



National Center for Medical  Legal Partnership

The Health Impact Assessment (HIA)

of the Commonwealth Edison (ComEd)
Advanced Metering Infrastructure (AMI) Deployment

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April 2012

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I. INTRODUCTION AND BACKGROUND

Access to electrical service has become increasingly central to the lives of residents from an economic perspective as well as from a health perspective. Modern housing infrastructure relies on relatively low-cost, plentiful electricity to illuminate both indoors and out, air-condition homes in the warmer regions of the country, and, to a lesser degree, heat homes in winter. Residential electricity affords light, warmth, and cooling to American homes, and decisions about its use dictate indoor temperature and humidity as well as whether or not alternative sources of energy, such as candles or stoves, are used for light and heat. Consumer decision-making about energy use and equity issues related to energy access shape health. Despite the health dimension of home energy use, this realm is typically beyond the purview of health departments and health care clinicians. Energy, in the form of electricity, is traditionally overseen by state regulators of utility service.

Residential electricity consumption is measured through a meter that displays the number of kilowatt hours used by the household. Approximately every thirty days, a utility will capture that information by doing a manual read of the meter's consumption, and this information appears on the customer's bill as the total kilowatt hours consumed during the prior billing period. In other words, customers pay for electricity based on usage incurred during the prior month. Many bills also show customers how the most recent month's usage compares to their prior month's usage, and in some cases, how the most recent month's usage compares to the prior twelve months of usage. In all cases, this usage information is not typically broken down by time of day, and not presented in "real time," that is, at the time of the actual usage. In order to connect or disconnect service, the utility must arrange to have a technician come to the premise to manually activate the meter.

Advanced Metering Infrastructure (AMI) has implications for both the utility and residential customers because it can present more timely and incremental data to both parties on electricity consumption as well as eliminate the need for the utility to visit a premise for service connection or billing. AMI replaces existing mechanical meters with digital or "advanced" meters that record customer usage in 15-minute increments. The new meters, coupled with a new two-way communication system and new data management systems, allow the utility to remotely connect and disconnect service, as well as read and obtain detailed customer usage on a 24/7 basis often in increments as small as 15 minutes. This information shows a very detailed picture of customer usage throughout the day and night. Because the meter

communicates directly with the utility via a two-way wireless communication system, the utility no longer has to send out meter readers but can instead read the meter, and if necessary send a signal to the meter to turn it on or off (including disconnection for nonpayment) from a remote location. The two-way communication enabled by AMI allows the utility to monitor if there is any usage at all, thus helping to determine which customers have a power outage. It also enables faster service connections and disconnections, since service can be activated remotely from a central control facility rather than at the point of use.

AMI is also typically associated with the introduction of new pricing programs as a mechanism for decreasing overall usage and changing when electricity is used. These pricing programs, referred to as “dynamic” or “time-based,” track the operation of the national wholesale electricity markets. In these markets, electricity prices are higher during “peak” times when overall demand for electricity is high and the most expensive generators are used to provide this higher demand. These market costs are passed straight through to customers. Similarly, AMI can be used to offer rebates or penalties around peak usage (in the case of rebates, commonly referred to as a “peak time rebate,” and in the case of penalties, commonly referred to as “critical peak pricing”). In Illinois and in many other states, this time of “peak” demand typically occurs during hot summer afternoons. The use of time-based pricing programs differs from the traditional pricing structure, which typically charges customers one fixed price for all electricity consumed regardless of the time of day with only seasonal changes (winter and summer).

Digital meters are usually installed at the same place where the prior mechanical meters were located, typically places such as garages or outside of homes, and out of sight of the customer. In instances where AMI has been tested, customers can access more detailed usage information by viewing their usage profile on the utility’s website (which often shows a daily usage breakdown within 24 hours), installing an in-home device to bring the meter information into the customer’s home and display it to the customer directly, or on an expanded monthly bill. The costs of this infrastructure are passed along through the utility which delivers the electricity, typically recovered from customers in some combination of flat monthly charges and variable charges based on how much energy the customer used.

AMI has sparked great debate nationally among utilities, consumer advocates, and environmental organizations. Consumer advocates have raised concerns about the adverse impacts on residential customers due to the higher rates to pay for AMI, the

lack of evidence to support the long-term estimates of benefits, and the health and safety implications of remote disconnection for nonpayment in particular. The connection between access to affordable electric service and health has largely gone unacknowledged in debates about AMI deployment. Proponents of AMI have pointed to the potential for operational savings at the utility which will lower customer costs, improved outage management and the potential reductions in overall energy usage, particularly at peak times, enabled by the additional data an AMI system provides to both consumers and the utility.

A. What is being evaluated in this Health Impact Assessment (HIA)?

The purpose of this Health Impact Assessment is to evaluate the potential health impacts of the deployment of AMI for residential customers in the Commonwealth Edison (ComEd) service territory in Illinois. The purpose of this HIA is not to evaluate whether or not AMI meters should or should not be deployed, but rather to highlight the health and safety aspects of AMI for consideration by the Illinois Commerce Commission (ICC) as it reviews proposed AMI deployment plans. The data-driven, systematic nature of HIA offers a unique opportunity to incorporate health explicitly into the terms set by the ICC so that AMI deployment maximizes its potential to promote health and minimizes the likelihood that consumers, especially those from households which struggle to pay utility bills, will be harmed.

For the purposes of this HIA, there are three aspects to the AMI deployment that were examined for their potential health impacts on vulnerable customers, defined as five groups that are more vulnerable than the general population, which includes: the very young (from birth to age 5), older individuals (age 65 and older), individuals with functional disability status including those with temperature sensitive conditions, individuals who are socially isolated, and individuals with limited English proficiency or literacy. The three questions were:

1. First, whether or not AMI will raise customer rates for electricity service because of the additional infrastructure investment costs the utility will recover from its customers. If AMI does not provide operational benefits to offset its costs, fuel poverty¹ experienced by vulnerable customers will be exacerbated. Since AMI deployment requires a large capital investment, the principals sought to answer how vulnerable populations might be adversely affected by the increased electricity rates necessary to pay for an AMI investment. AMI deployments, as well as other large utility investments, are generally evaluated on a 15-20 year timeframe for the analysis of costs and benefits, and cost recovery from customers is

¹ The term “fuel poverty” means the inability of a household to afford essential electricity or other energy needs. Typically, this term means that the percentage of annual household income needed to pay for energy exceeds 10% of available income. Non-low income households typically pay no more than 2-3% of total household income for energy .

collected over the same time period. This means that oftentimes customers have begun paying for large capital investments, including AMI, before any benefits associated with that investment may accrue to them.

