

Index

- Allaz, B. 183
- Alvarado, F. 183
- ancillary service markets 7, 10–11
 - climate change and the future of the liberalised electricity markets 204–8
- arbitrage
 - arbitrage between markets, and market design 63–4
 - between day-ahead and re-dispatch market 117
 - imperfect arbitrage between markets 74
 - market arbitrage between real-time and wholesale markets 53
- auctions
 - bid mitigation, competition policy and market power 168–9
 - bidding incentives, re-dispatch (single-price) congestion management 116–19, 170–71
 - bidding market, re-dispatch (single-price) congestion management 113–16, 118–19, 133–4
 - block order trading 8, 32–3
 - competition role, climate change and the future of the liberalised electricity markets 203–4
 - intraday non-discriminatory auctions 33
 - long-term financial transmission rights (FTRs) allocation and congestion management 110
 - market design and bidding in congestion situations 170–72
 - pay-as-bid (discriminatory) auctions, day-ahead markets 25–7, 52
 - single-price (non-discriminatory), day-ahead markets 24–5, 26, 27, 52, 53
- Austria
 - competition law and market power 143–4
 - portfolio aggregation for imbalance settlement 47
 - price caps in day-ahead market 73
- Baldick, R. 64
- Baselice, R. 162
- Belgium
 - dual imbalance pricing system 44
 - pay-as-bid system 52
 - portfolio aggregation for imbalance settlement 47
- Bertoletti, P. 196–7
- bidding market *see* auctions
- blackouts
 - black-start capability services 57
 - generating unit outage, effects of 51–2
 - involuntary load reduction 69, 70–71
 - rolling blackouts, wholesale electricity markets 28, 67, 209
 - see also* scarcity
- block order trading 8, 32–3
 - see also* auctions
- Borenstein, S. 141, 182
- Bower, J. 64
- Bunn, D. 64
- Bushnell, J. 183
- Canada, long-term financial contracts 165
- Canton, J. 211
- capacity
 - adequacy *see* generation capacity adequacy
 - cross-border and re-dispatch cost (Swedish Interconnector) 172–6

- flow-based capacity model *see under*
 - congestion management and transmission rights, interface (zonal) approach
- model in three-market security domain, interface (zonal) approach 120–22
- net-transfer-capacity capacity model, congestion management and transmission rights, interface (zonal) approach 122–6
- procurement of operating reserve capacity, wholesale electricity markets, real-time balancing 53–7
- reserve capacity costs, wholesale electricity markets, real-time balancing 54–6
- reserve of last resort 83–4
- system re-dispatch and transmission network capacity 19–20
- caps *see* price caps
- Cervigni, Guido 1–185, 198–212
- Chao, H. 141
- Chile, capacity payments 77
- climate change and the future of the liberalised electricity markets 15, 198–212
 - ancillary service markets 204–8
 - cap and trade system 200
 - competition role and auctions 203–4
 - congestion management 203, 208
 - consumption reduction and sustainability 200
 - electric vehicles 210
 - global economic crisis, effects of 201
 - greenhouse gas emissions, reduction of 15, 200
 - imbalance prices 207
 - interruptible service agreements 209
 - intraday market transactions 204–5, 207–8
 - network congestion 208
 - price formation mechanism 206–7, 208
 - re-dispatch and congestion management 203, 208
 - real-time exchanges and generation scheduling decisions 205–6, 208
 - regulatory risk 204
 - renewable energy targets 198
 - retail market 208–11
 - short-term and ancillary service markets 204–8
 - smart meters and electricity consumption reduction 6, 209–10, 212
 - solar and wind generation share 198–9, 202–3
 - sustainability objectives and investment decisions 200, 203
 - wholesale electricity prices and generation capacity development 201–4
 - wind production variability 202–3 *see also* environmental issues
- Colombia
 - capacity payments 77
 - capacity support schemes 81, 82
- combined-cycle gas turbine technology 1, 5, 15
- Commisso, Andrea 67–85
- competition policy, auctions and climate change 203–4
- competition policy and market power 12–14, 17, 143–85
 - dominant position abuse in related markets 176–9
 - dominant position abuse, system operation business 179–80
 - market design and bidding in congestion situations 170–72
 - market design and bidding in congestion situations, product standardisation effects 8–9, 171
 - re-dispatch cost and cross-border capacity (Swedish Interconnector) 172–6 *see also* merger control
- competition policy and market power, generator's market behaviour 160–63
- competitive benchmark estimation 161–3
- inter-temporal constraints and cost estimation problems 161–2
- output gap analysis test 160–61
- reference price-cost margin, international comparison 162–3
- screening tests 160–61

