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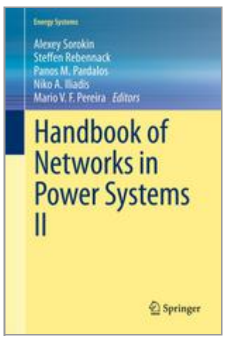
Costs and Constraints of Transporting and Storing Primary Energy for Electricity Generation

Abstract

This article describes the fuel transportation and storage components of the supply chain for electricity. We focus on dispatchable generation based on transportable fuels. Coal has very flexible transportation and storage requirements. Natural gas requires pressurized pipelines and storage facilities; or it can be liquefied, then stored and transported at very low temperatures, and then revaporized. Biomass presents logistical challenges related to its relatively low energy intensity and seasonality of supply. We review ways to model the physical constraints and cost characteristics that govern the transportation and storage of these fuels and examine their implications for decision models in restructured electricity markets.



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References (68)

1. Energy Information Administration (2010) International energy outlook 2010. U.S. Department of Energy, Washington, DC
2. Energy Information Administration (2010) Electric power annual 2008. Department of Energy, Washington, DC
3. Casten S (2010) Fuel swap: natural gas as a near-term CO_2 mitigation strategy. Public Utilities Fortn 148(4):40–44
4. Federal Energy Regulatory Commission (2005) The Western energy crisis, the Enron bankruptcy, and FERC's response. http://www.ferc.gov/industries/electric/indus-act/wec/chron/chronology.pdf. Accessed Sept 2009
5. Commonwealth of Massachusetts (2006) Electricity price, reliability, and markets report 2005.
6. Federal Energy Regulatory Commission (2008) 2007 state of the markets report
7. Clayton M (2006) Enough coal on hand to keep US cool? Christian Science Monitor, 25 May 2006
8. Bergerson JA, Lave LB (2005) Should we transport coal, gas or electricity: cost, efficiency and environmental implications. Environ Sci Technol 39(16):5905–5910 CrossRef
9. Hogan WW (1975) Energy policy models for project independence. Comput Oper Res 2:251–271 CrossRef
10. Murphy FH, Conti JJ, Shaw SH, Sanders R (1988) Modeling and forecasting energy markets with the intermediate future forecasting system. Oper Res 36(3):406–420 CrossRef
11. Energy Information Administration (2003) The national energy modeling system: an overview. U.S. Department of Energy, Washington, DC
12. Quelhas A, Gil E, McCalley JD, Ryan SM (2007) A multiperiod generalized network flow model of the U.S. Integrated energy system: part I – model description. IEEE Trans Power Syst 22(2):829–836 CrossRef
13. Quelhas A, Gil E, McCalley JD (2007) A multiperiod generalized network flow model of the U.S. Integrated energy system: part II – simulation results. IEEE Trans Power Syst 22(2):837–844 CrossRef
14. Wang Y, Ryan SM (2010) Effects of uncertain fuel costs on optimal energy flows in the U.S. Energy Syst 1:209–243 CrossRef
15. Liu Z, Nagurney A (2009) An integrated electric power supply chain and fuel market network framework: theoretical modeling with empirical analysis for New England. Nav Res Log 56(7):600–624 CrossRef
16. Ryan SM, Downward A, Philpott AB, Zakeri G (2010) Welfare effects of expansions in equilibrium models of an electricity market with fuel network. IEEE Trans Power Syst 25(3):1337–1349 CrossRef
17. Ryan SM (2009) Market outcomes in a congested electricity system with fuel supply network. In: IEEE Power Engineering Society General Meeting, Calgary
18. Ryan SM (2009) Demand price sensitivity and market power on a congested fuel and electricity network. In: IEEE Power & Energy Society General Meeting, Minneapolis, 25–29 July 2010
19. Freme F (2010) U.S. coal supply and demand: 2009 review (trans: Administration EI). U.S. Department of Energy, Washington, DC
20. U. S. Energy Information Administration Coal transportation information. http://www.eia.doe.gov/cneaf/coal/ctrdb/ctrdb.html. Accessed Jul 2010
21. U.S. Energy Information Administration (2006) Coal production in the United States – an historical overview. U.S. Department of Energy, Washington, DC
22. Joskow PL (1987) Contract duration and relationship-specific investments: empirical evidence from coal markets. Am Econ Rev 77(1):168–185
23. Joskow PL (1988) Price adjustments in long-term contracts: the case of coal. J Law Econ 31:47–83 CrossRef

