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Lessons from the Communications Industry in Standards Setting for the Smart Grid

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Abstract

This paper examines the development of standards for other communications technologies to determine whether they carry lessons for Smart Grid operators, policymakers, and technologists. The development of AM stereo suggests that, for certain industry structures, grave harm may be caused by consumer uncertainty about competing standards. By comparison, the early years of the landline telephone industry highlight some of the advantages of closed standards accompanied by vertical integration. However, as the landline industry and network matured, the ensuing battles between the network operator and equipment suppliers necessitated government involvement in the standard-setting process so that competitive forces could drive innovation. Most recently, the cellular telephony industry offered an excellent comparison of *de jure* and *de facto* standards. The first generation of U.S. cellular telephones relied on a single FCC-mandated *de jure* standard, while systems across the European Union varied from one country to the next. When the second generation of cellular technology arrived, the tables were turned and the U.S. relied solely on market forces to create multiple *de facto* standards, while all the countries in the European Union collaborated on a single *de jure* standard embraced by every national government. Lessons can readily be drawn about the interaction between the speed of standard setting and adoption rate, as well the impact of intellectual property, and interests vs. experts in the standard-setting process.

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Introduction

Through the addition of communications, monitoring, and intelligence to the electric grid, the Smart Grid offers an opportunity for a more reliable energy delivery network and higher-efficiency utilization of generation capacity. Communications, however, require common standards. This paper examines the development of standards for other communications technologies to determine whether they carry lessons for Smart Grid operators, policymakers, and technologists. Specifically, we examine the advent of AM Stereo, the landline telephony network, and first- and second-generation cellular telephony.

The development of AM stereo suggests that, for certain industry structures, grave harm may be caused by consumer uncertainty about competing standards. While competition among standards may spur greater research and technological advances among the leaders in a field, public jousting between standards proponents may simultaneously shrink the prospective market size.

The landline telephony industry provides an opportunity to watch the evolution of standards over the course of a century. The early years of the industry highlight some of the advantages of closed standards accompanied by vertical integration. However, as the industry and network matured, the ensuing battles between the network operator and equipment suppliers highlighted the need for government involvement in the standard-setting process so that competitive forces could drive innovation.

The cellular telephony industry offers an excellent comparison of *de jure* and *de facto* standards. The first generation of U.S. cellular telephones relied on a single FCC-mandated *de jure* standard, while systems across the European Union varied from one country to the next, and often within particular countries. When the second generation of cellular technology arrived, the tables were turned and the U.S. relied solely on market forces to create multiple *de facto* standards, while all the countries in the European Union collaborated on a single *de jure* standard embraced by every national government. This swapping of positions between the U.S. and EU enables us to compare the standard-setting procedures while controlling for national differences. Lessons can readily be drawn about the interaction between the speed of standard setting and adoption rate, as well the impact of intellectual property, and interests vs. experts in the standard-setting process. Additionally, the current transition from second to third generation cellular also foreshadows the potential costs of setting a standard too soon.

Smart Grid Background

Incensed by blackouts,[1] rising energy prices,[2] and greenhouse gas emissions,[3] many complain that the United States' electricity grid is antiquated and should be overhauled. Technologies and processes that would make the electric power grid more reliable, secure, efficient, and environmentally friendly are referred to as "Smart Grid" technologies. The promise of the Smart Grid includes more nuanced transactions between power consumers and providers, the deployment of new forms of power generation and storage, and reducing the need for capital investment by optimizing the utilization of existing network assets.[4]

Implementing the Smart Grid requires communications and interoperability throughout the power supply chain: from power generators to distributors to appliance manufacturers to consumers. And this communication must be two-way because the supply chain itself may be up-ended: consumers may sometimes function as power suppliers, through the use of on-site power generation and storage. Meanwhile, power distributors may find it more cost-effective to negotiate a demand reduction from consumers rather than adding higher-priced marginal additional generation capacity.

While industrial firms use more power than households, many businesses are unable to decrease their power usage because their manufacturing equipment must run and their office must remain open during the workday, when employees are present. Consumers, by contrast, often have more flexibility in aspects of their power consumption, particularly with regard to the operation of appliances, which account for approximately 22% of electricity consumption in the U.S. residential sector.[5] Clothes dryers, for example, can be run at any time of the day or night and are the second most

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[1] Matthew L. Wald, Richard Perez-Pena and Neela Banerjee, "The Blackout: What Went Wrong; Experts Asking Why Problems Spread So Far", *New York Times,* August 16, 2003; Section A; Column 5; Metropolitan Desk; Pg. 1; Nick Allen, Sean Hazlett, and Matt Nerlinger, Clean Energy; Smart Grid: The Next Infrastructure Revolution Morgan Stanley Research, March 25, 2009 ("power outages and disturbances cost the economy $25–180 billion annually.").

[2] Jeff Postelwait, "What the Smart Grid means for plant efficiency", *Power Engineering*, April 29, 2009 (available at http://pepei.pennnet.com/display_article/360323/6/HWACS/none/none/1/What-the-Smart-Grid-means-for-plant-efficiency/) ("the rising cost of electricity will remain the biggest factor in spurring interest in the greater efficiency that the Smart Grid offers,")

[3] Christian Feisst, Dirk Schlesinger, and Wes Frye, Smart Grid: The Role of Electricity Infrastructure in Reducing Greenhouse Gas Emissions, Cisco Internet Business Solutions Group White Paper, October 2008 (available at http://www.cisco.com/web/about/ac79/docs/wp/Utility_Smart_Grid_WP_REV1031_FINAL.pdf) at 2 ("A technology-enabled electric system . . . can reduce greenhouse gas emissions [by] . . . Reduc[ing] peaks in power usage by automatically turning down selected appliances in homes, offices, and factories; Reduc[ing] waste by providing instant feedback on how much energy we are consuming; [and] Encourag[ing] manufacturers to produce "smart" appliances to reduce energy use")

[4] Joe Miller, What Is the Smart Grid?, *SmartGridNews.com*, April 17, 2009 (available at http://www.smartgridnews.com/artman/publish/commentary/What_Is_the_Smart_Grid-567.html)

[5] D. Pimentel et al., "US Energy Conservation and Efficiency: Benefits and Costs," *Environment, Development and Sustainability* 6, no. 3 (2004): 286.

energy consumptive appliance in the average household, using the equivalent of 5 billion liters of oil per year of primary energy.[6]

Enabling communication among the many links in the supply chain and across many types of energy-consuming devices, ranging from refrigerators to wind turbines, requires wide-ranging coordination. In an effort to jumpstart this coordination, Congress, through Title XIII of the Energy Independence and Security Act (EISA) of 2007,[7] charged the National Institute of Standards and Technology (NIST) to "coordinate development of a framework that includes protocols and model standards for information management to achieve interoperability of smart grid devices and systems."[8] The NIST framework should consider not just technology, but also the policy and business implications of its recommendations.[9] "[I]nput and cooperation" is to be sought from the Federal Energy Regulatory Commission, the Department of Energy's Office of Electricity Delivery and Energy Reliability (OEDER), as well as non-governmental entities such as the Gridwise Architecture Council, the International Electrical and Electronics Engineers, the National Electric Reliability Organization, and National Electrical Manufacturer's Association.[10]

Thus far, the communications specifications being developed for Smart Grid technologies such as Home Area Networks and Advanced Metering Infrastructure "mostly are being championed by individual companies or a consortia made up of several corporations.[11] The Federal Energy Regulatory Commission (FERC) reports that this battle of standards has a cost: "General uncertainty over the development and evolution of standards . . . has some state regulators reluctant to proceed with [Advanced Meter Infrastructure] specifications, because they may discover a year or two later that they chose an inferior or unsupported technology."[12]

Would market-driven, rather than government-sponsored coordination of standards create a better result? And are there lessons from past standard-setting processes that might be applicable to the Smart Grid? This paper addresses such questions by reviewing the history of standards during the development of the landline and cellular telephony networks, as well as the advent and ultimate failure of AM Stereo radio technology. All of these analogies involve utility-scale services and customer premises equipment.

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[6] *Id.*
[7] H.R. 6, 110th Congress.
[8] EISA, § 1305.
[9] *Id.*
[10] *Id.*
[11] Betsy Loeff, "Way to Go? HAN Protocols Up For Grabs," *Utilimetrics Newsletter*, March 2009, http://www.utilimetrics.org/source/newsletter/index.cfm?fuseaction=Newsletter.showThisIssue&Issue_ID=81.
[12] 2008 Assessment of Demand Response and Advanced Metering, Federal Energy Regulatory Commission, at 18.

Communications Standards and Competition

Given the Smart Grid's origin as a communications network built by and for regulated utilities, there are significant parallels with the growth of the wireless and wireline communications networks in the United States. Just as those communications networks required action by both utilities and consumers, so will the Smart Grid. And, like telephony and radio, the mass adoption of customer premises equipment will be essential to the Smart Grid's success.

This working paper examines the role of standards and competition in the provision of communications equipment. "Standardization is basically a management technique used to reduce risk[.]"[13] By developing and adhering to a standard that is widely accepted, customers reduce the risk that the network equipment they purchase will be incompatible across multiple service providers and geographies. Service providers benefit from standards because they can engender more competition among equipment providers, at both the network and consumer levels.

Standards range from those decided by the marketplace (*de facto*) to those decided by law (*de jure*). The degree of openness of standards varies widely, ranging from open source to open interface.[14] Some standards encompass intellectual property owned exclusively by private parties, who may license it to others, while other standards eschew any privately-held patents or technology.[15]

This paper examines the role of the United States government in setting communications standards and how differing government approaches have impacted the success of proposed standards and those who relied upon them. Likewise, the paper explores the impact of a marketplace of competing standards on service economics, consumer behavior, and the public welfare. Given Congress' mandate to NIST to coordinate Smart Grid standards, lessons from past government involvement in communications standards may prove insightful.

The paper first examines the attempted commercialization of AM Stereo technology and service in the United States. As the federal government embraced a new wave of pro-competitive deregulation, the Federal Communications Commission (FCC) determined that a pro-competition approach should extend not just to companies, but to standards. AM stereo may prove an apt analogy to the Smart Grid because the scale of the radio industry is reminiscent of the utility industry, with thousands of regional and

[13] Carl Cargill & Sherrie Bolin, "Standardization: a failing paradigm" in Shane Greenstein & Victor Stango (eds.), *Standards and Public Policy* (New York: Cambridge University Press, 2007) at 296.
[14] Joel West, "The economic realities of open standards: black, white, and many shades of gray" in Shane Greenstein & Victor Stango (eds.), *Standards and Public Policy* (New York: Cambridge University Press, 2007) at 109.
[15] See, e.g., Glyn Moody, *Rebel Code: Linux and the Open Source Revolution* (New York: Basic Books, 2002) for a discussion of the efforts to create a personal computer operating system free of privately-held intellectual property.

local operators (radio stations and power companies) each making their own equipment decisions.[16]

Next, the paper next explores the impact of closed standards set by a vertical monopoly, as existed in the wireline telephony industry for many years. Contrary to the dogmatic ethos that demands 100 percent competition at all times, a review of the early years of the telephone system suggest that there may have been some advantages in the employment of a closed standard for telephone equipment and service at the outset. Opening this closed standard and unraveling the vertical integration in later years also provides a cautionary tale about how closed standards can stunt innovation.

Finally, the paper turns to the field of wireless communications, which is capable of offering ongoing insights as new generations of technology are rolled out and new players continue to enter the market. The evolution of the cellular telephone industry reveals how communications standards can impact not only consumers, but also a country's international competitiveness. The striking contrast between the U.S. and European governmental approaches to the first and second generations of cellular telephony technology also yield important lessons for policymakers who are unsure about when a standard should be finalized.

[16] As of 2007, there were more than more than 3,273 traditional electric utilities in the United States. See Electric Power Industry Overview 2007. Energy Information Agency, U.S. Department of Energy (available at http://www.eia.doe.gov/cneaf/electricity/page/prim2/toc2.html). And there "around 14,000" radio stations. See "Number of Licensed Radio Stations Grows", *Radio World*, March 21, 2008 (available at http://www.radioworld.com/article/62912).

Battling Standards and Collateral Damage: The Case of AM Stereo

One method of setting standards for the Smart Grid is for the government to step aside and allow the private sector proponents of various standards to compete in the marketplace, in a Darwinian contest to weed out the weak. Before embarking on this path, regulators would be wise to revisit the introduction of AM stereo technology to the United States.