- competition policy and market power,
 - market structure 144–60
 - ability and incentives to exercise 145
 - competition among generators 147–8
 - competitive assessment 151–2
 - delivered price test 151
 - demand elasticity 3–5, 146–7
 - direct methods to assess market power 154–60
 - equilibrium market model to assess market power 154
 - Hirschman–Herfindahl Index (HHI) for market concentration 152, 153
 - hypothetical monopolist (SSNIP) test 149–50, 152–3
 - market definition analysis 149–51
 - market power, residual demand elasticity assessment 154–5
 - market share threshold 151–2
 - market-power assessment 149–54
 - merger control and market definition 151
 - pivotality analysis 155–60
 - pivotality analysis, benchmarks 159–60
 - pivotality analysis and competitive interaction 156
 - pivotality analysis, price increase incentives 157–9
 - pivotality analysis, technical constraints 156–7
 - transmission constraints 148
 - transmission constraints and geographical boundaries 151, 153
 - wholesale electricity markets, competitive constraints 146–8
 - wholesale electricity markets, standard approach to 152–4
- competition policy and market power, market-power mitigation measures 163–9
 - bid mitigation 168–9
 - conduct and impact tests 168–9
 - generation capacity divestiture 163–5
 - long-term financial contracts 165–6
 - price caps in spot markets 167–8, 169
 - structural tests 168–9
 - virtual power plants (VPP) (option contract) 166, 169
- congestion management 7, 11–12, 13
 - climate change and the future of the liberalised electricity markets 203, 208
 - market design and bidding in congestion situations 170–72
- congestion management and transmission rights 86–142
 - network development 137–41
 - network development, coordination between transmission and generation investment 138
 - network development, market investors, merchant model 139–41
- congestion management and transmission rights, interface (zonal) approach 119–31
- capacity model in three-market security domain 120–22
- flow-based capacity model 126–7
- flow-based capacity model, accounting for nodal details 127–31
- flow-based capacity model, flow reliability margin (FRM) 129
- flow-based capacity model, generation shift keys (GSKs), impact of 128–31
- flow-based capacity model, net exports and nodal injections, link between 128–9, 134
- net-transfer-capacity capacity model 122–6
- congestion management and transmission rights, locational differentiation of electricity's incremental cost 93–101, 176
- contingency constraint 93
- general formulation of nodal incremental costs 99–101, 104
- locational incremental cost 95–9, 133
- network constraints 93
- security domain 93–5
- security-constrained optimal dispatch 99–101

- congestion management and
 - transmission rights, network effects and locational differentiation of value of electricity 87–101
- DC (direct current) approximation 88–9
- least resistance path 89
- power flows 88–93
- power transfer distribution factor (PTDF) matrix 92–5, 100–101, 102–3, 109–10, 121, 128–9, 130
- superposition 88–9, 91–2
- congestion management and
 - transmission rights, nodal price differentiation 101–11
 - explicit nodal market and flowgate methodology 101–6, 110
 - implicit nodal market and bid-based security-constrained economic dispatch 105–6, 177–8
 - long-term financial transmission rights (FTRs) 106–11
 - long-term financial transmission rights (FTRs), FTR allocation and auctions 110
 - long-term financial transmission rights (FTRs), FTR obligations and options 111
 - long-term financial transmission rights (FTRs), simultaneously feasible transmission rights and revenue adequacy 107–10
 - market-clearing prices 9, 13, 104–5, 137
- congestion management and
 - transmission rights, nodal and zonal debate 131–7
 - congestion cost 132–3
 - generation investment incentives 136
 - implementation and operation complexity 135
 - market liquidity 134–5
 - market power 133–4
 - market power in export-constrained area 134
 - network development, regulatory incentives 135–6
 - political pressure for single national price for customers 136–7
 - surplus distribution properties 137
- congestion management and
 - transmission rights, re-dispatch (single-price) congestion management 111–19, 132–3
- arbitrage between day-ahead and re-dispatch market 117
- bidding incentives created by 116–19, 170–71
- bidding incentives and perfect market competition 118
- bidding incentives and risk 119
- bidding market 113–16, 118–19, 133–4
- day-ahead bidding by competitive generators expecting a transmission constraint 116–19
- examples 114–16
- principles of 112–16, 170
- consumers
 - political pressure for single national price for 136–7
 - smart meters and electricity consumption reduction 6, 209–10, 212
 - switching, and capacity requirements 80–81
- contingency constraint, congestion management, locational differentiation of electricity's incremental cost 93
- continuous trading, wholesale electricity markets, intraday markets 33–4
- Cramton, P. 64
- Creti, Anna 186–97
- day-ahead markets
 - re-dispatch (single-price) congestion management 116–19
 - wholesale electricity *see* wholesale electricity markets, day-ahead markets
 - see also* intraday markets
- Defeuilley, C. 196
- delivered price test 151
 - see also* pricing
- demand
 - elasticity and market structure 3–5, 146–7

