# Privacy and the New Energy Infrastructure

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ABSTRACT

This article examines the privacy consequences of the diffusion of smart grid and smart metering technologies. It illustrates how high resolution electricity usage information can be used to reconstruct many intimate details of a consumer's daily life, and provides examples of how that information could be used in ways potentially invasive of an individual's privacy. The article then examines the nature of existing protections for such information, and evaluates their adequacy in protecting against some of these potentially invasive uses. The article concludes that state legislators and public utility commissions should examine the codes of conduct governing utility disclosure of consumer information in their various jurisdictions to address this new privacy threat.

## I. INTRODUCTION AND OVERVIEW

The drive to re-tool the United States' electricity generation and distribution networks may inadvertently raise a monster with unparalleled abilities to invade residential privacy. The nation's much called-for transition to smart electricity grids, driven by benevolent—or at least benign—intentions, requires the deployment of smart meters that collect detailed information about residential electricity use. These technologies can provide a window into the activities within the homes, exposing once private activities to anyone with access to electricity usage information.

Privacy scholars have long sought to drive home their privacy-related concerns by utilizing a salient analogy to frame worries and give connotation to their foretold consequences of inadequate privacy protection. George Orwell's *Nineteen Eighty-Four*, which depicts a society burdened by all but constant surveillance, has provided the standard metaphor when framing such concerns among academic commentators and judges alike.[1] However, the metaphor has its limitations.[2] Specifically, it assumes a malevolence and deliberation on behalf of the privacy invader, as well as a kind of omnipresence that, while chilling, can often seem a

[1] *See, e.g.*, Daniel J. Solove, *Privacy and Power: Computer Databases and Metaphors for information Privacy*, 53 Stanford L. Rev. 1393 (2001); Arizona v. Evans, 514 U.S. 1, 25 (1995) (Ginsburg, J., dissenting) ("As automation increasingly invades modern life, the potential for Orwellian mischief grows." (quoting *Arizona v. Evans*, 866 P.2d 869, 872 (Ariz. 1994))).

[2] *See* Solove, *supra* note 1, at 1398.

little farfetched. Other authors have put forward replacement metaphors, at least in the context of database management and information privacy, in recognition of these limitations and the further fact that metaphors, in structuring dialogue, play a critical role in developing solutions.[3] For example, Dan Solove has proposed that Kafka's *The Trial* be used instead to frame discussions surrounding databases and information privacy, urging that the faceless bureaucracy with the potential to make potentially costly mistakes should play a more central role in privacy discussions.[4] Another analogy was provided, though inadvertently, by Douglas Kysar and James Salzman who argued that the role of information in policy construction is often understood piecemeal by the various vested interests and likening it to a group of blind men attempting to describe an elephant while each could investigate only a part of the animal.[5]

Though each of these analogies helpfully highlights a particular aspect of privacy and the need for privacy protection, they each treat the privacy problem as though it were static. As such, they fail to provide the discussion with a normative bite. Rather, discussions surrounding privacy, when so framed, can do little other than underscore certain descriptive realities as problematic and prey on privacy intuitions. Yet the data set clung to as private is co-constituted by the uses of the data and the ease of access to it.[6] The privacy landscape is dynamic and shifting. Simply examining a context in which there is a potential for privacy invasion is not enough; one must endeavor to understand the various influences driving change and progress in that area, that is, to see the situation as a vector rather than a stationary value.

To shine the light on this aspect of the so-called "privacy problem," consider another metaphor plucked from the European cannon: Mary Shelley's *Frankenstein*. Dr. Frankenstein, driven by curiosity, the specter of scientific greatness, and most importantly the benevolent goal of curing humanity of disease and even death, constructed from corpses a nameless artificial man, and then gave him life.[7] It was not until the deed was done, the "switch" thrown, that he saw the monster he had visited upon the world.[8] He ran from the room in disgust, and attempted in vain to ignore his creation.[9]

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[3] *See id.* (recognizing that "the way we conceptualize a problem has important ramifications for law and policy," and arguing that Kafka's *The Trial* provides the more prescient vision of a "thoughtless process of bureaucratic indifference, arbitrary errors, and dehumanization, a world where people feel powerless and vulnerable, without any meaningful form of participation in the collection and use of their information.").

[4] *See* Solove, *supra* note 1, at 1398.

[5] *See* Douglas A. Kysar & James Salzman, *Forward: Making Senese of Information for Environmental Protection*, Texas L. Rev. 1347, 1349 (2008) (quoting John Godfrey Saxe's poem *The Blind Men and the Elephant*, in THE POETICAL WORKS OF GODFREY SAXE 111, 112 (Houghton Mifflin 1882)).

[6] This insight is usually formulated in the context of the "reasonable expectation of privacy" test, where authors have noted that expectations of privacy shift as, for example, the technology that allows for privacy invasion becomes more common-place and the "invasions" more anticipated. *See*, Lerner & Mulligan, *infra* note 31, at n.28 (citing Orin S. Kerr, *The Fourth Amendment and New Technologies: Constitutional Myths and the Case For Caution*, 102 MICH. L. REV. 801, 808 (2004); Susan Friewald, *Online Surveillance: Remembering the Lessons of the Wiretap Act*, 56 ALA. L. REV. 9, 39 & n.205 (2004)).

[7] Dr. Frankenstein described his motivations thus:

> I entered with the greatest diligence into the search of the philosopher's stone and the elixir of life; but the latter soon obtained my undivided attention. Wealth was an inferior object; but what glory would attend the discovery, if I could banish disease from the human frame, and render man invulnerable to any but a violent death!

MARY SHELLEY, FRANKENSTEIN, ch. 2 *available at* Literature.org, http://www.literature.org/authors/shelley-mary/frankenstein/chapter-02.html (last visited Nov. 22, 2008).

[8] In the Doctor's words:

Frankenstein's lessons for privacy are twofold. The first lesson is simply the law of unintended consequences: efforts driven by benign and even benevolent motivations can nonetheless be twisted to unfortunate or even malevolent ends. The second lesson is one of responsibility. The tragedy of Frankenstein is that, upon seeing the lids open on the yellow eyes of his monster, the doctor abandoned him in the laziest of attempts at redemption. It was the abandonment that in fact led to the monster's isolation and horrific deeds.[10] Once created, the beast needed looking after.

The modern era does not want for benevolent causes, but perhaps more so than in the past, gathering information is seen as the first step in crafting solutions. Enthusiastic authors from a wide range of professional disciplines have pointed toward the horizon and the dawning of an era of "data-driven policy."[11] Too long has decision making been trapped in a paradigm of top-down implementation, they say, while information gaps plague the efficacy and efficiency of efforts to direct change. Technological advancements, paired with a new sensitivity to empirical data, have brought us to the brink: "A . . . revolution in government decision-making is waiting to be unleashed."[12]

> By more effectively harnessing these [information] technologies, government can begin to close data gaps that have long impeded effective policymaking. As problems are illuminated, policy-making can become more targeted, with attention appropriately and efficiently directed; more tailored, so that responses fit

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> I had worked hard for nearly two years, for the sole purpose of infusing life into an inanimate body. For this I had deprived myself of rest and health. I had desired it with an ardour that far exceeded moderation; but now that I had finished, the beauty of the dream vanished, and breathless horror and disgust filled my heart.

*Id.* ch. 5, http://www.literature.org/authors/shelley-mary/frankenstein/chapter-05.html (last visited Nov. 22, 2008). For accuracy's sake, the image of Dr. Frankenstein throwing a switch is one created by directors of later movie adaptations. The event in the novel itself is considerably more subtle and vague. *See id.*

[9] *See id.*

[10] Late in the story, the monster chided Frankenstein:

> 'I am thy creature, and I will be even mild and docile to my natural lord and king, if thou wilt also perform thy part, the which thou owest me. Oh, Frankenstein, be not equitable to every other, and trample upon me alone, to whom thy justice, and even thy clemency and affection, is most due. Remember, that I am thy creature; I ought to be thy Adam; but I am rather the fallen angel, whom thou drivest from joy for no misdeed. Everywhere I see bliss, from which I alone am irrevocably excluded. I was benevolent and good; misery made me a fiend. Make me happy, and I shall again be virtuous.'

*Id.* ch. 10, http://www.literature.org/authors/shelley-mary/frankenstein/chapter-10.html (last visited Nov. 22, 2008).

[11] *See, e.g.,* Daniel Esty & Reece Rushing, *The Promise of Data-Driven Policy Making*, ISSUES IN SCIENCE AND TECHNOLOGY (Summer 2007), *available at* http://www.issues.org/23.4/esty.html (discussing how data-driven decision-making would be useful in the contexts of education, healthcare, and environmental regulation); Ann H. Cary, *Data Driven Policy: The Case for Certification Research*, 1 POLICY, POLITICS, & NURSING PRACTICE 165 (2000) (discussing nursing certification requirements and the connection between professional certification requirements and job performance generally); Ann M. Dellinger et al., *Risk to Self Versus Risk to Others: How Do Older Drivers Compare to Others on the Road?*, 26 AM. J. PREVENTATIVE MED. 217, 221 (2004). Such enthusiasm seems to have gotten a shot in the arm with the election of Barak Obama, who is renowned for his attention to empirical data in crafting policy. *See* David Leonhardt, *Obamanomics*, N.Y. TIMES MAG. (Aug. 20, 2008) *available at* http://www.nytimes.com/2008/08/24/magazine/24Obamanomics-t.html?pagewanted=3&_r=1 (last visited Nov. 28, 2008) (quoting Nobel laureate James Heckman as saying of the Obama campaign " 'I've never worked with a campaign that was more interested in what the research shows.' ").

[12] Esty & Rushing, *supra* note 11.

> divergent needs; more nimble, able to adjust quickly to changing circumstances; and more experimental, with real-time testing of how problems respond to different strategies. Building such a data-driven government will require sustained leadership and investment, but it is now within our reach.[13]

But, so the adages go, information is power—and power corrupts. The dream of data-driven policy means—at least at the outset—the collection and analysis of more data. The rampant collection, analysis, and dissemination of data regarding parts of our lives that have not before been subject to such scrutiny may in turn be agar for growing an unforeseen monster of privacy invasion.

If the fable of Frankenstein is to teach us anything it must be that, in these pursuits, we should be careful in the beginning and careful with our follow-through. Where the risks of disclosure are low—either because information is scarce or the consequences of its dissemination are few—people tend not to implement careful measures for its protection. However, where the risks of disclosure are potentially grave, then measures for controlling access to information seems reasonable. Unfortunately, determining just which of these two scenarios applies is difficult until after the information has been compiled and then disclosed. As it was for Dr. Frankenstein, it is difficult to foresee all potential consequences until the switch is thrown.

Modern efforts at energy reform and environmental policy development provide a perfect example of this dilemma, as well as an opportunity to develop strategies for dealing with it. In order to address issues of global climate change and energy security, more detailed information about energy consumption patterns is needed. The basic motivation here is that, in order to get a handle on the problems, we must better understand the causes.[14]

In answer to this need, recent years have seen an explosion of smart meter installments in jurisdictions around the globe.[15] Smart meters help answer the need by collecting interval data about a resident's or company's electricity consumption, often in fifteen minute increments, and providing that information both to the consumer and to the electricity provider. Electric utilities large and small across the United States have initiated advanced metering infrastructure projects

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[13] *Id.* While Esty's and Rushing's enthusiasm for "data-driven policy" is infectious and inspired, it is worth tempering it somewhat with a few sober observations: numerical data itself may be a seed for wise policy-making, but it is a long way from seed to harvest. The methods of collecting data—in determining both form and amount—can skew pictures and direct inquiries unwittingly. The data itself may take on new meaning in the process of its collection (see discussion *infra*, Part III.A). Additionally, not all valuable evidence is quantitative in nature, so the very phrase "data-driven" policy may already unnecessarily narrow the ways in which we move forward with an evidence- or information-based decision-making model. Finally, there are good reasons to question the mantra of "the more information the better," at least in some circumstances. For example, Timothy Carson and Charles Plott have argued that requiring utilities to disclose otherwise confidential information about their energy demands to suppliers—usually efforts hoping to inject "transparency" into electricity markets—can actually harm market efficiency. *See* Timothy N. Carson & Charles R. Plott, *Forced Information Disclosure and the Fallacy of Transparency in Markets*, ECONOMIC INQUIRY (Oct. 2005), *available at* http://findarticles.com/p/articles/mi_hb5814/is_/ai_n29214146. According to them, it is a fallacy to think "greater information in markets necessarily improves market performance from the point of view of all participants." *Id.*

[14] For a more complete discussion of the problem sources and the ways in which detailed information may be used to craft solutions, see *infra* Part II.A.

[15] The Energy Retail Association based in Great Britain maintains a map indicating smart meter installation projects and pilots worldwide for electricity, gas, and water meters. Though the group is careful to state the map is not exhaustive of such projects, the data set is impressive, listing over fifty electricity-related projects in the continental U.S. alone. *See* Smart Meters: Key Resources, http://www.energy-retail.org.uk/test/smartmeters.html (last visited Oct. 28, 2008) (follow the "Google Map" hyperlink).

to install advanced metering technology throughout their service districts. These utilities include the likes of Alabama Power,[16] CenterPoint Energy Houston Electric,[17] PECO Energy Company,[18] PG&E,[19] San Diego Gas & Electric,[20] and Xcel Energy.[21] The Federal Energy Regulatory Commission reported recently that, all told, these efforts will result in the deployment of 40 million advanced metering devices by 2010.[22] From these devices will stream detailed information about consumer electricity use, the kind of information that will be needed if the country is to effectively address looming energy supply issues, energy security, and global climate change.

But just as more—and more detailed—data about home energy use is pouring into utilities,[23] the information that can be gleaned from that raw data is growing ever higher in resolution. From an electricity usage profile, modern analytical techniques can identify use of specific appliances within the homes, and will in the foreseeable future be able to pinpoint exactly where within the home those appliances are located.[24] The potential for gleaning potentially private information from this data is truly staggering, including when a resident showers, watches TV, and how often she prefers microwave dinners to a three-pot meal.[25] The richness and detail of the insights provided by this newly refined and individualized information is matched only by the number of potentially troublesome uses for such data, which range from the targeted and nefarious to the structural and discriminatory.[26] Furthermore, the fact of energy use itself has become tied to judgments about and individual's social responsibility, and so, while data collection booms, intuitions about the private nature of that data may well be shifting to be more protective of its disclosure.[27]

[16] Alabama Power: A Southern Company, "Your Meter is About to Get Smarter," http://www.alabamapower.com/residential/smartmeter.asp (last visited Sept. 9, 2008).

[17] Press Release, CenterPoint Energy to Begin Installing up to 125,000 Advanced Meters, Aug. 28, 2008, http://www.centerpointenergy.com/newsroom/newsreleases/fb6859363460c110VgnVCM1000005a1a0d0aRCRD/ (last visited Sept. 9, 2008).

[18] Before the Penn. Public Utility Commission, Direct Testimony of Frank J. Jiruska, Mar. 14, 2008, a*vailable at* http://www.exeloncorp.com/NR/rdonlyres/71890D18-6BF8-4F13-A998-298A22A4D995/4411/RRTPJiruskaDirectFinal.pdf.

[19] Press Release, PG&E Seeks to Upgrade SmartMeter™ Technology to Enhance Consumer, Operational Benefits, Jan. 17, 2008, *available at* http://www.pge.com/about/news/mediarelations/newsreleases/q1_2008/080117.shtml (last visited Sept. 9, 2008).

[20] *See* SDG&E: A Sempra Energy Utility, Frequently Asked Questions, http://www.sdge.com/smartmeter/faq.shtml (last visited Sept. 9, 2008) ("[I]t's anticipated that all customers will eventually receive smart meters by the end of 2011.")

[21] Xcel Energy, SmartGridCity, http://www.xcelenergy.com/smartgrid/ (last visited Sept. 9, 2008); Xcel Energy, *SmartGridCity™: Design Plan for Boulder, Colo*., *available at* http://www.xcelenergy.com/smartgrid/media/pdf/SmartGridCityDesignPlan.pdf.

[22] Federal Energy Regulatory Commission, Assessment of Demand Response & Advanced Metering 2007, Staff Report [hereinafter "FERC 2007 Demand Response Assessment"], at ii, *available at* http://www.ferc.gov/legal/staff-reports/09-07-demand-response.pdf. *See also* Press Release, Federal Energy Regulatory Commission, Staff Report Marks Growth of Nationwide Demand Response Efforts, Sept. 7, 2007, *available at* http://www.ferc.gov/news/news-releases/2007/2007-3/09-07-07.pdf ("[I]f all the announced deployments actually occur, more than 40 million new advanced meters will be deployed in the next several years").

