AC interconnectors 182
AC power lines 109, 118
access charges 205, 221
access rights 221
access rules 153, 233, 235, 241, 257–8
‘active’ TSOs 234, 239
incentives for 239
airline industry 65
Alberta
mixing planned and merchant
transmission in 119
MW-mile charges in 107
transmission network organization
in 148
zero-congestion policy in 91, 102,
119
algorithms 246
alternating current (AC) power lines
109, 118
altitude over sea level 273–3, 274
aluminium–zirconium wires 115
amortization charges 162
ancillary services, cost of provision of
146, 272, 273, 274, 275
Anderson, D. 67
arbitrage 16, 155, 188
areas of influence method 250
Areva 72, 79
Argentina
transmission investment in 235
transmission network organization
in 148
transmission pricing in 249, 250
association of European Transmission
System Operators (ETSO) 187,
264
asymmetry of information 121–4,
151–2, 192, 193, 224
attributes of transmission investments
136–47
auctions 88, 109, 111, 118, 163, 168,
191, 221, 233, 234, 235, 236
Australia
energy only market in 39–40
HVDC link with 141, 155
transmission investment in 155
transmission pricing in 249
Australian Competition and Consumer
Commission 237
Austria
net inter-TSO payment of 267, 271
transmission pricing in 265, 266, 271
average cost of transmission 253–4
average participation (AP) method 11,
263–4, 267, 268, 275, 283–5
Averch, H. 66–7
Bailey, E. 66
balancing market 158, 160, 163, 166
Bar-Ilan, A. 33–4
Barthold, L.O. 115
base-load plants 3–4, 22–30, 43, 49
Beesley, M. 66
Belgium
cost of capital in 76
generation investment in 70, 72
net inter-TSO payment of 271
transmission pricing in 265, 266, 271
Ben-Tal, A. 209
benchmarking 135, 162, 164, 180
benefit/cost ratios 172, 174–5, 238, 245
BETTA (British Trading and
Transmission Agreements) 182
Bjorndal, M. 193, 223
blackouts see power cuts
Borenstein, S. 108, 126
Bower, J. 67, 71
Brennan, M.J. 35
British Electricity Association 59, 66
British Energy 81
Brown, R.E. 230, 231
Brunekreeft, G. 107, 118, 124, 127
budget-balance constraint 151, 152,
159

289
‘bundled’ transmission services, prices for 165–6
Bushnell, J.B. 110, 187, 224, 231
California
congestion in 132
generation investment in 57, 58, 62, 65
independent system operators 54
power shortages in 1, 31, 37, 45, 126
capacity charges 204, 205, 214, 217, 222, 269
capacity expansion model 223
capacity factor 75, 79
capacity margins 4, 41–6, 47, 199
capacity obligations 6, 11–12, 166
capacity payments 6, 35–7, 40, 158
capacity reserves 45
capital costs 13–14, 55, 68, 69, 70, 72–80, 81, 120, 161–2, 273
capital intensity 13–14, 55, 66–7, 74, 81
carbon price trading 71, 80
categorization of transmission investments 137–43
CCGT see combined-cycle gas turbine (CCGT) plants
CEER (Council of European Energy Regulators) 235, 237, 285
Central Electricity Generating Board (CEGB) 41, 157, 164
Chao, H.-P. 138
Chile, transmission pricing in 249, 250
circulated fluidised bed combustion technology 69
coal-fired plants 219
technological switch to/from 58, 60, 61, 62, 63, 64, 65, 66
factors affecting 67, 68–72, 81
coopulations of network users, investment by 233, 235, 239, 283
incentives for 240–241, 242
combined-cycle gas turbine (CCGT) plants 4, 41–2, 46, 54, 244, 256
factors affecting location of 270–277
technology change to/from 13–14, 54–5, 69, 70, 71–2, 73, 74–5, 79, 80, 81
combined heat and power producers 62, 64
Comitology 189

competitive bidding see auctions
complementary goods 2
computer systems 15, 124
congestion 4, 8, 10, 16
economically optimal level of 7, 14
EU regulation on management of
189, 190–191, 196, 201
growth of 131–2
pushed across borders 15, 140
revenue adequacy in congestion management 222
social cost of 172
three distinct costs associated with 14, 88–90
see also congestion costs;
congestion rents; cost of congestion to load
unhedgeable 172, 173, 174–5, 177, 178
zero-congestion policy 14, 91–3, 95, 106, 119
strategic manipulation of 102–3
congestion charges
bilateral schedules liable for 166
efficiency properties of 199–202
FTRs as hedge against 191, 192, 221
incentive effect of 193, 221
in New York ISO 132