- markets relevant to different levels
 - of 151
 - residual demand elasticity
 - assessment 154–5
 - see also* generation capacity adequacy
- dominant position abuse
 - and market power 176–9
 - retail prices and hedging problem 176, 187, 190–91
 - system operation business 179–80
 - see also* competition policy and market power
- electric vehicles 210
- environmental issues
 - and retail competition 189, 191
 - see also* climate change and the future of the liberalised electricity markets
- equilibrium market model to assess market power 154
- Europe
 - Climate and Energy Package 15, 198, 208–9
 - competition law and market power 143
 - day-ahead markets, block order trading 32–3
 - day-ahead trading model 23
 - electric vehicles 210
 - electricity market design 146–7
 - electricity regulation and competition law 13
 - Emissions Trading System (ETS) 200
 - E.ON case 180
 - EU27 generation capacity, production and consumption 3, 4
 - flow-based capacity model 126–7
 - inter-temporal constraints and cost estimation problems 162
 - long-term over-the-counter (OTC) markets 34–5
 - market design 61–2
 - market design, arbitrage between markets 63
 - market design, network security constraints 62
 - NASDAQ OMX Commodities Europe 35
 - net transfer capacity (NTC) model 122
 - network-related restrictions, absence of 58
 - pool market-clearing systems 29
 - procurement of operating reserves 55, 56
 - re-dispatch (single-price) congestion management 113
 - renewable energy, solar and wind generation share 198–9
 - renewables and price formation mechanism 206–7
 - renewables and real-time exchanges and generation scheduling decisions 205–6
 - scarcity pricing mechanisms 29
 - smart meters and electricity consumption reduction 6, 209–10, 212
 - system operation business, unbundling 180
 - system operations, real-time balancing, tertiary control 51
 - system re-dispatch 59
 - transmission network development 141
 - universal service and supplier of last resort 193–4
 - see also* individual countries
- Fabra, N. 64, 182
- Federico, G. 64, 164, 166, 183
- financial penalties
 - generation capacity adequacy 79
 - see also* pricing
- Finland, capacity requirements, reserve of last resort 83–4
- flow-based capacity model *see under* congestion management and transmission rights, interface (zonal) approach
- France
 - dual imbalance pricing system 44
 - long-term contracts and power exchanges 35
 - pay-as-bid system 52