[23] *See infra* Parts II.B and C.

[24] *See infra* Parts II.C and III.B.

[25] *Smell infra* Part III.B.

[26] *See infra* Part III.B.4.

[27] *See infra* Part III.A.

Ironically, however, smart meters are often touted as harbingers of *more* privacy: "Because smart meters send information electronically to [the utility] daily, . . . meter readers will no longer have to enter your property."[28] Already we see the benevolent drivers of data collection and aggregation veiling naiveté with regard to the power and potential dangers of the process.

And all the while there lurk reasons to be concerned. Electric utilities face new pressures that could conceivably drive them to look for new sources of revenue. Potential climate change legislation and other possible causes of operation-cost increases mean utilities may go looking for ways to cover the new costs.[29] While the natural method to do so is via a rate pass-through, it is not the only method.[30] Indeed, rate pass-throughs may find themselves subject to stronger resistance than usual in light of the general economic downturn and nation-wide concern over the economy. What's more, e-commerce has proven that collection and sale of personal information can be a lucrative endeavor. This confluence of forces may well push utilities toward more invasive behavior than they have engaged in before now.

In short, electric utilities are (or soon will be) collecting more information than they have in the past, and there is more reason to sell it to other parties. Existing privacy protection

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[28] Smart Reader Facts, San Diego Gas & Electric: A Sempra Energy Utility, *available at* http://www.sdge.com/documents/smartmeter/SM-Fact_Sheet-Green.pdf. SDG&E is not the only one excited about the privacy benefits of advanced meters:

> Some utilities have worked closely with builders for many years and arranged that essentially all meters are outside and near the front of the property, easily reached by the utility meter reader. But this is not the norm. Meter readers commonly must go around to the back of the house, into the dog's fenced area, behind the foundation planting bushes, and other inconvenient places to read the meter. It's inconvenient for the customer, too. The requirements to keep the dog in on the 14th of the month, or let the meter reader into the basement are all nuisances that customers find increasingly annoying as more of them are working during the day.

Edison Electric Institute, *Deciding on Smart Meters: The Technology Implications of Section 1252 of the Energy Policy Act of 2005*, at 13 (Sept. 2006) (Prepared by Plexus Research, Inc.).

[29] *See, e.g.,* Xcel Energy, Inc., Annual Report (Form 10-K), at 35 (Feb. 20, 2008) ("[C]hanges in regulations or the imposition of additional regulations, including additional environmental regulation or regulation related to climate change, could have an adverse impact on our results of operations and hence could materially and adversely affect our ability to meet our financial obligations, including paying dividends on our common stock."); PG&E Corp., Annual Report (Form 10-K), at 26 (Feb. 22, 2008) ("The new California legislation [AB 32], as well as current federal and other state regulatory initiatives relating to emissions of carbon dioxide and other GHGs, particulates and other pollutants, could cause the Utility's compliance costs and capital expenditures to increase. These laws could require the Utility to replace equipment, install additional pollution controls, purchase various emission allowances or curtail operations."); San Diego Gas & Electric Co., Annual Report (Form 10-K), at 6 (Feb. 26, 2008) ("[S]tate-level laws and regulations as well as proposed national and international legislation and regulation relating to GHG emissions . . . may limit or otherwise adversely affect the operations of the company. The company may be affected if costs are not recoverable in rates and because the effects of significantly tougher standards may cause rates to increase to levels that substantially reduce customer demand and growth."); Duke Energy Corp., Annual Report (Form 10-K), at 74 (Feb. 29, 2008) ("Under the proposed S. 2191 legislation [the so-called "Lieberman-Warner Bill"], in addition to allowances allocated at no cost, Duke Energy currently estimates the costs of purchasing needed allowances to cover Duke Energy's projected emissions in 2012 could range from approximately $930 million to $2.8 billion.").

[30] A rate pass-through is simple and intuitive: if the costs of production go up for the utility, the cost of consumption goes up for the consumer, and so the utility passes the new costs off to its customers. Many utilities, though conceding climate legislation poses a risk to their profitability, are nonetheless confident that shifting costs can be recovered in this way.

imposed by state statutes may well be inadequate to prevent such behavior.[31] For such potentially dramatic privacy consequences, the solution may be fairly simple. Amending PUC regulations to explicitly require the protection of this information and opt-in measures prior to the information's sale or disclosure could be formulated to answer much of the concern. Furthermore, PUC regulations across the country are being overhauled in response to shifting rate structures, driven by federal initiatives and economic realities of electricity generation. Thus, the solution could be developed and implemented in relatively short order.

While the reasons for collecting more and higher resolution energy usage data are compelling, and efforts on this front should not be hindered, it may be prudent to take a second look at how the collected data will be managed and protected, lest we accidently raise a monster while attempting to find a cure.[32]

## II. THE DATA SET

The data regarding an individual's electricity consumption is compiled for a number of reasons and serves a number of purposes. The data set is ever-shifting in its uses and expanding in scope and detail. As such, what follows is an attempt to describe the data set as a vector, if you will, with its origins, driving motivations and future directions, as opposed to simply disusing its current status.

### A. *Motivating Data Collection: Why We Need More—and More Detailed—Energy Usage Information*

To understand the rapidly changing area of electricity consumption analysis and data collection, as well as that data's potential implications for the privacy of consumers, it is necessary to first understand how the information has been traditionally gathered and what the motivations driving the changes. "The standard method of gathering billing data from a meter is quite simple. The utility reads the meter at the beginning of the billing period and again at the end of the billing period. From these readings, it determines the energy and maximum demand for that period."[33] This method means assigning electricity consumption numbers to intervals smaller than billing periods is left to guesswork.

Several modern shifts in the perception and practice of electricity generation and consumption urge the conclusion that this guesswork, no matter how careful, is no longer adequate. Peak electricity demands occurring in the middle of the day through early evening are beginning to strain many utilities' production capacity, though during other times of day there is a wealth of capacity, and thus the specifics of *when* power is consumed are becoming all the more important in power management. What's more, with the looming likelihood of federal

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[31] *See infra* Part IV. Furthermore, as electricity records may well be considered business records collected by third parties, the Fourth Amendment may offer little protection as well. For a careful and insightful discussion of this point, see Jack I. Lerner & Deirdre K. Mulligan, *Taking the "Long View" on the Fourth Amendment: Stored Records and the Sanctity of the Home*, 2008 STAN. TECH. L. REV. 3, http://stlr.stanford.edu/pdf/lerner-mulligan-long-view.pdf.

[32] Another concern: monsters are not well tolerated, and if the information gathered leads to monstrous privacy invasion, it may well negatively impact the sustainability of the data-based approach. In order to take full advantage of the tool of data-driven policy, we must not get over-hasty in its implementation.

[33] John V. Grubbs, *Metering of Electric Power and Energy*, in ELECTRIC POWER GENERATION, TRANSMISSION, AND DISTRIBUTION § 25.4.3 (Interval Data Metering) (Leonard L. Grigsby, ed., CRC Press 2006).

regulation of greenhouse gasses, GHG-belching utilities are looking for ways to minimize unnecessary production, that is, attempting to tune generation to demand in order to mitigate environmentally damaging emissions. As such, electric utilities need better consumption information to deal with booming peak demands.[34] Additionally, utilities need the information to accommodate distributed energy sources which are tying into the grid[35]; consumers want higher resolution data to help them curb unneeded or unintentional consumption[36]; and electricity rate structures are shifting such that fluctuations in the daily prices of electricity will be passed on to consumers more than they have in the past, driving a need for more accurate billing methods.[37] The confluence of these and other pressures has pushed data gathering on individual electricity consumption to new heights.

### 1. Demand Response Capability and Enhancing Load Management

The need for more information regarding electricity consumption were brought into sharp relief with California's energy crisis in 2001, which gave flesh to the then-specter of electricity demand outstripping load generation. In the wake of the crisis, it quickly became evident that, in order to efficiently manage load generation in response to booming demand, utilities would need to better understand consumer habits of use, so that spike demands might be anticipated.[38] "The collection of information about energy consumption from residential and commercial buildings at frequent intervals is a core component of the demand response system."[39] Furthermore, information is valuable both in managing demand response efforts and ensuring electricity generation is operating efficiently and effectively.[40] Simply put: better load modeling requires more detailed information. Real-time information can further assist in monitoring loads, and so allow utilities to adjust to the unexpected more quickly and more effectively.

### 2. Accommodating Variable Input from Renewable Resources

Another motivation for collecting detailed information about consumer electricity usage is to facilitate a shift toward a more diverse energy portfolio and integrate renewable energy resources into the grid. The twin challenges of climate change and energy security militate in favor of tapping into low-emitting, locally produced energy in such forms as wind and solar

[34] *See infra* Part II.A.1.
[35] *See infra* Part II.A.2.
[36] *See infra* Part II.A.3.
[37] *See infra* Part II.A.4.
[38] Indeed, where smart meters had before been brushed aside as an unnecessary expense, the California crisis shifted the analysis. Sam Lubell, *Tracking Energy Use with Digital Meters*, N.Y. TIMES (Apr. 19, 2001) (Reporting that residents often resisted the increased costs of smart meters, but quoting a General Electric officer shortly after the California energy crisis as saying, "'That was at a time when energy was plentiful and people didn't care. That environment has changed dramatically. We are looking very carefully at California right now.").
[39] Lerner & Mulligan, *supra* note 31, ¶ 2.
[40] As Amy Abel reported to Congress regarding the deployment of smart meter technology:

> It is expected that grid reliability will increase as additional information from the distribution system is available to utility operators. This will allow for better planning and operations during peak demand . . . . It is estimated that a 4% peak load reduction could be achieved using Smart Grid technologies.

Amy Abel, CRS Report to Congress: Smart Grid Provisions in H.R. 6, 110th Congress, RL 34288 (Dec. 2007) at CRS-3, *available at* http://fas.org/sgp/crs/misc/RL34288.pdf.

power. “A more distributed grid, by its very architecture, can improve efficiency by matching local supply with demand. With multiple decentralized energy sources, electricity can be generated close to the point of use, avoiding the losses and congestion that result from long-distance transmission.”[41] Such resources are highly variable in their production, however, and a efforts are ongoing to manage the fluctuating input from such sources efficiently and effectively, and in a way that does not disrupt other users of the grid.

At least part of the answer lies in more information. In order to manage the network and diversity of resources, utilities have to know “what is happening in every corner of the grid at any instant.”[42] They can thus pair draws with appropriate sources, and better manage meeting the needs of those tied in to the grid, and take advantage of environmentally friendly additions to the area’s electricity production.[43]

### 3. Demand-Side Management: Driving Consumer Actions Through Awareness and Social Pressure

Energy efficiency and electricity conservations are often discussed as yet untapped resources: after all, one way to address environmental and energy security woes is simply to decrease demand, and so relieve pressures driving pollution emission and energy import.

Disseminating usage information to consumers is one way of tapping into that resource. Often, consumers are unaware of low-level, constant draws, the management of which can affect impressive reductions in both usage and correlated emissions. Providing consumers with real-time or detailed information about their consumption—and its costs—has proven to be a wildly successful method for driving energy efficiency efforts and changes in consumptive behavior. Consumers that are aware of their energy usage patterns can adjust them.[44] A Department of Energy study carried out in the Pacific Northwest concluded that “[g]iving people the means to closely monitor and adjust their electricity use lowers their monthly bills and could significantly reduce the need to build new power plants.”[45]

Additionally, providing the usage information can bring social pressures to bear on consumption behavior, driving use down even further. Studies have shown that, when information is provided as relative to the performance of others, combined with a normative assessment of which results are more desirable (e.g. a smiley face next to low electricity consumers and a frowny face next to excessive consumers), reductions can be both deep and sustained.[46] Such information also allows for the introduction of competition. Sometimes called the “Prius effect” after the real-time fuel-efficiency data Toyota’s Prius hybrid vehicle provides

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[41] Declan Butler, *Energy Efficiency: Super Savers: Meters to Manage the Future*, 445 NATURE 586, 587 col. 1 (Feb. 8, 2007).

[42] *Id*. at 586 col. 2.

[43] *See generally* M.G. Lauby & W.P. Malcolm, *North American Industry Trends Supporting Intelligent Grids*, International Conference on Intelligent Systems Applications to Power Systems (Nov. 2007).

[44] For an impressive bibliography concerning the effect of providing consumption information to electricity consumers on their usage rates, see Lynn Fryer Stein, *California Information Display Pilot Technology Assessment*, Prepared for Sothern California Edison by Primen, Inc. (Dec. 2004), pp. 35–38, *available at* http://www.ucop.edu/ciee/dretd/documents/idp_tech_assess_final1221.pdf.

[45] Steve Lohr, *Digital Tools Help Users Save Energy, Study Finds*, N.Y. Times (Jan. 10, 2008). *See also* M. Venables, *Smart Meters make Smart Consumers*, IEEE ENGINEERING & TECHNOLOGY 23, 23 (Apr. 2007).

[46] *See* John Tierney, *Are We Ready to Track Carbon Footprints?*, N.Y. TIMES, Mar. 25, 2008, *available at* http://www.nytimes.com/2008/03/25/science/25tier.html. *See also* CASS SUNSTEIN & RICHARD THALER, NUDGE (2008).

drivers with while driving, people with access to such information often compete with themselves and with others for better scores on fuel efficiency and electricity consumption.[47]

The demand-side management use of detailed electricity consumption data is one of the most powerful motivating factors behind such information collection. Not only does the information facilitate DSM efforts, but it is an ever more commonly cited motivation by researchers on electricity load information.[48] Even more impressively, curiosity and the opportunity for cost savings for residential users has become the basis for new business models. One manufacturer of electronic devices that allow users to determine their energy use and real-time costs boasts, "If you can measure it, you can manage it."[49]

4. Shifting Rate Structures

A fourth motivation for collecting detailed information about a single house-hold's electricity consumption involves a move to change the rate structure governing the billing of electricity use.[50] The essence here is this: instead of being priced at a more-or-less constant rate with only a rough relation to the time of use both during the day and within the year, electricity will be rated to match fluctuating demand throughout the day.[51] These rate fluctuations will be passed on to consumers under a variety of so-called "dynamic pricing" schemes. Such schemes have the twin purposes of activating the demand side of the electricity market by providing economic incentives to go along with the consumption information and so further support DSM

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[47] *See*, *e.g.*, Michael S. Rosenwald, *For Hybrid Drivers, Every Trip Is a Race for Fuel Efficiency*, WASHINGTON POST, at A01, May 26, 2008, *available at* http://www.washingtonpost.com/wp-dyn/content/article/2008/05/25/AR2008052502764.html.

[48] *See*, *e.g.,* Jukka V. Paatero & Peter D. Lund, *A Model for Generating Household Electricity Load Profiles*, 30 INT'L J. ENERGY RESEARCH 273, 273 (2006) ("Accurate knowledge of the household consumer loads is important when small scale distributed energy technologies are optimally sized into the local network or local demand side management . . . measures are planned."); A. Prudenzi, *A Neuron Nets Based Procedure for Identifying Domestic Appliances Pattern-of-Use from Energy Recordings at Meter Level*, 2 IEEE Power Engineering Society Winter Meeting 941, 941 (2002) (stating that studies of consumer electric needs "can provide a large support to DSM . . . strategies and to [m]arketing policies as well." (citations omitted)).

[49] TED: The Energy Detective, http://www.theenergydetective.com/index.html (last visited Oct. 28, 2008).

[50] For an excellent discussion of the traditional paradigm of electric utility price structuring and its inadequacy in light of dwindling supplies, looming climate challenges, and an eroding transmission infrastructure, see Irma S. Russel & Jeffrey S. Dennis, *State and Local Governments Address the Twin Challenges of Climate Change and Energy Alternatives*, 23 NAT. RES. & ENV'T 9, 9–10 (Summer 2008). *See also* David B. Spence, *Can Law Manage Competitive Energy Markets?*, 93 CORNELL L. REV. 765 (2008) (discussing the transition from regulation to markets in the energy industry); Matthew J. Libby, *Deregulating the Electricity Market: What Can Be Learned from California's Mistakes*, 22 MAINE BAR J. 236 (2007).