non-discriminatory 217
in PJM 131–2, 173–4
and revenue adequacy 222
congestion costs
compared with congestion rent and cost of congestion to load 14,
88–90
definition of 89
economic models focusing on 139
LMPs reflecting 166
measurement of 120–121, 172
trade-off between security and reduction in 235
trade-off between transmission investments and reduction in
113, 139, 175–6, 187
ways to reduce 125
congestion rents
compared with congestion costs and cost of congestion to load 14,
88–90
definition of 89
economic models and merchant investment 9, 110–118, 156, 171, 177, 236, 237, 241, 242
optimal transmission investment and 95–6, 99–102, 106–7, 112–16
PJM projects financed from 144
transmission rights yielding 9, 89, 110–113, 115, 191, 236, 247
congestion revenue rights (CRRs) 109–10, 111, 112, 115
constant returns to scale 113–14, 187
construction costs
electricity transmission lines 275
gas grid infrastructures 276
location and 171
plant type and 3, 67, 71, 73–4, 76, 79, 81
consumer surplus 116, 117
control areas 140
cost–benefit analysis 172, 173
cost causality, locational signals based on 16, 188, 189–90, 200, 201, 202, 204–17, 222, 223, 224, 225, 245, 250, 253, 254, 259, 277
cost minimization 120–121, 122, 197, 206, 230, 278, 279, 280, 282
cost of capital 114–15, 118, 171, 236
cost of congestion to load 14, 88, 90
cost of service regulation 119, 135, 156, 161, 166, 179, 233, 240, 260
cost of unserved load 120, 121, 122, 125
cost reflectiveness see cost causality, locational signals based on
Council of European Energy Regulators (CEER) 235, 237, 285
Credit Suisse First Boston (CSFB) 70, 71
credits 234, 235
Crew, M.A. 124, 187
Curien, N. 190
CUSC (Connection and Use of System Code) 159
Czech Republic, transmission pricing in 265, 266
day-ahead markets 166, 188
DC power lines 114–15, 118, 171, 236
see also high-voltage direct current (HVDC) transmission links
de Luze, G. 77
‘deep’ interconnection policy 134, 142, 168–70
delivery to load criteria 167–8
demand charges see capacity charges
demand schedules 158
demand uncertainty 30–31
Denmark
net inter-TSO payment of 271
transmission pricing in 271
Department of Energy see DOE (Department of Energy)
depreciation rates 161
DGEMP (Direction Générale de l’Energie et des Matières Premières) 68, 71, 72
digital technology 66
direct current (DC) power lines 114–15, 118, 171, 236
see also high-voltage direct current (HVDC) transmission links
discount rate 97, 116
discrete decisions 190, 193, 224
distributed generation 230, 238, 258, 259, 260, 261, 262, 280
distribution networks
coordination between transmission investment and 17, 138, 231, 258–62, 277, 280
definition of 258
regulation of 234
Dixit, A.K. 31–3
DOE (Department of Energy)
Annual Energy Outlook 71
see also EIA-DOE (Energy Information Agency and Department of Energy)
dual fired plants 59–66
dual price functions 193
economic efficiency principle 16, 189–90, 199–202, 217, 220, 222, 224, 245, 248
economic models of transmission investment 15, 132–3, 139, 154, 181
‘economic’ transmission investments 15, 133, 139, 142–3
in PJM 143–4, 171–3, 174–5, 176–7
versus ‘reliability’-driven transmission investment 133, 175–7, 180
economies of scale 8, 9, 10, 14, 87, 187 compared with lumpiness 101–2, 113–16
and market power 108 transmission pricing with 151, 204, 250
efficient size of network 8–9
efficient use of network 8
effort, reward for 120, 121, 123–4
EIA-DOE (Energy Information Agency and Department of Energy) 58, 65, 68, 69, 70
see also DOE (Department of Energy)
electric power network models 132–3
Electric Transmission Week 181
Electricité de France 24, 75, 76–7, 79, 81, 148
electricity utilities, investment by 56–64, 67
emissions 41, 43
emissions trading 71, 80
energy balancing costs 160–161, 162
energy charges 269
energy only markets 12, 39–40
engineering reliability criteria in England and Wales 158, 160, 162–3
factors affecting 154
ignored by economic models 15, 132–3, 181
ISO responsible for applying 148, 165
minimizing cost while complying with 278, 280
PJM’s 165, 167–9
reliability investment to restore 142 transmission investments driven by 134, 144–5, 162–3, 176, 177, 180