2. Second, whether or not new pricing programs enabled by AMI will provide benefits to customers or increase costs to vulnerable customers at a time when they can least afford it. Proponents of dynamic pricing argue that by linking prices for the average residential consumer more closely to the actual costs, customers will be motivated to reduce electricity usage during peak times and to reduce overall consumption. Opponents of dynamic pricing are concerned that more volatile prices will cause economic hardship for vulnerable populations, such as low-income or fixed-income individuals, if these dynamic programs are made mandatory vs. continued use of flat rate pricing, or if the impact of those who participate voluntarily does not result in the predicted impact on electricity prices for all customers. Because the cost recovery of these AMI projects is typically started in the first five to seven years, it is important to focus in the potential health impacts over that time.
3. Third, whether or not the use of a remote service switch to disconnect service, particularly in the case of disconnection for nonpayment, will have adverse impacts on vulnerable populations. While service restoration times should improve, disconnection for nonpayment could happen much more rapidly for customers than under current practice, which requires disconnection manually. Remote disconnection can be detrimental to the health of vulnerable populations, particularly those who rely on medical devices, such as nebulizers.

B. What is the significance of this HIA?

The connection between access to affordable electric service and health has largely gone unacknowledged in debates about AMI deployment. To address this gap, the National Center for Medical-Legal Partnership, Citizens Utility Board, Consumer Affairs Consultant Barbara R Alexander, and Energy Programs Consortium Consultant Lynne Snyder conducted this HIA between July 2010 and April 2012 to examine the potential health impacts of AMI deployment, and the consumer protections associated with AMI, and to make recommendations to address the potential adverse impacts on vulnerable populations.

It has been the assumption throughout this preparation of the HIA that ComEd would seek to file a proposal for full deployment of AMI and that such a proposal would outline the costs and potential benefits of such an investment. In the fall of 2011, the Illinois legislature created a new ratemaking system for electric utilities that would include deployment of AMI throughout a utility's service territory. ComEd will file an AMI deployment plan with the ICC in April, 2012. As a result, this HIA is intended to provide additional information that the ICC should consider in any proposal for full scale AMI deployment.

The HIA report is organized as follows: Section II describes the HIA scoping process and the assessment methods employed. Section III describes the assessment findings and impacts related to the core components of this HIA: the cost of AMI deployment and impacts on customers; dynamic pricing programs and impacts on customers; and reliability of service and remote disconnection. Section IV describes a set of recommendations to respond to identified impacts, and Section V provides a monitoring plan to track the impacts of this HIA.

C. Why does the issue of AMI matter to health?

Electricity is vital to health and safety. A household without electricity lacks lights, running water (if the house requires a pump to provide water), refrigeration, cooling fans and air conditioners, and, during the winter period, most heating sources. Even if the household heats with natural gas or propane heaters, those heating systems cannot operate without electricity. It is common for a household that is denied electricity to turn to alternative and often dangerous means of providing light and heat in the home. These means include candles, which can result in house fires, alternative generators or heat sources that generate deadly carbon monoxide. In addition, lack of proper heat in the home can result in death due to hypothermia or the worsening of chronic health conditions like asthma or diabetes. While there is no national compilation of deaths due to the use of unsafe methods of providing lighting and heating in a disconnected dwelling, there are instances reported every year of the deaths of children and adults due to the use of a candle in a dwelling without electricity or heat.²

² In research on candle fires and utility disconnections, the National Fire Protection Association has found that one in four fatal home fires involving candles occurred in homes where the power had been shut off. The

However, delivery of electricity can have its own negative health implications. The power plants that generate electricity can be a source of pollution emissions that can negatively impact consumers with lung diseases such as asthma and chronic obstructive pulmonary disease, particularly when older plants are put online at peak demand times, to supplement the supply of electricity generated by more modern plants during periods of lower demand for electricity (non peak periods). In addition, using electricity inefficiently can result in higher energy bills, which can make fuel poverty worse. Other ways beyond AMI for improving energy efficiency, such as weatherizing a home or replacing older appliances with more energy-efficient models, are likely to reduce home energy bills and have the potential to decrease the demand for electricity during peak periods.

Deployment of AMI within Commonwealth Edison’s service territory represents a transformation of the relationship between utility and residential customers, facilitating the collection and dissemination of more detailed information about energy usage, new opportunities to communicate this information in order to influence customer behavior around energy usage, and managing energy consumption from the standpoint of infrastructure operations as well as rates governing the pricing of electrical service. It may also have unintended consequences – for example, deployment is likely to influence the health of the Illinois population given the demonstrated connections between access to electrical service, health and safety – especially for residents of low- and moderate-income households. This HIA identifies and analyzes the elements of this transformation, related to the cost and terms of residential electrical service, with the goal of making visible the implications for health of AMI deployment in order to inform decision-making.

D. What is the proposal being assessed?

ComEd was the first electric utility to request that the Illinois Commerce Commission (ICC) approve a “system modernization project” which would include AMI

association has also noted that people use candles differently when they use them for actual light—walking around with them, for instance, and keeping them lit rather than extinguishing them when they leave a room. Marty Ahrens, Home Candle Fires, National Fire Protection Association (June 2010)

investments in 2008. The ICC rejected ComEd’s request, in large part because the Commission felt it lacked sufficient information regarding the costs and benefits of any particular proposal such as AMI. To correct this deficiency, the ICC ordered that an AMI workshop process be initiated to develop project goals, timelines, evaluation criteria and technology selection criteria for a pilot of up to 150,000 meters throughout the ComEd service territory.

In October 2009, the ICC approved a pilot consisting of approximately 100,000 meters in the Company’s Maywood Operating Area (the I-290 corridor of the Chicago area composed of suburban communities) and 30,000 meters in the Chicago metropolitan area. The ICC also approved a smaller subset of the meters to be used as a test of dynamic pricing programs vs. customers staying on traditional “flat rate” programs, and home energy management tools (a “Customer Applications Pilot” or CAP). ComEd installed the new metering system in late 2009 and early 2010 and implemented the CAP starting in June 2010 through May 2011.

This test of approximately 8,000 residential customers was one of the largest in the country, and the only one of its kind to be designed as an “opt-out” test of dynamic pricing. Customers were randomly assigned to a new rate and provided with a variety of in-home devices and different pricing programs to test whether the particular program would result in overall usage reduction (conservation), lower usage during peak times, and overall customer satisfaction with the technology and pricing program assigned. While customers could choose to leave the pricing program pilot at any point, they were not allowed to choose another pricing program or technology in preference over returning to standard utility service, creating what is known as an “opt-out” pilot. The purpose of this CAP was to determine if customers would change their usage behavior, i.e., use less overall or use less during certain peak pricing periods. If one or more of the pricing and technology options could be predicted to have a significant impact if operated on a full-scale basis, these actions could result in lower electricity prices for all customers. The rates that the CAP tested (listed in detail in Appendix 7) included:

- An inclining block rate, where the customer pays more for each block of use – e.g. 7.5 cents for the first 100 kWh, 9.5 cents for the second 100, 12.5 cents for the third.
- A “critical peak price” which imposes a very high price for energy use at designated “critical peak” times, such as from noon until 5 p.m. Customers

using electricity during those times are charged more than they are at all other times.