Historically, radio technology standards were specified and approved by the Federal Communications Commission (FCC). When it came time to plant its imprimatur of approval on a specific technology to convert AM radio to stereo, the FCC demurred. The result has been described as a "day-late and buck-short[,]"[17] and also as a "debacle[.]"[18]

The Role of the Regulator in Setting Standards

Within a little more than a decade of its introduction, FM listenership surpassed that of monaural AM radio.[19] Technology to transform AM into stereo, first demonstrated in around 1959 by RCA and Philco, was expected to be AM's rejoinder.[20] While FM technology offered a greater frequency range, there were still several potential advantages to an AM stereo offering: 1) it could be broadcast over longer distances than FM, which was an issue for mobile radio reception (e.g. in automobiles); 2) it would be less susceptible to the fading and multipath issues that impacted FM stereo reception in automobiles; 3) more rural communities lacked FM stations so AM stereo was their only possibility for stereo radio reception; and 4) AM stereo broadcasters believed a stereophonic offering was necessary to ensure the long-term competitiveness of their station relative to FM.[21]

An FCC Notice of Inquiry into AM stereo in July 1977[22] garnered 90 responses,[23] leading the FCC to conclude that "a great interest in this service exists", however further

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[17] "Marketing Blunders Abounded in CE History", *Consumer Electronics*, Vol. 40, No. 3, January 17, 2000.

[18] Anthony R. Gargano, "The race begins", *Broadcast Engineering*, July 1, 2007; and "Broadcasters Offer Open Letter for Open Standards", *Consumer Electronics Daily*, June 20, 2007.

[19] W.A. Kelly Huff, "FM Stereo and AM Stereo: Government Standard-Setting vs. the Marketplace", Paper Presented at Annual Meeting of the Association for Education in Journalism and Mass Communication, July 2-5, 1988 at 4 (available at http://www.eric.ed.gov/ERICDocs/data/ericdocs2sql/content_storage_01/0000019b/80/1d/a6/fb.pdf).

[20] Bruce C. Klopfenstein & David Sedman (1990). Technical standards and the marketplace: The case of AM stereo. *Journal of Broadcasting & Electronic Media*, 1990, Vol. 34, No. 2, 171-194; Mark J. Braun, *AM Stereo and the FCC: Case Study of a Marketplace Shibboleth* (Ablex Publishing Corporation: Norwood, NJ, 1994) at 40.

[21] Klopfenstein & Sedman (1990), *supra* note 20, at 178.

[22] Federal Communications Commission, Notice of inquiry: AM stereophonic broadcasting, 42 F.R. 34910 (1977).

investigation was needed "before any standards are to be adopted."[24] Meanwhile, marketplace experimentation had already begun: Kahn Communications, Motorola, and Magnavox each launched their own, incompatible, AM stereo broadcasting systems.[25]

By April 1980, the FCC's Office of Science and Technology recommended that the Commission "adopt a single AM stereo system"[26] because "if no standard were chosen . . . the general public would have a difficult time perceiving the nuances in the differences between systems [and] incompatible systems would impose additional costs and uncertainties on both broadcasters and consumers."[27] Likewise, "[b]roadcasters and the consumer electronics industry urged the Commission to act quickly in selecting a system."[28] The Commission, noting that Magnavox was the leading choice in its testing to date,[29] agreed to conduct further technical evaluation, however it cautioned that futher testing might yield a tie between multiple systems.[30] Suggestions to prevent a tie included ordering multi-mode systems that could accommodate more than one AM stereo technology, or perhaps choose a standard using a lottery.[31]

Yet, in the background, deregulation was in the air. Under President Carter, the federal government dramatically limited its oversight and control over the airlines,[32] trucking companies,[33] the railroads,[34] and other industries. The push for shrinking government involvement in industry accelerated under President Reagan, who promptly established a cabinet-level Task Force on Regulatory Relief.[35] This emphasis on market-driven decisions impacted the FCC with the arrival of Reagan's new FCC Chairman

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[23] Federal Communications Commission, Notice of proposed rulemaking: AM stereophonic broadcasting, 43 F.R. 48659 (1978).
[24] *Id.*
[25] Klopfenstein & Sedman (1990), *supra* note 20, at 178.
[26] Federal Communications Commission, Further notice of proposed rulemaking: AM stereophonic broadcasting, 45 F.R. 59350 (1980).
[27] Klopfenstein & Sedman (1990), *supra* note 20, at 179.
[28] Federal Communications Commission, Report and order in the matter of AM stereophonic broadcasting, 47 F.R. 13152 (1982).
[29] FCC makes it Magnavox for AM stereo, *Broadcasting*, April 14, 1980, at 27.
[30] Federal Communications Commission (1980), *supra* note 26.
[31] *Id.*
[32] Carole Shifrin, "Carter Signs Airlines Deregulation Bill; Airline Deregulation Designed to Boost Competition", *Washington Post*, October 25, 1978.
[33] "Carter Signs Bill For Deregulation Of Truck Lines; Kennedy Comments Carter Signs Trucking Bill A Display of Harmony", *New York Times*, July 2, 1980.
[34] Mark H. Rose, Bruce Edsall Seely, & Paul F. Barrett, *The Best Transportation System in the World: Railroads, Trucks,Aairlines, & American Public Policy in the 20th Century* (Ohio State University Press, 2006), at 205.
[35] See, e.g., Larry N. Gerston, Cynthia Fraleigh, & Robert Schwab, *The deregulated society* (Wadsworth, 1988); and John Logan Palmer & Isabel V. Sawhill, *The Reagan experiment: an examination of economic and social policies Under the Reagan Administration* (Urban Institute, 1982).

Mark Fowler,[36] and a new focus on deregulating content requirements in the radio industry.[37]

Chairman Fowler proved a receptive audience when one AM stereo technology proponent, Kahn Communications, argued that the marketplace would be less likely to reach an incorrect decision than the FCC and that manufacturers could make hardware supporting more than one technology, if necessary.[38] Broadcasters ABC and NBC echoed the preference for a marketplace decision, rather than a government mandate; however the majority of responses "preferred that the Commission select a single AM stereo system."[39] General Electric adroitly noted that system deployment must precede consumer preferences, and, thus the marketplace was not ready to decide.[40] Hardware manufacturers such as Matsushita, Sony, and the Consumer Electronics Group of the Electronics Industries Association noted that a multi-mode system would be prohibitively expensive.[41] And developers of four of the five leading AM stereo technologies (Harris, Magnavox, Motorola, and Belar) announced that they "did not favor a marketplace approach and would accept any FCC choice."[42]

Notwithstanding the requests of many hardware manufacturers and radio station operators for the FCC selection of an AM stereo standard, the Commission decided in 1982 that the ranking of various technologies was too close, so it would leave standard selection to the private market.[43] This decision was based on the Commissions' concern about a lack of uniform test procedures, and a belief that the proper weighting of the evaluation criteria was purely subjective and likely to vary significantly among analysts.[44] The FCC expected its hands-off approach would benefit "private parties who . . . [may] assign their own value weights to the various characteristics of the [competing] systems."[45] Further, the FCC expected that its decision to not favor a particular manufacturer's preferred standard meant that the overall field of manufacturers would be increased, thus leading to greater cost reductions driven by increased competition.[46] And by not anointing a specific manufacturer's system as the winner, other manufacturers would continue to innovate their own systems, rather than being forced to pay patent

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[36] Klopfenstein & Sedman (1990), *supra* note 20, at 178.

[37] W.A. Kelly Huff, "FCC Policy and AM Stereo: From Governmental Standard-Setting to the Marketplace", Paper Presented at Annual Meeting of the Speech Communication Association, November 3-6, 1988 at 15; Jason B. Meyer, "The FCC and AM Stereo: A Deregulatory Breach of Duty", *University of Pennsylvania Law Review*, December 1984, Vol. 133, No. 1, 265 at 269 (describing Fowler as "an avowed advocate of deregulation).

[38] Federal Communications Commission, Report and order in the matter of AM stereophonic broadcasting, 47 F.R. 13152 (1982).

[39] *Id.*

[40] *Id.*

[41] *Id.*

[42] Klopfenstein & Sedman (1990), *supra* note 20, at 179 (citing "Airing Gripes over AM Stereo", *Broadcasting*, October 13, 1980, pp. 38-40).

[43] Federal Communications Commission (1982), *supra* note 38.

[44] *Id.*

[45] *Id.*

[46] *Id.*

licensing fees to owner of the winning standard. In short, the FCC grounded its decision in the belief that it should not "override the inherent benefits of consumers making their own choices rather than having their decisions made by government."[47]

The Commission considered it unlikely that "no system would be adopted widely enough to sustain AM stereo in the market" because "if a threshold level of acceptance is necessary for success, it will be gained by some systems failing and other systems gaining their shares of the market."[48] Delayed adoption due to uncertainty about which standard would ultimately prevail was deemed to be tied to "the cost of making a mistake."[49] If the cost of a mistake were low, consumer would be less hesitant to make a purchase before a decisive winning standard emerged.

The Commission's decision was not lacking in dissent. Commissioner James Quello, along with Commissioner Joseph Fogarty concurring, "questioned the role of the marketplace in setting technical standards. He felt that expecting one system to emerge as the standard in a reasonable amount of time was 'sheer folly[.]'"[50] Meanwhile, Commissioner Abbott Washburn noted decried that "whichever system or systems evolve will be based not on true consumer preference resulting from comparisons... but rather on the size of promotion and merchandising expenditures[,]" and the FCC had a successful track record of standard setting in the area of new communication technologies.[51]

Competing Standards: A Petri Dish for Innovation or Uncertainty?

In the aftermath of the FCC decision, manufacturers Harris, Kahn, Magnavox, and Motorola chased electronics companies and radio broadcasters. The broadcasters, however, hesitated to invest in AM stereo broadcasting equipment because no single manufacturer had sold a critical mass of AM stereo-capable radios. Radio sales were slowed by consumer uncertainty about which manufacturer's AM stereo standard would prevail and which would become obsolete. Almost two years after the FCC decision, only 315 of the 4,650 AM radio stations in the U.S. had adopted AM stereo technology: approximately 6.8% market penetration.[52] And by 1986, only two manufacturers, Motorola and Kahn, were left:[53] simultaneously battling for supremacy and casting aspersions on their sole remaining competitor.[54]

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[47] *Id.*
[48] *Id.*
[49] *Id.*
[50] Klopfenstein & Sedman (1990), *supra* note 20, at 181.
[51] Federal Communications Commission (1982), *supra* note 38.
[52] Meyer (1984), *supra* note 37, at 278.
[53] However Harris had licensed Motorola's technology in order to produce its own equipment. See Braun (1994), *supra* note 20, at 134.
[54] Stanley M. Besen & Leland L. Johnson, Compatibility Standards, Competition, and Innovation in the Broadcasting Industry, RAND Corporation, Report No. R-3453-NSF, November 1986 at 5.

A National Telecommunications and Information Administration (NTIA) study found that broadcasters were not adopting AM stereo for two reasons: 1) fear of choosing the wrong system; and, 2) the paucity of available receivers for consumers.[55] Meanwhile manufacturers were reluctant to produce receivers because so few broadcasters were committed.[56] In short, it was "It became a three-way stalemate, the ultimate chicken-egg situation with none of the major stakeholders – broadcasters, consumers or manufacturers – willing or able to take the first step."[57]

Critics of the FCC decision regarding AM stereo believe the FCC failed its mandate to protect the public interest by relying solely on market competition to set AM stereo standards. Citing judicial review of an earlier FCC decision, Meyer notes that the FCC neglected its "duty to analyze independently . . . whether competition would be in the public interest[,]" thus, "'abdicat[ing] one of the primary duties imposed upon it by Congress.'"[58] The result of abdication was setting of standards by companies with the most market power and deepest pockets, rather than those with the most innovative technology.[59] Prior to the AM stereo decision, the FCC "had always responded to innovative broadcasting technologies by promulgating a single set of technical standards thereby" ensuring the interoperability of equipment from various manufacturers.[60] It is typically in network industries, such as communications, that standards are most essential.[61] The failure of the FCC to set such standards for AM stereo resulted in higher prices, delays in implementation, and inefficient use of the spectrum.[62] Further, Schreiber argues that leaving market actors to set standards sets them up for potential antitrust violations for cartel-like behavior.[63]

Outside the United States, by comparison, a standard for AM stereo emerged. In Brazil, Canada, and Australia, Motorola's C-Quam technology was adopted as the AM stereo standard.[64] Within two years of Australia choosing Motorola technology as its standard, 60 percent of AM radio stations there offered stereo broadcasting.[65]

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[55] "AM Stereo and the Future of AM Radio," National Telecommunications and Information Administration, U.S. Department of Commerce, February 1987.

[56] National Telecommunications and Information Administration (1987), *supra* note 55.

[57] Richard V. Ducey, Mark R. Fratrik, & Joseph S. Kraemer, Study Of The Impact Of Multiple Systems For Mobile/Handheld Digital Television, BIA Financial Network Report for the National Association of Broadcasters, January 14, 2008 (available at http://www.nabfastroad.org/jan14rptfinaldouble.pdf) at 27.

[58] Meyer (1984), *supra* note 37, at 269 (quoting *FCC v. RCA Communications, Inc.*, 346 U.S. 86, 94-95 (1953)).

[59] *Id.* at 282.

[60] Meyer (1984), *supra* note 37, at 274.

[61] Klopfenstein & Sedman (1990), *supra* note 20, at 173.