England and Wales capacity payments system in 6, 35–7, 40
cost of capital in 76
generation investment in 4, 35–8, 41–2, 47, 54, 57, 59, 65, 66, 67, 68, 69, 70, 72, 78, 80
net inter-TSO payment of 271
regulatory framework for transmission in 159–62, 180
transmission investment in 132, 142, 158–9, 162–4, 175, 177
transmission network facilities in 136
transmission network organization in 147–8
transmission pricing in 12, 37, 142, 158, 159–60, 161–2, 168, 169, 182, 249, 271
wholesale market arrangements in 12, 157–62, 179, 220
Enron 77, 81
Erie West HVDC 169–70
ETSO (association of European Transmission System Operators) 187, 264
EU see European Union (EU)
European Commission 189, 228
European Parliament and Council 187
European Union (EU) Directives 54, 164
inter-TSO payments in 263–4, 265, 267, 268, 269, 271
internal electricity market of 54, 189, 237, 246
nodal transmission tariffs in 263–70, 271
Regulations see European Regulation 1228/2003 on Conditions for Access to the Network for Cross-border Exchanges of Electricity regulatory responsibilities in 135 transmission investment policy in 146
exit fees 175
expected amount of unserved energy 36
expected net present cost 97–8, 104
expected value of capacity 36
externalities 7, 87, 102, 108, 187
feasible sets of transmission rights 109–11
Federal Energy Regulatory
Commission (FERC) 135, 141, 164, 165–6, 170, 172, 173, 191
Felder, F. 118
FERC (Federal Energy Regulatory
Commission) 135, 141, 164, 165–6, 170, 172, 173, 191
financial guarantees 256
financial transmission rights (FTRs) 3, 10, 110–112, 167, 168, 169, 171, 172, 191–2, 221
fines see penalties
Finland
cost of capital in 76, 79
generation investment in 42–3, 71, 72, 79, 81
net inter-TSO payment of 271
transmission pricing in 271
Fionon, D. 77, 80
Firecone Ventures Pty Ltd 118
fixed costs of generation 3, 22, 23, 40, 195, 197
recovery of 4, 6, 24, 26, 39
see also construction costs
fixed costs of transmission 14, 94, 95, 119
recovery of 9, 10, 11, 14, 15, 16, 92–3, 100–102, 107, 108, 117–18, 144
see also construction costs
Florence Regulatory Forum 189–90, 201, 217, 246
Florence School of Regulation 264
Ford, A. 37
forward contracts 160, 192
France
cost of capital in 75, 76–7
HVDC link with 141, 157
transmission network facilities in 136
transmission network organization in 147–8
transmission pricing in 265, 266, 271
free riders 108, 116–18, 127
fuel costs
congestion influenced by 139
technology choice influenced by 30, 68, 69, 70, 71, 73, 78, 79, 80, 81
correlation between electricity price and 14, 75
fuel mix see generating technologies, choice of
functional separation 135–6, 147–8
future grid development, information on 257
game theory 103
Gans, J. 120
gas-based electricity generation 41–2, 43, 126, 219, 244, 256
factors affecting location of 270–277
peaking plants 3–4, 22, 46
technological switch to/from 13–14, 54–6, 57–65, 66, 80
factors affecting 65–72, 73, 74–5, 77–80, 81
gas bubble 78, 81
gas grid infrastructures 16, 274, 275–6
gas losses in pipeline 273–5
gas only plants 58, 59, 60, 61, 62, 63, 64, 65, 66
gearing rate 14, 38, 75, 76
generating technologies, choice of 13–14, 30, 54–81
generation, investment in 3–7, 12–14, 21–52, 54–81
case examples 263–77
generation capacity
investment cycles and 35–9
investment in liberalized markets 41–6
irreversibility and uncertainty and 30–35, 47
modelling optimal level of 21–30, 47–52
paying for capacity in practice 39–41
generation investment strategies 102–7
generator deliverability investments 166, 168–9
generator interconnection investments 137–8, 167
geographic scope of TSOs 179
Germany
generation investment in 70
Index

net inter-TSO payment of 271
transmission pricing in 265, 266, 271
Gilbert, R. 126, 221, 247
Glachant, J.-M. 77, 80
‘gold-plating’ 123
Gollier, C. 79
government subsidies 13, 16, 54, 67, 73, 81, 82, 150, 151
graft 123–4

Greece
net inter-TSO payment of 271
transmission pricing in 271
Green, R.J. 39, 67, 190
Gribik, P.R. 110
grid codes 162, 234, 238, 240, 242
grid equilibrium model 194–6
GRTN (Gestore Rete Trasmissione Nazionale) 59, 66