- portfolio aggregation for imbalance settlement 47
- re-dispatch (single-price) congestion management 113
- gas turbine technology, combined cycle 1, 5, 15
- gate closure
 - and market transactions 19, 20–21, 23, 35–7, 39, 58–60
 - net contract position 36–7
 - net physical position 37, 38
 - see also* wholesale electricity markets, system operations
- generating unit outage, effects of 51–2
 - see also* blackouts
- generation capacity
 - development, and climate change 201–4
 - divestiture, market-power mitigation measures 163–5
 - withholding, scarcity effects of 13
- generation capacity adequacy 10–11, 16, 67–85
- investment decisions, coordination of 74–6
- involuntary load reduction 69, 70–71
- price capping and market power 73, 76–7, 81–2
- price insensitivity in day-ahead to real-time timeframe 70
- rationale for generation capacity support schemes 68–76
- risk structure 69, 74–6
- scarcity hours, importance of 68–9
- scarcity pricing and involuntary load reductions, regulatory solution 27–30, 70–71, 72, 74
- scarcity pricing and price caps 72–3
- under-remuneration in scarcity situations 69
- value of lost load (VoLL), flaws in assessment of 69–71, 74
 - see also* demand
- generation capacity adequacy, capacity requirements 78–84
 - capacity payments 76–8
 - capacity support schemes 16, 81–2
 - centralised capacity exchanges 81
 - and consumer switching 80–81
 - energy options backed by generation capacity 81–3
 - financial penalties 79
 - forward reserve requirements 80
 - reserve of last resort 83–4
 - reserve requirements 78–81
 - restructured markets, and price variation 79–80
- generation capacity adequacy, missing money problem 71–4
- imperfect arbitrage between markets 74
- lack of transparency 74
- market power mitigation measures 71–3
- out-of-market procurement of reserve services 73–4
- price duration curves 72
- generation investment incentives, congestion management, nodal and zonal debate 136
- generation shift keys (GSKs), impact of, interface (zonal) approach 128–31
- generators
 - competition among 147–8
 - localisation decisions, congestion management and transmission rights 138–9
 - market behaviour and competition policy *see* competition policy and market power, generator's market behaviour
- Germany
 - long-term contracts and power exchanges 35
 - portfolio aggregation for imbalance settlement 47
 - price-cost margin estimation 162
 - procurement of operating reserves 56
 - re-dispatch (single-price) congestion management 113, 171
 - renewable energy generation 201–2
 - renewables and intraday volumes 205
 - system re-dispatch 60
 - wind production 202
 - wind production and re-dispatch problems 203

- Giulietti, M. 193
 global economic crisis, effects of 201
 Green, R. 182, 183, 211
 greenhouse gas emissions, reduction of
 15, 200
see also climate change and the
 future of the liberalised
 electricity markets
- Hansen, P. 196
 Harvey, S. 141, 182
 Hirschman–Herfindahl Index (HHI)
 for market concentration 152,
 153
 Hogan, W. 141, 182
 hourly consumption
 hourly-block 8, 9, 22, 32, 34
 lack of information on 6, 28, 47–9,
 70, 209
 smart meters and electricity
 consumption reduction 6,
 209–10, 212
 hypothetical monopolist (SSNIP) test
 149–50, 152–3
- imbalance settlement 10, 39–49
 prices and climate change 207
 prices, system operations 42–3
 volumes assessment, system
 operations 40–42
- interface (zonal) approach,
 congestion management *see*
 congestion management and
 transmission rights, interface
 (zonal) approach
- interruptible service agreements *see*
 blackouts
- intraday markets
 transactions and climate change
 204–5, 207–8
 wholesale markets *see* wholesale
 electricity markets, intraday
 markets
see also day-ahead markets
- investment decisions
 coordination of, generation capacity
 adequacy 74–6
 generation investment incentives,
 nodal and zonal debate
 136
- Ireland
 procurement of operating reserves
 55
 value of lost load (VoLL) and
 scarcity 28
- Italy
 capacity payments 77
 capacity support schemes 81
 congestion management 176–9
 day-ahead markets, adjustment
 trades for generators after
 market-clearing 32
 dual imbalance pricing system 44
 generation capacity divestiture 163
 intraday non-discriminatory
 auctions 33
 long-term contracts and power
 exchanges 35
 national uniform withdrawal price
 136
 pay-as-bid system 52
 pivotality benchmarks 159–60
 portfolio aggregation for imbalance
 settlement 47
 price-cost margin estimation 162
 procurement of operating reserves
 (*ex ante* MSD market) 55, 56,
 59
 renewables and system operators'
 ancillary services costs 205
 retail competition and prices
 charged to consumers 192
 system operation business,
 unbundling 180
 system re-dispatch 59
 value of lost load (VoLL) and
 scarcity 28
- Joskow, P. 182, 196
- Kahn, E. 182
 Kristiansen, T. 141
- liberalised electricity markets
 future of *see* climate change and
 the future of the liberalised
 electricity markets
 retail competition 188–91
- Lindén, A. 211
 Littlechild, S. 197