[51] At present, electricity is usually rated at only two or three levels—e.g. peak, shoulder, and off-peak times—and those rates are only adjusted a few times a year. Such structures are poor approximations of the rapidly shifting supply/demand balance for electricity. *See* Severin Borenstein et al., *Dynamic Pricing, Advanced Metering, and Demand Response in Electricity Markets*, Paper CSEMWP-105 at 5–6, Center for the Study of Energy Markets, U.C. Berkeley (Oct. 2002), *available at* http://repositories.cdlib.org/ucei/csem/CSEMWP-105 (follow the "Download the Paper" hyperlink). Prior to this rough step-approximation of the supply/demand relationship, electricity pricing was even less connected to traditional market influences: "For most of the last century, electricity was sold in regulated environments in which the retail price did not vary based on the time it was used. Customers faced a constant price for electricity regardless of the supply/demand balance in the grid." *Id.* at 7.

projects,[52] as well as to provide accurate billing of use and so make the electricity distribution structures more economically efficient.[53]

There are several different forms of demand-based pricing, ranging from a simple step-increases in rates retroactively attributed to consumers through consumption estimates, to tying consumer billing to highly volatile spot-markets for electricity:

> [T]ime-of-use (TOU) pricing, offers customers an on-peak and off-peak rate schedule that is consistent from day to day; say, from noon to 6 p.m. the rate is higher than the rest of the day . . . . [F]ixed critical peak pricing (CPP-F), includes a TOU rate on most days and a considerably higher "critical" rate on 15 of the hottest days of the summer, with customers informed a day ahead of time when these high rates will be in effect . . . . [V]ariable critical peak pricing (CPP-V)[] is the most dynamic option. It differs from CPP-F in that the high-price period on "critical" summer days varies—*the critical rate can change from minute to minute*. Customers are told about this variance on the day it happens through data transmitted to their smart meters by the utility or through phone or e-mail notification.[54]

Presumably, consumers would be given a choice of billing structure, allowing them to opt-in to structures based on their own risk aversion: the most volatile pricing schemes offer the greatest savings potential if residents are willing to actively monitor and deliberately shift their usage patterns on a detailed level but could hammer consumers that are unwilling to closely control their use, while something like TOU pricing would offer more consistent monthly billing, but less potential for savings.

In a study carried out by the DOE, residential consumers were given devices to set price preferences, allowing them to prioritize use and set their level of demand per appliance:

> Behind the fairly simple consumer settings was a sophisticated live marketplace, whose software and analytics were designed by I.B.M. Research. *Every five minutes*, the households and local utilities were buying and selling electricity, with prices constantly fluctuating by tiny amounts as supply and demand on the grid changed. "Your thermostat and your water heater are day-trading for you," said Ron Ambrosio, a senior researcher at the Watson Research Center of I.B.M.[55]

While the intricacies of rate restructuring and efforts to "activate" the demand side of electricity transmission are fascinating and many, for our purposes the point here is simply this: Rapidly shifting prices combined with the desire for billing precision and increased consumer control requires highly detailed information about electricity consumption. The consumer, or at least devices put in place to act on the consumer's behalf, must know how much energy is needed and at what times in order to navigate the morass of pricing and use priorities.

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[52] *See* Lerner & Mulligan, *supra* note 31, ¶¶ 1-2.

[53] *See* Borenstein et al., *supra* note 51, at 7–12.

[54] Elizabeth Svoboda, *Will Demand-Based Pricing Solve California's Energy Crisis?,* IEEE SPECTRUM (Aug. 2004), http://spectrum.ieee.org/aug04/3824 (emphasis added).

[55] Lohr, *supra* note 45 (emphasis added).

B. *Trends in Refining Data Resolution: Smart Meters and Home Area Networks*

Smart meters and "advanced metering infrastructure," integral components to the so-called "smart grid," appear to be the accepted answer to the urgent demand for more detailed information about consumer power usage. "Smart grid" refers generally to the bundle of technologies that allow for greater electricity load monitoring and management, including smart meters, smart appliances, and communications devices; it is the collection of innovations that together constitute a "distribution system that allows for flow of information from a customer's meter in two directions: both inside the house to thermostats, appliances, and other devices, and from the house back to the utility."[56] Smart meters or advanced meters as defined by the Federal Energy Regulatory Commission "refer[] to technologies and communications systems necessary to record customer consumption at least hourly and allow for daily or more frequent retrieval of the consumption data."[57]

By collecting interval data regarding electricity consumption, smart meters offer much higher resolution data than has been previously available to information users.[58] While usage data has traditionally been measured on a monthly basis,[59] smart meters generally collect information in fifteen minute intervals as a default, but many if not most models being rolled out are capable of collecting information even more frequently.[60] Furthermore, as battles rage over potential metering standards, many arguments have pushed for collecting as much information as possible: the more information collected, the more responsive the system. Settling for anything less than the most information we can get, so the argument goes, is to merely insure the metering infrastructure's premature obsolescence, and high resolution information is required for the

[56] CRS-Report for Congress, *Energy Independence and Security Act of 2007: A Summary of Major Provisions*, Congressional Research Service [hereinafter "EISA CRS-Summary"] at 20, *available at* http://energy.senate.gov/public/_files/RL342941.pdf.

> "The Smart Grid could allow appliances to be turned off during periods of high electrical demand and cost and give customers real-time information on constantly changing electric rates. The goal is to use advanced, information-based technologies to increase power grid efficiency, reliability, and flexibility, and reduce the rate at which additional electric utility infrastructure needs to be built."

Id. at 20 n.9.

[57] Federal Energy Regulatory Commission, Assessment of Demand Response & Advanced Metering 2007, Staff Report [hereinafter "FERC 2007 Demand Response Assessment"], at 23, *available at* http://www.ferc.gov/legal/staff-reports/09-07-demand-response.pdf.

[58] In their discussion of this point, Lerner and Mulligan noted:

> Current utility practices include saving many years' worth of customer usage data to facilitate customer dispute resolution as well as load and other research. These data retention practices are expected to persist.5 If all the data generated by demand response systems is retained, a customer's monthly record will shift from a record of one data point reflecting average monthly usage to a record of 750 to 3,000 distinct and time-stamped data points per month that reflect actual energy use.

Lerner & Mulligan, *supra* note 31, ¶ 3.

[59] *See id.*

[60] *See, e.g., The Solarwave Smart Sub Meter*, Solarwave, http://www.solarwave.ie/HowItWorks.htm (last visited Nov. 5 2008) (default metering at fifteen-minute intervals but capable of taking data every minute); *Single Phase Meters*, Elster, http://www.elsterelectricity.com/en/single_phase.html (last visited Nov. 5 2008) (REX2-EA meter and gREX AMI meter capable of fifteen minute interval data); Itron, CENTRON Cannon MCTL meter data sheet, *available at* http://www.itron.com/asset.asp?path=/products/specsheets/itr_016104.pdf (capable of data collection in 5, 15, 30, or 60 minute intervals).

success of demand response efforts on wholesale electricity markets and effective billing of customers in rapidly varying price structures.[61]

Not only will smart meters provide a lot more information about an individual's electricity consumption, they will do it for a lot of individuals. In 2006, "utilities announced new deployments of more than 40 million advanced meters between 2007 and 2010."[62] These efforts to implement advanced metering technology reach across the country[63] and around the world.[64]

The scope of these efforts—and the number of people to be connected to the grid through a smart meter—is only likely to increase. In addition to the myriad utility and state diffusion efforts, there are significant federal legislative drivers of the deployment of advanced metering infrastructure. Briefly, section 1252 the Energy Policy Act of 2005 ("EPAct") was the first step, requiring that states consider implementing time-based metering and communications.[65] Then, in December 2007, President George W. Bush signed into law the Energy Independence and Security Act of 2007 ("H.R. 6" or "EISA"),[66] a sweeping statute that, as the New York Times reported, "will slowly but fundamentally change the cars Americans drive, the fuel they burn, the way they light their homes and the price they pay for food."[67] EISA's policy statement regarding electricity distribution announced unequivocally that

> [i]t is the policy of the United States to support the modernization of the Nation's electricity transmission and distribution system to maintain a reliable and secure electricity infrastructure that can meet future demand growth and to achieve . . . [the d]eployment of 'smart' technologies (real-time, automated, interactive technologies that optimize the physical operation of appliances and consumer devices) for metering, communications concerning grid operations and status, and distribution automation.[68]

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[61] Indeed, American Electric Power Service Corporation has asked the North American Energy Standards Board that the "Meter Data Reporting Interval" standard be set at five minutes. *See* Jim Sorrels & Dan Francis, Comments of American Electric Power Corporation on Draft Recommendations for Proposed Measurement and Verification Business Practice Standards for Demand Response Programs Administered in Wholesale Markets that May be the Subject of Individual Tariffs Filed and Approved by the Federal Energy Regulatory Commission at 4, Oct. 22, 2008, *available at* www.naesb.org/pdf4/dsmee100608aep.doc.

[62] FERC 2007 Demand Response Assessment, *supra* note 57, at ii (citing 2006 FERC Demand Response Assessment). *See also* Press Release, Federal Energy Regulatory Commission, Staff Report Marks Growth of Nationwide Demand Response Efforts, Sept. 7, 2007, *available at* http://www.ferc.gov/news/news-releases/2007/2007-3/09-07-07.pdf ("[I]f all the announced deployments actually occur, more than 40 million new advanced meters will be deployed in the next several years"). Most new devices, and the ones described by the FERC reports cited here, are two-way devices. However, millions of one-way data-storing meters have been deployed over the last 15 years, which, for the purposes of this paper, are no different in their privacy implications.

[63] *See*, *e.g.*, *supra* notes 16–21.

[64] *See supra* note 15.

[65] Energy Policy Act of 2005 [hereinafter EPACT], 109th Cong. § 1252 (2005) Pub. L. No. 109-58, 119 Stat. 595 (codified at scattered sections of USC titles 16, 26, and 42) (amending the Public Utility Regulatory Policies Act of 1978 [hereinafter PURPA 1978], Pub. L. No. , to include § 111(d)(14)).

[66] Pub. L. No. 110-140 (2007).

[67] John M. Broder, *Bush Signs Broad Energy Bill*, N.Y. TIMES, Dec. 19, 2007.

[68] EISA, *supra* note 66, § 1301, (5).

Congress included in EISA a number of incentives to drive the further diffusion of smart meters and smart grid technology.[69] Specifically, the DOE is tasked with monitoring developments related to smart grid technologies and business practices,[70] and to report to Congress biannually on the status of technology diffusion.[71] More substantively, the DOE was directed to perform research and develop instruments to measure peak load reductions and energy efficiency saving correlated with the deployment of smart grid technology,[72] and to establish a program to reimburse 20% of qualifying smart grid investments.[73] Finally, EISA expanded upon the step taken by section 1252 of EPAct; states must now "consider requiring electric utilities demonstrate that prior to investing in non-advanced grid technologies, Smart Grid technology is determined not to be appropriate. States must also consider regulatory standards that allow utilities to recover [s]mart [g]rid investments through rates."[74]

While utilities and governments drive to reduce the temporal grain size of the usage data, efforts are also underway to reduce its spacial grain size and thereby determine from which plug within the house electricity is being drawn, or to which appliance.[75] In addition to adding layers to the information collected regarding an individual's electricity consumption, these "home-area networks" (HANs) allow for significantly more control over energy consumption.[76] As one reporter noted when explaining CURRENT's launch of the nation's first HAN in January, 2008:

> [w]ith a customer's permission, the temperature at the [consumer's] thermostat can be adjusted automatically from the utility control center during periods of high electricity demand. In the future, appliance and other devices will be enabled to respond automatically to energy savings commands.[77]

Thus, not only does the additional information about appliance-by-appliance or plug-by-plug usage afforded by HANs assist consumers in more deliberately managing their electricity consumption, the technology can actually offer them the ability to control the state of their energy drawing appliances from afar. The control need not be located in a third party or with the utility, however. Some businesses are developing technology to allow consumers themselves to

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[69] *See generally*, EISA, *supra* note 66, Title XIII. *See also* EISA CRS-Summary, *supra* note 56, at 20 (discussing EISA Title XIII); CRS Report RL 34288, *supra* note 40, at 6–8. Worthy of note here, the EISA incorporated many of the principles set out in a bill proposed earlier in 2007 by Representatives Boucher and Dingell, conspicuously titled the Smart Grid Facilitation Act of 2007. *See* CONG. REC. E2665, col. 1(daily ed. Dec. 28, 2007) (Speech of Hon. John D. Dingell) (discussing the Committee on Energy and Commerce's contribution to the development of the EISA as "engross[ing]" the proposed Smart Grid Facilitation Act of 2007, H.R. 3237, 110th Cong (2007)).

[70] EISA, *supra* note 66, § 1303 (setting up the Smart Grid Advisory Committee and Smart Grid Task Force).

[71] EISA § 1302.

[72] EISA § 1304.

[73] EISA § 1306.

[74] CRS Report RL 34288, *supra* note 40, at 8 (discussing EISA § 1307 as amending PURPA 1978 (16 U.S.C. 2621 (d))).

[75] While explicit appliance identification and control over energy consumption is indeed being developed, it may add little to the privacy discussion in this context. As is outlined *infra* Part III.B, the high resolution of time-of-use data provided by smart meters may well be enough to identify most household appliances from the energy use profile alone.

[76] *See* FERC 2007 Demand Response Assessment, *supra* note 62, at 26.

[77] Reuters, *CURRENT Deploys the First Real-Time Utility Home-Area Network (HAN) in the Nation*, http://www.reuters.com/article/pressRelease/idUS182515+22-Jan-2008+PRN20080122 (last visited Sept. 13, 2008).

remotely control their home's electricity consumption, via a pc or even cell phone.[78] As hinted earlier, the process may even be automated such that appliances know when to turn themselves on or off depending on the real-time price of electricity throughout the day.[79]

### C. *Expanding the Scope of Collected Data*: *The Plug-In Hybrid and Mobile Energy Use Tracking*

The data set regarding an individual's electricity consumption is very likely to expand beyond the home. Electrifying automobiles is a commonly discussed and arguably critical component in solving the twin issues of environmental and energy security. The cornerstone of the discussion is the plug-in hybrid electric vehicle (PHEV), which is a car that utilizes electric power taken from an electric grid in conjunction with a standard combustion engine.

The insight here is simple, but powerful: existing power plants rarely operate at full capacity, so millions of cars could be charged without requiring the construction of new plants.[80] Indeed, "the existing grid capacity could power 217 million light-duty vehicles (three-quarters of the light-duty fleet)."[81]

While there are some social benefits to the technological shift from gasoline to electric or electric-hybrid engines,[82] most commenters agree that the real benefit promised by the transition

[78] Jaymi Heimbuch, *AlertMe Smart Plugs Help Automate Home Energy Use*, Treehugger.com, http://www.treehugger.com/files/2008/10/alertme-smart-plug-helps-monitor-home-energy-use.php (last visited Dec. 2, 2008). *See also Energy Saving with AlertMe*, http://www.alertme.com/energy-saving/ (last visited Dec. 2, 2008); Home Manageables, http://www.homemanageables.com/ (last visited Dec. 2, 2008) (advertising that "Homemanageables provides innovative remote home control and automation solutions. Create a smart home that enables you to remotely control and monitor your lighting, appliances, thermostats, and more. Ensuring energy savings, safety, convenience, and control.").

[79] *See supra* note 55; Patent No. 7,110,832 B2, Energy Management System for an Appliance (filed Oct. 23, 2002).

[80] *See* Declan Butler, *Plug In, Turn On . . . Sell Out*, *inset in* Butler, *supra* note 41, at 588 col. 1.

[81] *Id*. col. 2 (citing Michael Kintner-Meyer, Kevin Schneider, & Robert Pratt, *Impact Assessment of Plug-in Hybrid Vehicles on Electric Utilities and Regional U.S. Power Grids, Part 1: Technical Analysis*, Pacific Northwest National Laboratory, Department of Energy (Nov. 2007) [hereinafter "PNNL PHEV Impact Assessment"], http://www.pnl.gov/energy/eed/etd/pdfs/phev_feasibility_analysis_combined.pdf). "The U.S. electric infrastructure is designed to meet the highest expected demand for power, which only occurs for a few hundred hours a year, at most (about 5% of the time). For the remainder of the time, the power system is underutilized." PNNL PHEV Impact Assessment, *supra*, at 2. A study performed by the National Renewable Energy Laboratory in conjunction with Xcel energy concluded: "The actual electricity demands associated with PHEV charging are quite modest compared to normal electricity demands. Replacing 30% of the vehicles currently in the Xcel Energy service territory with PHEV-20s deriving 39% of their miles from electricity would increase total load by less than 3%." K. Parks, P. Denholm, & T. Markel, *Costs and Emissions Associated with Plug-In Hybrid Electric Vehicle Charging in the Xcel Colorado Service Territory*, National Renewable Energy Laboratory, Department of Energy Tech. Rep. No. NREL/TP-640-41410, at 23 (May 2007) [hereinafter "NREL/Xcel PHEV Report"], *available at* http://www.nrel.gov/docs/fy07osti/41410.pdf.