harmonizing transmission pricing practices 15, 133, 232, 263
Harvey, S.M. 88, 191
Hawdon, D. 35
hedging 39–40, 52, 78, 79, 81, 111–12, 191–2, 221, 236
unhedgeable congestion 172, 173, 174–5, 177, 178
Henney, A. 157
Hirst, E. 132
horizontal integration of TSOs 133–4, 150
Hungary, transmission pricing in 265, 266
Hunt, S. 56, 67
HVDC (high-voltage direct current) transmission links 134, 141, 155–6, 157, 169–71, 173, 182
hydro-electric generators 31, 43, 44, 58, 60, 61, 62, 65, 66, 69
Hydro-Quebec 182

Iberian System 243
ICRP (investment cost-related pricing) 250
IEA (International Energy Agency) 57, 62, 64, 68, 71, 73
IGF-CGM (Inspection Générale des Finances & Conseil Général des Mines) 75, 76, 79
incentive alignment 151–2
incentive regulation see performance-based regulation (PBR)
incomplete contracts 152
independent power producers (IPPs) 73
investment by 56–64, 77–8, 81
independent system operators (ISOs)
congestion revenue rights (CRRs) issued by 109, 110, 111
creation of 54
FTR option rights issued by 111
model of 148, 221
planning by 102
rationale for 148–9
regulatory challenges associated with 149–50
see also PJM (Pennsylvania–New Jersey–Maryland)
independent transco model 147–8, 179, 192–3, 220–221
indivisibility see lumpiness
information rent 121–4
installed capacity markets 40–41
integrated gasification combined cycle technology 69
inter-TSO investments 15, 132, 133, 134, 139–42, 147, 150, 157, 163–4, 176, 179
in PJM 173–5
inter-TSO payments in the EU 263–4, 265, 267, 268, 269, 271
interconnection charges 158, 159
interconnection rules 134, 167, 170
internal electricity market 54, 189, 237, 246
nodal transmission tariffs in 263–70, 271
International Energy Agency (IEA) 57, 62, 64, 68, 71, 73
intra-TSO investments 15, 132, 133, 134, 139, 147, 150, 176, 179, 180
in PJM 171–3
inverse price elasticity rule 248
investment at risk 236, 239, 240
investment cost-related pricing (ICRP) 250
investment cycles 35–9
investment lags 33–4
investment strategies 2–3, 98, 102–7
Ireland
net inter-TSO payment of 271
transmission pricing in 271
irreversible investment under uncertainty 13, 31–5, 47
Ishii, J. 67
ISO New England 143, 176
ISOs see independent system operators (ISOs)
Italy
generation investment in 4, 57, 59, 65, 66, 70, 80
net inter-TSO payment of 271
transmission network organization in 147–8
transmission pricing in 265, 266, 271
Johnson, L. 66–7
Jörsten, K. 193, 223
Kaye, R.J. 262
Khator, S.K. 231
King, S. 120
Laffont, J.-J. 151, 163
Larsen, E. 35
Latorre, G. 209, 223
Léautier, T.-O. 120
legacy infrastructure considerations 145–6
Leung, L.C. 231
levelized cost methodology 55, 68, 71, 72, 73, 79
Lévêque, F. 190
lignite 67
line type 7
linear lumpy technology 113–16
linear mixed-integer programs 208–9
load-duration curve 4, 22–5, 48, 49, 51–2
load reduction programs 138
lobbying 108, 118, 127
locational signals see locational transmission signals, long-term; nodal energy pricing
locational transmission signals, long term
information-related 256–7, 277
transmission charges 187–228, 240–250
access rules and 257–8
case examples 262–77
incremental charges for new network users 250–255
for retiring generators 255–6
LOLP (loss of load probability) 5, 6, 35–7, 40
Long Island, HVDC links with 155, 171, 173
Long Island Power Authority (LIPA) 155, 171, 173
long-term contracts 13, 14, 38–9, 78, 79, 80, 134, 155–6, 157, 171, 173
two types of 221
long-term locational signals see locational transmission signals, long term
loss of load probability (LOLP) 5, 6, 35–7, 40
lump-sum charges 269
lumpiness 7–8, 9, 10, 14, 87, 95, 97, 154, 187, 188
compared with economies of scale 101–2, 113–16
merchant transmission investment with 119, 156–7
transmission pricing with 191–2, 201, 204, 221, 250
Luxembourg
net inter-TSO payment of 271
transmission pricing in 271
MAAC (Mid-Atlantic Area Council) 165
MacKerron, G. 75
marginal cost of generation 195
equilibrium energy price compared with 4, 13, 22–6, 37, 39, 40, 95–6, 165, 166
depicted for new network users 250–255
globally 251
geographically differentiated 8, 95, 244
known to regulator 197