- A “peak time rebate” which does the same thing as a critical peak price but instead of charging more, customers who use less energy during peak hours receive a bill credit.

ComEd provided customers with in-home display units showing energy consumption and price, as well as programmable control devices to regulate home heating and air conditioning systems. ComEd also solicited pilot customers to go to their account on the ComEd website, view their usage information in more detail, and learn how to respond to the specific pricing program that the customer was enrolled in.

In November 2011, the Illinois General Assembly authorized a new program for increases in electric rates based on a formula if specific performance metrics are reached. As part of its obligations under the new rate structure, ComEd committed to spend approximately \$1.1 billion investing in smart grid technologies, including AMI, over a ten-year period across its entire service territory. The law requires ComEd to prioritize its investments based upon how quickly customer value from those investments can be created. It also requires ComEd to detail its consumer education strategies that will accompany its investments, and creates a consumer education fund.

In April 2012, the ICC is expected to receive ComEd’s plan for AMI deployment and to rule on proposed changes in terms of electrical service and pricing in connection with AMI. At that time, interested parties will have the chance to weigh in on ComEd’s proposed deployment plan. Under the law, the ICC must approve ComEd’s plan if it concludes that ComEd’s plan will be cost-beneficial to consumers, and ComEd is required to introduce a peak time rebate program 60 days after deployment approval.

E. What is the Significance of this Policy?

The national debate on AMI deployment has been vigorous, particularly before state public service commissions that regulate investor-owned utilities within their boundaries. The \$4.5 billion in financial assistance for smart grid deployment and demonstration projects included in the American Reinvestment and Recovery Act

(2009) has stimulated AMI deployment proposals in many states.³ The California Public Utilities Commission approved cost recovery for AMI investment of over \$5 billion for three investor-owned electric and natural gas utilities.⁴ Illinois' new law would mandate \$1.1 billion in AMI investment for each electric utility opting to take advantage of the new law. Given the capital costs involved for AMI technology and smart grid upgrades, consumer advocates have raised concerns about the adverse impacts on residential customers due to the higher rates to pay for AMI, the lack of evidence to support the long-term estimates of benefits, and the health and safety implications of remote disconnection for nonpayment in particular.⁵ However, the connection between access to affordable electric service and health has largely gone unacknowledged in debates about AMI deployment.

F. Why use an HIA to analyze the AMI policy?

There are many different factors that influence health, from those that are beyond individual control (e.g., age, gender, genetics) to those that are linked to individual behavior (e.g., smoking, drinking, exercising, eating) to structural factors, such as:

- Access to public services and infrastructure (such as education and health care),
- Living and working conditions (such as housing quality and workplace hazards), and
- Social and economic factors (such as social cohesion and neighborhood poverty).

One recent peer-reviewed analysis estimated that genetics was responsible for 20% of health status, healthcare comprised another 10%, and the remaining 70% of health

³ The U.S. Department of Energy awarded ARRA funds for Smart Grid projects, including many AMI deployment projects to utilities and entities in 42 states. See, http://www.doe.gov/sites/prod/files/oeprod/DocumentsandMedia/FINAL_Combined_SGIG_Selections--By_State_Updated_2011_06_10.pdf

⁴ This total was calculated by The Utility Reform Network (TURN) based on final California Public Utility Commission orders authorizing deployment and cost recovery of AMI for Pacific Gas & Electric, Southern California Edison, San Diego Gas & Electric, and Southern California Gas Co.

⁵ AARP, National Consumer Law Center, National Association of State Utility Consumer Advocates, Consumers Union, Public Citizen, The Need For Essential Consumer Protections: Smart Metering Proposals And The Move To Time-Based Pricing (September 2010). Available from www.nasuca.org This publication made recommendations for consumer protection policies to accompany any evaluation of or approval of AMI deployment.

status was attributable to social, environmental, economic and behavioral factors (Health Affairs, 2002).

A health impact assessment (HIA) is a tool used to assess this wider range of health factors. Implicit in the definition of HIA is the idea that health is a function of many factors, and that a combination of approaches and types of knowledge is needed to measure or capture the full range of impacts on health. An HIA, therefore, is “a combination of procedures, methods and tools that systematically judges the potential, and sometimes unintended, effects of a policy, plan, program or project on the health of a population and the distribution of those effects within the population. HIA identifies appropriate actions to manage those effects” (Quigley et al International Association for Health Impact, 2006). A core principle of Health Impact Assessment is health equity, and specifically focuses on the health impacts of policies on vulnerable populations.

At its core, a health impact assessment is an approach to policy analysis that makes visible the consequences *for health and safety* of a policy decision. An HIA is a systematic, data-driven methodology to evaluate the health outcomes likely to be associated with a specific policy or program decision, with a focus on policy arenas outside the traditional realm of public health and health policy, including for example: energy, education, housing, immigration, criminal justice, and employment. These impacts are identified, prioritized, and evaluated systematically in order to make recommendations about how to minimize negative impacts and maximize positive impacts. Conducting an HIA involves reviewing literature, court cases, or media coverage to develop hypotheses that link the policy decision to health impacts. This flexible research process typically involves six steps:

1. *Screening* involves determining whether or not a HIA is warranted and would be useful in the decision-making process;
2. *Scoping* collaboratively determines which health impacts to evaluate, the methods for analysis, and the workplan for completing the assessment;
3. *Assessment* includes gathering existing conditions data and predicting future health impacts using qualitative and quantitative research methods;
4. Developing *recommendations* engages partners by prioritizing evidence-based proposals to mitigate negative and elevate positive health outcomes of the proposal;

5. *Reporting* communicates findings; and
6. *Monitoring* evaluates the effects of a HIA on the decision and its implementation as well as on health determinants and health status.

