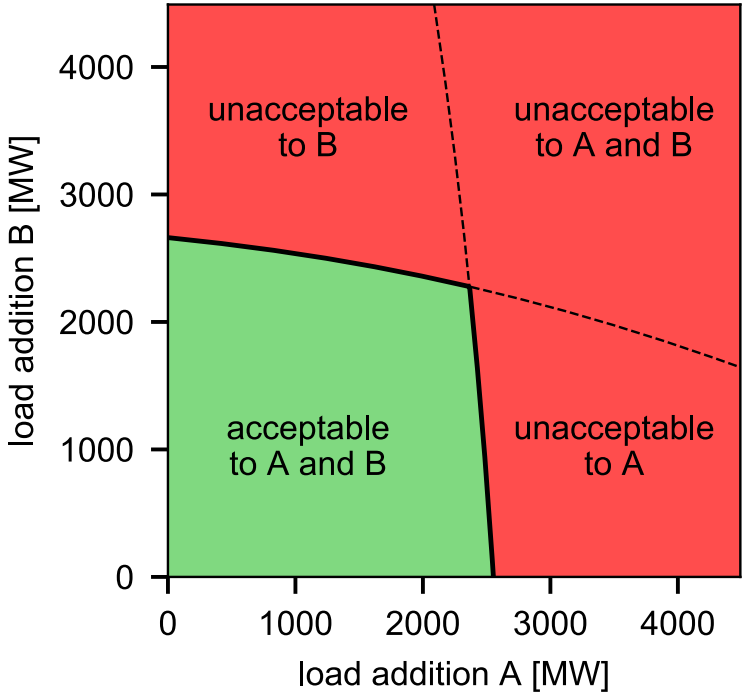
“How much capacity do we save by accounting for interconnectors?”



- Demand: 2010-2014 profiles for GB & FR (net demand)
- Wind power
  - assumed independent of demand
  - GB: 2010-2014 data (re-analysis data for constant site locations)
  - FR: related to GB using Gaussian copula model (calibrated on 2014 data)
- Characteristic generators + generic availabilities, adjusted to hit LOLE=3 hours target for isolated system

Capacity allocation curve

Two risk constraints, two load additions



Quantify ability to carry more load, under the **LOLE=3hr** standard.

Pareto frontier of possible answers: the **capacity allocation curve.**

Mechanisms for capacity allocation (markets, multi-lateral agreements, or implicit agreement) are essential.

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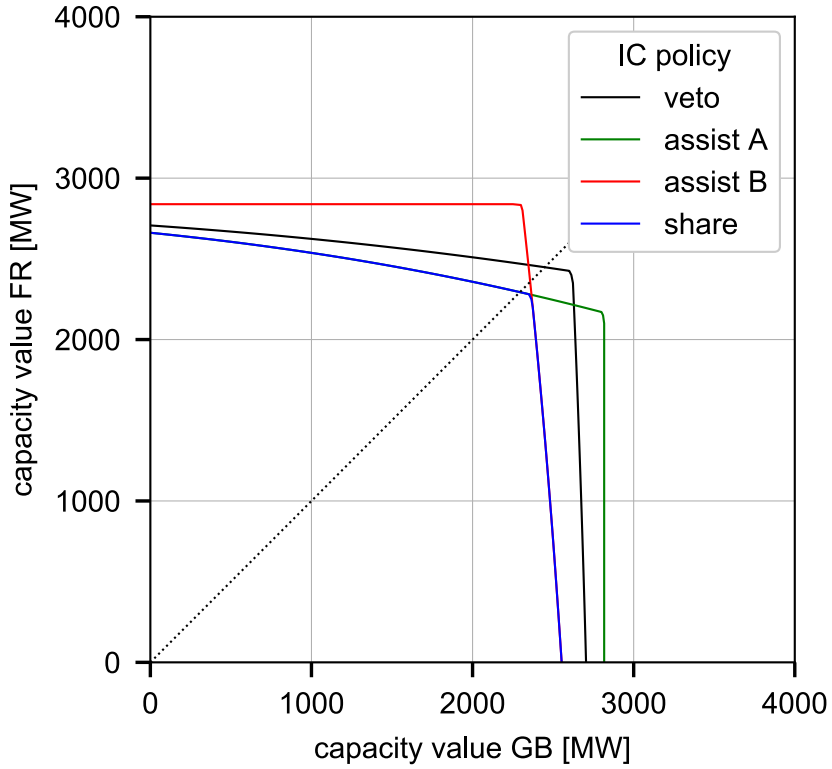
arXiv:1811.03131, S Tindemans, M Woolf, G Strbac, "Capacity Value of Interconnection Between Two Systems"