wind power 103
marginal cost of transmission
compared with congestion cost 139, 175, 187
compared with congestion rent 100, 101–2, 106, 113
compared with nodal price differential 8, 95–6
transmission prices reflecting 153, 253–4
marginal locational pricing see nodal energy pricing
marginal opportunity cost of consumption 4, 25
market design 140, 181
market power
absence of 188, 193, 224, 245
diversification as insurance against 41–2
and fixed cost recovery 14, 108, 117–18
of local suppliers due to transmission limitations 119
price distortions caused by 5, 39, 42, 88
transmission rights and 110, 112, 247
underinvestment as a method of abusing 113, 236
market windows 172, 173, 174–5, 176–7
Massachusetts Institute of Technology (MIT) 55, 71, 72, 73–6
McDaniel, T. 124
mean load factor 75
mean reversion 34–5
measuring transmission capacity 145
Mercados Energéticos for Osinerg (Peruvian Energy Regulatory Agency) 254
merchant plants 38, 73, 74, 77, 81
merchant transmission investment 14, 88, 102, 108–18, 236, 239
congestion rents and 9, 110–118, 156, 171, 177, 236, 237, 241, 242
financing costs for 156
long-term contracts undertaken by 134
mixing planned and merchant transmission 9, 118–19, 180–181, 237, 242
in PJM 155, 169–71, 173
policy initiatives based on 126–7
regulatory framework
accommodating 150, 155–7, 191, 221, 237
Mid-Atlantic Area Council (MAAC) 165
Midwest ISO (MISO) 165
Mishan, E. 67
MISO (Midwest ISO) 165
MIT (Massachusetts Institute of Technology) 55, 71, 72, 73–6
monitoring and control equipment 15, 144
mothballing 12–13, 31, 33, 35, 37–8, 45
National Grid Company (NGC) 12, 42, 157–64, 234
Nemirovskii, A. 209
net investment
definition of 21
in selected countries 42, 43, 44, 45
net local demand curve 89
net power output 272
net present value 98, 276
net social benefit 105–6
NETA (New Electricity Trading Arrangements) 12, 158, 162
Netherlands
net inter-TSO payment of 271
transmission pricing in 265, 266, 271
network operating practices 133, 140, 144
network upgrade costs 142, 168–70, 172
New Electricity Trading Arrangements (NETA) 12, 158, 162
New England, HVDC links with 141, 171, 182
New England Power Pool 146
New England regional expansion plan 143, 176
New York City
HVDC links with 155, 156, 171, 173
market power in 126
New York ISO 112, 132
New Zealand
average participation (AP) method used in 283, 284
transmission network organization in 147–8
Newbery, D.M. 38, 67, 78, 79, 132
NGC (National Grid Company) 12, 42, 157–64, 234
‘Nimby’ constraints 143, 171
nodal energy prices
congestion managed by 197, 198–9, 201, 211, 212, 214–15, 216, 217, 222
definition of 8
financial transmission rights and 10, 112, 191, 221
locational signals in 11, 240–245, 261, 262, 263, 277
and optimal investment mix 10, 88, 90 in PJM 8
nominal capacity 272–3
non-discriminatory prices 16, 188–90, 200, 201, 202, 204, 217–20, 223, 224, 248
non-linear mixed-integer programs 208–9
Nord Pool 43, 45
NordNed Cable 182
Norway
generation investment in 43–4, 54, 57, 59
net inter-TSO payment of 271
transmission network organization in 148
transmission pricing in 249, 271
nuclear power plants
base-load plants 3–4, 22, 43
technological switch to/from 13–14, 54, 55, 58, 60, 61, 62, 63, 64, 65, 66
factors affecting 67, 69, 71–2, 73–80, 81
nuclear Pressurized Water Reactor (PWR) 71–2
NVE (Norwegian Energy Regulatory Authority) 59
O’Neill, R.P. 10, 188, 194, 223
obligation capacity 6, 11–12, 166
Ofgem (Office of Gas and Electricity Markets) 12, 162, 164, 182, 159, 161, 162, 164
oil-fired plants 60, 61, 62, 63, 64, 65, 66
oil tankers 35
Olmos, L. 268
OMEL 268
open access 233, 235, 241
open-cycle gas turbines 22, 69
operating and maintenance costs 68, 69, 75, 79, 81, 146, 161–2
opportunity cost of investment 237
optimal transmission
cost recovery for 99–102
dynamic 96–7
option value 97–8
static 93–6, 102–3
strategic manipulation of optimal transmission planning 105–7
option rights 110–111
option value 6, 13, 31, 32, 33, 34, 79, 80, 97–8, 102
Outhred, H.R. 262
participation constraint, TSO 150–151
participation factor 252–3
‘passive’ TSOs 233, 235, 239