- locational differentiation
 - incremental cost *see* congestion management and transmission rights, locational differentiation of electricity's incremental cost
 - network effects *see* congestion management and transmission rights, network effects and locational differentiation of value of electricity
- locational pricing, real-time balancing 59
- long-term financial transmission rights (FTRs), and congestion management *see under* congestion management and transmission rights, nodal price differentiation
- long-term transactions
 - market-power mitigation measures 165–6
 - wholesale electricity markets 34–5
- López, A. 164, 166, 183
- Mansur, E. 182, 183
- market
 - arbitrage between real-time and wholesale markets 53
 - energy and operating reserve markets, integration of 63–4
 - equilibrium market model to assess market power 154
 - investors, merchant model 139–41
 - liquidity, nodal and zonal debate 134–5
 - market-clearing algorithm and spot market 63–4
 - market-clearing prices, nodal price differentiation 9, 13, 104–5, 137
 - position and physical nomination 35–8
 - spot market *see* spot prices and consumption
 - structure and competition policy *see* competition policy and market power, market structure
- market design
 - bidding in congestion situations 170–72
 - wholesale *see* wholesale electricity markets, market design
- market power
 - and competition policy *see* competition policy and market power
 - concentration levels, retail competition 189–90
 - congestion management, nodal and zonal debate 133–4
 - missing money problem *see* generation capacity adequacy, missing money problem
 - mitigation measures *see* competition policy and market power, market-power mitigation measures
 - switching rates, retail competition 186–7, 191
- markets, restructured, and price variation 79–80
- merger control 144, 151, 153, 163 *see also* competition policy and market power
- Meyer, N. 211
- missing money problem *see* generation capacity adequacy, missing money problem
- Moselle, B. 181
- Motta, M. 181
- net exports and nodal injections, link between, interface (zonal) approach 128–9, 134
- net-transfer-capacity capacity model, interface (zonal) approach 122–6
- Netherlands
 - merger control and market definition 151
 - portfolio aggregation for imbalance settlement 47
 - price-cost margin estimation 162
 - re-dispatch (single-price) congestion management 113
 - smart meters 212
 - system re-dispatch 60
- network

- congestion, climate change and
 - the future of the liberalised electricity markets 208
- constraints, locational differentiation of electricity's incremental cost 93
- development, congestion
 - management and transmission rights 137–41
- development, regulatory incentives 135–6
- effects and locational differentiation of value of electricity *see* congestion management and transmission rights, network effects and locational differentiation of value of electricity
- market design and security
 - constraints 62
 - security constraints, system operations 57–61
- Newbery, D. 182, 183
- nodal incremental costs, locational differentiation of electricity's incremental cost 99–101, 104
- nodal price differentiation, and congestion management *see* congestion management and transmission rights, nodal price differentiation
- nodal and zonal debate *see* congestion management and transmission rights, nodal and zonal debate
- Nordic countries
 - Nordpool 29, 34, 73
 - out-of-market procurement of reserve services 73
 - portfolio aggregation for imbalance settlement 47
 - transmission congestion and market zones 172–6
 - see also* individual countries
- Norway
 - retail competition 191–2
 - value of lost load (VoLL) and scarcity 28–9
- O'Donoghue, R. 181
- output gap analysis test 160–61
- Padilla, A. 181
- pay-as-bid (discriminatory) auctions, day-ahead markets 25–7, 52
- Peck, S. 141
- Perekhodtsev, Dmitri 18–185
- Poletti, Clara 186–97
- pool market-clearing systems, day-ahead markets 22–3, 29, 33
- power
 - exchange, day-ahead markets 22, 23
 - exchange, long-term contracts 35
 - flows, network effects and locational differentiation of value of electricity 88–93
 - transfer distribution factor (PTDF) matrix 92–5, 100–103, 109–10, 121, 128–9, 130
- price caps
 - cap and trade system, and climate change 200
 - and market power, generation capacity adequacy 73, 76–7, 81–2
 - market power, generation capacity adequacy 73, 76–7, 81–2
 - scarcity pricing *see* scarcity in spot markets 167–8, 169
 - spot markets, market-power mitigation measures 167–8, 169
- pricing
 - and clearing rule, day-ahead markets 24, 27, 29, 32
 - comparison regulation, retail competition 191–5
 - conditions of scarcity, day-ahead markets 27–30
 - delivered price test, competition policy 151
 - dual imbalance pricing systems 43–5
 - duration curves, missing money problem 72
 - formation mechanism, and climate change 206–7, 208
 - increase incentives, and market structure 157–9
 - insensitivity, day-ahead to real-time timeframe 70
 - pay-as-bid (discriminatory) auctions, wholesale electricity markets, day-ahead markets 25–7, 52