Effects of real-time operation

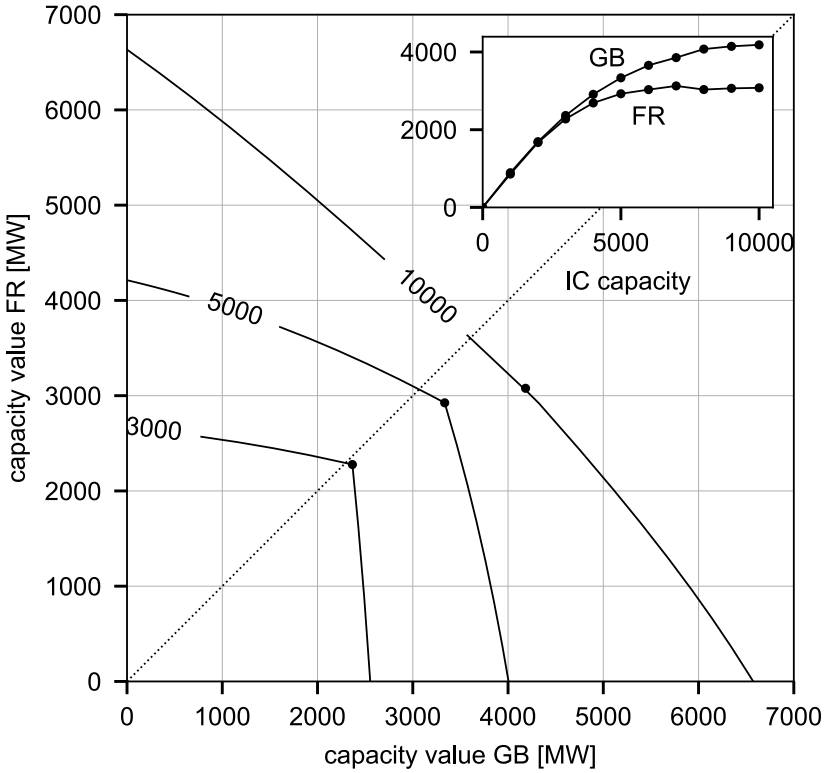


Range of real-time market outcomes is bracketed by **four operational policies**:

- **veto**: both areas have veto power over exports
- **assist A**: always prioritise A
- **assist B**: always prioritise B
- **share**: shared shortfalls

arXiv:1811.03131, S Tindemans, M Woolf, G Strbac, "Capacity Value of Interconnection Between Two Systems"

Capacity allocation



Range of capacities:
3GW, 5GW, 10GW

Qualitative difference between small and large interconnector capacities

Asymmetry between GB/FR contributions

arXiv:1811.03131, S Tindemans, M Woolf, G Strbac, "Capacity Value of Interconnection Between Two Systems"

Towards more complex systems

Previous results used exact* convolution method, which does not scale well.

Monte Carlo sampling is flexible, but noisy.

$$ELCC = \text{Pareto maximal set of } \{(l_{GB}, l_{FR}) \colon r_{IC}(l_{GB}, l_{FR}) \leq r_0\}$$

$$r_{IC}(l_{GB}, l_{FR}) = E_X[m_{IC}(l_{GB}, l_{FR}; X)] \approx \frac{1}{N}\sum_i m_{IC}(l_{GB}, l_{FR}; x_i)$$

$$\widehat{ELCC} = \text{Pareto maximal set of} \left\{(l_{GB}, l_{FR}) \colon \frac{1}{N}\sum_i m_{IC}(l_{GB}, l_{FR}; x_i) \leq r_0\right\}$$

How reliable is this estimate, as a function of N?