[82] *See* Declan Butler, *Plug In, Turn On . . . Sell Out*, *inset in* Butler, *supra* note 41, at 588 col. 3 (noting that charging vehicles on power from the electric grid "would require running power plants at higher constant levels, but because they are more efficient than car engines, the net balance would be a [reduction in overall emissions.]"). *See also Xcel/NREL Study Finds PHEVs May Reduce Emissions, Ownership Costs*, http://petrochemical.ihs.com/news-07Q1/nrel-xcel-phev.jsp (last visited Dec. 1, 2008). Even without affecting a net decrease in emissions, the scheme is arguably a victory for environmental protection because it centralizes transportation emissions so that, instead of coming from thousands of tailpipes, they come from the few stacks at the local power plant. Such a shift could make pollution control easier by focusing it in a single location, though of course there are looming and important

stems from a correlated change in the usage habits and payment structures. In order to tap into their huge potential of emissions reductions and cuts in oil dependency, the ways in which the nation's PHEVs are charged must be managed:

> PHEV studies have all made the critical, yet under-emphasized, assumption that the charging behavior of these vehicles, and thus their impact on the existing grid, will somehow be controlled. NREL [National Renewable Energy Laboratory] suggests charging will occur overnight, PNNL [Pacific Northwest National Laboratory] assumes the entire PHEV load will be "managed to fit perfectly into the valleys of load demand without setting new peaks" and the Electric Power Research Institute (EPRI) asserts that PHEVs will significantly reduce greenhouse gas emissions given the existence of "programs to actively manage the charging load."[83]

The importance of this assumption cannot be over-stated: by controlling the times at which PHEVs are charged, the PHEV fleet not only takes advantage of existing generating capacity, the batteries the cars can be used later as a distributed energy source. PHEV owners charge up at night with low-cost electricity, drive to work the next day, then plug-in and sell excess energy back onto the grid, thus satiating some of the peak demand and thereby reducing the need to construct new generating capacity.

There are several models for how such a PHEV-full world might look, and how charging up cars might be controlled and managed.[84] But common to them all is another under-emphasized assumption, namely that *you* the driver would get to sell back *your* stored energy. That means the utility will have to be able to tell that it is your car plugged into the outlet at your workplace, and not a solar array that's been fitted to the top of the office building. The plug of the PHEV will by necessity have to act like a smart meter of sorts, communicating with the utility's central hub to facilitate resource management and billing (or, in this case, buying). Without this information, the utility would not be able to control loads and electricity quality as accurately, and the market incentive to use PHEV's as a distributed resource would evaporate.

This means that, if high market penetration of the PHEV becomes a reality, an electric utility's information about consumer habits will no longer be confined to the home. If PHEVs are adopted and used as most would like, electricity usage data captured by utilities would become a one-stop shop for discovering person's daily routines and tracking their activities. This already cues some legal concerns regarding location tracking, a recent hot issue because of the GPS chip included in every cell phone.[85] But to fully understand the potential privacy consequences of this data set—both as expanded by the potential adoption of PHEVs and refined

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environmental justice concerns, since the plants themselves are generally surrounded by minority populations who would have to bear the brunt of the increased emissions from the plant.

[83] John Clark & Michael Lamb, *Controlling the Charge: Exploring the Promise of PHEVs*, Utility Products, *available at* http://www.v2green.com/docs/control_charge_utility_prod200801.pdf (referring to the PNNL PHEV Impact Assessment and the NREL/Xcel PHEV Report, both *supra* note 81.

[84] *See, e.g.* Rocky Mountain Institute, *Smart Garage*, http://move.rmi.org/capabilities/smart-garage.html (last visited Sept. 13, 2008); *See* Daniel Roth, *Driven: Shai Agassi's Audacious Plan to Put Electric Cars on the Road*, WIRED MAGAZINE, Aug. 18, 2008, *available at* http://www.wired.com/cars/futuretransport/magazine/16-09/ff_agassi.

[85] *See*, *e.g.*, Ian James Samuel, *Note: Warrantless Location Tracking*, 83 N.Y.U. L. REV. 1324 (2008).

through the ongoing deployment of smart meters—it is necessary to understand just what the data contains, and what can be gleaned from it.

## III. HIDDEN IN THE DATA

The data concerning an individual's energy use that is being collected now or in the foreseeable future holds implications for privacy in two ways. First, the meaning of the raw data itself is shifting as electricity consumption is increasingly paired with environmental impact and social responsibility. As the fact of energy use comes to be viewed in a different light by the public at large, it may be that individuals want to guard the information more just at the same time that utility companies are starting to gather more information and make it more readily available (at least to some).[86] Second, the increasing resolution of the data, and its expanding scope, make it now possible to deduce far more from an individual's consumption information than used to be the case. Indeed, algorithms can be devised to pinpoint, from an individual's power profile, when she watches TV, washes her clothes, cooks herself dinner, or takes a bath.[87]

### A. *The Shifting Meaning of Energy Use*

The paired concerns of global climate change[88] and energy independence[89] have turned a spotlight on energy consumption habits.[90] At its most blunt, the rhetoric surrounding these issues makes certain kinds of energy users out to be bad people.

On the first concern, energy consumption far outstrips all other sectors in its contribution to the United States' greenhouse gas emissions inventory, contributing eight-six percent of the nation's annual carbon dioxide equivalent ($CO_2e$) load.[91] Of that slice, electricity generation is the largest emitter of greenhouse gasses.[92] So, the inescapable conclusion goes, electricity

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[86] *See* discussion *infra*, Part III.A.

[87] *See* discussion *infra*, Part III.B.

[88] I use climate change here to mean anthropogenic global warming as caused by the emission of greenhouse gasses such as carbon dioxide and methane. On the general proposition that climate change is anthropogenic, see Intergovernmental Panel on Climate Change, IPCC Fourth Assessment Report: Climate Change 2007, http://www.ipcc.ch/ipccreports/assessments-reports.htm (follow "Working Group I Report, 'The Physical Science Basis'" hyperlink; then follow the "Summary for Policymakers" hyperlink) and Massachusetts v. EPA, 127 S. Ct. 1438, 1446, 1448–49 (2007) (noting that "[a] well-documented rise in global temperatures has coincided with a significant increase in the concentration of carbon dioxide in the atmosphere. Respected scientists believe the two trends are related," and later discussing the increase in carbon dioxide concentrations is related to human activities).

[89] I use energy independence here in reference to the general notion that reliance on oil imports for politically volatile parts of the world has impacts on the country's economic and national security.

[90] *See, e.g.*, Editorial Staff, *Energy Independence*, WASH. POST at A20, Sept. 23, 2008 (urging that energy policies striving for energy independence be sensitive to "what motivates people to change their behavior and investors to develop alternative energy sources.").

[91] In its most recent report on the U.S. GHG emissions inventory, the EPA stated that:

> Energy-related activities were the primary sources of U.S. anthropogenic greenhouse gas emissions, accounting for 86 percent of total emissions on a carbon dioxide (CO2) equivalent basis in 2006. This included 97, 37, and 13 percent of the nation's CO2, methane (CH4), and nitrous oxide (N2O) emissions, respectively.

Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2006, (Apr. 2008; USEPA # 430-R-08-005) at 3-1, *available at* http://www.epa.gov/climatechange/emissions/usinventoryreport.html (follow "Energy (PDF)" hyperlink).

[92] *See id.* at 3-8 n.7. In 2006, energy use resulted in the emission of 5,637.9 teragrams of $CO_2e$ (Tg $CO_2e$), 2,328.2 of which was attributable to electricity generation. Also of interest to the instant discussion, the next largest

conservation is one way to mitigate climate change effects. The flurry of interest in compact fluorescent light bulbs, far more efficient than their incandescent counterparts, illustrates the point that individual consumer energy habits are now widely understood to be part of the climate change solution.[93] What's more, use of electricity produced from power plants belching greenhouse gasses has become stigmatized in much the same way that public perception of smoking, once thought to be the habit of movie stars, has shifted and now conceives it as unfortunate, irresponsible, or even disgusting.[94] Similarly, energy consumption is becoming ever more indicator of a person's social responsibility. As mentioned earlier, understanding environmental consequences and an individual's environmental attitudes is tied to her so-called "ecological behavior," that is, behavior that mitigates unnecessary detrimental impacts on the environment writ large.[95] This connection—the very connection that makes informing people about their energy use such an effective tool for DSM measures[96]—also bottoms another, more malicious inference: those not engaging in ecological behavior should know better.

As to the energy security concern and desire for energy independence, the focus of the discussion is largely on oil imports and the transportation sector. More and more, driver's of gas-guzzling SUV's are seen as perpetuating the nation's dependence on oil imports from politically volatile places of the world and so leaving the nation's economy vulnerable to manipulation by powers that are somewhat less stable or "friendly" than we might like.[97] As such, more and more people are turning to more fuel-efficient or even hybrid-electric vehicles.[98]

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component of the energy use slice of nation's GHG emissions pie was the combustion of fossil fuels for transportation purposes, which resulted in the emission of 1,861.0 Tg $CO_2e$ in 2006. *See id*. at 3-7, tbl. 3-6.

[93] *See, e.g.,* Michael Barbaro, *Wal-Mart Puts Some Muscle Behind Power-Sipping Bulbs*, N.Y. Times, Jan. 2, 2007, *available at* http://www.nytimes.com/2007/01/02/business/02bulb.html (discussing Wal-Mart's retail initiative to support the diffusion of low-draw light bulbs and stating that "it turns out that the long-lasting, swirl-shaped light bulbs known as compact fluorescent lamps are to the nation's energy problem what vegetables are to its obesity epidemic: a near perfect answer, if only Americans could be persuaded to swallow them."); Stephanie Rosenbloom, *Home Depot Offers Recycling for Compact Fluorescent Bulbs*, N.Y. Times, June 24, 2008, *available at* http://www.nytimes.com/2008/06/24/business/24recycling.html (discussing Home Depot's efforts to support the market for C.F.L.'s); Rebecca Smith, *Ten Innovations that will Reduce the Amount of Energy We Use*, WALL ST. J. Oct. 18, 2006, *available at* http://www.realestatejournal.com/homegarden/20061018-smith.html (discussing the effect consumers can have on electricity supply problems and climate change emissions).

[94] *See, e.g., Energy Companies Risk Tobacco-Style Stigma over new Coal Power*, New Energy Focus.com, Sept. 16, 2008, http://www.newenergyfocus.com/do/ecco.py/view_item?listid=1&listcatid=94&listitemid=1696 (last visited Oct. 16, 2008) (warning that **"**Britain's energy companies could gain the same kind of reputation as tobacco companies if they build a new generation of coal power plants without using carbon capture and storage technology.**"**).

[95] *See, e.g.*, M. L. Dennis et al., *Effective Dissemination of Energy Related Information*, 45 AM. PSYCH. 1109 (1990); F.G. Kaiser et al., *Environmental Attitude and Ecological Behavior*, 19 J. OF ENVTL. PSYCH. 1, 1 (1999).

[96] *See supra* Part II.A, G. Wood & M. Newborough, *Dynamic Energy-Consumption Indicators for Domestic Appliances: Environment, Behavior and Design*, 35 Energy & Buildings 821, 825–29 (2003) (describing the efficacy of various forms of feedback schemes in achieving energy consumption reductions)

[97] *See* Robert F. Kennedy, Jr., *Better Gas Mileage, Greater Security*, N.Y. Times, Nov. 24, 2001 (Opinion); The White House, *Twenty in Ten: Strengthening America's Energy Security*, http://www.whitehouse.gov/stateoftheunion/2007/initiatives/energy.html (last visited Oct. 18, 2008) (summarizing President George W. Bush's energy security initiatives as set out in his 2007 State of the Union address including a plan to drive increases in the fuel economy of cars, light trucks, and SUVs). *See also* Sierra Club, *Driving up the Heat: SUVs and Global Warming*, http://www.sierraclub.org/energy/suvreport/energy.asp (last visited Oct. 18, 2008) ("Due to the increasing number of gas-guzzling vehicles, America is more dependent on foreign oil now than we were at the height of the 1973 energy crisis.").

[98] *See supra* Part II.C.

Here again, the impression becomes, the amount of energy an individual consumes is illustrative of social responsibility, though of a slightly different brand than before.

The shifting meaning of an individual's energy consumption habits is not without its salient examples. In 2007, the day after Al Gore received an Oscar for Best Documentary in for his production *An Inconvenient Truth*, the Tennessee Center for Policy Research reported that Al Gore's Nashville home consumed significantly more electricity than the national average (to the tune of a 20 fold increase).[99] Roughly a year later, the center reported that the former Vice-President's energy use had increased by ten per cent during the intervening year despite Gore's installation of energy-efficient renovations.[100] Drew Johnson, president of the research center, chided, "A man's commitment to his beliefs is best measured by what he does behind the closed doors of his own home. Al Gore is a hypocrite and a fraud when it comes to his commitment to the environment, judging by his home energy consumption."[101] These stories were picked up and pushed into public awareness by many of the largest news companies in the world including the New York Times,[102] the Cable News Network (CNN),[103] Fox News,[104] the British Broadcasting Corporation (BBC),[105] and The Telegraph out of London.[106] Thus, the disclosure of usage habits was illustrated to be a potential source of embarrassment and cause for directed ridicule.[107]

### B. *Reconstructing Daily Routines*

The collection of information on electricity usage patterns is important for a myriad of reasons ranging from the more or less benign reason of utility self-interest in operating efficiency

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99 *See* Press Release, "Al Gore's Personal Energy Use is His Own 'Inconvenient Truth," Tennessee Center for Policy Research, Feb. 26, 2007, http://www.tennesseepolicy.org/main/article.php?article_id=367 (last visited Sept. 3, 2008).

100 *See* Press Release, "Al Gore's Electricity Consumption Up 10% Despite 'Energy-Efficient' Renovations, Tennessee Center for Policy Research, June 17, 2008, http://tennesseepolicy.org/main/article.php?article_id=764 (last visited Sept. 3, 2008).

101 *Id*.

102 *See* Mike Nizza, An Inconveniently Easy Headline: Gore's Electric Bill Sparks Debate, The Lede, NY Times blog, Feb. 28, 2007, http://thelede.blogs.nytimes.com/tag/al-gore/ (last visited Sept. 5, 2008); John Tierney, *Three Questions for Al Gore*, NY Times blog, July 17, 2008, http://tierneylab.blogs.nytimes.com/2008/07/17/3-questions-for-al-gore/ (last visited Sept. 5, 2008).

103 *Energy Crisis Threatens U.S. Survival, Gore Says*, CNN.com, July 18, 2008, http://www.cnn.com/2008/POLITICS/07/17/gore.energy/index.html (last visited Sept. 5, 2008).

104 *See* Steve Milloy, *Al Gore's Inconvenient Electric Bill*, FoxNews.com, Mar. 12, 2007, http://www.foxnews.com/story/0,2933,257958,00.html (last visited Sept. 5, 2008).

105 *See Gore Accused of Energy Hypocrisy*, BBC News (online), Feb. 27, 2007, http://news.bbc.co.uk/2/hi/americas/6401489.stm (last visited Sept. 5, 2008).

106 *See* Tom Leonard, *Al Gore's Electricity Bill Goes Through the (Insulated) Roof*, THE TELEGRAPH (London), Aug. 5, 2008, *available at* http://www.telegraph.co.uk/news/worldnews/northamerica/usa/2153179/Al-Gore%27s-electricity-bill-goes-through-the-(insulated)-roof.html (last visited Sept. 5, 2008).