[62] Mark P. Schreiber, "Don't make waves: AM stereophonic broadcasting and the marketplace approach", *Hastings Communications and Entertainment Law Journal*, Vol. 5, 821, 829-30 (1983).

[63] *Id.* at 830.

[64] FCC Report and Order, FCC 93-485, ET Docket 92-298, Adopted: October 25, 1993, Released: November 23, 1993.

[65] Klopfenstein & Sedman (1990), *supra* note 20, at 188.

Finally, in 1993, Congress mandated Motorola C-Quam as the U.S. standard.[66] By this point in time, however, FM stereo's dominance over music broadcasting was near total. AM radio programming consisted primarily of news and talkradio, neither of which benefited much from stereophonic presentation.[67] During the 13 years of competing technological standards, no new AM stereo systems were introduced to the marketplace.[68] Instead, the remaining technology proponents, Motorola and Kahn, remained embroiled in lawsuits that dragged their customers, such as General Motors, into litigation as well.[69] And the general public sat on the sidelines, desiring a greater degree of certainty that an investment in an AM stereo system would not be obsolete due to changing standards.[70]

Lessons from the Battle

A ready comparison point for AM stereo is FM stereo technology, where the government mandated interconnection standards for all equipment, including the sockets.[71] The result was a far faster adoption curve for FM radio.

While the government may be hard-pressed to make justifiable standards decisions in fast moving, technology-driven markets[72] the history of AM stereo suggests that even an imperfect standard may be better than none at all because manufacturers, consumers, and service providers place a high value on certainty. Uncertainty creates what RAND describes as "Excess Inertia", where "[a] standard may not be adopted even when its adoption would be in the interest of all users, because potential adopters are not confident that others will follow."[73]

Many manufacturers would be happier to own a smaller share of a large and certain market than to own 100 percent of a small, and uncertain market. This was demonstrated by the pronouncements of Harris, Magnavox, Motorola, and Belar that they preferred <u>any</u> government-mandated standard to the lack of an FCC decision. Of course, these manufacturers no doubt expected affordable licensing terms if a standard other than their own were chosen.

Service providers are often hesitant to invest in infrastructure compatible with a particular *de facto* standard until consumer acceptance is likely. Yet consumers look to service provider commitments before purchasing hardware themselves.[74] "Letting the market decide" has a different meaning when the market is dependent on a "closed premarket of giant industrial corporations," such as radio stations who must buy special

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66 Braun (1994), *supra* note 20, at 27.
67 Kimberly A. Zarkin & Michael J. Zarkin, *The Federal Communications Commission: front line in the culture and regulation wars* (Westport Conn.: Greenwood Press, 2006).
68 Klopfenstein, & Sedman (1990), *supra* note 20, at 185.
69 Braun (1994) *supra* note 20, 136-37.
70 *Id.* at 184.
71 Gerald Brock, *Telecommunication policy for the information age: from monopoly to competition* (Cambridge Mass.: Harvard University Press, 1994), 92
72 Ducey, Fratrik, & Kraemer (2008), *supra* note 57, at 27.
73 Besen & Johnson (1986), *supra* note 54, at 5.
74 Klopfenstein & Sedman (1990), *supra* note 20, at 186.

broadcasting equipment. Indecision by those in the pre-market will further dampen consumer interest.

In a world where consumer demand for a service is likely, but multiple standards are in competition, hardware manufacturers and service providers must make an investment in advance of customer feedback. The big challenge for AM Stereo was that FM stereo offered higher fidelity and better frequency response than AM stereo, which had narrower channel spacing and was, thus, more likely to cause co-channel interference.[75] At the same time, AM had certain advantages that could have enabled it to succeed; specifically, the AM signal could travel much greater distances and cover more mountainous terrain than FM.[76] As consumers and service providers weighed these pros and cons, the presence of competing standards added considerably to the list of cons, particularly when some manufacturers were publicly denouncing the other standards and engaging in litigation to enjoin the sales of competitors.

While multisystem receivers could have solved compatibility issues for AM stereo, such systems would have been more expensive and, thus, resulted in less favorable economics.[77] Perhaps as we move into the digital world, multi-standard compatibility for Smart Grid-enabled products can be accomplished through software upgrades, which require little marginal cost.[78]

Like many electric utilities, AM radio stations were local, rather than national players. As such, both the AM stations and power companies need only focus on consumer adoption of compatible hardware in their own local jurisdiction. However the equipment manufacturers are national, thus offering no local refuge from the national battle of standards. It is likely that consumers will need to purchase at least some Smart Grid-compatible equipment on their own, just as AM stereo listeners needed to purchase their own receiver. And, akin to the AM Stereo scenario, witness the 16-year long, yet-to-be-decided battle among the creators of Smart Grid "communication protocols like ZigBee or HomePlug (or any of the other 10 protocols vying to be 'the one.')"[79]

Because the radio industry had a different business model than power companies, it had less flexibility in financing consumer adoption of AM stereo. Radio stations generate revenue from subscribers indirectly by charging advertisers. By contrast, power companies charge[80] consumers directly. This gives power companies the possibility of financing some components of Smart Grid-compatible consumer equipment (e.g. a Smart Grid-enabled washing machine) and billing the consumer over time to recoup the cost. Radio stations, by contrast, could not easily finance radios.

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[75] Braun (1994), *supra* note 20, at 39, 44.
[76] *Id.* 46.
[77] Ducey, Fratrik, & Kraemer (2008), *supra* note 57, at 27.
[78] However there may still be significant one-time engineering expenses for each upgrade.
[79] Conrad Eustis, Smart Residential Appliances: Utility View Point, Presentation by Portland General Electric at ConnectivityWeek, June 9, 2009 (available at http://www.pointview.com/data/2009/06/28/pdf/Conrad-Eustis-4229.pdf).
[80] No pun intended.

Both wireline and wireless telephone companies, however, have the ability to finance or rent customer equipment, akin to what the power companies could do. Accordingly, it is to telephony case studies that we turn next.

Vertical Integration's Virtues and Vices: The Evolution of Wireline Telephony

An issue for the Smart Grid will be the extent to which it is vertically integrated. Historically, the generation, transmission, and sales functions in the power sector have often fallen under a single corporate umbrella. While the number of independent power producers has increased dramatically in the last decades, consumers usually interact solely with their local distribution company, which provides their meter and their service. Should power companies provide Smart Grid-enabled equipment as well? To the extent there is a profit to be earned from such equipment sales, power companies may seek to leverage their monopoly over the power network to dominate the equipment market as well, perhaps requiring consumers to purchase additional in-home Smart Grid equipment from the power company.

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The history of the landline telephony industry provides multiple lessons about the potential advantages and pitfalls of vertically integrating customer premises equipment and communications networks. In an industry's nascent stages, vertical integration may also provide significant benefits to the consumer by "obtain[ing] efficiencies which may be beneficial both to the monopoly and to consumers."[81] Yet, over time, there is a risk that a dominant firm may abuse its monopoly power in one market segment to dominate an adjacent segment,[82] thus stifling innovation and cost-reductions.

Traditionally the United States has a tradition of restricting vertical monopolies, ranging from the integration of shoe manufacturers with shoe stores to ownership of theatres by motion picture companies.[83] While most know that this restriction ultimately led to the historic breakup of AT&T's dominance of the customer premises equipment market,[84] few recall the initial benefits accruing to telephony end users by the company's vertical integration in its early years. It is to these benefits that we first turn.

Lowering Trial Costs and Ensuring Network Integrity Through Vertical Integration

The early years of the telephone industry exemplify how certain aspects of vertical integration can potentially foster the adoption of new technologies and practices. By 1920, Public Utility Commissions (PUCs) in 38 states were required to ensure the

[81] Paul L. Joskow and Roger G. Noll, The Bell Doctrine: Applications in Telecommunications, Electricity, and Other Network Industries, *Stanford Law Review*, Vol. 51, No. 5, May 1999, at 1256.
[82] See, e.g., David A. Balto, A Whole New World?: Pharmaceutical Responses to the Managed Care Revolution, *Food and Drug Law Journal*, Vol. 52, No. 5, May 1999, 89 (discussing the abuse of reservation systems by their airline owners and similar risks in pharmaceutical manufacturer ownership of pharmacies).
[83] Joskow & Noll (1999), *supra* note 81, at 1254.
[84] See *United States v. Western Electric Co.*, 569 F. Supp. 990 (D.D.C. 1983) (known as the Modified Final Judgment or MFJ).

quality of the telephone system.[85] In turn, these PUCs expected the telephone carrier, usually AT&T, to take responsibility for the "quality, safety, and effectiveness of each component of its network."[86] This implied that the telephone carrier controlled not only the network infrastructure, but also customer premises equipment. The regulatory benefits were clear: consumers would not face a "no man's land in which neither the long distance nor local companies had responsibility."[87] And regulators had fewer entities to oversee.

In the view of regulators at the time, "the burden of properly maintaining telephone service rests with the telephone utility and not with its subscribers" so the companies "should not permit subscribers to maintain parts of their line."[88] Indeed, companies allowing subscribers to purchase their own "telephone instruments" were "engaging in improper telephone practices."[89] This was so, in part, because the telephone network design at the time was precarious. In many locales, parties shared a telephone line with other residences, known as a party line. If the telephone equipment installed by one subscriber was incompatible with the network, this could create immediate difficulties for the others sharing the party line. Further, network cables were extremely susceptible to outside interference, as line shielding and twisting of the copper pairs had yet to be perfected.

While AT&T had many independent competitors,[90] each adopted a similar practice of insisting that customers only attach phone company-owned equipment to the network.[91] Almost all carriers insisted on the exclusive use of carrier-provided telephones in order to "protect the network from harm due to malfunctioning equipment."[92] The carriers received innumerable benefits from this approach, ranging from monopoly profits on equipment to an ability to make long-terms plans without fear of competition.[93]

As the physical infrastructure outside the telephone company's immediate control, customer premises equipment was rapidly seen as a weak link that required attention. One weakness of early telephone handsets was their power system. Early telephone

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[85] Alan Stone, Public Service Liberalism: Telecommunications and Transition in Public Policy, (Princeton, NJ: Princeton University Press, 1991) at 221.
[86] *Id.*
[87] *Id.*.
[88] *Id.* at 222 (citing Ellsworth Nichols, *Public Utility Service and Discrimination: managerial problems, regulations, and practices*, (Rochester, N.Y: Public Utilities Reports, Inc., 1928) at 473-74).
[89] *Id.* (citing *Letcher Telephone Co.*, PUR 1916E, 486, 494).
[90] Before the Great Depression, the Bell companies no more than a 33% share of the rural telecommunications market. See William P. Barnett & Glenn R. Carroll, Competition and Mutualism among Early Telephone Companies, *Administrative Science Quarterly*, Vol. 32, No. 3 (September 1987) at 403.
[91] Gerald W. Brock, *The Telecommunications Industry: The Dynamics of Market Structure* (Cambridge, MA: Harvard University Press, 1981) at 236.
[92] *Id.* at 236.
[93] *Id.* at 236-37.

handsets relied on wet cell batteries contained within the phone itself.[94] Early telephones were sometimes called "coffin telephones" because their components were placed in a large wooden box in conjunction with batteries to power them.[95] These bulky batteries required telephone owners to occasionally mix corrosive chemicals together, which could cause significant damage if leaked.[96] Early dry cell batteries, while less corrosive and requiring less maintenance, tended to last less than six months each.[97] In short, these batteries were one of the weakest links in the telecommunications chain: according to AT&T, these temperamental batteries caused up to ninety percent of the companies service calls.[98] In addition to compromising the effectiveness of the telephone to which a defective battery was connected, poor local circuits could "unbalance" a longer circuit, thus, ruining others' telephone service.[99]

The Bell system solution, begun in the 1890s, was to replace these individual wet cell batteries with a common system battery managed by Bell at the network-level.[100] Doing so required additional challenges for the Bell system, ranging from the need for increased central office power to integration of lower power transmitters into the network,[101] however the benefits were substantial. This solution eliminated a substantial number of customer service calls and significantly reduced the cost of customer premises equipment. Additionally, it lowered the likelihood of power surges on the telephone line stemming from overpowered handsets.

Even after taking central control of the batteries powering telephone handsets, cross-talk and other line interference could still emanate from faulty telephones. The two-way nature of the telephone network meant this could impact the service of others by tying up common switches. For many years, AT&T successfully argued that a host of evils would befall everyone if third-party telephones were connected to the network:

> "if a toaster is defective, it may blow a fuse, but it cannot affect the electrical service of others. An improperly designed or maintained telephone, when put into operation, can distort the electrical current flowing to it from the switching center in such a way as to cause return signals that interfere with the quality of service not only for that customer but for his neighbors as well, causing wrong numbers, busy signals,

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[94] See an examples at http://www.porticus.org/bell/images/1900_common_battery.jpg and http://www.telephonearchive.com/phones/wood/coffin-1879-natl-bell.html

[95] Gerald Brock, The Second Information Revolution (Cambridge, MA: Harvard University Press, 2003) (2003) at 132.