- reference price-cost margin, international comparison 162–3
- scarcity 27–30, 70–71, 72–3, 74
- single-price (non-discriminatory) auctions, day-ahead markets 24–5, 26, 27, 52, 53
- single-price (re-dispatch) congestion management *see* congestion management and transmission rights, re-dispatch (single-price) congestion management
- spot prices *see* spot prices and consumption
- SSNIP test (small but significant non-transitory increase of price) 149–50, 152–3
- volatility problems, day-ahead markets 26
- see also* financial penalties; transaction costs
- product
 - choice and service quality, retail competition 188–9
 - standardisation effects, competition policy and market power 8–9, 171
- production constraints, and market design 62
- production/consumption programmes, wholesale electricity markets 35, 36–8
- profit-maximising strategy, day-ahead markets 26–7, 29, 32
- Rahman, D. 64
- Rajaraman, R. 183
- Ranci, Pippo 1–17
- Rassenti, S. 64
- re-dispatch
 - congestion management *see* congestion management and transmission rights, re-dispatch (single-price) congestion management
 - congestion management and climate change 203, 208
 - cost and cross-border capacity (Swedish Interconnector) 172–6
 - real-time balancing
 - generation scheduling decisions and climate change 205–6, 208
 - wholesale electricity markets *see* wholesale electricity markets, real-time balancing
- regulation
 - incentives, network development, nodal and zonal debate 135–6
 - price comparison regulation, retail competition 191–5
 - retail competition 191–5
 - risk, and climate change 204
- Reitzes, J. 183
- renewable energy targets 15–17, 198
 - see also* climate change and the future of the liberalised electricity markets
- reserve
 - capacity costs, real-time balancing 54–6
 - requirements, generation capacity adequacy 78–81
 - reserve of last resort 83–4
 - services, out-of-market procurement of 73–4
- retail competition 14, 186–97
 - climate change and the future of the liberalised electricity markets 208–11
 - customer class segmentation 188–9
 - energy conservation and distributed generation 191
 - environmental issues 189
 - liberalisation costs and benefits 188–91
 - market power and concentration levels 189–90
 - market power and switching rates 186–7, 191
 - overview 187–8
 - price comparison regulation 191–5
 - prices charged to consumers 191–2
 - pricing information complexity 192
 - product choice and service quality 188–9
 - product differentiation 189
 - regulation 191–5
 - retailing costs and wholesale procurement 189–90

- risk structure 187–8
- transaction costs and switching rates 191–2
- transmission and distribution tariffs 187–8
- universal service and supplier of last resort 193–4
- wholesale market efficiency 190–91
- risk structure
 - bidding incentives, re-dispatch (single-price) congestion management 119
 - generation capacity adequacy 69, 74–6
 - retail competition 187–8
- Roques, F. 85
- Rosenberg, A. 141
- scarcity
 - conditions, day-ahead markets 27–30
 - generation capacity withholding, effects of 13
 - hours, importance of 68–9
 - pricing 70–71, 72–3, 74
 - value of lost load (VoLL) 28–9
 - see also* blackouts
- screening tests, generator's market behaviour 160–61
- security
 - domain, locational differentiation of electricity's incremental cost 93–5
 - implicit nodal market and bid-based security-constrained economic dispatch 105–6, 177–8
 - model in three-market security domain, interface (zonal) approach 120–22
 - network security constraints, market design 62
 - network security constraints, system operations 57–61
 - security-constrained optimal dispatch, locational differentiation of electricity's incremental cost 99–101
- Sheffrin, A. 182
- single-price (non-discriminatory) auctions, day-ahead markets 24–5, 26, 27, 52, 53
- single-price (re-dispatch) congestion management *see* congestion management and transmission rights, re-dispatch (single-price) congestion management
- smart meters and electricity consumption reduction 6, 209–10, 212
- Smeers, Y. 182–3
- solar and wind generation share 198–9, 202–3
 - see also* climate change and the future of the liberalised electricity markets
- Spain
 - capacity payments 77–8
 - intraday non-discriminatory auctions 33
 - portfolio aggregation for imbalance settlement 47
 - price-cost margin estimation 162
 - procurement of operating reserves (restriction market) 55, 56, 59
 - re-dispatch (single-price) congestion management 113, 170–71
 - renewables and intraday volumes 205
 - system operation business, unbundling 180
 - system re-dispatch 59
 - wind production 202
- spot prices and consumption
 - dominant position abuse 176–9
 - interface (zonal) approach *see* congestion management and transmission rights, interface (zonal) approach
 - long-term contracts, effects of 165–6
 - market-clearing algorithm 63–4
 - nodal price differentiation *see* congestion management and transmission rights, nodal price differentiation
 - pay-as-bid (discriminatory) auctions 25–7, 52
 - price caps 167–8, 169
 - reserve capacity *see* reserve and retail competition 190–91
 - and scarcity *see* scarcity