107 A parallel tale illustrating the shifting meaning of resource consumption is seen in the stories surrounding the Georgia drought of the 2007 summer. As water became an increasingly scarce resource, the usage of water donned a new stigma. *See*, *e.g.*, Associated Press, "Georgia Farmers to Atlanta: Stop Hogging our Water," MSNBC.com, Nov. 14, 2007, http://www.msnbc.msn.com/id/21793386/ (last visited Sept. 9, 2008); Jim Strickland, Video: "Water Hog?", CNN.com, http://www.cnn.com/video/#/video/us/2007/11/12/strickland.ga.water.hog.wsb (last visited Sept. 9, 2008) (reporting on a mansion located in the drought-stricken area that retained its immaculate and lush green lawns and implying that such vanities are inappropriate and irresponsible in the face of resource scarcity).

to the noble interests of mitigating environmental impacts and driving national energy security.[108] However, the information collected for these purposes holds a good deal of information about individual consumers, information that may trigger some to call it private and grimace at the possibilities for its misuse. As intuitions surrounding privacy shift with the changing uses of data—and the growing abilities of those with access to it[109]—privacy analyses must consider not only the static portrait of relevant technology and law, but engage their dynamic realities and look forward to the next act in the play. In this light, I present here not only the present state of technology and research in energy usage data collection and analysis, but attempt to give context to the entire field by sketching out past research lines, their convergence in the present, and motivations driving future development in this area.[110]

Two research paths concerned with electricity consumption and load management are converging. The first of these is the empirical research and load monitoring carried out through the employment of devices such as non-intrusive appliance load monitors on single homes for the collection of population sample data.[111] These devices allow electricity loads to be recorded once or even multiple times per second, providing very detailed information about a resident's electricity usage. Such devices and related research is important allow both for greater oversight (and so control) over the building's electricity usage and monitoring efficiency, as well as the development of extensive appliance load libraries, which can then be used to identify the load signals of specific appliances from within an aggregated load usage profile.

The second field of research pertinent to our discussion is the development of mathematical methods and use of artificial neural networks to glean detailed usage information from low-resolution interval data.[112] With the rapid installation of millions of smart meters across the country, and the potential for tracking and person's electricity usage beyond the walls of her own home—through, for example, the tracking of PHEV charges—these research efforts and the soon to be expansive data set housed at an electric utility could be used unveil the intimate details of millions of consumers' day-to-day life.[113]

As the interval of the data collected by smart meters decreases[114]—thereby creating higher- and higher-resolution load profiles—and the ability to disaggregate low-resolution data into the specific appliance events that constitute it, we move closer and closer to the potential that electricity usage data will be a one-stop-shop for peering into the private activities of residential customers.

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[108] *See* discussion *supra* Parts II.A, III.A.

[109] *See* discussion *supra* Parts I, III.A (outlining how privacy intuitions with respect to certain pieces of information are likely tied to the consequences of that information's disclosure).

[110] Other authors have seen the importance of describing technological drivers of privacy invasion dynamically rather than statically. *See*, *e.g.*, Paul Ohm, *The Rise and Fall of Invasive ISP Surveillance*, Draft at 3, 22, *available at* http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1261344 ("explor[ing] the history, evolution, and nature of ISP surveillance" and citing DAN SOLOVE, UNDERSTANDING PRIVACY 50–51 (2008) as advocating for "a dynamic view of privacy, because notions of privacy change over time and place.").

[111] *See infra* Part III.B.1.

[112] *See infra* Part III.B.2.

[113] *See infra* Part III.B.3.

[114] By "decreases" here, I do not mean a technological transition, but rather a policy shift on the part of the utility collecting the information. Many of the smart meters being deployed today can be readily set to collect usage information on one-minute intervals. Early on, this level of detail deemed unnecessary, and utilities usually opted to retrieve residential usage information every half hour. However, the trend has quickly moved toward shorter intervals. Indeed, in the span of drafting this article, Xcel moved from collecting 15-minute interval data to 5-minute interval data in their "Smart Grid City." Interview, Dan XXX, Head Ratemaker, Xcel Energy, Feb. 9, 2009.

1. Empirical Research and Real-Time Monitoring: The Non-Intrusive Appliance Load Monitor

The drive for high-resolution energy usage data from which to forecast load demand or optimize service led naturally to an investigation of individual appliances and their relative contribution—both in time and amount of draw—to the overall load. Such information had to be obtained from the customers themselves:

> The energy consumption of any particular appliance can be measured readily in a laboratory, but this does not necessarily indicate the energy assumption of the appliance in typical use. For example, the energy consumption of a refrigerator in a household where the door may be frequently opened may be vastly different than under laboratory conditions.[115]

What's more, laboratory research cannot shed light on use habits.

Early efforts to get at this information were rather cumbersome and intrusive, often involving "a monitoring point at each appliance of interest and wires . . . connecting each to a central data-gathering location."[116] This meant a researcher or utility employee would have to enter the home and run a myriad of wires throughout the house in order to set up the monitoring system, then install a separate device for the collection of all the gathered data logged from the separate input of the many monitored appliances—a monitoring station that would be in addition to the ever-present electricity meter used to determine billing. In effect, the appliance load monitoring methods employed "complex data-gathering hardware but simple software."[117]

In the mid-1980's, George Hart and Fred Schweppe turned the research on its head with the development of the non-intrusive appliance load monitor (NALM),[118] which "reverses this balance[] with simple hardware but complex software for signal processing and analysis."[119] The NALM insight was simple in form, but profound in consequence: If a device could be appended to the existing metering infrastructure that would allow for real-time logging of

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[115] Patent No. 4,858141, Non-Intrusive Appliance Monitor Apparatus [hereinafter "NALM Patent"], col. 1, ll. 23–29 (filed Apr. 14, 1986).

[116] George W. Hart, *Nonintrusive Appliance Load Monitoring*, 80 PROCEEDINGS OF THE IEEE 1870, 1871–72 (Dec. 1992).

[117] *Id*. at1870, col. 2. Though left out of the instant technical review, parallel research is underway which looks into industrial and commercial consumers of electricity in addition to the residential research outlined here. *See, e.g.,* L.K. Norford & S.B. Leeb, *Non-intrusive Electrical Load Monitoring in Commercial Buildings Based on Steady State and Transient Load-Detection Algorithms*, 24 ENERGY & BUILDINGS 51 (1996).

[118] Christopher Laughman et al., *Advanced Nonintrusive Monitoring of Electric Loads*, IEEE POWER AND ENERGY 56 (Mar./Apr. 2003). Non-intrusive appliance load monitors do not have a single, consistently used acronym throughout the research literature. As NALM was the one coined by the device's inventor, it is the one I use throughout this paper. However, other researchers use NILM, NIALM, or NIALMS when discussing these devices. *See, e.g. id*. at 56–57 (NILM); Steven Drenker & Ab Kader, *Nonintrusive Monitoring of Electric Loads*, IEEE Computer Applications in Power 47 (1999) (NIALMS). For the sake of precision, it should be noted here that there are two basic forms of the NALM: the manual set-up NALM (MS-NALM) and the automatic set-up NALM (AS-NALM). The MS-NALMS require manual identification of appliance signatures through appliance monitoring and consumer interviews. *See* Hart, *supra* note 116 at 1870–72. I focus in this article on the AS-NALM, as its capabilities and development are more relevant to the instant discussion. Thus, the discussion *infra* which purports to explain the operation of a NALM is actually only examining the operation of an AS-NALM.

[119] Hart, *supra* note 116, at 1871. *See also* Laughman, *supra* note 118.

electricity consumption (the simple hardware), the information of appliance use might be able to be reconstructed from the overall load data (through the application of complex software) and thereby remove the need for intruding within the residential space and installing new equipment within the home.

Though initially thought a daunting task to work backwards from an appliance's demand to the identity of the appliance itself, the load signatures of various appliance categories are surprisingly unique.[120] The principle issue thus became the disaggregation of specific appliance load signatures from a household energy profile—that is, finding the load signal of a specific appliance amidst the noise of a whole household's many energy draws.[121] In brief: "The hardware handles edge detection and data communications, and software uses pattern-recognition algorithms to determine specific appliance usage."[122] When broken down, the process employed by the NALM to answer this question goes like this:

[1] *Installation and Data Recording*: the NALM is installed, usually at the power meter of the building,[123] to intercept load information. It receives the analog waveform data of consumer electricity draw, which is then normalized to adjust for supply-side variations.[124]

[2] *Edge Detection*: the recorded information is examined for signal edges, that is, for those steep jumps or fall-offs in electricity draw that indicate the turning on, off, or cycling of a home appliance. In Figure 2, *infra*, the edges are the vertical steps in the energy profile.[125]

[3] *Cluster Analysis*: step events are plotted in "*p*-space," a plot of real versus reactive power draws. Essentially, this means all the events are plotted according to two characteristics, how much energy they draw and how much energy they waste (or, more precisely, store and then return to the power source).[126] The step events are then organized into clusters

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[120] *See* F. Sultanem, *Using Appliance Signatures for Monitoring Residential Loads at Meter Panel Level*, 6 IEEE TRANSACTIONS ON POWER DELIVERY 1380, 1380 col. 1 (1991). *See also, id.* at 1381 col. 2 (providing illustrative graphs of load signatures for a refrigerator, a washing machine motor, and a fluorescent light). This conclusion, arrived at by researchers nearly a generation ago, rested on an assumption of high-resolution data—an assumption that is not always met in modern energy profile research, but which is becoming increasingly less important for the point's validity. *See* discussion *infra*, Part III.B.2.

[121] *See* Sultanern, *supra* note 120.

[122] Drenker & Kader, *supra* note 118, at 50.

[123] *See id*. at 47 ("NIALMS electronics connect to the total load at a single point, usually the electric service entrance . . .").

[124] *See* Hart, *supra* note 116, at 1882.

[125] *See id*.

[126] *See id*. at 1883. *See also* Drenker & Kader, *supra* note 118, at 48 (discussing scatter plots in "the complex power signature space."). The concepts of real and reactive power in AC circuits are complicated and their details lie beyond the scope—and needs—of this paper. For our purposes, it is enough to understand that electricity flow along power lines oscillates, and so can be analogized to a person climbing up and down the ladder of a water tower. The work done in order to get up and then down the ladder is the "real power" in this analogy, while the water basin itself is the appliance. The higher towers are like energy-hungry appliances, and so measuring an appliance's real power is roughly like counting the number of rungs on the ladder of the water tower. If the water basin at the top of the tower leaks, the person trudging up and down the ladder might carry a bucket of water up with him in order to keep the basin full. The amount of water dumped into the basin to be later let out through the leak—and not carried back down by our intrepid climber—maps onto the appliance's reactive power in the analogy. *See*

of similar events (think: drawing lines around points that are close together on the scatter plot).[127] "Ideally, each cluster represents one kind of state change of one appliance."[128]

[4] *Appliance Model Construction*: the clusters of step events are next organized into appliance models, which are mappings of an appliance's various electricity draws when operating in its various states, and the signals that will be observed as it transitions between states. Appliance models come in two basic types: on/off models, and finite state machine models. Simplified examples of each—using only real power signatures—are provided below.[129]

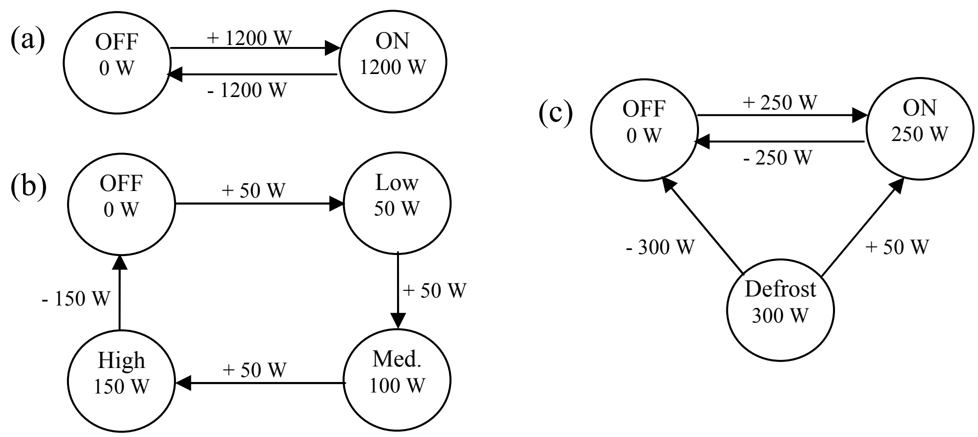


**Figure 1:** Appliance models for (a) "generic 1200 W two-state appliance, e.g., toaster"; (b) "'three-Way' lamp"; (c) "refrigerator with defrost state."[130]

[5] *Behavior Tracking*: using the appliance models constructed in step 4, appliance use is now tracked in real time as signals are identified as they appear rather than through later reconstruction.[131] Statistics are tabulates concerning each appliance's use. While any number of statistical analyses are possible here, tracking the duration of appliance use is important to the next step in the NALM process. In the context of privacy concerns, it is worth noting some other kinds of tracking that could easily be performed at this stage: for example, an appliance's frequency of use might be of interest to marketing departments

[6] *Appliance Naming*: once constructed, the appliance models are named so they can be recognized, not merely by the series of step events pulled from the energy profile, but as "washing machine," "water heater," "oven," etc. For this, NALMs refer to a library of

Peter W. Sauer, *What Is Reactive Power?*, A Power Systems Engineering Background Paper (Sept. 2003), *available at* http://www.pserc.wisc.edu/Sauer_Reactive%20Power_Sep%202003.pdf.

[127] There are a number of ways of performing the cluster analysis, and so grouping distinct events into categories to be identified as the repeated operation or state-change of a single appliance. *See* Hart, *supra* note 116, at 1883.

[128] *See id*. at 1883. *See also* Drenker & Kader, *supra* note 118, at 48.

[129] *See* Hart, *supra* note 116, at 1883.

[130] *Id*. at 1875. The appliance models here were reconstructed for this paper, but are for all intents and purposes identical to those originally provided by Hart.

[131] *See id.* at 1883.

known appliance models, searching for the nearest match with those observed in the electricity profile.[132]

A number of heuristic principles are employed in order to ease the disaggregation of individual appliance signals from the noise of a household's total electricity consumption by framing a backdrop understanding of the total load. For example, the so-called "switch continuity" principle guides appliance naming by imposing the assumption that, generally, only one appliance switches on at a time, and that simultaneous appliance events are very rare.[133]

Employing these procedures for data recording and analysis, a NALM is capable of providing utilities or researchers with detailed information about the electricity consumption habits of residents. Figure 2, below, shows a portion of individual's energy load profile that has been parsed by a NALM, each edge labeled with the corresponding appliance.

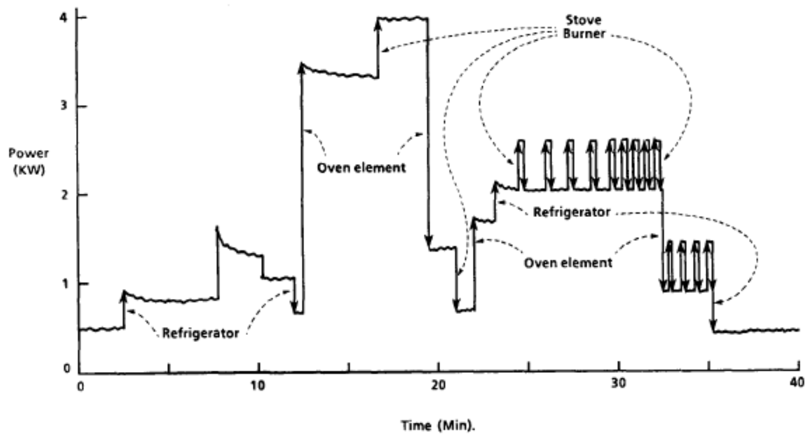


**Figure 2:** "Power v. time (total load) shows step changes due to individual appliance events."**[134]**

Using ever advancing NALM technology, a remarkable number of electric appliances can be identified by their load signatures, and with impressive accuracy. Researchers have all but mastered identification of the larger common household appliances such as water heaters, well pumps, furnace blowers, refrigerators, and air conditioners, with recognition accuracies approaching perfection.[135] Ongoing work focuses now on the myriad smaller electric devices

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[132] *See id.* at 1884; Drenker & Kader, *supra* note 118, at 49 (referring to this step as "appliance identification"). The libraries of appliance models are made obsolete as new appliances are introduced and extend their market penetration and others fall out of favor and out of home use. There is, however, a rich and ongoing line of research in the construction and upkeep of these libraries, as well as the development of taxonomies to ease their navigation and facilitate decision-making algorithms. *See, e.g.,* H.Y. Lam & W.K. Lee, *A Novel Method to Construct Taxonomy of Electrical Appliances Based on Load Signatures*, 53 IEEE TRANSACTIONS ON CONSUMER ELECTRONICS 653 (2007); W.K. Lee et al, *Exploration on Load Signatures*, International Conference on Electrical Engineering, (2004); K.H. Ting et al., *A Taxonomy of Load Signatures for Single-Phase Electric Appliances*, POWER AND ELECTRONICS SPECIALIST CONFERENCE, IEEE (2005). Indeed, some researchers believe the compilation of and investigation into appliance load signatures is in many ways cornerstone to the entire endeavor. *See* W.K. Lee, *supra*. It is important to note here that not all libraries are made equal for our purposes, as the data contained therein may be tied to the resolution of the electricity load information used in its construction. Libraries of appliance models that rely on 50 Htz appliance load signatures to identify individual appliances are not as useful if the data recorded at the meter is compiled in one second or one minute intervals.