[96] Stone (1991) *supra* note 85, at 80.

[97] *Id.*

[98] *Id.*

[99] *Id.* at 81.

[100] Claude S. Fischer, America calling: a social history of the telephone to 1940 (Berkeley: University of California Press 1992) at 38.

[101] *Id.*

> incorrect billings, transmission difficulties, and similar problems."[102]

While many of the fears about technological ruin stemming from third party equipment ultimately proved unfounded, the leasing of equipment by the telephone company did provide a significant benefit by lowering the cost of trial for new customers. Rather than a large capital outlay to start telephone service, customers paid a small amount each month for their equipment. Further, this enabled customers to avoid technological risks. The rapid quality and distance improvements in the early years of telephony meant that customer premises equipment could become obsolete before it would have otherwise reached the end of its useful life. Leasing equipment forced the service provider to bear the risk of obsolescence instead. And, because the service provider's changes to the network were often the cause of customer premises equipment obsolescence, the service providers, as lessors of customer equipment, were in a better position to analyze that risk and ensure it was either mitigated or factored into equipment pricing.[103]

Because the value of the telephone was directly proportional to the size of the network, many early telephone users were unsure the device and service would have sufficient utility to warrant a major upfront investment in equipment. Leasing equipment from the service provider obviated this risk for customers if their service contract was for a limited time period. Encouraging trial by new customers, in turn, added to the user base and made the network more attractive for subsequent customers.

Customers appreciated aspects of the "one-stop shopping" offered by their combined equipment lessor and service provider. According to an earlier FCC Commissioner, this created excellent accountability to the customer:

> "If anything went wrong, you knew it was AT&T's fault–and so did the company. They took responsibility and they fixed it. After all, they had manufactured the handset, wired your house, run the lines out to the street, to the switching station, and installed and operated the 'long lines' networking the country. AT&T's customer representatives were deprived of the argument that your problem was the fault of some other company."[104]

In sum, the vertical integration of equipment manufacture and leasing with service provision provided many benefits in the early days of telephony. The service provider could effectively strengthen one of the weakest links in the network, and use

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[102] Alan Stone, How America Got On-Line: Politics, Markets, and the Revolution in Telecommunications (Armonk, NY: M.E. Sharpe 1997) at 17.
[103] Stone (1991), *supra* note 85, at 105.
[104] Nicholas Johnson, "Carterfone: My Story", *Santa Clara Computer & High Technology Law Journal*, Vol. 25 (2009) at 684. The fact that the Model 500 remained in production for 35 years contributed to its extensive market penetration.

technological standardization to extend the network more broadly. Meanwhile customers faced a lower cost of trial, did not have to fear technological obsolescence of their handsets, and needed to call only one company when communications problems developed, regardless of whether it was a hardware or network issue. And Public Utility Commissions and the Federal Communications Commission had fewer equipment manufacturers to regulate.

But at the Cost of Innovation …

The view that the Bell companies should monopolize service from end-to-end began to shift once nearly universal telephone service had been achieved.[105] No longer could AT&T argue that it needed a monopoly to increase economies of scale. And AT&T could not demonstrate joint-costs between the provision of telephone service and equipment.[106]

The Bell system had maintained a competitive advantage by disallowing interconnection.[107] After its promulgation by AT&T, the FCC approved Tariff Number 132, which provided that "No equipment, apparatus, circuit or device not furnished by the telephone company shall be attached to or connected with the facilities furnished by the telephone company, whether physically, by induction or otherwise."[108] Because AT&T had no "meaningful competition", it also lacked challenges from market innovators. This significantly impacted customer choice: "Like the range of colors Henry Ford offered his car buyers, AT&T's phones also only came in a colorful black. . . . this elimination of opportunity costs also eliminated opportunity benefits. What was saved for consumers in increased costs was denied to customers in increased efficiencies." [109]

Hush-A-Phone and Carterfone

The first serious test of the prohibition against "foreign attachments" to the telecommunications network was from the producer of the Hush-A-Phone, a "cup-like device that snapped onto the telephone instrument to provide speaking privacy and shield out surrounding noises."[110] The device only made an acoustic, rather than electrical, connection to the phone handset. Nonetheless AT&T "warned" retailers against selling the Hush-A-Phone product because it violated the foreign attachments rule in AT&T's tariffs. After unsuccessfully petitioning the FCC for assistance, Hush-A-Phone's inventor appealed to the Circuit Court for the District of Columbia, which held that the Hush-A-Phone was permissible because it was "privately beneficial without being publicly detrimental."[111] In other words, "foreign attachments" could only be restricted if there were demonstrably detrimental to the network itself, not merely to the individual's own use of the telephone; and blanket prohibitions were unacceptable.

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[105] Peter Temin with Louis Galambos, The Fall of the Bell System: A Study in Prices and Politics (New York: Cambridge University Press, 1987) at 7.
[106] *Id.* at 12.
[107] Brock (1981), *supra* note 91, at 110.
[108] Matthew Lasar, "Any lawful device: 40 years after the Carterfone decision", *ARS TECHNICA*, June 26, 2008 (available at http://arstechnica.com/articles/culture/carterfone-40-years).
[109] Johnson (2009), *supra* note104, at 684.
[110] Brock (1994), *supra* note 71, at 80-81.
[111] *Hush-A-Phone Corp. v. United States*, 238 F.2d. 266, 269 (D.C. Cir. 1956)

Shortly after the Hush-A-Phone decision, the Carter Electronics Corporation sought FCC permission to sell the Carterfone, a device that acoustically coupled a telephone handset to a mobile radio. The FCC, under pressure from AT&T,[112] refused to give the device formal approval because it violated AT&T's tariff by enabling a connecting between telephone lines and other means of communication.[113] Carter Electronics filed a private antitrust suit against AT&T, which was eventually remanded to the FCC for decisionmaking.[114] Not only did the FCC ultimately permit interconnection of the Carterfone device to the telephone network, it also initiated a new set of rules, Part 68[115], in 1975 that "addresse[d] connection of terminal equipment to the public telephone network, [and] permit[ted] consumers to connect equipment from any source to the public network if such equipment fits within the technical parameters outlined" by the FCC and the manufacturers of such equipment met the FCC's equipment registration and certification procedures.[116] Noting its lessons from the case, the FCC concluded that the Carterfone case "convince[d] us that there can be inter-connection without harmful technical effects" and that there should only be a prohibition against devices causing "actual harm," rather than a mere loss of control of potential harm.[117]

<u>Protective Connection Appliances</u>

To proactively address the interconnection requirements stemming from the Carterfone decision, AT&T offered Protective Connecting Arrangement (PCA) equipment to handle network signaling required by third party telecommunications equipment,[118] thus "buffering" the network from third-party hardware.[119] AT&T argued that such equipment was essential because "improper signaling" from third party telephone "could cause the central office to fail to respond, to prematurely terminate a call, or to cause errors in billing."[120] To justify the need for PCAs, AT&T's management "clothed their fear of the unknown in specific scenarios for disaster" and neglected the many past examples of successful third-party interconnection with the telephone network, such as private branch exchanges (PBXs) and proprietary military equipment.[121]

The proposed charge per month for every device attached to the network was to be $2.00,[122] essentially depriving third party equipment manufacturers of part of their

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112 Zarkin & Zarkin (2006), *supra* note 67, at 62.
113 Brock (1994), *supra* note 71, at 84.
114 *In the Matter of Use of the Carterfone Device in Message Toll Telephone Service*, 13 FCC 2d 420 (1968).
115 47 C.F.R. Part 68.
116 Jason Oxman, The FCC and the Unregulation of the Internet, Federal Communications Commission, Office of Plans and Policy Working Paper No. 31, July 1999, at 14.
117 *Use of the Carterfone Device in Message Toll Telephone Service v. American Telephone & Telegraph Co.*, 14 F.C.C.2d 571, 572 (1968).
118 Joseph P. Fuhr, Antitrust and regulation: Forestalling competition in the telecommunications terminal equipment market, *Review of Industrial Organization*, Vol 3. (March 1988) at 101.
119 Temin (1987), *supra* note 105, at 44.
120 Brock (1994), *supra* note 71, at 86.
121 Temin (1987), *supra* note 105, at 44-45.
122 Brock (1994), *supra* note 71, at 86-88.

profit and creating a disincentive to purchase third-party equipment. Often the cost of the PCA exceeded the cost of the third party equipment to be connected.[123] Professor Temin speculates that PCAs would have created far less uproar if AT&T had offered them for free to customers; however, at the time, AT&T argued that doing so would benefit a few advanced equipment users at the expense of the general rate base.[124]

The FCC responded to AT&T's PCA plan by requesting the National Academy of Sciences to determine whether hardware-based network protection was indeed necessary, or whether the network could be equally well-protected through a set of standards and equipment certification.[125] The National Academies concluded that dangers of third party equipment included hazardous voltages, excessive signal power levels, excessive longitudinal imbalance, and improper network control signaling,[126] however these could be addressed equally well by clear interconnection standards and certifications. The FCC determined the PCA plan was "unnecessarily restrictive" and that standard plugs and jacks should be used to connect all terminal equipment.[127]

Ultimately the best evidence of the pent-up innovation in the telephony industry was AT&T's rapidly shrinking share of the customer premises equipment market: in 1982, 90 percent of American households still leased an AT&T telephone, however this decreased to 30 percent by 1986, after the Modified Final Judgment ordering the divestiture of AT&T. [128] AT&T's own "[i]nnovations in terminal equipment were slowed by the need for compatibility with older central office equipment."[129]

Lessons about Vertical Integration for the Smart Grid

The evolution of the wireline telephony network offers multiple ideas for Smart Grid proponents and policymakers. First, as in the early days of telephony, consumers may be more inclined to participate in the Smart Grid initially if the utilities provide the relevant equipment to them. This lowers the upfront cost to the consumer and allows utilities to more easily troubleshoot technical issues on the customer premises. A particularly compelling argument for utility ownership of Smart Grid-related customers premises equipment is the substantial demand and supply management benefit available to utilities who reach a critical mass of Smart Grid participants. Additionally, utilities with customers on the Smart Grid can better optimize their own network by more quickly pinpointing outages and tallying monthly usage without showing up in-person to read each customer's meter.

It is possible that power utilities could sell or lease interface devices akin to the Protective Connection Appliances offered by the Bell System. Indeed, one power

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[123] Brock (1994), *supra* note 71 at 87.
[124] Temin (1987), *supra* note 105, at 46.
[125] Technical Analysis of the Common Carrier/User Interconnections Area, Report to the FCC by National Academy of Sciences, Computer Science and Engineering Board, June 1970.
[126] FCC Approves Direct Interconnection of Terminal Equipment, in "Washington Update," *Computer*, IEEE Computer Society, Vol. 9, No. 1, pp. 14, January 1976.
[127] Brock (1994), *supra* note 71, at 92.
[128] Joskow & Noll (1999), *supra* note 81, at 1271-72
[129] Brock (2003), *supra* note 95, at 133-34.

provider, Portland General Electric, is advocating the installation of sockets for Smart Grid chips on a wide-range of consumer appliances, which would be paid for incrementally by electric utilities: about $20 per appliance if deployed in volume.[130]

The stifling of consumer hardware innovation by telephone companies and the complicity of the regulators, on the other hand, suggests that Smart Grid policymakers at the national level need to be wary of state Public Utility Commissions who have either been captured by the utilities or lack the resources or expertise to manage technical interconnection standards and the oversight of hundreds or thousands of equipment suppliers. NIST is well positioned to play a role similar to that of the National Academy of Sciences in the AT&T case by being an honest broker for open standards that preserve network integrity for utilities, without overburdening aspiring hardware manufacturers.

How the Timing of Standards Affects Market Size and Adoption Rates: Lessons from Cellular Telephony

Smart Grid policymakers face numerous questions about the standard-setting process: how long should they wait before announcing standards, should there be more than one standard, and how will adoptees of the current standard(s) be able to adapt to subsequent generations of technology? The evolution of cellular telephony presents an excellent opportunity to examine these issues in the context of a global marketplace, where the United States and European Union differed in their approach.

The First Generation: A National U.S. Standard vs. a Balkanized European Market

Between the early 1970s and mid-1980s, the large-scale commercialization of wireless telephony services "developed on three continents nearly at the same time[.]"[131] Revolutionary advances in enabling technologies, such as microprocessors needed for automatic switching and new radio frequency modulation techniques catalyzed the development of wireless telephony technology, while ever-increasing mobility of the workforce fueled demand.[132]

<u>United States</u>

In 1970, the FCC granted AT&T permission to develop a cellular telephony system.[133] Subsequently, in 1977, the FCC authorized construction of the first experimental cellular telephone system in the United States, to be built in Chicago by a

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[130] Conrad Eustis, Smart Residential Appliances: Utility View Point, Presentation by Portland General Electric at ConnectivityWeek, June 9, 2009 (available at http://www.pointview.com/data/2009/06/28/pdf/Conrad-Eustis-4229.pdf) (describing $3.50 per appliance non-recoverable engineering expense, a socket and wiring cost of $6.50, and a communications device cost of about $10.)