Another element central to HIA practice is collaboration and working with stakeholders to design, conduct, and communicate the results of the HIA. This builds capacity at the local and organizational level to participate effectively, informed by the best scientific evidence, in decision-making that affects health. Conducting an HIA can also help decision makers assess policy proposals, avoid unintended consequences and costs, and advance smarter, cost-effective policies that promote health. Ultimately an HIA should:

- Save costs over the long-term by identifying ways to minimize adverse health outcomes that come with costs such as lost productivity, higher health services utilization, higher rates of disability and premature death.
- Be a flexible process that can be tailored to the timeframe of decision-making, whether policies are made after a day-long deliberation to one that spans years. An HIA generally saves time by offering non-partisan, problem-solving forum that has potential to defuse conflict and resolve policy differences efficiently.
- Promote smart economic development by identifying and addressing potential concerns proactively.

G. Project Team and HIA Timeline

The AMI HIA was a joint project between four principals with generous support from the Health Impact Project, a collaboration between the Robert Wood Johnson Foundation and the Pew Charitable Trusts. The National Center for Medical-Legal Partnership (NCMLP) was the coordinating grantee, with partners the Citizens Utility Board (CUB), Energy Programs Consortium Consultant Lynne Snyder and Consumer Affairs Consultant Barbara R Alexander. The project principals received technical assistance from Human Impact Partners, and collaborated with national organizations, such as the National Consumer Law Center and AARP, and regional organizations, including Land of Lincoln Legal Aid and Loyola University, who both have medical-legal partnerships. In addition, the project team entered into an agreement with ComEd to gain access to data associated with its AMI pilot programs.

The HIA project began in July 2010. Project principals conducted meetings with community partners to gather initial feedback on ComEd's pilot and potential research questions. Local community organizations were used to distribute and gather HIA surveys throughout the fall of 2010. Between October 2010 and September 2011, research was gathered and assessed. A draft report was prepared for review and input from the funder in November 2011 and was revised over subsequent months before its release in April 2012. A full list of the project team principals and stakeholder advisory group is in Appendix 1.

II. HIA SCOPE AND METHODS

A. Scoping the HIA: Identifying Health Impacts of Interest

In the scoping stage of HIA, relevant stakeholders develop goals for the HIA and prioritize research questions, methods, and parameters to guide the assessment. This HIA focuses on “vulnerable populations” as a subset of residential customers generally, since most utility proposals focus on the “average” customer, but rarely do utility regulators or policymakers have information about subsets of residential customers that might respond differently from or require specific needs compared to “average” customers. This HIA defines vulnerable customers as five sub-populations that are generally more vulnerable than the general population: children under age 5; individuals over age 65; individuals with functional disability status including those who live with temperature-sensitive conditions; individuals who are socially isolated; and, those who have limited English proficiency or literacy.

The principals used the HIA scoping process to develop a set of hypotheses about AMI and health, based on presentations made at the summer 2010 meetings and with the input they received from community stakeholders. These hypotheses became the basis for the three sets of research questions that form the core for the HIA analysis.

1. AMI PATHWAYS TO HEALTH

The project team began the scoping step of this HIA by drawing out several pathway diagrams that hypothesized the potential impacts of the AMI proposal on health (see pathways in Appendix 2). These pathway diagrams then served as the basis for community input and identifying the research questions to guide the HIA.

The first pathway identified the potential positive and negative health impacts of AMI deployment generally, irrespective of the variable pricing programs and with particular attention to impacts on groups identified as vulnerable. Hypothesized impacts include the potential for increased electrical bills for cost recovery of AMI deployment; potential changes in non-ionizing (EMF) radiation exposure; potential changes in reliability or remote connection; and possibility for remote disconnections.

The second, third and fourth pathways set out hypotheses concern related to dynamic pricing, in particular critical peak pricing, peak time rebates, and time of use rates, with attention to the impact on vulnerable populations. These health impacts were scoped to consider the potential for pricing plans to influence changes in usage, either the level of peak load demand for energy or overall usage, the resulting potential impact on green house gas emissions, and changes in prices of energy and impact on health.

Ultimately, the pathway diagrams identified a number of domains or determinants of health impacts that are potentially influenced by AMI, including fuel poverty, housing adequacy, loss of electricity generally and from remote disconnection for non payment specifically, non-ionizing (EMF) radiation, unintentional injuries and premature deaths, vulnerability to heat or cold, and ambient air pollution. All scoping pathways shared the same set of health determinants and hypothesized range of health outcomes, irrespective of the type of rate plan for electrical service.

FUEL POVERTY: The financial pressures of trying to pay high home energy bills, and related decisions not to use needed electricity in order to avoid high bills, leads to tradeoffs among household budget items that are often labeled “heat or eat.” A national telephone sample survey across 13 states offers a window into the choices made by low-income households that receive federal energy assistance grants (LIHEAP) (NEADA, 2011): In response to high home energy bills, 72% of energy assistance recipients reduced expenses for household basics, 24% report going without food for at least one day, 37% report going without needed medical or dental services, and 34% go without the appropriate dose of a prescribed medication (NEADA, 2011). A variant of this phenomenon might be labeled “cool or eat” and refers to influence of concern about the cost of electricity in summertime on the decision to use air-conditioning, even during a heat advisory (Sheridan, 2006). Fuel poverty influences food insecurity, for young children and for seniors, and has been demonstrated to negatively affect the early growth and development of young children (Frank et al., 2006; Cook et al., 2008; Nord and Kantor, 2006; Bhattacharya et al., 1992). It is also directly related to the disconnection of service for nonpayment.

HOUSING ADEQUACY: The physical environment of a home itself has myriad influences on health, some related to the fiscal strains associated with energy insecurity and of poverty itself, and others related more specifically to AMI, for example, anticipated exposure to non-ionizing (EMF) radiation from the meter. NEADA’s survey of energy assistance recipients documents a range of ways in which

energy insecurity influences how they use their homes, from closing off rooms that are too cold or costly to heat, maintaining indoor temperatures that are unsafe or unhealthy, and leaving home for part of the day (NEADA, 2011). Overcrowding is one result of such responses, associated with declines in mental health status and social connection (Liddell and Morris, 2010; Thomson et al., 2009).

Access to adequate heating in wintertime and cooling in summertime, especially by means of central air-conditioning, is demonstrated to promote health and safety. Central air-conditioning is the single most significant factor predicting positive health outcomes in summertime, in the United States and around the globe (Davies et al., 2003; Barnett, 2007; Rogot et al., 1992; Bouchama et al., 2007). Disparities in access to central air-conditioning, for example, account for two-thirds of the disparity in summer death rates for urban African Americans, compared with their white peers (O'Neill et al., 2005). In addition to maintaining adequate indoor temperature, heating and cooling improve indoor air quality. Lack of access to central heating or air-conditioning is associated with the accumulation of moisture and growth of mold, as well as higher nitrogen dioxide levels, which make childhood asthma symptoms worse (Belanger and Triche, 2008).