[133] Hart, *supra* note 116, at 1874. Another such heuristic principle is the "zero loop-sum constant" which holds simply that the "sum of the power changes in any cycle of state transitions is zero." *Id.* at 1875.

[134] *Id.* at 1871.

[135] Drenker & Kader, *supra* note 118, at 50 (Table II).

around the home such as personal computers,[136] laser printers, and differentiating fluorescent from energy-saving light bulbs.[137] It also bears noting here that the success of this kind of load disaggregation is not limited to electric utilities; similar approaches have been successfully used to break down residential gas use into appliance events as well.[138]

Zooming out from the relatively short time interval examined in Figure 2 helps bring the privacy concerns surrounding this kind of data collection and analysis better into focus. Figure 3 provides one household's electricity profile over a 24-hour period with many of the appliance events labeled:

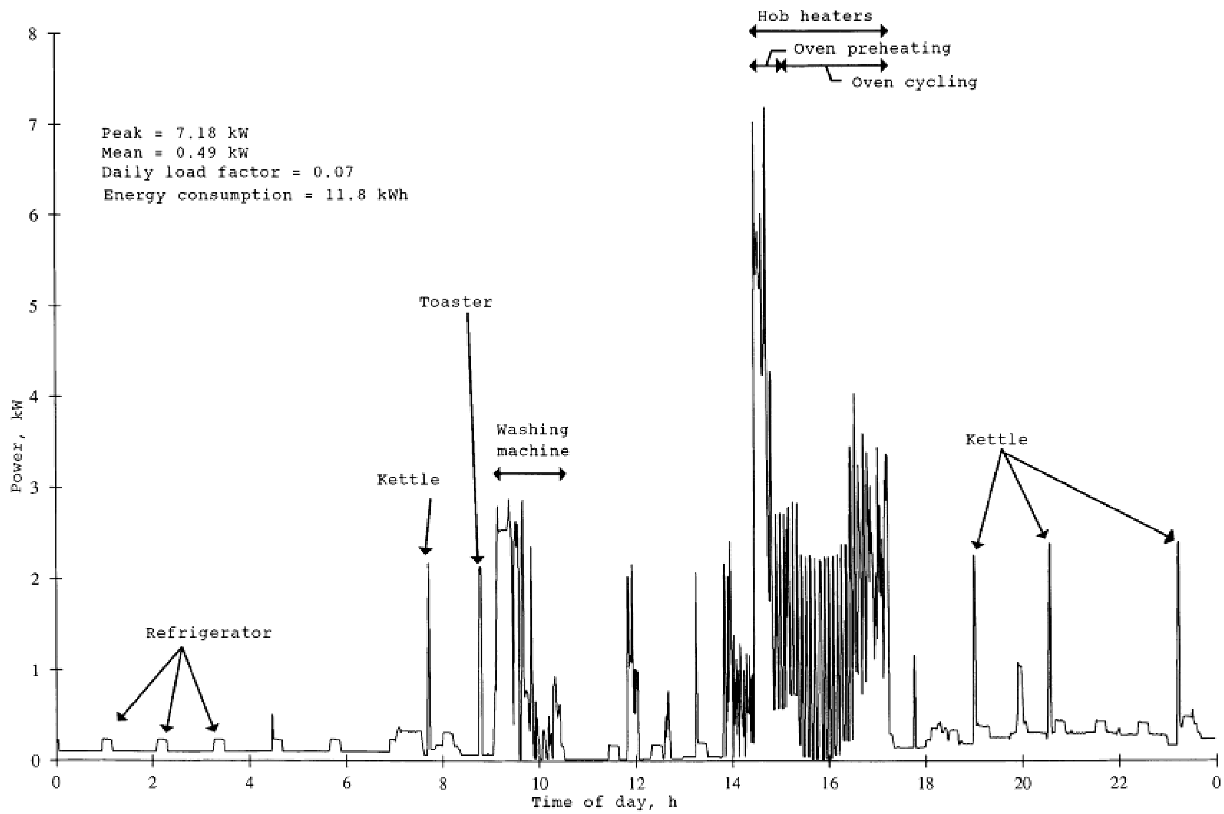


**Figure 3:** Household Electricity Demand Profile Recorded on a One-minute Time Base[139]

With the whole of a person's home activities laid to bare, the NALM provides a better look into home activities that would peering through the blinds at that house.[140] However, as

[136] Ting et al., *supra* note 132.

[137] Lee et al., *supra* note 132.

[138] *See* M.L. Marceau & R. Zmeureanu, *Nonintrusive Load Disaggregation Computer Program to Estimate the Energy Consumption of Major End Uses in Residential Buildings*, 41 ENERGY CONSERVATION & MANAGEMENT 1389, 1391 (2000) (citing S. Yamagami et al., *Non-intrusive Submetering of Residential Gas Appliances*, Proceedings of the ACEEE 1996 Summer Study on Energy Efficiency in Buildings 193 (1996)).

[139] G. Wood & M. Newborough, *Dynamic Energy-consumption Indicators for Domestic Appliances: Environment, Behavior, and Design*, 35 ENERGY AND BUILDINGS 821, 822 (2003) (citing M. Newborough & P. Augood, *Demand-side Management Opportunities for the UK Domestic Sector*, IEE Proceedings of Generation Transmission and Distribution 146 (3) (1999) 283–293).

initially conceived and commonly used, NALMs are installed on only a few homes with an eye to generalize from the specific observations to entire communities or appliance classes in order to tune load management operations and forecast future load needs.[141] To this end NALMs have been highly successful, with a number useful applications, including (1) supporting changes in rate structuring by allowing for measurement of electricity consumption in real-time as correlated with price shifts in electricity throughout the day, (2) "bill disaggregation" allowing for electric bills to be based on direct measurements rather than rough estimates, (3) "bill resolution" allowing companies to pinpoint sources of a consumer's high-bill complaints, and (4) "load diagnostics" facilitating analysis of whether a consumer's equipment is operating at its most efficient.[142]

2. Load Simulation and Detail Extraction from Low Resolution Data.

Another line of research has attempted to work backward from large data sets of aggregated electricity consumption information to glean more detailed usage information, rather than beginning with a single home's activities and working to generalize use patterns. The driving motivation here, once the many factors influencing overall electricity use are identified and accounted for, is to use them for the bottom-up construction of load simulations; by determining the relevant factors influencing electricity consumption, one can simulate and predict future uses by checking to see which factors are or will be satisfied and watching the numbers fall out.

At the outset, several different periodicities are readily recognizable when looking at aggregated electricity usage data. Consumption varies annually (as weather patterns cause consumer shifts in heating and air conditioning), weekly (as work schedules determine when consumers are at home to use their electric appliances, and to a certain degree what kinds activities they'll engage in), and daily (as certain appliance uses tend to correspond with certain times of the day).[143] Each of these periodicities point to factors driving the social practices which in turn lead to electricity consumption, namely, the environment (seasonal patterns), economic obligations (work patterns), and the myriad diurnal routines and habits such as eating, watching television, cooking, etcetera. Thus, load simulations must account for these variables, anticipating increased use during times of extreme temperatures, weekends, and dinner time.

From this first insight follow a host of others, and new avenues for discerning factors that influence electricity consumption patterns. Different kinds of consumers will have different energy requirements, so teasing out the influence of social category on end use and electricity consumption can valuably inform load simulations which attempt to forecast use in areas with known demographics. For example, research has shown delineated the differences in availability at home for various social types of electricity consumers including working adults, senior

[140] Indeed, as one colleague noted when I presented him with this graph, from the data provided in Figure 3 you can even determine the nationality of the household resident: "Only a Brit would make so many pots of tea in the course of a day."

[141] *See* NALM Patent, *supra* note 115, at col. 1, ll. 32–35 ("It is the energy consumption of appliance classes (e.g. all refrigerators or all water heaters), and their trends, that utilities are most interested in obtaining.").

[142] Drenker & Kader, *supra* note 118, at 50–51.

[143] *See* S.F. Ghaderi et al. *Forecasting Electricity Consumption by Separating the Periodic Variable and Decompositions the Pattern* [sic], 2007 IEEE Int'l Conference on Industrial Engineering and Engineering Management 292 (Dec. 2007).

citizens, house wives, and children of school age.[144] Further research is being pursued which attempts to capture home availability in even richer colors, exploring patterns of at-home behavior and the predictability and success of interruptions to those routines.[145] In addition to the type of user, differences in consumption vary with the type of activity, and profiles of energy uses that differentiate between activities can be constructed for things like leisure time, housework, cooking, personal hygiene.[146] These profiles of both user types and activity types can then be compared to an individual's load profile using probabilistic algorithms to determine their membership to the various social typologies and frequency of engagement in various activities.[147] These algorithms can then be paired with data regarding the market penetration of various appliances to improve accuracy their accuracy.[148]

Demand forecast systems utilizing this type of analysis predicted loads through a method of triangulation of sorts, drawing from data about who would in the residence at various times, what kinds of things they might be doing, and what load those things would likely require. While statistical modeling of this sort can be sophisticated and highly accurate for certain purposes, the most efficient and responsive energy management systems (and most accurate energy profile profiling mechanisms) must grow from more detailed data.

3. Convergence: Household Usage Habits Gleaned from Advanced Metering Infrastructure.

The massive ongoing distribution of smart metering technology[149] provides a wealth of data that, while less detailed in its data-logging than most NALMS,[150] is still far more detailed than the survey data generally relied upon for the probabilistic modeling of loads based on social class and activity type. The question remains: just what can be discovered by looking into an energy profile constructed from smart meter data-logging?

In many ways, smart meters provide enough information to skip out on the need for NIALM hardware.[151] Commercially available smart kWh-meters can be readily modified to sample at small enough intervals to be useful in the application of analytics developed for NALM.[152] Where gaps remain, information about the market penetration of various appliances

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[144] A. Capasso et al., *Probabilistic Processing of Survey Collected Data in a Residential Load Area for Hourly Demand Profile Estimation*, 2 Athens Power Tech 866, 868 (Sept. 1993) (Proceedings: Joint International Power Conference).

[145] Kristine S. Nagel et al., *Predictors of Availability in Home Life Context-Mediated Communication*, 6 CHI LETTERS 457 (Nov. 2004).

[146] Capasso, *supra* note 144, at 869.

[147] *See generally id*.

[148] *See* Jukka V. Paatero & Peter D. Lund, *A Model for Generating Household Electricity Load Profiles*, 30 INT'L J. ENERGY RESEARCH 273, 274, 277–79 (2005).

[149] *See supra* Part II.B.

[150] *See supra* Part III.B.1.

[151] *See* Hannu Pihala, *Non-intrusive Appliance Load Monitoring System Based on a Modern kWh-Meter*, VTT Publication 356, Technical Research Centre of Finland (May 1998), *available at* http://www.vtt.fi/inf/pdf/publications/1998/P356.pdf (illustrating that a modern "kWh-meter can be used at the same time for billing, power quality[,] and appliance end-use monitoring.")

[152] *See id*. at 16.

can be used to fill them in, improving the accuracy of the appliance identification in much the same way as was done with those predicting loads by profiling energy profiles above.[153]

An Italian study published in 2002 used fifteen-minute interval data—the same resolution collected by most smart meters today—to identify heavy-load appliance uses within an electricity usage profile.[154] Researchers there were able use artificial neural networks to pinpoint the use washing machines, dishwashers, and water heaters with accuracy rates of over 90 percent from within the noise of the aggregated load information.[155] As libraries of load signatures expand and more research pours into similar efforts, the details extractable from smart meter data will become ever richer. Add to this the fact that many smart meters are able to record at higher rates,[156] and the capabilities for gleaning highly detailed information about household activities from the data only increases. Efforts in such a vein—as with NALMs—focus on the development of sophisticated software. Once the relatively simple hardware for data collection is in place, resolving the picture of household activities found within electricity usage profiles becomes a matter only of data analysis—and the development of analytic tools continues.

This, more than any other part of the smart meter story, parallels Shelley's fable of Frankenstein: while researchers do not currently have the ability to identify every appliance event from within an individual's electricity profile, the direction of the research as a whole and the surrounding context and motivations for such research point directly to developing more and more sophisticated tools for resolving the picture of home life that can be gleaned from an individual's electricity profile. Before the switch is thrown and the information unleashed upon the world for whatever uses willed, it may be prudent to look into data protections lest the unforeseen consequences come back to haunt us.

In sum, all the steps involved in NALM analysis discussed in Part III. B.1 can be run with the data collected by smart meters. While the data recorded by smart meters is lower in resolution, inductive algorithms and mathematical methods are quickly filling the gaps. Importantly, smart meters will provide information on millions of consumers as meter replacement efforts are in full swing across the country[157]—this in contradistinction with the few and usually consenting consumers under the watch of NALMs. The result: highly detailed information about activities carried on *within the four walls of the home* will soon be readily available for millions of households nationwide. What's more, the sheer volume of the research and development in this area helps understand the field as a vector, one that points directly at more and more-detailed information collected concerning the activities of millions of people. While the motivations for this aggregation of data may be noble, the potential for serious privacy invasion is only growing, and so the need for care lest we raise a monster.

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[153] A. Prudenzi, *A Neuron Nets Based Procedure for Identifying Domestic Appliances Patern-of-Use from Energy Recordings at Meter Panel*, IEEE Power Engineering Society Winter Meeting 941, 942 col. 1 (2002).

[154] *See id*.

[155] *See id*. at 946 col. 1.

[156] *See supra* note 60.

[157] *See supra* Part II.B (describing smart meter installation efforts).

4. Appliance Event Tracking and Profiling Electricity Profiles: Stepping into Private Spaces?

Data collection via NALMs has sparked privacy concerns before. In mid-2001, MIT's *Technology Review* ran a story on NALMs, reporting that, "[in] essence, non-intrusive load monitoring is an information technology. And like any such technology, it could gather information that customers would prefer to keep to themselves."[158] A researcher reported there that he could use prototypes then monitoring laundry facilities on campus to tell when a student was washing shoes as uneven loads put "uneven strain[s] on a washer's motor" that could be perceived in the collected data.[159] While the story concluded with a precautionary note on potential privacy implications, the concerns were thoroughly overshadowed by the NALM's limited implementation. Though it was anticipated that NALMs might play a greater role in future development and green building, the article was careful to distinguish the NALM from smart meters, whose relatively low-resolution data paled in comparison to the non-intrusive load-monitoring technology, which was sampling loads several hundred times per second.[160]

But to ignore the dynamic nature of the field and the increasing abilities of those with access to smart meter information is to fall into the same trap as Dr. Frankenstein. Professor Paul Ohm recently illustrated that new pressures on profitability, along with modern advancements in technological capability, are pushing internet service providers (ISPs) to engage in more invasive behavior than they have in the past.[161] There, pressures on ISPs from copyright holders to curb trafficking in copyrighted materials and to find new sources of revenue, combined with recent technological advancements that allow for the efficient tracking of internet use, create a perfect storm to which a consumer's private information lies exposed.[162]

A similar story of evaporating restraint and constraints could easily develop in the context of electric utilities and electricity consumption information.[163] As has been shown, technological constraints prohibiting the collection of detailed information on a wide-scale have been overcome. Simultaneously, while electric utilities have generally shown restraint concerning the disclosure of information they gather from customers, utilities also face new business obstacles in the form of shifting market places and the likely imposition of climate change legislation. Under such pressures, utilities may well take advantage of assets that they have not before utilized, for example, by selling collected usage information to marketing agencies or other interested parties.[164] Furthermore, some businesses may aggressively pursue the information; efficiency consultants, for example, could use collected smart metering data to

[158] Alan Leo, *The Measure of Power: Non-Intrusive Load Monitoring Gives Detailed Views of Where Power is Going, With Payoffs for Utilities, Consumers, and maybe Big Brother*, TECHNOLOGY REVIEW MAGAZINE (June 28, 2001).

[159] *Id*.

[160] *See id*.

[161] *See* Ohm, *supra* note 110, at 5–11.

[162] *See id*.

[163] *Cf. id*. at 11–22.

[164] In support of the point that collections of private information can be considered an asset, see the growing line of cases in which companies filing for bankruptcy are ordered to sell their customer information as a part of liquidating their assets and covering their obligations: *e.g.*, In re 3DFX Interactive, Inc., 389 B.R. 842 (Bankr N.D. Cal, 2008); In re Exaeris, Inc., 380 B.R. 781 (Bankr D. Del., 2008); In re Egghead.com, 2001 WL 35671549 (Bankr N.D. Cal., 2001) (unreported). Such disclosure may not be possible in all circumstances, see *infra* Part. IV (regarding existing protections on personal information held by utilities).

identify possible clients, as well as identify efficiency holes that could be plugged to save consumers energy costs.