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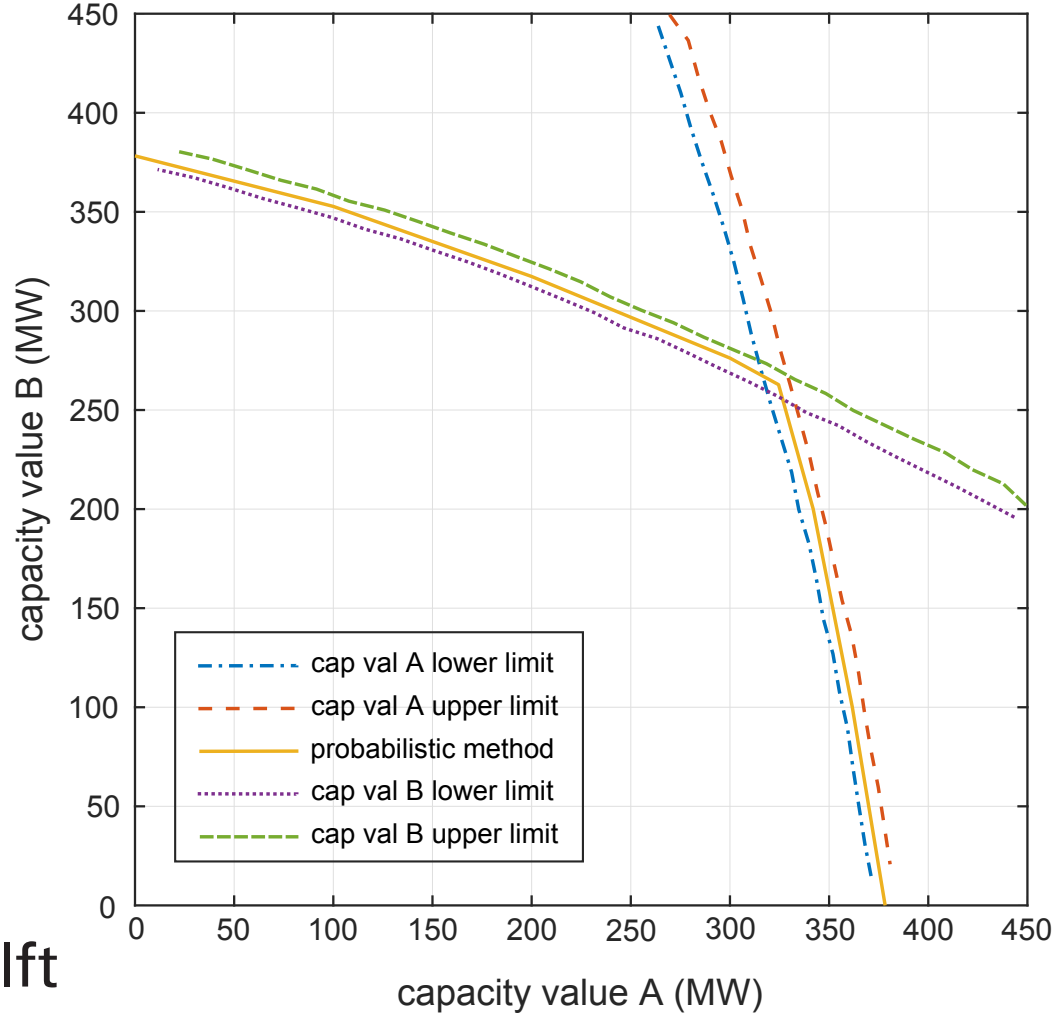
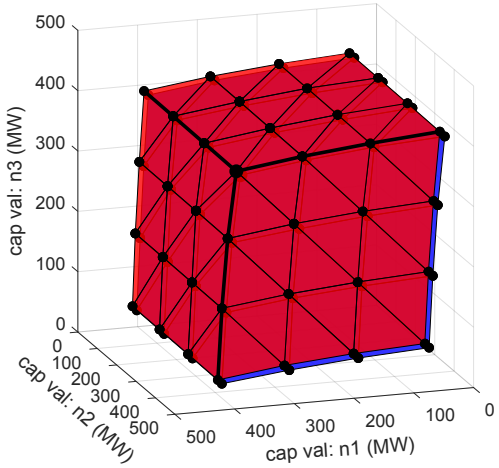
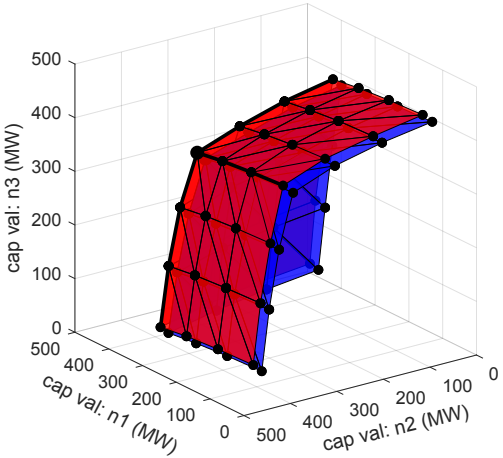

capacity value B (MW)
capacity value A (MW)
0
50
100
150
200
250
300
350
400
450
cap val A lower limit
cap val A upper limit
probabilistic method
cap val B lower limit
cap val B upper limit


cap val: n3 (MW)
cap val: n2 (MW)
cap val: n1 (MW)
0
100
200
300
400
500


cap val: n3 (MW)
cap val: n1 (MW)
cap val: n2 (MW)
0
100
200
300
400
500

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Conclusions / discussion

- The capacity contribution of interconnection is
  - not a value, but a curve
  - qualitatively different for small and large capacities
  - asymmetric
  - dependent on real-time market outcomes

  → it's complicated

- Methodology
  - Make sure you ask the right question!
  - convolution and 2D system is useful for scoping results
  - Monte Carlo method is required for complex systems

- How do we use this in design and operation of capacity markets?

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