24. Joskow PL (1990) The performance of long-term contracts: further evidence from coal markets. Rand J Econ 21(2):251–274 CrossRef

25. MacDonald JM (1994) Transactions costs and the governance of coal supply and transportation agreements. J Transp Res Forum 34(1):63–74

26. Dennis SM (1999) Using spatial equilibrium models to analyze transportation rates: an application to steam coal in the United States. Transp Res Part E 35:145–154 CrossRef

27. Bienstock D, Shapiro JF (1988) Optimizing resource acquisition decisions by stochastic programming. Manage Sci 34(2):215–229 CrossRef

28. Energy Information Administration (2010) Annual energy outlook 2010. Energy Information Administration, Washington, DC

29. O'Neill RP, Williard M, Wilkins B, Pike R (1979) A mathematical programming model for allocation of natural gas. Oper Res 27(5):857–873 CrossRef

30. De Wolf D, Smeers Y (2000) The gas transmission problem solved by an extension of the simplex algorithm. Manage Sci 46(11):1454–1465 CrossRef

31. De Wolf D, Smeers Y (1996) Optimal dimensioning of pipe networks with application to gas transmission networks. Oper Res 44(4):596–608 CrossRef

32. Ríos-Mercado RZ, Wu S, Scott LR, Body EA (2002) A reduction technique for natural gas transmission network optimization problems. Annals Oper Res 117:217–234 CrossRef

33. Martin A, Möller M, Moritz S (2006) Mixed integer models for the stationary case of gas network optimization. Math Program 105:563–582 CrossRef

34. Chebouba A, Yalaoui F, Smati A, Amodeo L, Younsi K, Tairi A (2009) Optimization of natural gas pipeline transportation using ant colony optimization. Comput Oper Res 36:1916–1923 CrossRef

35. Andre J, Bonnans F, Cornibert L (2009) Optimization of capacity expansion planning for gas transportation networks. Eur J Oper Res 197:1019–1027 CrossRef

36. Djebedjian B, Shahin I, El-Naggar M (2008) Gas distribution network optimization by genetic algorithm. In: Ninth International Congress of Fluid Dynamics & Propulsion, Alexandria, 2008

37. Steinbach MC (2007) On PDE solution in transient optimization of gas networks. J Comput Appl Math 203:345–361 CrossRef

38. Midthun KT, Bjorndal M, Tomasgard A (2009) Modeling optimal economic dispatch and system effects in natural gas networks. Energy J 30(4):155–180

39. Guldmann J-M (1983) Supply, storage, and service reliability decisions by gas distribution utilities: a chance-constrained approach. Manage Sci 29(8):884–906 CrossRef

40. Energy Information Administration (2009) Major legislative and regulatory actions (1935–2008). http://www.eia.doe.gov/oil_gas/natural_gas/analysis_publications/ngmajorleg/ngmajorleg.html. Accessed Sep 2010

41. Duann DJ (1991) Direct gas purchases by local distribution companies: supply reliability and cost implications. J Energy Dev 15(1):61–91

42. Guldmann J-M, Wang F (1999) Optimizing the natural gas supply mix of local distribution utilities. Eur J Oper Res 112:598–612 CrossRef

43. Avery W, Brown GG, Rosenkranz JA, Wood RK (1992) Optimization of purchase, storage and transmission contracts for natural gas utilities. Oper Res 40(3):446–462 CrossRef

44. Bopp AE, Kannan VR, Palocsay SW, Stevens SP (1996) An optimization model for planning natural gas purchases, transportation, storage and deliverability. Omega 24(5):511–522 CrossRef

45. Butler JC, Dyer JS (1999) Optimizing natural gas flows with linear programming and scenarios. Decis Sci 30(2):563–580 CrossRef