The next question is, inevitably, so what? What are the risks of this potential disclosure? While part of the point of the dynamic nature of privacy intuitions and concerns is that forethought is not always enough to anticipate the serious problems, still the scope and number of potential uses for such information in rather stomach-churning ways is staggering with even a half-hearted brainstorming session. The table below attempts to illustrate this potential through presenting some questions to which electricity usage data collected within an advanced metering infrastructure could provide answers:

| *Concern Type* | *Related Questions Answered by Detailed Usage Data*[165] |
|---|---|
| **Nefarious Uses** | • When are you usually away from home?[166]<br>• Is your household protected with an electronic alarm system? If so, how often do you arm it?<br>• And the *Psycho* question: when do you usually shower (and so prompt a long draw from your water heater)?[167] |
| **Insurance Adjusting**[168] | • How often do you arrive home around the time the bars close?<br>• How often do you get a full night's sleep v. drive sleep deprived?<br>• How often are you late to work, or rushing to get there on time? Does the time it takes you to get from your home to your workplace require that you break the speed limit to get there?<br>• Do you have a propensity for leaving appliances turned on and leaving the house, say, a curling iron or a stove range? |

[165] By "answered" I mean answerable through the application of those data analysis processes described in Parts III.B.1–3 or near-term extrapolations therefrom applied to interval usage data collected from a single household (sometimes including the expansion of this data sat through PHEV electricity tracking).

[166] This seems to have become the standard question brought up in this context. *See*, *e.g.*, Lerner & Mulligan, *supra* note 31, ¶ 4. Though included here because it seems to get the privacy juices flowing, it is not clear that this is a real privacy concern: coming and going from one's house is readily observed by a passer-by.

[167] Justice Scalia noted this litmus test in *Kyllo*, though without the dramatic title it finds here, when he noted with concern that the thermal imaging technology used in that case might reveal at what hour each night the lady of the house takes her daily sauna and bath—a detail that many would consider 'intimate.' " Kyllo v. United States, 533 U.S. 27, 38 (2001).

[168] Indeed, RMI's discussion of their "Smart Garage" system, a vision of a PHEV-integrated electricity grid, includes an information dialogue with insurance providers. RMI, *What is the Smart Garage?*, http://move.rmi.org/move-news/what-is-the-smart-garage.html (last visited Dec. 3, 2008) (diagram, top-center).

| | |
|---|---|
| **Targeted Marketing** | • On what days and during what times do you watch TV? How much home time do you spend in front of your computer?<br>• How often do you eat in? Do you tend to eat hot or cold breakfasts? What's the relative frequency of microwave dinners to three-pot feasts in your home? How often do you entertain?<br>• Are any of the appliances in your household failing or operating below optimal efficiency? Do you own (and so presumably like) lots of gadgets? Are you a Laundromat person, or do you have your own washer and drier?<br>• Are you a restless sleeper, getting up frequently throughout the night (and so likely turning on lights, etc.)? |
| **Inquiries Regarding Disputed Issues** | • In a custody battle, say: Have you ever left your child home alone? If so, how often, and for how long?<br>• In a worker's comp hearing: How is it, with your disabled back, you were able to turn on the TV in the upstairs of your home less than a minute after turning off the lights downstairs? |
| **Inquiries Regarding Regulated Activities** | • Alabama recently passed a tax provision requiring obese state employees to pay for their health insurance unless they actively work to reduce their body mass index.[169] So: why haven't you used your treadmill at home any time in the last week? You clearly have not been out of the house and away from a computer or TV long enough for aerobic exercise. |
| **Discrimination & Profiling** | • Race and ethnicity<br>• Non-traditional family typologies<br>• Gender or Sex<br>• Age<br>• Used to direct prosecutorial discretion or law enforcement investigation |
| **Medical Questions** | • Do clinically depressed or bipolar individuals have distinctive energy profiles? What about people with behavioral disorders? Could you tell if someone hadn't been taking their medication? |
| **The Monster Not Imagined** | **?** |

The concerns presented here fall into two broad categories: concerns about the leak or inadvertent disclosure of the information, and concerns regarding the systematic disclosure or sale of the information. This division helps direct efforts at containing the potential problem,

[169] *See* Don Fernandez, *Alabama 'Obesity Penalty' Stirs Debate*, WebMD Health News, Aug. 25, 2008, http://www.webmd.com/diet/news/20080825/alabama-obesity-penalty-stirs-debate (last visited Nov. 4, 2008) (quoting a clinical director for the Alabama State Employees Insurance Board as saying "As long as you are aware [of your obesity] and are doing something to correct it, there won't be a fee."). *See also* Associated Press, *Extra Pounds May Mean Higher Insurance Costs*, INT'L HERALD TRIBUNE, Aug. 22, 2008, http://www.iht.com/articles/ap/2008/08/21/america/NA-US-Obesity-Penalty.php.

discussed later. The thrust of these concerns, though, is a concern about a probationary state, where individual activities are restrained for fear—not just of being caught doing something they should have been doing—but of being put on the defensive for something they may not have done at all. This is the fear of becoming a false positive, either for illegal or embarrassing activities, whether the fear is legitimate (and the likelihood of analytic methods resulting in false positive matches for whatever behavior investigated is high), or a specter (because the likelihood of the method fingering a false positive is low), the result is the same: people start ordering their daily lives as if they may be being watched. This is precisely the scenario where information gathering itself becomes a form of surveillance.[170]

But this gloomy scenario puts the cart before the horse. After all, intuitions about the private nature of different kinds of information are tied to the consequences and frequency of its disclosure. So, before really understanding the privacy implications of the information, we must get a handle on how the information may be protected from the moment the switch is thrown on smart meters.

## IV. (LACKING) DATA PROTECTIONS

Legal protections of private information and private spaces come in many different forms, from constitutional protections to consumer protection movements and, important for the instant context, business and utility regulations. As electric utilities face new pressures and even transitioning business models, now is the time take heed of Shelly's fable and to shore up regulatory protections, lest we find ourselves facing a monster.

The threshold question presented in any privacy discussion is whether a Constitutional protection attaches to the context of concern. Other authors—most notably Jack Lerner and Deirdre Mulligan—have dealt squarely with Fourth Amendment concerns related to advanced metering infrastructure and high-resolution energy usage information.[171] As such, I do not delve deeply into the topic here. The lessons of their investigation should, however, be kept in mind—namely, that interval data of electricity consumption appears to be in something of a no-man's-land under Supreme Court Fourth Amendment jurisprudence. On the one hand, the Court has upheld the sanctity of the home as the touchstone for privacy protection.[172] Technology that effectively pierces the blinds, exposing information about activities inside the home requires a warrant before it is employed. It would appear that electricity usage data, as it contains many intimate details about the in-home activities of consumers, allows investigators to see through walls into the home and so access to the information should be restricted to essentially a need-to-know basis.[173] On the other hand, business records collected and kept by third parties enjoy far

[170] Stan Karas, *Enhancing the Privacy Discourse: Consumer Information Gathering as Surrveillance*, 7 J. TECH. L. & POL'Y 29 (2002), *available at* http://grove.ufl.edu/~techlaw/vol7/issue1/karas.html. *See also* infra note 191.

[171] The instant discussion is meant merely to bring out some of the issues and not provide a comprehensive treatment of these concerns. *See* Lerner & Mulligan, *supra* note 31, ¶¶ 7–8, 11–30.

[172] *See id*. ¶¶ 14, 18 (discussing Kyllo v. United States, 533 U.S. 27, 37-40 (2001), a case in which the Supreme Court ruled law enforcement's use of thermal imaging without a warrant to spot areas of relative heat within a residence, areas later discovered to be used for growing marijuana).

[173] "In the home, our cases show, all details are intimate details, because the entire area is held safe from prying government eyes." *Kyllo*, 533 U.S. at 27. It should be noted here, though, that the court's reasoning in *Kyllo* relied at least in part on the fact that thermal-imaging technology was not readily available and thus the law enforcement officer's techniques seemed even further from "naked-eye surveillance." *Id.* at 34-40. In the context of smart meter technology, the massive deployment efforts discussed in the Introduction and Part II.B would almost

fewer privacy protections, the underlying theory being that consumers elected to transact with the business, and to engage in activities open to observation by the public.[174] Traditional electricity metering information has generally been treated as business records and so lies unprotected by the Fourth Amendment.[175] Though Lerner and Mulligan seem optimistic that courts will "take the long view" on Fourth Amendment protections and extend them to smart metering data, my own analysis is that the law as it stands does not decide the matter, and the jurisprudence could easily be used to justify either result.

In addition to that imposed by the Constitution, however, the collection of electricity consumption data occurs beneath a regulatory framework imposed, for the most part, by state legislators and public utility commissions.[176] What follows is an examination of just how the existing regulatory framework will protect—or leave exposed—the privacy-problematic consumption information obtained through smart meters. First, as Colorado will soon be home to the nation's first smart grid city, the State's relevant PUC regulations serve as a case study for the discussion. Next, other regulatory structures as exemplified by other states are examined and compared to Colorado's. Finally, some observations are made regarding the smart metering and the European Union Data Protection Directive of 1995, which "establishes common rules for data protection among Member States of the European Union."[177]

### A. *The Colorado Case Study*

Xcel Energy has announced it is developing a smart grid pilot project in Boulder, Colorado, which is to be the United States' first "smart grid city."[178] As a part of the project, the utility will be collecting fifteen-minute interval data on Boulder residents through the installation of smart meters.[179]

How, then, does Colorado's existing statutory scheme protect consumers against disclosure of this information? Well, Colorado prohibits utilities from disclosing "personal information" to other parties.[180] Under Colorado's PUC regulations, personal information can

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certainly render the technology "readily available," which may cut against Fourth Amendment protections. More likely, though, the focus would come down on the information-extracting algorithms that allow users to glean the details of appliance activities from the smart meter data. Those are likely to be less common and less available than the meters themselves, which may make the analogy stronger and so bolster the argument for Fourth Amendment protection.

[174] *See id*. ¶¶ 19–22 (discussing Smith v. Maryland 442 U.S. 735 (1979); United States v. Miller, 425 U.S. 435 (1976); Couch v. United States, 409 U.S. 322 (1973)).

[175] *Id.* ¶¶ 25–30.

[176] I say "for the most part" here because federal laws and initiatives are driving (however slowly) the restructuring of electricity rates in important ways, and so are part of the framework that informs relevant regulations. *See*, *e.g.*, Spence, *supra* note 50, at 772–773.

[177] DANIEL J. SOLOVE, MARC ROTENBERG, & PAUL M. SCHWARTZ, INFORMATION PRIVACY 900 (2006) (discussing the European Union Data Protection Directive of 1995, Directive 95/46/EC, [hereinafter "EU Data Directive"] *available at* http://ec.europa.eu/justice_home/fsj/privacy/law/index_en.htm (follow "HTML version" or PDF version" hyperlink)).

[178] *See* Press Release, Xcel Energy Announces First Smart Grid City in the Nation: Boulder, Colo., to be Fully Integrated Smart Grid City, Xcel Energy, Mar. 12, 2008, *available at* http://smartgridcity.xcelenergy.com/news/releases/03-12-2008.html (last visited Dec. 3, 2008).

[179] Data obtained by calling Xcel Energy's "SmartGrid City" information line at 1.877.887.3339.

[180] 4 COLO. CODE. REGS. § 723-1-1104 [hereinafter "CCR § 1104], states:

1104. Personal Information – Disclosure.

only be disclosed with the signed consent of the affected customer authorizing "disclosure to the particular requestor."[181] Nobly, this protection prevents utilities from requiring the signature of a sweeping consent to disclosure as a condition of connecting to the grid. Each specific request for personal information from the utility must be approved by the customer. So far so good.

However, the definition of "personal information," rather than assuaging privacy concerns, confuses the matter. In the first instance "personal information" is defined broadly to mean "any any individually identifiable information obtained by a regulated entity from a customer, from which judgments can be made regarding the customer's character, habits, avocations, finances, occupation, general reputation, credit, health, or any other personal characteristics." [182] As shown earlier, the interval data on electricity consumption soon to be collected across the country for millions of households may contain information from which judgments and conclusions can be made regarding very specific habits of conduct carried on within the privacy of the home.[183] Thus it would seem that individual energy profiles that included interval readings would fit nicely within the regulations' protection of "personal information."

But the definition does not stop there. In order to clarify its scope, the definition lists specific classes of information are not to be considered "personal" and so subject to the consent disclosure restriction.[184] These include, *inter alia*, "information necessary for the billing and collection of amounts owed to a public utility or to a provider of service using the facilities of a public utility."[185] In the case of smart meter data, this may well prove an exception that

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(a) A utility may not disclose a customer's personal information to any third party, unless the request is either signed by the customer, or is supported by a disclosure form signed by the customer authorizing disclosure to the particular requestor.

(b) Notwithstanding paragraph (a) of this rule, a utility may disclose personal information in response to warrants, subpoenas duces tecum, court orders, requests from emergency service providers, or as authorized by § 16-15.5-102, C.R.S. A utility may also disclose information regarding a customer's typical or estimated average monthly gas, steam or electric bill, if such information is requested by a licensed real estate broker or others with similar purchase or sale interests in the customer's property.

(c) A utility shall provide any person requesting personal information with a form with which the customer may authorize disclosure. The form shall explain the customer's rights under this rule. The requestor shall obtain customer authorization for each request, unless the customer has authorized the release of all personal information at any time.

(d) A utility may disclose personal information requested by a federal, state, or local governmental agency including, but not limited to: the Commission; state and local departments of social services; and federal, state, and local law enforcement agencies. Written requests shall be on official letterhead. In the case of a telephone request, the employee of the regulated entity shall verify the caller's identity by obtaining the caller's office telephone number and returning the call, unless the employee knows the caller is an authorized governmental representative. A person requesting information in person shall demonstrate that he or she properly represents a governmental agency.

[181] CCR § 1104(a), *supra* note 180.
[182] 4 COLO. CODE REGS. § 723-1-1004(t).
[183] *See* id.; *supra* Part III.B.
[184] *See* CCR § 1104, *supra* note 180.
[185] *See id*. The entire list of definitional exclusions in this provision reads as follows:

Personal information does not include: a customer's telephone number if it is published in a current telephone directory or is scheduled to be published in the next telephone directory; information necessary for the billing and collection of amounts owed to a public utility or to a provider of service using the facilities of a public utility; or Standard Industrial Code information used for purposes of directory publishing.

swallows the rule. As rates may fluctuate throughout the day,[186] it would certainly be valid to argue that interval data on electricity consumption is critical to billing process: without the interval data, the argument would go, a customer's bill would likely be miscalculated. The argument has particular bite as many of the reasons driving the collection of more detailed consumption information relate to ensuring efficiency—including economic efficiency—in electricity generation and distribution.[187] If successful, however, smart meter data would be unprotected from disclosure by utilities, and gloom and doom story tellers could pick and chose from any of the list stomach turning uses listed earlier.

### B. *Other Regulatory Approaches.*

Not all states have regulation like Colorado's under which interval data would land in legal limbo. For example, Connecticut's Department of Public Utility Control defines protected "customer information" as

> customer-specific information which the electric distribution company or its predecessor electric company acquired or developed in the course of providing electric distribution services and includes, but is not limited to, *information that relates to the quantity, time of use, type and destination of electric service, information contained in electric service bills* and other data specific to an electric distribution company customer.[188]

Connecticut utilities can only freely disclose such "customer information," including information required for billing and load reporting, to their generation entities or affiliates.[189] All other disclosures require the utility "receive prior affirmative written customer consent."[190] While these provisions appear well suited to handle the potential privacy problems surrounding the collection of usage data by smart meters, the language seems to have been drafted with an eye to regulating the disclosure and sale of customer lists in competitive electricity markets. The disparate focus in the context—a protection for utility secrets used for the protection of consumer private information—leaves a big question mark about how the provisions would be implemented if disclosure practices were challenged under them.

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*Id*.