Lack of access to basic, reliable electrical service during the heating season contributes to the deterioration of indoor air quality. For the 11.3% of Chicago area households whose primary heating fuel is electricity (20.3% for households living in poverty), a rise in the price for power or the perception that power is newly unaffordable can lead to the decision to cut back on needed heating or to the loss of service during certain times of the year (data from American Housing Survey). There is a greater risk of exposure to nitrogen dioxide, carbon monoxide, and residential fires when a gas oven, stovetop, or portable space heater is used for heat. In the summertime, lack of air-conditioning contributes to the accumulation of moisture and growth of mold. Year-round, the loss of electrical power is associated with an increased risk of fire from the use of candles for light. These exposures contribute to the burden of childhood asthma and to unintentional injuries and premature deaths from fires. To the extent that AMI deployment leads to greater fuel poverty, and if the remote disconnect capacity of digital meters is used without regard to existing consumer protections, the following types of exposures are likely: moisture/mold; carbon monoxide; nitrogen dioxide; and fires.

HEALTH IMPACTS FROM LOSS OF ELECTRICITY GENERALLY: The limited systematic evidence available about the outcomes of the loss of electrical service

comes from studies of blackouts that affect entire neighborhoods (Beatty et al., 2006), while knowledge of the adverse impacts of shutoffs of service for nonpayment tends to be more anecdotal, reported in news accounts, legal cases, and collections of case studies investigated by the CDC and other public agencies. For example, the Onandaga County Medical Examiner's Office conducted a retrospective review of all deaths over a five year period (1999-2004) to identify cases linked to the loss of residential electrical service, finding 7 deaths associated with the shutoff of service, 4 of which occurred following the unintentional disconnection of service due to weather and 3 due to disconnection of for non-payment (Stoppacher et al., 2008).

LOSS OF ELECTRICITY AFTER REMOTE DISCONNECTION FOR NON-PAYMENT: There are no systematic data on remote disconnection for non-payment in Illinois. Other states have examined the practice of remote disconnection. For example, in Maine, Central Maine Power Company's (CMP) submitted evidence concerning the actual actions taken by the Company to effectuate its disconnections of service. Of the over 54,000 notices that were "worked" in 2008, almost 30,000 (almost 60%) were left connected.⁶ The reasons for those left connected include collection of funds, check, customer showed receipt, customer made arrangements, declaration of medical emergency, leaving a "green card" if a customer was not home, etc. Thousands of customers avoided disconnections by having contact with the field worker at the time of disconnection. The Company exercised its discretion to not disconnect service based on what occurred at the time of physical disconnection of service. Shutoff of service for nonpayment increases the likelihood that consumers will use risky, alternative means to heat or light their homes, degrading the quality of housing, influencing the rate of unintentional injuries and deaths, and increasing homelessness and instability of housing for elders and persons living with a disability. No data exists in Illinois on what, if any, the effect a premise visit and attempt to contact has on the decision to extend service, and ComEd did not use a remote service switch to terminate service for customers eligible for disconnection in its pilot.

DIGITAL METERS AND NON-IONIZING (EMF) RADIATION: There is controversy over the potential effects of non-ionizing radio frequency radiation emitted by AMI meters. FCC regulation of these electronic devices concerns the thermal effects of

⁶ CMP Response to Oral Data Request 01-15, attachment 1 in Docket No. 2009-217 before the Maine PUC.

radiation, rather than the non-thermal effects that are of concern. There are no peer-reviewed studies that focus on AMI meters and the health effects of associated radio-frequency emissions; much of the literature draws on studies of cell phones and microwave transmission towers, which do not give the same amount of length of exposure (CCST, 2010). There is no scientific consensus about the range and extent of non-thermal health impacts linked to AMI meter wireless transmitters.

UNINTENTIONAL INJURIES AND PREMATURE DEATHS: Another health determinant that is the focus for this HIA is unintentional injury and death, related not only to fuel poverty and the adequacy of housing but also to how households respond to the loss of electrical service, particularly if someone in the home relies on an electrically-powered medical device, or to a consumer's decision not to use electrical service because of concerns about cost. There are the fire and poisoning risks related to the use of gasoline generators, kerosene space heaters, gas stoves and ovens and candles. Low-income households and seniors are acutely vulnerable: about one-quarter (26%) of households nationally that receive energy assistance grants include a member who uses a medical device that requires electricity, and one-third (33%) report that they have used their kitchen stove or oven for heat (McGwin; NEADA, 2011).

VULNERABILITY TO HEAT OR COLD: The responses of a population to ambient and changing temperatures reflect a number of factors, including the capacity of the housing infrastructure to concentrate or buffer weather conditions and the degree to which a population, especially vulnerable subgroups, adjust, such as by changing clothing or moderating activity. Impacts can be measured by mortality, emergency room visits and hospitalizations, among others. For example, a series of studies of temperature and mortality rates among U.S. cities finds that deaths increase by 2 to 4 percent per degree Fahrenheit as temperatures climb above a city's heat threshold and up to 6 percent per degree F with a drop in temperature below the area's cold threshold (Braga et al., 2001; Medina-Ramon and Schwartz, 2007; Anderson and Bell, 2009). These effects are exacerbated among the very young or very old, minorities and socially isolated individuals. Chronic ailments made worse by exposure include cardiovascular and cerebrovascular disease, respiratory conditions, diabetes, kidney disease, and neurological and movement disorders.

AMBIENT AIR POLLUTION: Coal-fueled electricity generating plants emit a variety of air pollutants that harm health, including particulate, heavy metals such as mercury, acidic gases, and other carbon-based compounds that accelerate the pace of

climate change (EPA, 2011 for webpage on power plants). As stated on EPA website “Mercury causes neurological damage, including lost IQ points, in unborn babies and young children exposed during the first few years of life. Metals such as arsenic, chromium, and nickel can cause cancer. Acid gases because lung damage and contribute to asthma, bronchitis and other chronic respiratory disease, especially in children and the elderly”⁷. Use of new pricing programs may result in reduction in peak energy usage or overall energy usage, thus eliminating some power plant emissions and perhaps lengthening or delaying the time for building new power plants. AMI also eliminates the need for physical premise visits for activities such as meter reading, connection and disconnection of service. This avoided activity is likely to lower ambient air pollution levels by removing trucks and their related emissions from the road.

2. COMMUNITY INPUT

During the preparation of this HIA, the HIA project team met with stakeholders in the ComEd service territory to gather information on their experiences using electricity and any questions or concerns they might have around AMI. Community members requested the HIA make policy recommendations around a specific set of stakeholder questions, consistent with the HIA’s three sets of policy questions. The main questions from community partners were focused on the potential health impacts on vulnerable populations, and if costs were higher, the potential for forcing budgetary tradeoffs. Sample questions included:

- Is there evidence regarding how dynamic pricing programs affect vulnerable populations? If the evidence shows those populations will be negatively affected, how can those negative impacts be addressed?
- Will disconnections for nonpayment increase if remote disconnection is relied upon? What impact will this have on vulnerable customers and the financial assistance agencies that provide crisis assistance to these customers?