[131] Kalle Lyytinen & Vladislav V. Fomin, "Achieving high momentum in the evolution of wireless infrastructures:the battle over the 1G solutions", *Telecommunications Policy*, Vol. 26 (2002), pp. 149–170 at 156.

[132] *Id.*

[133] *Id.* at 158.

subsidiary of AT&T called Advanced Mobile Phone Service (AMPS).[134] This was promptly followed by deployment of a system in the Baltimore-Washington, DC area by Motorola and American Radio Telephone Services Inc.[135] Both of these systems were car-based, and the network was organized around car usage;[136] owing, in part, to the still bulky size of mobile telephones and antennas, and, in part, to the belief that car-driving salesmen were the most likely early adopters of the technology.

Rather than let each system operator develop its own air interface, the FCC made a ruling in 1982, based on proposals from AT&T and Motorola, mandated that the AMPS technical specification, which had been made public, was to be the standard for all wireless telephony licensees.[137] And rather than rapidly evolve to a second generation standard as AMPS began to show its age, the FCC allowed revision of the AMPS standard "to cope with its initial technological limitations."[138] Because AMPS was initially designed around 1971, it did not take into account the use of microprocessors, digital switches, or microwave links and is considered by many to be "top-heavy."[139] AMPS had other shortcomings as well, because it had been developed by manufacturers (Bell Labs and Motorola) focusing solely on the air interface, rather than system operators, it lacked "standardized billing solutions, roaming, [and] switching interfaces between different networks, and the like."[140]

One of the most significant shortcomings of AMPS was its inefficient utilization of wireless spectrum. AMPS was based on Frequency Division Multiple Access (FDMA) technology, which allocated a separate transmission and reception channel for each conversation.[141] The result was that one channel was always unused unless both people were talking at the same time, and often both channels were unused if there was a lull in the conversation.[142]

The most significant advantage of AMPS was its ubiquity and the sheer size of the United States market. Provided that carriers in adjacent and far-flung markets could work out a mutually acceptable roaming agreement and handle the back-office billing, a challenge for many operators,[143] first generation cellular telephone users in the United States could travel thousands of miles relying on the same handset. As a result, AMPS

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[134] James B. Murray, Jr., Wireless Nation: the frenzied launch of the cellular revolution in America (Cambridge, MA Perseus Publishing 2001) at 24.
[135] *Id.*
[136] Lyytinen & Fomin (2002), *supra* note,131 at 156, n.9.
[137] *Id.* at 158.
[138] *Id.* at 158.
[139] Rudi Bekkers & Jan Smits, Mobile Telecommunications: Standards, Regulations, and Applications ()Boston: Artech House, 1997) at 152; see also Vladislav V. Fomin, "The Role of Standards in Sustainable Development of Cellular Mobile Communications", *Knowledge, Technology, & Policy*, Vol. 14, No. 3, Fall 2001 at 58 (describing AMPS as "technically obsolete" by the time of its commercial introduction).
[140] Lyytinen & Fomin (2002), *supra* note 131, at 158.
[141] Dan Steinbock, Wireless Horizon: Strategy and Competition in the Worldwide Mobile Marketplace (New York: American Management Association, 2003) at 43.
[142] *Id.*
[143] Gary Garrard, Cellular Communications: Worldwide Market Development (Boston: Artech House, 1998) at at 39.

became “the most popular analog standard in the world,” with over 50 million subscribers around the end of the twentieth century,[144] including systems in Latin America, Europe, and Asia.[145]

Europe

While the European Community was working to integrate the economies of Europe, cellular telephony standards were initially left to national authorities and operators. The result was a continent-wide patchwork that hampered roaming and left most equipment manufacturers with insufficient economies of scale and relatively low adoption rates. Only the Nordic countries, which collaborated on a joint standard, rose above the fray to achieve double the cellular penetration rate of the United States by the late 1990s, with the Swedish and the Finnish networks boasting thirty to forty thousand subscribers each.[146]

Recognizing that a truly successful mobile communications network might exceed national borders, in 1969, the Nordic Mobile Telephone (NMT) Group was established by telecommunications operators of the four countries to develop cross-border roaming solutions and identify commonly available frequencies.[147] Cooperation between the carriers was enhanced by the fact that each had its own national market, and, thus, was not in competition with other group members.[148] Because the group was composed of operators, rather than equipment manufacturers, service issues like billing were included in the specification. Having allowed roughly ten years for development of equipment supporting the NMT standard, the first NMT system, operating in the 450 mHz frequency, went live in 1981.[149] The four NMT operators reached their maximum capacity nearly five years earlier than projected,[150] necessitating the release of NMT in the 900mHz band in 1984 to offer additional capacity.[151]

Some European countries chose to utilize standards set by the first-movers: NMT and the U.S. AMPS system. By 1993, NMT based systems were operational in 36 countries, including Switzerland,[152] France, Austria, Belgium, Spain, and the Netherlands.[153] Operators in Italy, the United Kingdom, Spain, Austria, and Ireland adopted a variant of the AMPS system called the Total Access Communications System

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[144] Dan Steinbock, *The Nokia Revolution: The Story of an Extraordinary Company That Transformed an Industry* (New York: American Management Association 2001) at 95.
[145] Vladislav V. Fomin, “The Role of Standards in Sustainable Development of Cellular Mobile Communications”, *Knowledge, Technology, & Policy*, Vol. 14, No. 3, Fall 2001 at 59.
[146] Lyytinen & Fomin, (2002), *supra* note 131, at 159.
[147] *Id.*
[148] *Id.* at 160-161.
[149] Bekkers & Smits (1997), *supra* note 139, at 51.
[150] Lyytinen & Fomin, (2002), *supra* note 131, at 163.
[151] Steinbock (2001), *supra* note 144, at 96.
[152] Jeffrey L. Funk, Global Competition Between and Within Standards: The Case of Mobile Phones (New York: Palgrave, 2002) at 41.
[153] Bekkers & Smits (1997), *supra* note 139, at 31.

(TACS).[154] By the late 1990s, TACS systems had nearly 15 million subscribers, with the lion's share in Italy and the United Kingdom, followed by Spain.[155]

Advantages of the TACS system were multifold. First, AMPS handsets and network equipment were already being produced in volume for the U.S. market, which yielded purchasing economies of scale for European operators. Second, in the UK regulators wanted all carriers to use an identical established standard in order to ensure competition. By the early 1990s, the UK had become the most competitive cellular market in Europe by virtue of battles between the country's seven licensed carriers, led by Cellnet and Vodafone.[156]

The larger states that insisted on developing their own standard fared less well. In Germany, the Siemens-developed C-Netz standard yielded a less than one percent penetration rate for Deutsche Bundespost, Europe's largest telecom operator, perhaps due to the services' high price.[157] Likewise, a French system based on the homegrown Radiocom 2000 standard yielded significant consumer dissatisfaction with both a complicated cost structure and slower network rollout.[158] As a result, the second cellular telephony operator in France, Societe Francaise Radiotelephone, promptly licensed NMT technology for its network.[159]

The competitive impact of Europe's patchwork of standards can be compared to the government-mandated unified standard of AMPS applied to the large U.S. market: By the peak of first generation cellular telephony in 1991, North America, led by the United States, accounted for more than half of all worldwide cellular telephony users.[160] As a result, U.S. cellular telephone equipment manufacturers at the time, particularly Motorola, possessed a significant competitive advantage over manufacturers firms from smaller countries, such as Nokia of Finland and Ericsson of Sweden.[161]

First generation cellular's potential lesson for the Smart Grid is that a uniform national standard and ubiquitous equipment compatibility can provide a significant edge in adoption rates and economies of scale in equipment production.

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[154] *Id.* at 30-31 (noting that TACS provided for narrower, and, thus, more spectrally efficient, channel spacing than AMPS).
[155] Steinbock (2001), *supra* note 144, at 95.
[156] Lyytinen & Fomin, (2002), *supra* note 131, at 163.
[157] *Id.* at 164; Bekkers & Smits (1997), *supra* note 139, at 30-31; and Population Statistics: 2006, Eurostat, European Commission (available at http://www.eds-destatis.de/downloads/publ/KS-EH-06-001-EN-N.pdf) at C-1.
[158] *Id.*
[159] *Id.* at 82.
[160] Steinbock (2003), *supra* note 141, at 25.
[161] *Id.* at 23.

Second Generation: A Unified European Standard vs. Competing U.S. Standards

When developing second generation cellular systems, which offered increased capacity, greater ability to transfer data, integrated messaging, and enhanced security,[162] the approaches of the United States and Europe reversed. The United States no longer relied on a single nationwide FCC-mandated standard, as it had done with AMPS; while European operators coordinated a uniform continent-wide system, GSM, that allowed international roaming across scores of countries –a sharp contrast to the prior competition between NMT, TACS, C-Netz, and Radiocom 2000. The result: by 2000, Western Europe had the highest wireless telephony penetration rate (36.8 percent), followed by the Asia-Pacific region (31.1 percent), and then, finally, the United States (15.5 percent).[163]

EU: A Contintent-Wide *De Jure* Standard

Observing that "not less than 10 incompatible technical standards" were in use across European cellular systems,[164] the European Commission (the EC) determined that "full interoperability is the only basis on which a Community-wide open competitive terminal equipment and services market can thrive" and "a substantial reinforcement of resources applied to standardization" was necessary to achieve this goal.[165] In 1982, the European Conference on Postal and Telecommunications Administrations (CEPT), comprised of national monopolist telecommunications providers, created the Groupe Special Mobile (GSM) committee to develop a pan-European 900-mHz band second-generation cellular telephony system.[166]

CEPT was later replaced by European Telecommunications Standards Institute (ETSI), an organization that could employ weighted voting when consensus could not be reached.[167] This voting scheme offered less opportunity for minorities to block new standards.[168] Further ETSI's membership included equipment manufacturers and other stakeholders, in addition to the traditional operating companies;[169] and ETSI's operating

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[162] Steinbock (2001), *supra* note 144, at 107.
[163] *Id.* at 29.
[164] Garrard (1998), *supra* note 143, at 87-88.
[165] Commission el the European Communities. Green Paper on the Development of the Common Market for Telecommunications Services and Equipment, COM (87) 290 final, Brussels, 30 June 1987, p 20, 22.
[166] Raymond Steele, Chin-Chun Lee, & Peter Gould, GSM, cdmaone and 3G Systems (New York: John Wiley & Sons 2001) at 65.
[167] Stanley M. Besen, The European telecommunications standards institute: A preliminary analysis, *Telecommunications Policy*, Vol. 14, No. 6, pp. 521–530 (1990) at 521-23 (the number of votes accruing to each member country was weighted by the country's population).
[168] *Id.* at 523. Despite the creation of ETSI, for GSM standards wireless carriers retained control of deployment standard based on a GSM Memorandum of Understanding. Rudi Bekkers & Joel West, The limits to IPR standardization policies as evidenced by strategic Patenting in UMTS, *Telecommunications Policy*, Vol 33., pp. 80-97 (2009).
[169] Leif Hommen with Esa Manninen, "The Global System for Mobile Telecommunications (GSM): Second Generation", in Charles Edquist (ed.), The Internet and Mobile Telecommunications System of Innovation (Northampton, MA: Edward Elgar, 2003) at 73.

procedures were more open and publicly accessible.[170] Without ETSI, some feared "that Europe might have balkanized around competing standards, leading to interface problems and higher unit costs."[171] Through the CEPT and ETSI process, it is noteworthy that system designs from France and Germany were ultimately rejected, despite the stature of those two countries as the largest markets in Europe.