incentives for 240
path ratings 125
payback period 172, 173, 174–5
peaking plants 3–4, 22–30, 40, 46, 49, 51–2
Peco, J.P. 260, 280
penalties 6, 40, 125, 166, 234, 235, 240
Pérez-Arriaga, J.I. 190, 193, 205, 230, 245, 246, 248, 250, 254, 262, 263, 268, 286
perfect competition 33, 90, 112, 113, 188, 197, 200, 204
perfect information 188, 193, 197, 223–4
performance attributes of transmission networks 146–7
performance-based regulation (PBR) distribution networks 259, 260
transmission investment 88, 102, 119–25, 135, 180, 240
difficulties for transcos 14–15, 124–5
direct approach to 120–121
NGC revenues 161–2
policy initiatives based on 126–7
two approaches to reducing
information rent 121–5
performance norms for TSOs 135, 180
permits for new transmission links 149
physical attributes of transmission
network components 143–5
Pindyck, R.S. 31–3, 35
PJM Interconnection 127–8, 167, 170, 175, 178, 181
PJM (Pennsylvania–New Jersey–Maryland)
capacity markets operated by 6, 11, 40, 166
congestion charges in 131–2, 173–4
creation of 54
expansion of 140, 165, 173
financial transmission rights (FTRs) used by 110–112, 167, 168, 169, 171, 172
HVDC projects involving 155, 169–70, 171
industrial organization and wholesale market design in 11–12, 165–6
nodal energy pricing by 8
Operating Agreement 167, 168
Regional Transmission Expansion Plan (RTEP) 167, 168, 169, 171, 172, 173
Reliability Assurance Agreement 167, 168
reliability criteria in 165, 167–9
reports 58
transmission investment in 132, 143–4, 167–79
transmission pricing in 142, 164–6, 167, 168–70, 173, 254
PJM West (Allegheny Power Systems) 140
planning approach, traditional
distribution investment 230, 280
generation investment 230, 278–80
transmission investment 14, 15, 87–8, 102–7, 118–19, 230, 278–80
compared with competitive regulatory framework 234, 237–8, 281–3
plant decommissioning see retiring
generators
plant size 79, 81
Pollitt, M. 67
pool system 6, 12, 35–7, 40, 43, 45, 146, 158, 165
Pope, S.L. 191
Portugal
net inter- TSO payment of 271
transmission pricing in 265, 266, 271
postage stamp tariff 142, 249
power cuts 14–15, 36, 41, 115, 120, 121, 124, 125, 126
Power Exchange 37
power flow studies 163
power transfer distribution factors (PTDFs) 195, 197, 204, 206
practical transmission planning policy 105–7
pre-construction formalities 33
price capping 5–6, 7, 12, 14, 39–41, 125, 154
reducing power of incentive mechanism 122–5
price discrimination 16, 188–90, 200, 201, 202, 204, 217–20, 223, 224, 248
price-duration curve 4, 23, 25, 49, 51
price elasticity of demand 5, 10, 11, 119
price-taking agents 193, 197
primal linear program (PLIP) 198
primal mixed-integer program (PIP) 194
privatization 65
production set 223
productivity improvements 162
profit maximization 2, 47, 106, 192, 199, 214, 242, 281
profit sharing 122–4, 135, 152, 180
property rights 154
proportionality principle in average participation 283–4, 285
public consultation 161
public goods 41, 154, 177
public interest 1, 5, 18, 134, 135
pulverised fuel technology 69
Quebec, HVDC links with 141, 182
R&D costs 81
RAENG (Royal Academy of Engineering) 68, 69, 72, 73
Ramsey rule 11, 217, 248
ratchet mechanisms 122, 123, 135, 152, 161–2, 180
rate of return (ROR) on investment guaranteed 67
high 114
investment risk premiums affecting 93
normal 123
regulation 88, 102, 122, 125, 126, 127, 166
rationing 25, 36, 41, 138, 154
RAV (regulatory assets value) 161
‘real’ option 31
real-time markets 138, 166, 188
reconductoring existing lines 15, 144
Rede Electrica de Espana (REE) 59, 66, 233
redispersing costs see congestion costs
reference periods (seasons) for network design 222
regional transmission investment planning process 135
regional transmission operators (RTOs) 127–8, 141, 165, 179, 221
regulatory assets value (RAV) 161
regulatory framework for distribution 261
regulatory framework for transmission 134–6, 179–80, 230–231
in England and Wales 159–62, 180
European see European Regulation 1228/2003 on Conditions of Access to the Network for Cross-border Exchanges in Electricity
principles to guide 150–157
regulatory paradigms 17, 232–8, 278–83