⁷Reducing Air Pollution from Power Plants. Environmental Protection Agency. Updated March 27, 2012. <http://www.epa.gov/powerplants/>

- Will rates go up to pay for AMI? If so, what can be done to help those customers who already find electricity unaffordable?
- Will customers understand these new rate options? What type of customer education will they receive from ComEd about the impact of the various rate options on their monthly bills?

While the last question regarding customer education was outside the scope of this HIA, qualitative data in Section III will discuss the experience of ComEd customers during the recent AMI pilot deployment.

3. HIA RESEARCH QUESTIONS

Based on these scoping pathways and hypothesized impacts, as well as input from the community, the project team specified the following three sets of questions to guide the HIA:

1. How will the cost of AMI deployment impact health outcomes in general? How much greater will the impact be on vulnerable populations as a result of AMI deployment?
2. Will dynamic pricing programs result in decreased usage and/or a shift in usage, or will it not have any impact on usage?
3. How will digital metering technology affect reliability of service and how will it impact the number of remote disconnections? How will the ability to disconnect for non-payment affect the number of disconnections and how will that impact vulnerable populations?

B. Assessment: What Methods and Data were Used in the HIA?

This HIA employed mixed research methods to assess the research questions, including:

LITERATURE REVIEW. HIA team members conducted literature reviews focusing on digital metering and AMI, as well as the biomedical and social scientific literature related to fuel poverty, temperature exposure, and access to residential utility service. The review of the energy literature included an analysis of legislation and regulatory cases in Illinois and other states related to AMI and to health and safety-based regulated consumer protections. Three analytic background papers were produced as a result of this review, on the issues of cost, reliability of service, and remote disconnection. The review of the biomedical and social scientific literature related to health and safety centered on a group of meta-reviews published since 2000 (Braubach et al., 2011; Thomson et al., 2009; Astroma et al., 2011; Liddell and Morris, 2010; Marmot Review Team, 2011; Snyder and Baker, 2010), together with citation searching on Pub Med based on publications cited in the meta-reviews. AMI and health-related literature data was gathered and summarized.

In addition to the original literature reviews conducted by HIA principals, the HIA drew on two reports produced in connection with ComEd's AMI pilot. The first is an evaluation of the AMI pilot's Customer Applications Pilot of the 8,000 households, developed by the Electric Power Research Institute (EPRI), under contract to ComEd. The second is an evaluation of the costs and benefits predicted for AMI deployment, based on the operational performance of the technology in ComEd's pilot, developed by the consulting firm Black & Veatch, under contract to ComEd.

EXISTING DATASETS. To develop a health profile for the geographic areas included in the ComEd AMI pilot, as well as those within ComEd's service territory, eight existing data sources were used to approximate, at the level of the county, a profile of specific risk factors. These datasets include:

- U.S. Census Bureau's American Housing Survey (AHS), which offers detailed data for Cook County and for the surrounding metropolitan region (a proxy for ComEd's service territory).

- CDC’s Behavioral Risk Factor Surveillance Survey (BRFSS), a telephone sample survey that gives estimates at the county level for a range of self-reported health-related measures of status, access to care, and behavior.
- National Energy Assistance Directors’ Association (NEADA)’s annual national telephone sample survey of energy assistance (LIHEAP) recipient households in selected states.
- Claritas data, a commercial product based on U.S. Census data that was used in the design of ComEd’s AMI pilot was provided by ComED.
- The United States Department of Agriculture (USDA) provided datasets related to food insecurity throughout the country.
- The County Health Rankings Project, a set of indicators that measure population health in every county in the United States.
- Vital statistics data, which provide a snapshot of population health status and needs.

PRIMARY DATA. The HIA team also negotiated an agreement with ComEd to obtain access to the pilot program data which ComEd considered confidential in part because some of the data was not yet available to the public. This included demographic information from a survey conducted of those customers participating in the pilot program, the number of bills eligible for disconnection and plans for evaluation as laid out in the EPRI evaluation. As a result, the HIA team was able to obtain primary data on the impact of the CAP pricing pilot on, for example, lower income households, those with elderly household members, or those with disabilities or other vulnerable conditions for limited analysis.

SURVEYS. The HIA team commissioned two original surveys to capture the experiences of low-income household electrical consumers with AMI during the ComEd pilot period.

One survey was administered to customers in the pilot territory who were applying for LIHEAP, either in paper format or online. The survey was self-administered and the inclusion of confidential information (name, telephone, ComEd customer number) was optional.

In addition, a survey was conducted in the Maywood neighborhood of Chicago by a field epidemiological group based at Loyola University of Chicago Stritch School of Medicine's Department of Preventive Medicine and Epidemiology. The Loyola group has fielded a series of neighborhood surveys in Maywood, related to unemployment, poverty, and health among Hispanic residents, and offered to field a small-scale, illustrative survey related to the ComEd pilot, on behalf of the HIA project. Given the HIA team's interest in documenting the experiences of elders and at-risk populations as identified by the HIA literature review, the Maywood survey sampling frame was designed to capture the experiences of African Americans and elders; out of 50 respondents, 40 were to be African American and 10 Hispanic in ethnic identity and within each ethnic category, a minimum of 10 elders were to be interviewed. To be eligible to participate, potential respondents had to be at least 18 years old, live within the ComEd pilot footprint, be residential customers of ComEd and pay their own electrical bill. The first 50 respondents who met the criteria were offered \$40 in exchange for completing a 30-minute interview. Interviews were transcribed and coded by the research group. In total, 51 interviews were completed. The majority of respondents were women (84%), African-American (69%), and the mean age was 63. The survey attempted to determine trade-offs that people had to make as a result of higher energy bills, as well as how customers' usage had changed after their enrollment in the AMI pilot. This is not meant to be a representative sample.