Compared to its analog predecessors, the GSM system increased radio base station complexity relative to switch complexity, implemented Subscriber Identity Module (SIM) cards to separate subscriber identity from handsets, and offered short message service (SMS) built into each handset.[172] GSM's ability to handle higher capacity meant its infrastructure costs were only about one-third of that of comparable analog systems.[173] In addition to improvements in voice quality, handsets became smaller, lighter, and offered longer battery life; and each offered more confidentiality and security than analog systems, which were prone to eavesdropping.[174]

By the time the first GSM system went live in mid-1991, more than 26 companies had participated in the standards development process.[175] Since its launch, GSM has proven more successful than any other second generation cellular telephony system on several metrics: subscribers (over a billion by 2004)[176]; roaming range (by September 1996, 167 cellular operators from 103 countries and states, including those in Africa, Asia, the Middle East, and North America);[177] and unprecedented economies of scale for equipment manufacturers.[178]

Intellectual Property Issues

Nicknamed "The Great Software Monster" by Nokia's engineers,[179] the GSM system required the extensive development of new intellectual property to be brought to life. Most of this intellectual property (IP) was already owned by major equipment manufacturers, thus a free worldwide license for all GSM-related patents was not forthcoming. As a compromise, ETSI proposed that owners of intellectual property essential to implementing the GSM standard license it under "fair, reasonable, and non-discriminatory conditions" to all carriers and other manufacturers.[180] Because the GSM standard "was so technically advanced … it gave none of the rival manufacturers a competitive advantage."[181]

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[170] Rudi Bekkers, *Mobile Telecommunications Standards: GSM, UMTS, TETRA, and ERMS* (Boston: Artech House, 2001) at 143, 145.
[171] David Lazer & Viktor Mayer-Schonberger, "Panel I: Telecommunications Developments In The European Union: Governing Networks: Telecommunication Deregulation In Europe And The United States", *Brooklyn Journal of International Law*, Vol. 27, 2002, at 832.
[172] Hommen (2003), *supra* note 169, at 74-75.
[173] *Id.* at 75-76.
[174] *Id.* at 77.
[175] Ian Poole, Cellular communications explained: from basics to 3G (Amsterdam: Elsevier, 2006), at 7.
[176] *Id.* at 79.
[177] Hommen (2003), *supra* note 169, at 73.
[178] Poole (2006), *supra* note 175, at 79.
[179] Steinbock (2001), *supra* note 144, at 110.
[180] Bekkers & West (2009), *supra* note 168, at 81.
[181] Besen (1990), *supra* note 167, at 528.

Actual practice, however, was not always fair, reasonable, and non-discriminatory. Motorola, Siemens, Alcatel, Nokia, and Ericsson cross-licensed GSM-related patents to each other, "creat[ing] high barriers to entry" for other potential hardware manufacturers by charging them ten to thirteen percent royalties on each license,[182] as much as $15 per handset.[183] In response to a lawsuit by Ericsson in 2005, a UK cellular handset manufacturer, Sendo, argued that "the GSM patents held by the major European makers constituted an illegal cartel intended to keep out new entrants."[184] One unstated goal of tying the GSM standard to privately-held patents was to keep Japanese manufacturers out of the market.[185]

Of the 132 patents initially essential for GSM, about 50 percent were owned by Motorola,[186] 16 percent by AT&T, and 8 percent by both Phillips and Bull.[187] Ericsson was able to offer aspects of its AXE switching technology as currency to cross-license GSM technology.[188] And Nokia, Siemens, and Alcatel acquired cross-licenses from Motorola.[189] Motorola attempted to use its patents to prevent the spread of GSM to other parts of the world where Motorola was trying to sell systems based on a competing standard.[190]

The United States: Let Many Standards Bloom

The only requirement for digital cellular systems in the United States was that they be "backwards compatible" with AMPS. This compatibility was essential because, unlike Europe, which allocated new spectrum for GSM operators, the FCC had no initial plans to release new spectrum for digital cellular, and many existing operators were uninterested in replacing the infrastructure for which they had already incurred sunk costs.[191] Further, rural cellular operators did not yet need the extra capacity offered by digital cellular technology because rural markets were sparsely populated and, thus, underutilized.[192] Ultimately, two U.S. digital standards emerged: D-AMPS and CDMA.

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[182] Bekkers & West (2009), *supra* note 168, at 81.
[183] Joel West, "The economic realities of open standards: black, white, and many shades of gray" in Shane Greenstein & Victor Stango (eds.), *Standards and Public Policy* (New York: Cambridge University Press, 2007) at 90-91.
[184] Bekkers & West (2009), *supra* note 168, at 92.
[185] West (2007), supra note 183, at 90-91.
[186] Through its multiple European development centers, Motorola had become a member of ETSI. See Funk (2002), *supra* note 152, at 67.
[187] Hommen (2003), *supra* note 169, at 100.
[188] *Id.* at 100.
[189] *Id.* at 100.
[190] Rudi Bekkers, Geert Duysters, & Bart Verspagen, "Intellectual property rights, strategic technology agreements and market structure: The case of GSM", *Research Policy*, Vol. 31 (2002), pp. 1141–1161 at 20.
[191] For a discussion of reasons why existing firms may be unsuited to developing radical new technologies, see, e.g., Mary Tripsas, "Unraveling The Process Of Creative Destruction: Complementary Assets And Incumbent Survival In The Typesetter Industry", *Strategic Management Journal*, Vol. 18 (Summer Special Issue), (1997), at 119-120…
[192] Poole (2006), *supra* note 175, at 8.

D-AMPS

Because the FCC had already ruled that it would not choose a national standard for second generation cellular telephony,[193] the Cellular Telephony Industry Association (CTIA), under significant time pressure,[194] took the lead in selecting the first digital cellular standard for the United States: IS-54, known more commonly as D-AMPS: Digital AMPS.[195] Like Europe's GSM system, D-AMPS was based on Time Division Multiplexing (TDMA).

Because D-AMPS was developed when the FCC gave no indication it would offer additional spectrum for digital cellular, D-AMPS was designed to run on the same channels as AMPS analog cellular, including reliance on the less spectrum-efficient 30 kHz channel spacing of AMPS.[196] By creating D-AMPS as a digital extension of AMPS, it "would not be as technologically sophisticated as a completely new digital system."[197] The proponents of D-AMPS did make some efforts to catch up to GSM, releasing a new version, IS-36, in November 1994 that allowed for SMS messaging and a fax and data transmission mode.[198]

Domestically, D-AMPS penetration was only 0.1 percent of new subscribers in 1992, rising to 7.5 percent by 1994.[199] By 1999, this had increased to 27 percent of the U.S. market, but only 6 percent of the world market.[200] Internationally, it "did not fare well"[201]: despite garnering some 37 percent of the Latin American market and 3 percent of the Asian by 1999,[202] many of those operators later migrated to GSM-based systems to take advantage of GSM's higher capacity and lower-cost equipment.[203]

CDMA

Despite the CTIA approval of D-AMPS as the second generation cellular standard for the United States, a new system based on Code Division Multiplexing (CDMA), called CDMAone, was proposed. Unlike GSM, which was developed by a concerted effort of system operators and hardware manufacturers, CDMAone "owes its existence to one dynamic California company, Qualcomm Inc."[204] In 1994, four years after the CTIA adopted the D-AMPS standard, it approved CDMAone as another second generation

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[193] *Id.*

[194] William C.Y. Lee, Mobile Cellular Telecommunications: Analog and Digital Systems (New York: McGraw-Hill, 1995), at 486 (noting that the North America digital system needed to be available in just 3 years).

[195] *Id.* The system is also called U.S. Digital Cellular (USDC), American Digital Cellular (ADC), and North American Digital Cellular (NADC).

[196] Poole (2006), *supra* note 175, at 103.

[197] Hommen (2003), *supra* note 169, at 83.

[198] Bekkers & Smits (1997), *supra* note 139, at 200.

[199] Funk (2002), *supra* note 152, at 74.

[200] World Telecommunication Development Report 1999: Mobile Cellular, International Telecommunications Union (ITU), October 1999 at 7.

[201] Hommen (2003), *supra* note 169, at 84-85.

[202] ITU(1999), *supra* note 200, at 7.

[203] Vladislav V. Fomin, "The Role of Standards in Sustainable Development of Cellular Mobile Communications", *Knowledge, Technology, & Policy*, Vol. 14, No. 3, Fall 2001 at 61.

[204] Steele, Lee, & Gould (2001), *supra* note 166, at 1.

cellular standard, after major lobbying pressure from Qualcomm and its numerous licensees, such as Motorola, AT&T/Lucent, Nortel, Oki, and Samsung, as well as local cellular operators NYNEX, Ameritech, and PacTel.[205]

Several factors significantly influenced Qualcomm's ability to push through approval of a second standard several years after D-AMPS was adopted. First, in 1994 the FCC began to offer new spectrum for cellular telephony services, this time in the 1900 mHz range.[206] This heralded the arrival of new carriers, many of whom were not yet committed to D-AMPS, and the prospective *de novo* construction of systems in a different bandwidth by existing carriers. Second, early trials of D-AMPS yielded mixed results, including a failure to deliver the capacity improvements expected by many.[207] Third, the FCC sat on the sidelines, unwilling to crown D-AMPS as the sole acceptable second generation cellular standard.[208]

CDMAone's roots were in military spread-spectrum communications, which meant it was more sophisticated than D-AMPS,[209] and it offered a major capacity increase over its analog predecessor, handling twenty times more conversations in the same bandwidth.[210] In order to achieve higher capacity than TDMA systems, CDMAone required the invention of highly advanced digital signal processing (DSP) power in handsets.[211] Fortunately, such reliance was not misplaced, as DSP chips continued to fall in price and increase in processing power. CDMAone also required a more sophisticated radio interface than TDMA-based systems such as D-AMPS and GSM.[212]

While developed initially for the U.S. market, the first commercial CDMAone network was launched in Hong Kong in 1994, followed by a U.S. launch in 1996.[213] U.S. cellular operators were forced to choose between D-AMPS and CDMAone. The result was a split market: D-AMPS operators "could potentially serve areas with a population of 204 million;" while CDMAone operators addressed a market of 256 million.[214] Dividing the U.S. market also meant that neither D-AMPS nor CDMAone equipment manufacturers could achieve as significant an economy of scale as they had with AMPS

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205 Hommen (2003), *supra* note 169, at 84-85; Bekkers & Smits (1997), *supra* note 139, at 202.
206 See, e.g., Thomas W. Hazlett, U.S. Wireless License Auctions: 1994-2009, George Mason University School of Law, Information Economy Project Working Paper, July 14, 2009 (available at http://www.iep.gmu.edu/researchpage_2009_hazlett_uswirelesslicenseauctions.php).
207 Dave Mock, *The Qualcomm equation: how a fledgling company forged a new path to big profits and market dominance* (New York: American Management Association, 2005) at 109.
208 *Id.* at 100.
209 Poole (2006), *supra* note 175, at 113.
210 Hommen (2003), *supra* note 169, at 85.
211 Poole (2006), *supra* note 175, at 113.
212 Mock (2005), *supra* note 207, at 53-58. Because all CDMA users shared one wide frequency band, there was greater risk that handsets nearest to the base station would drown out those farther away. TDMA based systems, by comparison, pre-sliced the frequency into time bands so the interference caused by any one handset could only impact others on its same frequency slice.
213 Poole (2006), *supra* note 175, at 113; Steele, Lee, & Gould (2001), *supra* note 166, at 205.
214 Hommen (2003), *supra* note 169, at 83.

equipment a generation earlier.[215] By 1999, CDMAone represented 9 percent of the U.S. market.[216]

Because Qualcomm owned 48 key patents related to CDMAone technology, no other company could produce CDMAone equipment without first arranging a license with Qualcomm.[217] Qualcomm set "fairly reasonable" licensing rates at first, however these were raised after several licenses were sold.[218] Further, Qualcomm charged "high patent fees" for chips necessary for handsets, with the result being that Qualcomm controlled nearly the entire handset market until 1998, and CDMAone handsets cost three times the price of D-AMPS and GSM handsets.[219] Eventually, Nokia, Oki Electronics, and Motorola entered the CDMAone handset market and prices decreased.[220]

A number of cellular operators in Asia adopted the CDMAone standard for their own digital cellular systems, most notably in Korea.[221] By 1999, South Korea had become the largest CDMA market in the world, representing over 60 percent of all CDMA subscribers in the world.[222] Since then, however, the Korean government said it made a mistake in adopting the Qualcomm CDMAone standard because most other Asian countries would use a different version of CDMA, pioneered by Japan's NTT Docomo, for their third generation system.[223] CDMAone's adoption outside the U.S. was limited in part by the fact that many countries had already adopted and implemented GSM solutions years before CDMAone was commercially available.[224] Generally, uncertainty about which second generation standard would prevail in the U.S. made both D-AMPS and CDMAone made both less attractive to other countries.[225]

GSM Enters the United States

The auction of spectrum in the 1900 mHz band in 1994 created an entrée not only for CDMA, but also for GSM in the North American market. By modifying an upband version of GSM, called DCS-1800, previously created for operators in the United Kingdom, it became possible to adapt the European standard to the new frequencies being made available to the U.S. market.[226] Subsequently, some operators also used GSM to replace their 800 mHz analog and D-AMPS systems. Today, two of the largest cellular network operators in the U.S. use GSM-based systems: AT&T and T-Mobile.

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[215] While the market had grown considerably over the intervening decade, trifurcating the market still reduced opportunities for learning curve-based cost reductions in manufacturing.
[216] ITU (1999), *supra* note 200, at 7.
[217] Bekkers & Smits (1997), *supra* note 139, at 203.
[218] Funk (2002), *supra* note 152, at 75.
[219] *Id.* at 209, Qualcomm's higher fees stem, in part, from its heavier reliance on patent revenue than other manufacturers.
[220] *Id.* at 173.
[221] Hommen (2003), *supra* note 169, at 85.
[222] Steinbock (2003), *supra* note141, at 50.
[223] Funk (2002), *supra* note 152, at 83-84.
[224] Bekkers (2001), *supra* note 170, at 353.
[225] Funk (2002), *supra* note 152, at 74.
[226] Bekkers & Smits (1997), *supra* note 139, at 196.