- single-price (non-discriminatory) auctions 24–5, 26, 27, 52, 53
- smart meters and electricity consumption reduction 6, 209–10, 212
- and virtual power plants (VPP) 166
- see also* auctions; day-ahead markets; intraday markets
- SSNIP test (small but significant non-transitory increase of price) 149–50, 152–3
- Stern, J. 185
- Stoft, S. 64
- sustainability targets 15–17, 200, 203
- Sweden
 - capacity requirements, reserve of last resort 83–4
 - Interconnector case 172–6
 - value of lost load (VoLL) and scarcity 29
- Switzerland, system re-dispatch 60
- system operations
 - dominant position abuse 179–80
 - wholesale market *see* wholesale electricity markets, system operations
- Tirole, J. 196
- transaction costs
 - near time of delivery, wholesale electricity markets 19
 - and switching rates, retail competition 191–2
 - see also* pricing
- transmission constraints, and market structure 148, 151, 153
- transmission rights, and congestion management *see* congestion management and transmission rights
- UK
 - abusive bidding behaviour, Ofgem investigation 171
 - capacity payments 78
 - competition law and market power 144, 171
 - dual cash-out system 44–5
 - generation capacity divestiture 163
 - individual generator energy accounts 47
 - out-of-market procurement of reserve services 73
 - pay-as-bid system 52
 - pool market-clearing systems 29, 78
 - Pre-Gate Closure Balancing Trades (PGBTs) 60
 - price comparison regulation 194
 - price-cost margin estimation 162
 - re-dispatch (single-price) congestion management 113, 171
 - renewable energy generation 201–2
 - renewables and system operators' ancillary services costs 205
 - retail competition and prices charged to consumers 192, 193
 - retail pricing information complexity 192
 - smart meters and electricity consumption reduction 6, 210
 - system operation business, unbundling 180
 - system re-dispatch 59–60
 - system-balancing transactions 61
 - value of lost load (VoLL) and scarcity 28, 29
 - wholesale market liquidity 191
- universal service and supplier of last resort, retail competition 193–4
- US
 - automatic price-mitigation schemes 27
 - California power crises 73
 - capacity requirement system 79, 169
 - capacity requirements, centralised capacity exchanges 81
 - capacity requirements, forward reserve requirements 80, 169
 - capacity requirements, transmission congestion issues 80
 - delivered price test 151
 - electricity regulation 13
 - ERCOT and price caps 73
 - Federal Energy Regulatory Commission (FERC) 151, 159
 - Federal Power Act 143
 - generation resources, withholding 169