III. ASSESSMENT FINDINGS

A. Population and Health Characteristics

SUMMARY OF FINDINGS

- Across Illinois, almost 1 million households (924,152) are income-eligible to receive energy assistance and are at risk of adverse health outcomes related to fuel poverty, substandard housing, or temperature exposure. Particularly vulnerable are households that include a senior (33.8%), a young child (21.4%), or someone living with a disabling condition (10.7%). Commonwealth Edison’s 31 county service territory includes most of these households, as it encompasses 79% of the state’s population.
- The Cook County pilot footprint is home to a higher proportion of people within the HIA’s definition of “vulnerable populations.” The Chicago region’s population lives with a burden of chronic ailments including asthma (14.5% of all children), heart disease (28.9% of all adults), and diabetes (8% of adults). These illnesses, as well as kidney (renal) disease, neurologic diseases like Parkinson’s and other respiratory conditions (influenza, pneumonia, asthma, and chronic obstructive pulmonary disorder) are made worse by exposure to excessive or inadequate temperatures, as well as by increased indoor humidity linked to inadequate home heating or cooling and higher indoor levels of nitrogen dioxide from stoves or ovens used for heat.

Compared with the neighborhoods included in the AMI pilot, ComEd’s total service territory in northern Illinois includes populations at lower risk for adverse outcomes in some aspects and greater risk in others. Service territory household residents are less likely to live in poverty, are more likely to report their general health is excellent to very good (a commonly used and validated measure of health status), and have a lower rate of premature death, or years of potential life lost due to death before age 65. However, service territory residents are more likely to live independently, which can mean an elevated risk of adverse effects for seniors and those living with a disability that hinders mobility.

The HIA examined the demographic, socioeconomic, housing, and health-related characteristics of two groups of Illinois residents: those living within the ComEd pilot footprint (approximately 151,000 households, including the 8,500 households participating in the Customer Applications Pilot), and all residential customers within

ComEd's service territory (approximately 3.4 million households). Particular attention was paid to characteristics that make specific groups within the population more vulnerable to AMI impacts. Information was drawn primarily from three data sources: Claritus marketing data made available to the HIA team by ComEd, the County Health Ranking project, and vital statistics on leading causes of death, tabulated by county.

- Claritas, a commercial product based on U.S. Census data, was used in the design of ComEd's AMI pilot, to select participant groups whose demographic and socioeconomic composition reflect customers across the larger 31 county service territory (strengthening the validity and generalizability of pilot results).
- The County Health Rankings Project, a set of indicators that measure population health in every county in the United States. Two composite indicators include health outcomes (incorporating rates of death or mortality and illness or morbidity) and health factors (reflecting individual behavior, health care, social and economic characteristics, and the influence of the environment).⁸
- Vital statistics data, which provide a snapshot of population health status and needs.

Claritus data characterizes households within census tracts served by ComEd. Specific information about the households in the pilot footprint and in ComEd's service territory can be assembled using census-tract level demographic and economic data, for all tracts within Cook County that are within the pilot (representing 99% of the population of Cook County) and for tracts within the 31

⁸ The measures that are integrated into the summary indicators are defined as follows:

- Mortality reflects the years of potential life lost before age 75 (a standard measure of premature deaths, or deaths that could have been otherwise avoided through access to health care, changes in behavior, or other means)
- Morbidity combines 4 general measures of wellness from county-level survey data, including the self-reported health of adults, the mean number of days per month reported by adults to be physically or mentally unhealthy, and the percent of live births that are low birthweight (below 5 pounds)
- Health behaviors combines measures capturing tobacco use, diet and exercise, alcohol use, and sexual behavior
- Clinical care measures look at both access to care and quality of care (specifically, the rates of hospitalizations that would have been preventable if residents had adequate access to health care)
- Social and economic Factors –education, employment, income, family and social support, community safety
- Physical environment includes measures related to both air quality and the built environment

county service territory (representing 92% of the total population of these counties).⁹ The County Health Rankings and the leading causes of death for Cook County offers systematic estimates that may over- or under-estimate the characteristics of Commonwealth Edison customers who live within these counties.

POPULATION SIZE: The 31 counties served by ComEd are home to 79% of the state's population, or nearly 10 million out of 12 million residents. Cook County's population is about half that of the service territory counties, and AMI pilot households comprise about 4% of ComEd residential customers.

AGE PROFILE: The proportion of children younger than 5 years is comparable among AMI pilot households (within Cook County), service territory counties, and the state, while the proportion of seniors is greater for the service territory counties than for either Cook County alone or the state.

RACIAL AND ETHNIC IDENTITY: Cook County households participating in the AMI pilot are about twice as likely as service territory households overall to identify themselves as Hispanic or Latino (38%, compared with 18.9%) and just over half of pilot tract residents are identified as non-white (50.3%), compared with 32.1% of service territory tract residents.¹⁰ Across Illinois, about 14.5% of residents report their ethnic identity to be Black and 15.3% as Latino.

HOUSEHOLD SIZE: Service territory tract households are more likely to consist of one person living independently, nearly one-third (28%) of all households, compared with about a fifth (19.5%) of Cook County households.

INCOME AND POVERTY: The median income for Cook County AMI pilot tracts is comparable to that for the state of Illinois. Cook County did have a higher median income than did the 31 county area which served as a proxy for the service territory counties (\$51,313, compared with \$54,559 for Cook County and \$56,230 for Illinois).

⁹ Commonwealth Edison provided aggregate census data for service territory tracts, coded for participation in the AMI pilot and for the subset of customers' participation in the CAP, as a Claritus data product. Project funds and technical capacity did not permit original analysis of the census tracts, other than the data elements provided by ComEd.

¹⁰ The County Health Rankings report similar trends but different estimates, reflecting differences in sampling: at the county level, almost one-third (31 percent) of service territory county residents identify themselves as Black, compared with about one-quarter of Cook County residents (25.5%) and 14.5 percent of state residents as a whole, while Cook County has the highest proportion of residents identifying themselves as Hispanic (23.2 percent), much higher than the 8.8 percent of service territory county residents who identify as Hispanic (CHR).

Yet Cook County residents are more likely to live in poverty: 15.7% of AMI pilot tract residents live in households earning less than federal poverty, compared with 11.8% of residents in service territory tracts and 13.3% for Illinois, and 37.1% of pilot tract residents live in households that earn less than 200% of federal poverty, compared with 27.4% of service territory tract residents.¹¹

EDUCATION AND LITERACY: Fluency in spoken or written language is an important consideration for consumer education around AMI.¹² Two indicators of the capacity of residents to understand and to modify behavior in response to information from ComEd include measures of English proficiency and illiteracy. Cook County has the highest proportion of residents who are not proficient in English (15.2%), compared with residents of the service territory counties (11.7%), both higher than the 9.5% rate of non-proficiency for Illinois. Cook County also has the highest rate of illiteracy (19.2%), over double the rate for the service territory counties and considerably higher than the 12.9% illiteracy rate for Illinois.