And Apple's iPhone, the most popular smart phone on the market to date,[227] runs solely on the GSM network.

Who Won: The Continent-Wide de jure Standard or the Free Market Free-for-All ?

One way to evaluate the value of a "government [aka *de jure*] role in standard-setting is measure by the gap left when government declines to play a role."[228] In the case of cellular, such a comparison is possible because we can contrast how U.S. second generation standards, D-AMPS and CDMAone, which evolved without a government role have fared compared to the European government-sponsored second generation standard, GSM. There are multiple criteria that can be used is such a comparison. The most widely studied benchmarks for comparison are 1) adoption rates and market share; 2) spectral efficiency; 3) breadth of roaming available to subscribers; and 4) the impact on transitioning to the third generation cellular technology.

<u>Adoption Rates and Market Share</u>

By 2001, ten years after the launch of GSM (and five years after CDMAone's launch), GSM appeared to be strongly in the lead, with over 560 million users in 171 countries, representing 71% of the global digital market.[229] By comparison, there were roughly 80 million D-AMPS users, 95 million CDMAone users, and 70 million analog users.[230] By the end of 2007, GSM boasted 2.5 billion connections,[231] while CDMAone claimed 431 million users worldwide.[232]

The growth of GSM coincided with a dramatic expansion of the world cellular market. During the first generation of cellular technology, the United States represented more than half of the worldwide cellular telephony market.[233] By 2003, when the second generation of cellular technology was in full force, the growth of cellular outside the United States far outpaced domestic growth – leaving the United States with just one-sixth of the world market.[234] Western Europe, running almost entirely on GSM, represented about 36 percent of the worldwide market, while Asia-Pacific represented 31 percent.[235]

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[227] Jeff Smykil, "Nielsen: iPhone most popular handset in US for most of 2009", *ars technica*, December 22, 2009 (available at http://arstechnica.com/apple/news/2009/12/report-iphone-most-popular-handset-in-us.ars).
[228] Kathleen M.H. Wallman, "The Role of Government in Telecommunications Standard Setting", *CommLaw Conspectus*, Vol. 8, 2000, at 239.
[229] Aoife Sexton, GSMA - Roaming from a Verbal to a Visual World, GSM Association Presentation to International Telecommunications Union, September 19-21, 2001 (available at http://www.itu.int/osg/spu/ni/3G/workshop/presentations/sexton_.pdf).
[230] *Id.*
[231] 2008 Corporate Brochure, GSM Association (available at http://www.gsmworld.com/documents/gsm_brochure.pdf) at 2.
[232] CDMA Subscribership Reaches More Than 431 Million Around The Globe, CDMA Development Group Press Release, February 287, 2008 (available at http://www.cdg.org/news/press/2008/Feb27_08.asp).
[233] Steinbock (2003), *supra* note 141, at 50-51.
[234] *Id.*
[235] *Id.*

Several reasons are given for GSM's dominance. From the technologists' perspective, it was "digitalization [that] transformed the industry."[236] The insistence of U.S. carriers on "backwards compatibility" with the analog standard diminished adoption of the U.S. digital standards.[237]

From the economists' point of view, the driving force behind market growth was not technology, but globalization,[238] which created greater potential for economies of scale. Smaller "[j]urisdictions will evaluate their choices in light of what the dominant actor has chosen, and if the benefits of conformity with that dominant standard are high enough, they will choose that standard." [239] This enables smaller jurisdictions to leverage the large jurisdictions' research and development efforts and economies of scale in hardware production.

While no single European country offered a market as large as the United States, the collective adoption of GSM by the EU member and affiliate states meant that the entire European continent, including the UK, became a single jurisdiction that loomed as large as the United States. While Europe was growing, the United States jurisdiction was shrinking as its second generation market was bifurcated between D-AMPS and CDMAone, and, thus, "neither … ever emerged as a dominant force in international competition."[240] By contrast, the success of European companies in cellular telephony is all the more striking when one considers "the lack of European success – and U.S.-Asian dominance – in most other ICT sectors."[241]

Generally, "the higher the sales of chipsets, terminal, and network equipment, the lower the unit cost. Additionally, the variety of terminal equipment (handsets) tends to be greater." [242] The lower cost of handsets due to higher GSM sales created a virtuous circle: lower hardware prices begat more interest in GSM compatibility, which then further pushed down hardware prices, and increased the availability of GSM-compatible equipment. For small countries, "[a]doption of EU standards result[ed] in far cheaper handsets, as well as interoperability in Europe." [243]

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[236] *Id.* at 50.
[237] Charles Edquist, "Policy implications for the Future of the Sectoral System", in Charles Edquist (ed.), The Internet and Mobile Telecommunications System of Innovation (Northampton, MA: Edward Elgar, 2003) at 240.
[238] Steinbock (2003), *supra* note 141, at 51.
[239] David Lazer & Viktor Mayer-Schonberger, "Panel I: Telecommunications Developments In The European Union: Governing Networks: Telecommunication Deregulation In Europe And The United States", *Brooklyn Journal of International Law*, Vol. 27, 2002, at 832-833.
[240] Hommen (2003), *supra* note 169, at 88.
[241] Charles Edquist, "Policy implications for the Future of the Sectoral System", in Charles Edquist (ed.), The Internet and Mobile Telecommunications System of Innovation (Northampton, MA: Edward Elgar, 2003) at 239.
[242] Neil Gandala, David Salant, & Leonard Waverman, "Standards in wireless telephone networks", *Telecommunications Policy*, Vol. 27 (2003), at 329.
[243] David Lazer & Viktor Mayer-Schonberger, "Panel I: Telecommunications Developments In The European Union: Governing Networks: Telecommunication Deregulation In Europe And The United States", *Brooklyn Journal of International Law*, Vol. 27, 2002, at 833.

Another factor in GSM's market share dominance may stem from the timing of its rollout. By the time second generation cellular systems were rolled out in the United States, GSM was already used by 220 million subscribers in 133 countries.[244] It has been well-demonstrated in technology and network-related industries that small initial advantages can grow into large competitive advantages over time.[245] Thus, even if D-AMPS or CDMAone offered the same capabilities as GSM, their later release date may have hindered their market acceptance.

<u>Spectral Efficiency</u>

A key selling point of CDMAone was its higher capacity. TDMA-based systems, such as GSM and D-AMPS, function by allotting a maximum number of conversations, divided into multiple time intervals, to a pre-set slice of frequency. If there is no dialogue to transmit during a point in any of the conversations sharing that frequency, then that portion of the frequency is unused during that conversation's time slot. CDMA-based systems, by contrast, neither divide the spectrum into multiple frequencies nor divide conversations into particular time slots. Instead, akin to the backbone protocol used by the Internet (TCP/IP), CDMA handsets encode time-slices of conversations with a unique code that enables routing and re-assembly of the conversation by the network and the receiver. These slices of the conversation are then broadcast over a wide range of frequencies within the total frequency band allocated to the particular carrier.

CDMAone claims to offer ten times higher capacity than analog systems, while TDMA-based systems such as D-AMPS initially offered only three times more capacity than its analog predecessor.[246] Moreover, because CDMA-based systems do not subdivide the frequency into multiple channels, new cells can be added to CDMA system far more easily than can be added to TDMA-based systems.[247] In response GSM system vendors have sought to acquire additional spectrum to increase the capacity of GSM systems, as well as employ more advanced vocoders that allow them to subdivide their existing spectrum into more channels.[248]

By waiting until a more elegant solution could be perfected and reduced to practice, through the inevitable march of microchip cost reduction, the proponents of CDMA created a technically superior product.

<u>Portability</u>

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244 Murray (2001), *supra* note 134, at 308.

245 See generally Heli Koski & Tobias Kretschmer, "Survey on Competing in Network Industries: Firm Strategies, Market Outcomes, and Policy Implications", *Journal of Industry, Competition and Trade*, Vol. 4, No. 1, March 2004.

246 Lori Rosenkopf, Anca Metiu, & Varghese P. George, "From the Bottom Up? Technical Committee Activity and Alliance Formation", *Administrative Science Quarterly*, Vol. 46, No. 4 (Dec., 2001), pp. 748-772, at 757-758.

247 Poole (2006), *supra* note 175, at 133.

248 Martin Libicki, The Role of Technical Standards in Today's Society and in the Future, RAND Science and Technology Policy Institute, CT-172, September 2000 at 8-10.

Within the United States, nationwide roaming is sometimes accomplished through the use of dual-mode or tri-mode handsets that are capable of communicating on more than one cellular standard, including analog. Such multimode systems have a cost. Walt Mossberg, technology columnist for the *Wall Street Journal,* noted that, compared to Europe, "It's harder to do anything wireless in the U.S. . . . Any hardware innovator wishing to sell mobile wireless phones or other devices in the U.S. must make them in three varieties and court the slow-moving bureaucratic cellular phone carriers, such as AT&T and Verizon, who have a chokehold on innovation." [249]

Additionally, users of D-AMPS and CDMAone systems have a more difficult time roaming abroad. A failure to secure large-scale international adoption of U.S. second generation cellular standards left the U.S. "business community (and indeed all U.S. citizens) with inferior communications tools when traveling abroad."[250] U.S. travelers have been advised to "leave their telephones at home when they travel abroad."[251]

This is in sharp contrast to Europe's "continent-wide uniformity,"[252] and the relative ubiquity of GSM coverage around the world. A GSM phone will roam on any GSM network in the world, whereas CDMA phones "tend to be targeted towards a particular network, and there may be minor differences between networks."[253] Anecdotally, the "European business man abroad in the 1990s could enjoy sitting in a warm restaurant making a GSM call home, a U.S. traveler would be seen queuing up in the street in the pouring rain outside a public payphone with a telephone card in hand."[254]

Preparation for the Future: Readiness to Transition to the Third Generation

The International Telecommunication Union (ITU) defines third generation cellular as any system that can deliver data rates of at least 144 kbps in moving vehicles, 384 kbps for pedestrians, and 2 Mbps in an indoor office environment.[255] The ITU recognizes two standards meeting these requirements: Universal Mobile Telecommunications System (UMTS) and CDMA2000.[256] CDMA2000 represents a new generation of CDMAone, which was pioneered by Qualcomm. North American

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[249] Murray (2001), *supra* note 134, at 286.
[250] Stephen Temple, Chapter 2: The Agreement on the Concepts and the Basic Parameters of the GSM Standard (mid-1982 to mid-1987), Section 4: The GSM Memorandum of Understanding – the Engine that Pushed GSM to the Market, in Friedhelm Hillebrand (ed.), GSM and UMTS: The Creation of Global Mobile Communication (West Sussex, England: John Wiley & Sons, 2002) at 41.
[251] Wallman (2000), *supra* note 228, at 239.
[252] Id..
[253] Poole (2006), *supra* note 175, at 184.
[254] Stephen Temple, Chapter 2: The Agreement on the Concepts and the Basic Parameters of the GSM Standard (mid-1982 to mid-1987), Section 4: The GSM Memorandum of Understanding – the Engine that Pushed GSM to the Market, in Friedhelm Hillebrand (ed.), GSM and UMTS: The Creation of Global Mobile Communication (West Sussex, England: John Wiley & Sons, 2002) at 41.
[255] H. Anthony Chan & Sing Lin, "Standards and deployment issues in wireless data networks", IECON 02, 28th Annual Conference of the Industrial Electronics Society, IEEE 2002, Vol. 4, November 5-8, 2002, at 3407.
[256] Shosteck Group White Paper on TDMA 3G Migration Paths, CDMA Development Group, June 2001 (available at http://www.cdg.org/technology/cdma_technology/shosteck/overview.asp).

licensees of Qualcomm CDMAone technology, such as Motorola, Lucent, and Northern Telecom are active proponents of CDMA2000.