in US 135, 165–6, 167, 170, 180
regulatory hold-up 152
regulatory inefficiencies 66–7
regulatory risk 93
regulatory test 231, 232, 234, 235, 237–8, 242, 281
relays and switches 15, 124, 144
reliability assessments 167–8
reliability criteria see engineering reliability criteria
‘reliability’-driven transmission investments 15, 133, 142–3, 154, 241
in PJM 167–9, 175, 178
regulatory test allowing 238
versus ‘economic’ transmission investment 133, 175–7, 180
reliability of supply see engineering reliability criteria; ‘reliability’-driven transmission investments; security of supply
remote monitoring and control equipment 15, 144
remote supply function 88, 89
renewable energies 13, 58, 59, 60, 61, 62, 63, 64, 65, 66, 69, 82
see also hydro-electric generators; wind power
rent extraction goals 151
rental cost of transmission lines 94, 113, 115, 116, 120, 124
request for proposals (RFP) 155
Réseau de Transport de l’Electricité (RTE) transmission network 136, 157
retailers, long-term contracts with 38–9
retiring generators economic factors determining 12–13, 21, 31, 33, 47
growing number of 175
locational signals for 255–6
returns to scale see constant returns to scale; economies of scale
revenue adequacy 222
revenue requirement 161
Ring, B.J. 188, 194, 202
risk attitudes to 18, 153
regulatory 93
and technology choice 13–14, 73–80, 81
Rose, N. 67
Rosellón, J. 125, 191, 220
Rotger, J. 118
Roulet, M. 77
Royal Academy of Engineering (RAENG) 68, 69, 72, 73
Index

RPI-X remuneration 234–5, 240, 260
RTEC (Réseau de Transport de l’Electricité) transmission network 136, 157
RTOs see regional transmission operators (RTOs)
Rubio, F.J. 245, 246, 286
Santaholma, J. 72, 79, 80
scale factor 253
scarcity rent 202
Scarf, H.E. 190
Schmalensee, R. 66, 67, 139, 146, 152
Schwartz, E.S. 35
Schweppe, F.C. 244
Scotland–England interconnector 182
second-best regulatory mechanism 151
security of supply 147
capacity margins and 46
see also engineering reliability criteria; 'reliability'-driven investments
sensitivity analysis 73
SERP 107
Seven-Year Forward Statements (NGC) 158–9
‘shallow’ interconnection policy 134, 142, 170
share prices 46, 77
Sherk, C.J. 235
shirking 123
simulation studies 132
single system paradigm 247
Slovakia, transmission pricing in 265
Slovenia, transmission pricing in 265
SMD (standard market design) 164–5, 191
Smeers, Y. 190, 205, 245, 246, 248, 250
SO procurement behaviour 154
social cost of congestion 172
social welfare maximization 278, 281
software technologies 147
Spain
generation investment in 4, 57, 59, 65, 66, 70, 80
net inter-TSO payment of 271
requests for connection in 256
transmission investment in 146
transmission network organization in 147–8
transmission pricing in 265, 266, 267, 268, 269, 270, 271
Spanish Ministry of Industry, Tourism and Trade 276
spark spread 77
stability ratings 128
standard market design (SMD) 164–5, 191
standards 12, 158, 162–3
State Aid 73, 81
static models 224
stock market values 77
Stoft, S.E. 52, 108, 110, 119, 126, 187, 224, 231
stranded costs 3
Strange, W.C. 33–4
strategic behaviour 2–3, 98, 102–7
strategic generation investment problem 103, 104–5
subcontracting 123–4
subsidies 13, 16, 54, 67, 73, 81, 82, 150, 151
substation facilities 144, 230, 260
Sun, H. 124
sunk costs 30, 31, 33, 38, 47, 92–3, 247, 268
supernormal profits 26, 28, 47
Svenska Kraftnät 45
Sweden
generation investment in 44–5
net inter-TSO payment of 271
transmission pricing in 249, 268, 271
Sweeting, A. 157
Switzerland
net inter-TSO payment of 271
transmission pricing in 265, 266, 271
system balancing costs 160–161, 162
tariff pancaking 246–7
Tasmania, HVDC link with 141, 155
technology, locational price as function of 218–19, 223
technology changes see generating technologies, choice of
telecommunications industry 66
TenneT 182
Index

Texas congestion in 132
generation investment in 57, 58, 62, 65, 77
independent system operators covering 54
thermal efficiency 41, 46, 71, 273, 275
thermal limits 195, 198, 206, 215
thermal power plants 16, 44
timeframe of investments 14, 74–5, 81, 124, 242, 244