[186] *See supra* notes 54 & 55. Fluctuating rates are generally a result of a deregulated electricity market, that is, one in which electricity generation (as distinct from transmission) is subject to competitive pressures instead of regulated as a monopoly. Only about half the states in the U.S. have deregulated electricity markets, and Colorado is not one of them. While existing rate schemes in Colorado do not result in fluctuating prices, it is assumed here that, in one way or another they will—through either deregulation (less likely) or the implementation of a refined time-of-use pricing structure (more likely). The implementation of a smart metering would make little sense—at least from an environmental policy perspective—if pricing incentives and demand-side management efforts did not leverage the information into conservation. Indeed, Xcel Energy has proposed to the Colorado PUC a movement toward more dynamic rate-structures to take advantage of smart metering deployments. Interview with Daniel James, Manager, Pricing and Rates, Xcel Energy, Feb. 10, 2009.]

[187] *See supra* Parts II.A.1 & .4.

[188] CONN. DPUC Regs § 160224h-1(2) (emphasis added).

[189] CONN. DPUC Regs § 16-224h-4(a)(1). There are, however, some requirements placed on this disclosure process. *See* CONN. DPUC Regs § 16-224h-4(a)(3).

[190] CONN. DPUC Regs § 16-224h-4(a)(2).

California's Code also suffers from contextual uncertainty and, like Colorado's provisions, leaves somewhat uncertain the level of protection for information collected by smart meters—though more because of its patchwork structure than its substance.[191] At the outset, California Civil Code provides reasonably good protection of collected consumer information by effectively prohibiting non-anonymized data from being "distributed for commercial purposes, sold, or rented"[192] and requiring that businesses in possession of personal information about California residents "implement and maintain reasonable security procedures" to protect against inadvertent disclosure.[193] Furthermore, information no longer being used by the holder is to be destroyed or otherwise modified to "make it unreadable or undecipherable."[194] However, the tenor of these protections indicates the real concern of California legislators was targeted advertising,[195] so it is unclear just how broadly they will stretch in covering the dissemination of smart meter data—especially when there are so many noble causes clamoring for the information.

Under a section of California's Public Utility Code concerned with the implementation of a smart meter pilot program, the code provides: "To ensure customer privacy, unless specifically authorized by the customer, information based upon customer data may not be used for any commercial purpose."[196] However, as with Connecticut's provisions, "on the whole, the law [California's Public Utility Code] seems geared towards protecting the investor-owned utilities' data collections, including by not wholly composed of customer information, from adverse market consequences."[197]

Finally, California's treatment of utility-kept information for purposes of law enforcement further muddies the analysis of just how well protected the information is. California Penal Code section 1326.1 allows law enforcement agents to subpoena utility records, but later provides that "nothing in this section shall preclude the holder of the utility records from voluntarily disclosing information or providing records to law enforcement upon request."[198]

The discovery of regulatory difference does not necessarily coincide with the discovery of any real difference in practices between the various jurisdictions, nor does the finding of a hypothetical loophole mean that it is exploited. Best practices and utility codes of conduct may bridge the gap between some of these jurisdictions and so narrow the practical differences in

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[191] For an excellent overview of the legal framework at issue in California, see P.A. SUBRAHMANYAM, et al., NETWORK SECURITY ARCHITECTURE FOR DEMAND RESPONSE/SENSOR NETWORKS 14 (2005, rev. 2006) (report for the Network Security Architecture for Demand Response/Sensor Networks project, CIEE Award No. DR-04-03A, B, WA No. DR-005, under CEC/CII Prime Contract No. 300-01-043, conducted by CyberKnowledge and the University of California at Berkeley) [hereinafter "CEC DR Security Report"], pp. 20–33, App'x A, *available at* http://www.ucop.edu/ciee/dretd/ (follow "Draft Final Report (pdf)" hyperlink).

[192] CAL. CIV. CODE § 1798.60. *See also* CEC DR Security Report, *supra* note 191, at A-1 (stating that "the [California Civil Code] rules may influence the ways in which that [smart meter] data can be disseminated in the market, . . . or may play a role in protecting consumers from the deanonymization of information" and going on to discuss CAL. CIV. CODE §§ 1798.81–1798.82).

[193] CAL. CIV. CODE § 1798.81.5.

[194] CAL. CIV. CODE § 1798.81.

[195] *See* CAL CIV. CODE § 1789.82 (obligations cued "if the business knows or reasonably should know that the third parties used the personal information for the third parties' direct marketing purposes"); CEC DR Security Report, *supra* note 191, at A-3(discussing Cal. Civ. Code §§ 1798.83(a)(1), (e)(6)).

[196] CAL. PUC Code § 393(f)(7).

[197] CEC DR Security Report, *supra* note 191, at A-3.

[198] CAL. PENAL CODE § 1326.1(e).

information management, and also sure up seemingly flimsy regulatory protections.[199] However, whatever the current practices, concern over shifting practices due to the imposition of new business pressures is legitimate, and it may well be that weaker data protections are exploited once the potential for profit is recognized. It is also important to note here that Colorado—soon to be home to the first smart grid city in the nation—and California—whose utilities are currently deploying more smart meters than anywhere else in the country—are likely to be the first stages in which the privacy battles take place. As both states have relatively weak protections, it is fair to ask whether we want them to set the early precedent for business behavior and privacy protection concerning advanced metering data. Certainly, in order to avoid Frankenstein's catastrophe, that precedent should not be made by unwitting regulators that were o'er hasty to throw the switch. Rather, deliberate steps should be taken early to prepare for the information's release.

### C. *Observations Regarding the European Union Data Protection Directive*

In 1995, the countries of the EU adopted the European Union Data Protection Directive ("the Directive"), a common set of rules setting out data safeguards and standards of care.[200] The goal of protection outlined in the Directive is binding on EU countries, but the language itself is not. Each country is tasked with developing its own implementing legislation, it must be consistent with the standards set forth in the Directive.[201] However, examining the Directive's provisions offers some insight into how smart meter data may be considered and protected in Europe.

At the outset, Article 2(a) of the Directive defines "personal data" as "any information relating to an identified or identifiable natural person ("data subject"); an identifiable person is one who can be identified, directly or indirectly, in particular by reference to an identification number or to one or more factors specific to his physical, physiological, mental, economic, cultural or social identity."[202] Since high-resolution electricity consumption information could be used to

Categorization as "personal data" triggers several rights and obligations under the Directive. Article 6(1) requires that personal data (a) be "processed fairly and lawfully,"[203] (b) be "collected for a specified" purposes and not be further processed for other purposes,[204] (c) be merely adequate and not excessive for the purposes motivating its collection,[205] (d) be kept accurate,[206] and (e) be kept in a form allowing for identification for no longer than necessary.[207] Subsection (b) addresses the concerns raised earlier surrounding the systematic disclosure or sale of collected information: restrictions on further processing or use for other than the original purpose cut out the potential consumers of private information like insurance companies and

199 In California, for example, though the regulations do not apparently impose are requirement that enforcement officers obtain a subpoena to get at consumption information, "utilities may and often do refuse to release the records without a subpoena." CEC DR Security Report, *supra* note 191, at 25 n.t.

200 *See* INFORMATION PRIVACY, *supra* note 177, at 900.

201 *See id*. at 901.

202 EU Data Directive, *supra* note 177, art. 2(a).

203 *Id.* art. 6(1)(a).

204 *Id.* art. 6(1)(b).

205 *Id*. art. 6(1)(c).

206 *Id*. art. 6(1)(d).

207 *Id*. art. 6(1)(e).

targeted advertising firms. Subsection (c) and (e) take steps toward protecting electricity consumers against inadvertent disclosure of the information to parties that may nefarious intentions: information that contains no more detail than necessary and that must be scrubbed of its identifying information as soon as that information is no longer needed helps curb risks associated with the leak of such information.[208]

Thus, as with Colorado's PUC provisions,[209] the threshold definitions and general protections seem to provide ample room to protect the smart-metered electricity customer. While they do not offer perfect protection out of the box, they at least provide the skeletal structure to protect electricity consumers from privacy invasion. If combined with a system for aggregating and anonymizing the information, it seems that the Directive's provisions could be sufficient to guard against many of the concerns raised earlier in Part III.B.4.

However, also like Colorado's PUC provisions, the Directive provides exceptions that may cover smart meter data:

> *Article 13* – Exemptions and restrictions
>
> 1. Member States may adopt legislative measures to restrict the scope of the obligations and rights provided for in Articles 6 (1), 10, 11 (1), 12 and 21 when such a restriction constitutes a necessary measure to safeguard:
>     (a) national security;
>     (b) defence [sic];
>     (c) public security;
>     (d) the prevention, investigation, detection and prosecution of criminal offences, or of breaches of ethics for regulated professions;
>     (e) an important economic or financial interest of a Member State or of the European Union, including monetary, budgetary and taxation matters;
>     (f) *a monitoring, inspection or regulatory function connected, even occasionally, with the exercise of official authority in cases referred to in (c), (d) and (e)*;
>     (g) the protection of the data subject or of the rights and freedoms of others.[210]

Electricity consumption information is already used to investigate marijuana growth and drug manufacture.[211] As the resolution of electricity consumption information increases, it will only become more useful for such enforcement activities. While it turns on an interpretation of the term "occasionally," there at least is a good argument that such usage data fits within Article 13(f) of the directive as at least occasionally connected with defense, public security, or criminal investigations.

If such an argument is successful, any protections afforded electricity consumers by Article 6(1)(c) and (e) could potentially evaporate. Interests concerned with security and criminal investigations would most certainly argue they need to be able to examine historical

[208] Incidentally, the recommendations made to the California Energy Commission on the issue of privacy and security in demand response programs mirrors the principles in the EU Directive set forth here. *See* CEC DR Security Report, *supra* note 191, at 76–77.

[209] *See supra* Part IV.A.1.

[210] EU Data Directive, *supra* note 177, art. 13(1) (emphasis added).

[211] *See, e.g., Kyllo*, 533 U.S. 27 (2001).

usage records and further that highly detailed information can only lead to more accurate and efficient law enforcement. Thus those data management obligations under Article 6(c) and (e) could fall away.

The protections of 6(1)(b) fare something better, though may still be eroded somewhat (reasonably) in the name of law enforcement and defense. Where the data management obligations evaporate entirely if those management practices even *sometimes* stymie law enforcement efforts, disclosure restrictions that stymie law enforcement need only adjusted on a case-by-case basis in order to facilitate the information need.[212]

## V. CONCLUSIONS

Advanced metering technology is being implemented across the country, and soon detailed information about million's of people's electricity use will be streaming into electric utilities. From this data, an intricate picture of a person's household activities can be reconstructed, and the resolution or detail of these reconstructions is likely to increase. Furthermore, the diffusion of plug-in hybrid electric vehicles through the market may expand the scope of electric consumption information beyond the home, making electricity usage information a one-stop-shop for anyone wanting to see a record of an individual's daily routine.

The question thus becomes: What should be done about this? "It is remarkably easy to gaze deeply into one's navel and triumphantly extract therefrom a linty assortment of clever observations about the troubling implications of some social phenomenon. Coming up with solutions is considerably harder."[213] The questions of solutions is particularly difficult here, as the privacy concern and policy response don a kind of tail-chasing character: A proposed data service or data collection spurs specific privacy concerns based on the data resolution and surrounding technological storage and transmission protections. That privacy concern in turn drives a balancing of risks and public policies: consumers want privacy, but is absolute privacy worth putting off the deployment of important environmental and energy security infrastructure? The result of that balancing underlies a policy response. However, policies that set limitations on the collection or dissemination of potentially private information by either restricting the resale of data or inhibiting access to collection at the meter (say, if meter access was restricted technologically to ensure only the utility could get the sensitive information) in effect determine the scope of possible data services. The process is thus back where it started. All of this, of course, takes place within the context of existing privacy jurisprudence and positive law, which itself may shift with the new technological pressures.

[212] Another possible categorization of electricity usage data is possible—though somewhat less likely—under the EU Data Directive Directive, which would cue different data management responsibilities make applicable a different exception. Specifically, usage data is arguably not "obtained from the data subject," EU Data Directive, *supra* note 177, art. 11(1), as the equipment for its measurement and recording are provided and maintained by the utility, and the information collected is not so much asked for but obtained through a kind of surveillance. While it could be argued that the customer's opting-in to electric services makes the collection voluntary, it is fair to query just how voluntary electric service is in the increasingly technologized world. Even if covered, however, it appears Article 11's own exception would apply, as analysis could easily be construed as "processing for statistical purposes or for the purposes of historical or scientific research," thereby eroding the protections of section 11(1). *Id*. art. 11(2).

[213] Karas, *supra* note 170, at 60.

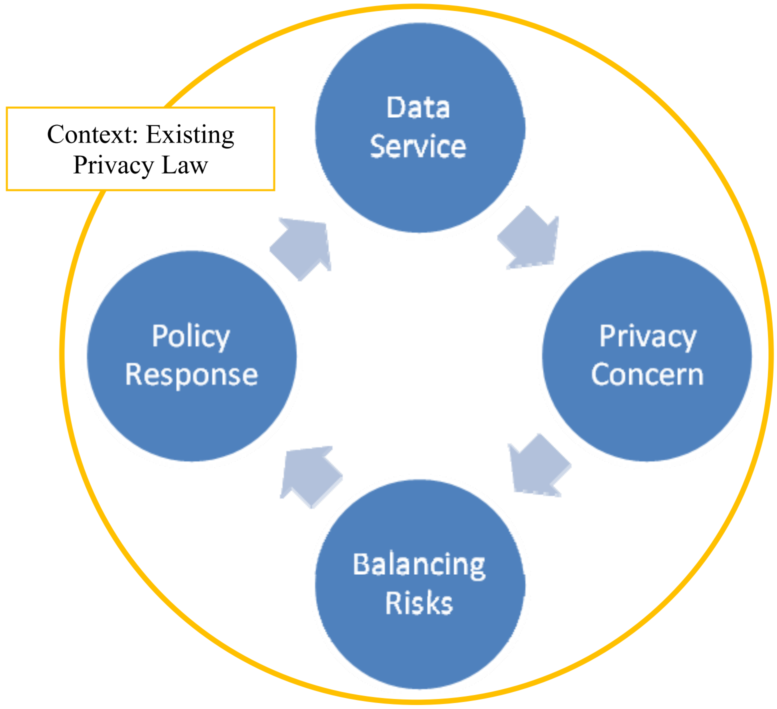


**Figure 4:** The dynamics of smart metering privacy concern.

Here—as with all attempts at anticipating problems—the solution must involve, first and foremost, drawing attention to the potential privacy problem posed by the massive deployment of smart metering technologies and the collection of detailed information about the electricity consumption habits of millions of individuals. From there, efforts to devise potential solutions must progress in parallel paths, the first in search of a regulatory fix, the second a technological one. The first protects against the systematic misuse of collected information by utilities, despite new pressures on their profitability, by ensuring the databases are used only for their principle purposes: informing efficient electricity generation, distribution, and management. Such regulatory fixes are not difficult. Indeed, Connecticut's relevant regulations may already provide adequate protection against many of the "troubling implications" of this growing data set.[214] Opt-in regulations are appropriate—at least in the short term—to protect consumers while the market for smart metering data develops and the full capabilities of those with access to that data are laid bare. As many states are taking a fresh look at their relevant regulations in connection with the restructuring of billing rates, swift action on this issue is both possible and easy.

The technological fix is a bit larger an obstacle, and solutions, on my part, more covered in lint. However, some recommendations are apparent even from this discussion. Specifically, the technological answer to these concerns must come in two parts: one addressing the security of the database as aggregated and kept by the utility, and the other addressing the security of transmitted data. The former part does not differ in any meaningful way dealing with database security of any other sort of information. The second part poses more subtle problems, though. Most notably, the structure of just what is being secured is not quite established – standards have yet to be finalized, creating the potential that solutions here would have to be tailored to individual smart meter deployment efforts. One possible approach might be to aggregate and encrypt the data being sent from smart meters back to the utility by putting additional hardware

[214] *See supra* notes 188–190 and associated text.

on each transformer. This would basically anonymize an individual's information to roughly the scale of a city block.[215] The cost of such an endeavor would likely be huge if attempted as an independent project, but if done in parallel with the deployment of smart meters, the added cost is likely far less. However, this would require the rapid development of such technology, as the deployment of smart meters has already begun.

In the final analysis, the privacy problem posed by smart metering is only a difficult one if the data gets unleashed before consequences are fully considered, or ignored once unfortunate consequences are realized. But to ignore the potential for privacy invasion embodied by the collection of this information is an invitation to tragedy.

[215] To the extent that this approach has any merit, credit is due wholly to Jonah Levine at the Center for Energy & Environmental Security, University of Colorado Law School. It should be noted, though, that while this would protect the information flowing to utilities from smart meters, it would not protect the flow of information over the telecommunications networks as utilized by home area networks and after-market technologies that allow for the remote control of one's energy consumption through, for example, her cell phone.