UMTS, like CDMA 2000, is based on Wideband CDMA technology and has been selected as the third generation cellular standard for Japan and the European Union. Rather than rely on the CDMA technology developed by Qualcomm to develop UMTS, Swedish cellular manufacturer Ericsson teamed up with Japanese cellular operator NTT Docomo to create a new version of CDMA that was better suited to migration from GSM,[257] and incorporated "plenty of network features" from GSM.[258] Some suggest that the Japanese variant of CDMA was chosen by ETSI specifically because it is not directly related to CDMAone, thus, denying Qualcomm the opportunity to charge European manufacturers to license the CDMAone patents.[259]

The fact that the European third generation cellular standard is based on CDMA, rather than TDMA, technology is a subject of frequent grandstanding by supporters of the CDMAone standard. In essence, CDMA technology "won the technical argument" that spread spectrum code based multiplexing was indeed commercially feasible and higher capacity than time-based multiplexing.[260] For advocates of less government regulation and hands-off industrial policy, this fact justifies the FCC's decision to not select a specific second generation cellular standard and, instead, allow various standards to compete. Pundits in *Foreign Affairs*, for example, trumpeted that:

> "Wisely, the United States refused to favor any given technology and instead allowed marketplace experimentation to guide development. That strategy yielded the superior code division multiple access (CDMA) technology . . . which uses spectrum more efficiently. The transition to the next generation of mobile telecommunications standards (which are based on CDMA technology) will be much smoother for those U.S. companies that have adopted CDMA . . . than for their European counterparts."[261]

In essence, the argument is that CDMAone users are more "future-proofed" and will save money in the long run because their transition to third generation standard CDMA2000 will cost less than converting from GSM to CDMA2000,[262] because it requires "only minor upgrades to the network and small capital investment."[263] In other words,

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[257] Funk (2002), *supra* note 152, at 50-51.
[258] Chan & Lin (2002), *supra* note 255, at 3410.
[259] Funk (2002), *supra* note 152, at 80-84.
[260] Steele, Lee, & Gould (2001), *supra* note 166, at 406.
[261] Philip J. Weiser & Thomas Bleha, "The FCC's Real Wrongs", *Foreign Affairs*, Vol 84, No. 5, pp. 161-165 (2005).
[262] Hak J. Kim, Martin B.H. Weiss, & Benoit Morel, "Real options and technology management: Assessing technology migration options in wireless industry", *Telematics and Informatics*, Vol. 26, No. 2, May 2009, pp. at 184.
[263] *Id.* at 182.

CDMAone could be viewed as a 2.5 generation (2.5G), rather than a second generation system.[264]

Operators offering UMTS, on the other hand, may be unable to reuse GSM base station hardware, thus, necessitating the installation of new hardware cabinets adjacent to existing systems "a significant investment" for GSM operators.[265] However the cost of upgrading to third generation must be evaluated in the context of the benefits it will provide to operators. Some predict such "[l]arge performance advantages in the new [UMTS] technology" that it will "make switching costs meaningless."[266]

It is noteworthy that UMTS is based on wider bandwidth than CDMAone.[267] This means that CDMAone and CDMA2000 hardware will not necessarily be compatible with UMTS systems. If the FCC does not name a *de jure* third generation cellular standard and United States cellular operators do not reach a consensus on a *de facto* third generation standard, there is a possibility that countries outside the U.S. and EU will once again adopt the European standard as their own. Then, "Europe's ability to achieve market dominance based on TDMA[-based GSM]" will not be a "bar to their being able to do so again with CDMA[-based UMTS]."[268]

Overall, it appears true that CDMAone operators will be able to transition to a third generation system more inexpensively than GSM operators. However, the additional cost of upgrading GSM networks to UMTS may not prove prohibitive; particularly if third countries adopt the UMTS standard and there are greater economies of scale for UMTS than CDMA2000.

Cellular Industry Parallels to the Smart Grid

Developers of Smart Grid equipment and standards may draw several lessons from the cellular industry's experience. First, <u>singular</u> standards adopted by large markets can yield economies of scale that lower costs for consumers and operators, which increases customer choice and adoption. Second, setting standards sooner often translates into getting to market sooner, and, thus, acquiring a critical mass of customers and operators sooner. Third, sometimes the first standard is not always the best standard from a technical perspective, however the cost of technical inferiority can sometimes be overcome by critical mass.

The lesson that it may be best to create a unified singular standard, as opposed to competing standards, is demonstrated by the European adoption of a uniform second generation cellular standard yielding "one of the great successes of European telecommunications policy, and the North American regulators' decision to let the market

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264 Steele, Lee, & Gould (2001), *supra* note 166, at 406.
265 Kim, Weiss, & Morel (2009), *supra* note 262, at 182.
266 Funk (2002), *supra* note 152, at 31.
267 Steele, Lee, & Gould (2001), *supra* note 166, at 406.
268 Martin Libicki, The Role of Technical Standards in Today's Society and in the Future, RAND Science and Technology Policy Institute, CT-172, September 2000 at 10.

determine standards is a great failure."[269] Because CEPT and ETSI established GSM as a uniform standard via an open process, it "cause[d] the forecasted installed based instantaneously to increase, making the standard more attractive to non-aligned firms."[270]

Both first and second generation cellular telephony underscore the lesson that open standards created by large countries (e.g., the United States) or region (e.g., Europe) are far more likely to be adopted as global standards.[271] This lesson has already been proven twice: first with AMPS (and its derivative TACS), which was adopted in over 100 countries;[272] and next with GSM, where "market sizes and economies of scale created by *ex ante* standardization lead actors into the dominant trajectory in the evolutionary process of standard creation."[273] In both cases, the result was a "positive feedback loop between falling handset prices, service charges, and growth in subscribers."[274]

The idea that prematurely setting a standard has the potential to "disadvantage . . . consumers in the longer run, if the mandated technology is inferior to one used elsewhere[,]"[275] is readily illustrated by comparing CDMAone and GSM. Second-mover Qualcomm was ultimately able to demonstrate that TDMA-based systems, such as GSM and D-AMPS, were inferior, from a capacity perspective, to CDMA-based systems, such as CDMAone. This explains why both third generation cellular standards, UMTS and CDMA2000, were built on a CDMA architecture. Thus, the competition between CDMAone and GSM may have yielded significant long range benefits to society. And, of course, pioneering a new standard was certainly profitable for Qualcomm, and some of its licensees, in the near-term. In short, there may be some benefits stemming from a standards competition that can partially offset the cost of market fragmentation.

The cellular industry has also provided practical evidence of the importance of timing when setting standards. GSM's market dominance suggests there may be a first mover advantage due to the "'a winner takes all' [dynamic] when systems achieve high momentum due to strong positive network externalities, and increased marginal returns."[276] By virtue of carriers around the world investing in GSM systems, this "effectively locked out"[277] the opportunity to later sell them a CDMAone system. At the same time, however, the FCC's more "patient" approach to selecting a second generation

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[269] Gandala, Salant, & Waverman (2003), *supra* note 242,at 326; see also Charles Edquist, "Policy implications for the Future of the Sectoral System", in Charles Edquist (ed.), The Internet and Mobile Telecommunications System of Innovation (Northampton, MA: Edward Elgar, 2003) at 239 (describing the allowance of multiple second generation cellular standards as "a serious policy failure for the U.S. as well as a great success for the EU.")
[270] Funk (2002), *supra* note 152, at 3 and 75.
[271] *Id.* at 3.
[272] *Id.* at 13.
[273] Edquist (2003), *supra* note 249, at 239.
[274] Vladislav V. Fomin, "The Role of Standards in Sustainable Development of Cellular Mobile Communications", *Knowledge, Technology, & Policy*, Vol. 14, No. 3, Fall 2001 at 62.
[275] Gandala, Salant, & Waverman (2003), *supra* note 242, at 329.
[276] Lyytinen & Fomin (2002), *supra* note 131, at 154-155.
[277] *Id.*

cellular standard ultimately yielded "a [technically] higher-quality standard[,]"[278] as demonstrated by the easier transition path for CDMAone carriers to a third generation system.[279] In short, a longer standard-setting process can yield better technical results, but perhaps at a higher market cost.

In sum, the evolution of the cellular industry highlights the challenge of balancing innovation, which may be more likely to emerge in a lengthier standards setting process, with the development of critical mass, which is often accorded to the first standard to be set. A technological solution to this conundrum might be to offer dual-mode equipment that embraces both current and next generation technology,[280] however such dual-functionality will inevitably increase equipment costs. From a procedural perspective, one scholar has suggested the key lessons from the cellular industry are to set standards quickly to lock in a first-mover advantage, however be careful to ensure that a wide net, including foreign companies, is cast when recruiting participants for the standard-setting process.[281] This approach reduces the risk that standards are set based on older, less efficient technology, while still quickly establishing a uniform *de jure* standard capable of generating economies of scale, wide geographic coverage, and avoiding market fragmentation.[282]

Conclusions

While AM Stereo, and wireline and cellular telephony each possess unique characteristics, their development path bears similarities to the challenges facing the Smart Grid. For example, all had to answer the question about whether intellectual property from innovators would be licensed to grow the market. Now a similar debate is occurring within the Smart Grid industry, as some proponents argue for open standards while others tout the virtues of open licensing instead.[283] Building on their experience with cellular telephony business models, pundits have dubbed one startup "A Qualcomm

[278] Luis M.B. Cabral & Tobias Kretschmer, "Standards battles and public policy" in Shane Greenstein & Victor Stango (eds.), *Standards and Public Policy* (New York: Cambridge University Press, 2007) at 330, 336-337.
[279] A similar result occurred in the field of HDTV, where Japan and Europe locked into an HDTV standard at a very early stage, while the United States allowed the standards competition process to continue. This approach "led to a better outcome for the U.S. in terms of the HDTV prototype." See Gandala, Salant, & Waverman (2003), *supra* note 242, at 331.
[280] Funk (2002), *supra* note 152, at 236-237.
[281] Rohit Sakhuja, Air Interface Standards for Digital Mobile Cellular Systems in the U.S., Europe and Japan, Master of Science Thesis, Massachusetts Institute of Technology, 1995, at 144; Richard K. Lester & Michael J. Priori, Innovation: The Missing Dimension (Cambridge, Mass.: Harvard University Press, 2004) (Highlighting complaints by Japanese cellular equipment manufacturers that they were excluded from the U.S. second generation cellular standard setting process).
[282] *Id.*
[283] See, e.g., Presentations by Stu Soffer of IPriori, Inc. and Steve Hemminger and Augie Rakow of Alston & Bird LLP at the Conference on The Intersection of Smart Grid Technology and Intellectual Property Issues, January 29, 2010 (available at http://www.alston.com/files/docs/Session%20I%20-%20Competitive%20IP%20Landscape.pdf).

for the Smart Grid."[284] And regulators are complaining that "some companies are already gumming up the works by pushing their own networking technology[.]"[285]

Proposed Smart Grid standards abound.[286] As regulators and industry groups decide which ones to adopt, the lessons of the AM Stereo technology debacle and the open-ended second-generation cellular telephony standard should be considered: consumers value certainty, and the first standard to achieve critical mass may have a long-term competitive advantage.

ETSI's cellular standard-setting in Europe, which involved not just service providers, but also hardware manufacturers and consumers, may provide an appropriate model for the Smart Grid standard-setting process. A group of large utilities have already called for "a concerted effort by all stakeholders including regulators, government agencies, utilities, vendors, commercial organizations and standards development organizations."[287]

Large consultancies are already proclaiming that, "[i]n the days to come, potential new lines of business for utilities will include installing and managing the customer equipment that makes the smart home possible."[288] And energy industry experts are advising utilities that commercial and industrial customers "will be interested in methods of financing the equipment, [and] utility/customer cost sharing arrangements[.]"[289] Regulatory oversight of such activities should build on the lessons of the wireline telephony industry: turnkey solutions and equipment leasing, rather than sale, can increase consumer adoption, however interfaces should be specified clearly enough to allow third parties to develop innovative new products that can safely interface with the Smart Grid network.

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[284] Michael Kanellos, "A Qualcomm for the Smart Grid?", GreenTech Grid, March 11, 2010 (available at http://www.greentechmedia.com/articles/read/a-qualcomm-for-the-smart-grid/). Qualcomm itself has entered the Smart Grid business as well. See "Qualcomm, Verizon Join Forces to Focus on M2M Wireless Communications", SmartGridNews.com, July 31, 2009 (available at http://www.smartgridnews.com/artman/publish/news/Qualcomm_Verizon_Join_Forces_to_Focus_on_M2M_Wireless_Communications_printer.htm).

[285] Martin LaMonica, "Time short to agree on smart-grid standards", GreenTech Report, CNET News, November 23, 2009 (available at http://news.cnet.com/8301-11128_3-10403437-54.html).

[286] See, e.g., Smart Grid Standards Assessment and Recommendations for Adoption and Development, draft v0.82, Enernex for California Energy Commission, February, 2009.

[287] "Smart Grid Standards Adoption: Utility Industry Perspective", Letter by American Electric Power, Avista, Centerpoint, Consumers Energy, Duke Energy, Electricité de France, Florida Power & Light, Oncor, Pacific Gas & Electric, Reliant Energy, San Diego Gas & Electric, and Southern California Edison to the Smart Grid Utility Executive Working Group and OpenSG Subcommittee of the Californa Public Utility Commission, (available at http://www.cpuc.ca.gov/NR/rdonlyres/.8E5CF3D8-EB44-4566-9678-09AEA75396E0/0/0904_AcceleratingSmartGridStandardsAdoption.pdf)

[288] "Smart Home: The Human Side of the Smart Grid", Capgemini, 2010 (available at http://www.us.capgemini.com/DownloadLibrary/files/factsheets/Capgemini_EUC_SmartHome_FS0310.pdf)

[289] "Perspectives For Utilities Implementing Smart Grids", Smart Grid Stakeholder Roundtable Group, July 21, 2009 (available at http://www.naseo.org/committees/energyproduction/documents/Smart_Grid_Stakeholder_Roundtable_2009-07-21.pdf).