Tirole, J.J. 41, 112, 113, 127, 134, 139, 151, 154, 156, 163, 169, 175, 177, 191, 201, 220, 221, 230
total revenue, generating plants 25–6
transaction costs 140
transcos
performance-based regulations for
see performance-based regulation (PBR)
planning by 102
see also independent transco model
transfer payments 89
transformer upgrades 144, 171
transmission
investment in 7–9, 14–15, 87–127, 232–42
coordination between distribution network investment and 17, 138, 231, 258–62, 277, 280
case examples 263–77
see also regulatory framework for transmission
transmission charges
England and Wales 12, 37, 142, 158, 159–60, 161–2, 168, 169, 182, 249, 271
harmonization of pricing practices 15, 133, 232, 263
locational signals in 187–228, 240–250
access rules and 257–8
case examples 262–77
incremental charges for new network users 250–255
for retiring generators 255–6
non-transaction-based 246
PJM 142, 164–6, 167, 168–70, 173, 254
transmission cost functions 14, 93, 94, 100, 101–2, 106, 112, 245, 248
transmission licences 158, 163, 234, 236
transmission line relief orders (TLRs) 131
transmission losses 8, 24, 146, 166
in distribution grids 280
economic incentives to reduce 235
in economic models of transmission investment 139, 175
locational signals related to 270
magnitude of 87, 100, 273, 274
mechanisms to account for 279
transmission network facilities, definition of 136–7
transmission network organization 147–50
transmission planning process, requirements of 154–5
transmission rights 9, 88, 89, 108–10, 138, 153, 163, 236, 241, 257
congestion revenue rights (CRRs) 109–10, 111, 112, 115
financial transmission rights (FTRs) 3, 10, 110–112, 167, 168, 169, 171, 172, 191–2, 221
and market power 110, 112, 247
paradox of 112–13
planning incorporating 154, 231
transmission service price structures 152–3
transmission signals, locational see locational transmission signals, long term
Transmission System Security and Quality of Service Standards 158, 162–3
transparency of long-term signals 215–16, 224–5
Transpower 283
tree pruning 15, 124
trigger price investment rule 32–3
Turvey, R. 67
TVO 14, 79
two-part tariffs 201
uncertainty
irreversible investment under 13, 31–5, 47
signals to reduce 255, 256–8, 277
types of 30–31
underwater links 155
unhedgeable congestion 172, 173, 174–5, 177, 178
unit commitment problem 193, 202, 223
United Kingdom see England and Wales; Scotland–England Interconnector
United States
blackouts in 124, 126
cost of capital in 75, 76
generation investment in 2, 4, 13–14, 37, 45–6, 47, 53–65, 67, 68, 71, 72, 73–4, 77–8, 80, 81
legacy infrastructure in 145–6
market power in generation in 126
obligation capacity in 6
regulatory framework for transmission in 135, 165–6, 167, 180
reliability of supply in 14–15
transmission congestion in 131–2
transmission investment in 142, 164–5, 180
see also PJM (Pennsylvania–New Jersey–Maryland)
transmission network facilities in 136
transmission network organization in 148, 179
transmission pricing policy in 164–5, 170
see also PJM (Pennsylvania–New Jersey–Maryland)
unreliability 92
unserved load, cost of 120, 121, 122, 125
upgrading lines 125
US Energy Information Administration (EIA) 164
use of system charges in England and Wales 142, 158, 159–60, 161, 168, 169, 182
regulatory framework for determining 161–2
useful life of a power plant 273
useful power delivered 272
value of lost load (VOLL) 5–7, 36, 40, 176
vertical integration model 147
regulatory challenges associated with 149
viability constraint, TSO 150–151
Vickers, J. 66
Victoria (Australia), HVDC link with 141, 155
Vogelsang, I. 107, 125, 192, 223
VOLL (value of lost load) 5–7, 36, 40, 176
voltage increases 144
voltage level, transmission charges related to 257–8
wholesale market prices 38–9, 42, 74, 77, 120, 133, 140
willingness to pay 5, 10, 41, 153, 197, 201, 214, 223–4
Wilson, R. 128, 138
wind power 65, 69, 103, 106–7, 256
wireless network 66
Wolfram, C.D. 67, 157
Wolsey, L.A. 206, 228
Woolf, F. 191
Yan, J. 67
Yarrow, G. 66
yield to equity 14, 75–6
zero-congestion policy 14, 91–3, 95, 106, 119
strategic manipulation of 102–3
zonal prices 3, 262, 267