46. Contesse L, Ferrer JC, Maturana S (2005) A mixed-integer programming model for gas purchase and transportation. Annals Oper Res 139:39–63 CrossRef

47. Gabriel SA, Kiet S, Zhuang J (2005) A mixed complementarity-based equilibrium model of natural gas markets. Oper Res 53(5):799–818 CrossRef

48. Gabriel S, Smeers Y (2006) Complementarity problems in restructured natural gas markets. In: Seeger A (ed) Recent advances in optimization, Lecture notes in economics and mathematical systems. Springer, Berlin, pp 343–373 CrossRef

49. Lise W, Hobbs BF (2009) A dynamic simulation of market power in the liberalised European natural gas market. Energy J 46(Special Issue):119–135

50. Shahidehpour M, Fu Y, Wiedman T (2005) Impact of natural gas infrastructure on electric power systems. Proc IEEE 93(5):1042–1056 CrossRef

51. Li T, Eremia M, Shahidehpour M (2008) Interdependency of natural gas network and power system security. IEEE Trans Power Syst 23(4):1817–1824 CrossRef

52. Liu C, Shahidehpour M, Fu Y, Li Z (2009) Security-constrained unit commitment with natural gas transmission constraints. IEEE Trans Power Syst 24(3):1523–1536 CrossRef

53. Takriti S, Krasenbrink B, Wu LS-Y (2000) Incorporating fuel constraints and electricity spot prices into the stochastic unit commitment problem. Oper Res 48(2):268–280 CrossRef

54. Takriti S, Supatgiat C, Wu LS-Y (2002) Coordinating fuel inventory and electric power generation under uncertainty. IEEE Trans Power Syst 17(1):13–18 CrossRef

55. Chen H, Baldick R (2007) Optimizing short-term natural gas supply portfolio for electric utility companies. IEEE Trans Power Syst 22(1):232–239 CrossRef

56. Geidl M, Andersson G (2007) Optimal power flow of multiple energy carriers. IEEE Trans Power Syst 22(1):145–155 CrossRef

57. Thomas S, Dawe RA (2003) Review of ways to transport natural gas energy from countries which do not need the gas for domestic use. Energy Convers Manage 28:1461–1477

58. Kuwahara N, Bajay SV, Castro LN (2000) Liquefied natural gas supply optimisation. Energy Convers Manage 41:153–161 CrossRef

59. Jaramillo P, Griffin WM, Matthews HS (2007) Comparative life-cycle air emissions of coal, domestic natural gas, LNG, and SNG for electricity generation. Environ Sci Technol 41(17):6290–6296 CrossRef

60. Cayrade P (2004) Investments in gas pipelines and liquefied natural gas infrastructure. What is the impact on the security of supply. The Fondazione Eni Enrico Mattei Note di Lavoro Series. Fondazione Eni Enrico Mattei

61. BP (2010) BP statistical review of world energy

62. Zheng QP, Pardalos PM (2010) Stochastic and risk management models and solution algorithm for natural gas transmission network expansion and LNG terminal location planning. J Optim Theory Appl 147:337–357 CrossRef

63. Haq Z (2002) Biomass for electricity generation. Energy Information Administration, Washington, DC

64. Dornburg V, Faaij APC (2001) Efficiency and economy of wood-fired biomass energy systems in relation to scale regarding heat and power generation using combustion and gasification technologies. Biomass and Bioenergy 21:91–108 CrossRef

65. Caputo AC, Palumbo M, Pelagagge PM, Scacchia F (2005) Economics of biomass energy utilization in combustion and gasification plants: effects of logistic variables. Biomass and Bioenergy 28:35–51 CrossRef

66. Sims REH, Rogner H-H, Gregory K (2003) Carbon emission and mitigation cost comparisons between fossil fuel, nuclear and renewable energy cost resources for electricity generation. Energy Policy 31:1315–1326 CrossRef

67. Gan J, Smith CT (2006) A comparative analysis of woody biomass and coal for electricity generation under various CO_2 emission reductions and taxes. Biomass and Bioenergy 30:296–303 CrossRef

68. Energy Information Administration (2007) Energy and economic impacts of implementing both a 25-percent renewable portfolio

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