- intraday non-discriminatory
 - auctions 33
 - market design, arbitrage between markets 63–4
 - market design, network security constraints 62
 - market power of generators, assessment of 151
 - market-power mitigation mechanisms 168, 169
 - national uniform withdrawal price 136
 - non-discriminatory auctions 53
 - out-of-market procurement of reserve services 73
 - pivotality benchmarks 159
 - price-cost margin estimation 162, 163
 - procurement of operating reserves 56
 - renewables and price formation mechanism 208
 - scarcity pricing mechanisms 29–30
 - Standard Market Design 61, 62
 - system re-dispatch 59
- value of lost load (VoLL)
 - flaws in assessment of 69–71, 74
 - and scarcity 28–9
 - Vandezande, L. 45
 - Vasilakos, N. 211
 - Vila, J.-L. 183
 - virtual power plants (VPP) (option contract), mitigation measures 166, 169
 - voluntary imbalances, wholesale electricity markets, system operations 43–4
 - Von der Fehr, N. 196
 - Von Hirschhausen, C. 162, 182
 - Waddams-Price, C. 193
 - Weigt, H. 162, 182
 - wholesale electricity markets 18–66
 - balancing market 19
 - climate change, prices and generation capacity development 201–4
 - competitive constraints 146–8
 - forward trading 20–38
 - gate closure and market transactions 19, 20–21, 23, 35–7, 39, 58–60
 - hourly consumption, lack of information on 28
 - injection and withdrawal programmes 23
 - long-term transactions 34–5
 - market participant's net contract position at gate closure 36
 - market position and physical nomination 35–8
 - market transactions 18–19
 - market-power mitigation measures and price equivalent to variable cost 27, 29
 - power exchange and long-term contracts 35
 - production/consumption programmes 35, 36–8
 - retail competition and market efficiency 190–91
 - rolling blackouts 28, 67, 209
 - spot-market designs and scarcity 29
 - standard approach to, and market structure 152–4
 - system imbalance settlement 20
 - system re-dispatch and transmission network capacity 19–20
 - transaction costs near time of delivery 19
 - value of lost load (VoLL) and scarcity 28–9
 - wholesale electricity markets, day-ahead markets 21–33, 63
 - adjustment trades for generators after market-clearing 32
 - auction model 23–7
 - bilateral 22
 - block order trading 32–3
 - inter-temporal constraints 30–33
 - organisation of 22–3
 - pay-as-bid (discriminatory) auctions 25–7, 52
 - pool market-clearing systems 22–3, 29, 33
 - power exchanges 22, 23
 - price volatility problems 26
 - pricing and clearing rule 24, 27, 29, 32

- pricing in conditions of scarcity 27–30
- profit-maximising strategy 26–7, 29, 32
- quantity rationing and scarcity 28
- single-price (non-discriminatory) auctions 24–5, 26, 27, 52, 53
- wholesale electricity markets, intraday markets 21, 33–4, 63
 - bilateral trading 34
 - continuous trading 33–4
 - non-discriminatory auctions 33
- wholesale electricity markets, market design 7–10, 61–4
 - arbitrage between markets 63–4
 - energy and operating reserve markets, integration of 63–4
 - network security constraints 62
 - and production constraints 62
- wholesale electricity markets, real-time balancing 7, 49–53
 - automatic control 50, 51
 - balancing market 52–3
 - balancing services 50–52
 - black-start capability services 57
 - frequency deviation and primary control 50
 - generating unit outage, effects of 51–2
 - locational pricing 59
 - market arbitrage between real-time and wholesale markets 53
 - operating reserve types 54
 - procurement of operating reserve capacity 53–7
 - procurement of operating reserves 55–6
 - reactive power and voltage power correction 56–7
 - reserve capacity costs 54–6
 - secondary control 50–51
 - system re-dispatch 59
 - tertiary control 51
- wholesale electricity markets, system operations 19–20, 38–61
 - balancing period and load profiling 47–9
 - dual imbalance pricing systems 43–5
 - gate closure, net contract position 36–7
 - gate closure, net physical position 37, 38
 - imbalance prices 42–3
 - imbalance settlement 39–49
 - imbalance volumes assessment 40–42
 - market participants, balance responsible party 47
 - network security constraints and market design 57–61
 - portfolio aggregation for imbalance settlement 45–7
 - system re-dispatch 58–60
 - system re-dispatch, imbalance prices 60–61
 - voluntary imbalances 43–4
- Wilson, C. 193
- wind production variability 202–3
- wind and solar generation share 198–9, 202–3
- Wolak, F. 182
- Wolfram, C. 162
- zonal (interface) approach, congestion management *see* congestion management and transmission rights, interface (zonal) approach
- zonal and nodal debate, and congestion management *see* congestion management and transmission rights, nodal and zonal debate