HEALTH STATUS: Health priorities for the Chicago region are reflected in the list of leading causes of death, which are readily available for Cook County and for Illinois¹³. By this metric, Cook County's population resembles that for the state of Illinois overall. Cancer, heart and cerebrovascular disease accounting for most deaths, and smaller numbers of deaths attributed to unintentional injuries, chronic lower respiratory disease (i.e., Chronic Obstructive Pulmonary Disease or COPD), and diabetes. The presence of nephritis as a leading cause of death for Cook County, but not for the state, indicates a potential concern, since kidney disease is a temperature-sensitive chronic ailment. During the 1995 Chicago heat wave, one of the leading risk factors for hospitalization among seniors was underlying kidney disease (Semenza, 1999).

¹¹ Two other measures of poverty underscore the greater needs of Cook County residents: 44 percent of Cook County residents report high housing costs, compared with 40 percent of service territory county residents, and 47 percent of Cook County children are eligible for free lunch, compared with 25 percent of children residing in service territory counties.

¹² Although language fluency and literacy were not conceptualized as within the scope of the HIA, it is important to note their potential importance in consumer education around energy use and the potential biases introduced into the HIA analyses by the differences in fluency and literacy between Cook County residents and residents of ComEd's broader service territory.

¹³ Illinois Project for Local Assessment of Needs, IPLAN System Data Report, query leading causes of death ICD-10 (2006), Cook County. At <http://app.idph.state.il.us/cgi-bin/vfpcgi.exe?IDCFfile-/data/iplanrpt.idc>.

According to the County Health Rankings, Cook County scores lower than most other Illinois counties on almost all aggregate measures or indicators of health, save for health behaviors and the built environment. The rate of premature death, or years of potential life lost due to death before age 65, is higher for Cook County (7,533 YPLL per 100,000 population) than for Illinois (6,859 YPLL), and the service territory has a lower rate (6,383) than either Cook County or Illinois overall.¹⁴

Cook County residents are more likely than service territory or Illinois residents to report that their general health is fair or poor, to report slightly greater numbers of days where they experience poor physical or mental health, a diabetes diagnosis, and to have given birth to a low-weight infant.

VULNERABLE POPULATIONS: The most basic profile of vulnerabilities comes from U.S. Census-based estimates of the size and characteristics of households who are eligible for federal Low-Income Home Energy Assistance Program (LIHEAP) grants. In fiscal year 2009, the most recent year for which data are available, 924,152 households are income-eligible for LIHEAP in Illinois (earning no more than 150% of federal poverty) (ACF, 2011). Of these households, 33.8% include someone at least 60 years of age, 21.4% include a child under 6 years, and 10.7% include someone with a disability. Over half of these households (57.5%) earn less than 100% of federal poverty. The pilot tract also features greater proportions of elders and higher levels of poverty.

¹⁴ Mortality (death) rate and years of potential life lost (YPLL) are two different ways to measure the extent to which a health or safety threat is associated with the premature or otherwise avoidable loss of life. Because the YPLL is estimated by subtracting the age at death from a set number, often the typical life expectancy for a population, this measure gives greater emphasis or weight to deaths among younger members of a population, while mortality rate, even when estimated separately for different age groups (age-adjusted), gives more emphasis on deaths among older members of the population. See "General Health Status," at <http://www.healthypeople.gov/2020/about/genhealthabout.aspx>

B. HIA Research Questions

1. HOW WILL THE COST OF AMI DEPLOYMENT IMPACT HEALTH OUTCOMES IN THE GENERAL POPULATION? HOW MUCH GREATER WILL THE IMPACT BE ON VULNERABLE POPULATIONS AS A RESULT OF AMI DEPLOYMENT?

Summary of Findings

- Significant proportions of residents have characteristics that put them at greater than average risk of adverse health impacts if they have less access to electrical service, or indicate a heightened risk, including difficulties paying for housing, health care, and food; problems heating or cooling their homes due to cost (including a lack of access to central air-conditioning, the single strongest protection against heat-related illness); reliance on electricity for heat or to power medical devices; and substandard housing quality.
- Based on the literature review, fuel poverty is tied to the diminished capacity of households to purchase basic necessities such as food and clothing, less access to health care and prescription medications, greater likelihood of involuntary loss of utility service for nonpayment, and greater hunger among seniors and young children. Fuel-poor households close off parts of their home to reduce energy bills and leave home for part of the day, incurring stress that can lead to criminal activity among teenagers and increased social isolation among adults. Even for seniors who are not low-income, sensitivity to the perceived price of electrical service can influence a decision not to use air-conditioning during summer heat. The implications of AMI for fuel poverty will determine whether these health outcomes are more or less likely, and are summarized in the summary table on page 81.
- Non-ionizing, (EMF) radiation emitted by AMI raises questions about long-term, adverse health impacts but the extent to which AMI will increase residential exposure to non-ionizing radiation is unknown. AMI meters emit radiation as part of their wireless transmission of usage information and operational status between household and utility. Exposure depends on the meter's technical specifications, configuration of installation, and duty cycles, but there is insufficient evidence at this time to evaluate the potential health impact. To date, all testing has documented with the AMI meters comply with the FCC's emission requirements, which concern thermal injury at higher frequencies
- A higher cost for electrical service, estimated to cost residential customers \$2-3 per month, is expected to pay for the investment in equipment. While the average bill for customers on dynamic pricing programs was on average slightly lower than the average bill for all residential customers without an

AMI meter, the average bill for customers on the flat rate, which we expect will be used in the AMI deployment, was higher. The costs for deploying AMI could lead to increased delivery services rates to pay for AMI prior to the realization of any benefits in the form of potential reductions in utility costs and the flow through of those cost reductions. Any increase in customer bills will exacerbate the impact of higher prices to pay for AMI for vulnerable customers. If the AMI technology and pricing programs were deployed as they were in the pilot, there is no certainty that these pricing programs and in-home technologies would result in lower customer bills to offset the higher costs to pay for AMI, though operational benefits recognized by the utility would help to offset some of the costs of AMI.

- Among vulnerable populations such as Cook County energy assistance applicants, a computer-assisted survey administered on an opt-in (voluntary) basis found greater stress related to paying utility bills and to making bill-related trade-offs that put health and safety at risk, compared with energy assistance recipients nationally. Compared with all households in the ComEd pilot footprint, respondents are much more likely to report a household member with a temperature-sensitive condition including asthma, chronic obstructive pulmonary disorder, and heart disease. A survey within one pilot footprint neighborhood (Maywood) highlights risks related to fuel poverty and the prevalence of temperature-sensitive conditions. Interview respondents reported being half as likely to use electricity for heating as pilot footprint customers, and therefore were buffered somewhat against the cost for fuel in winter, but also less likely to have access to central air-conditioning, presenting a potential health threat in summer. Many reported trouble paying household bills and turning down the air-conditioning in summertime in response to energy bills. The health status of this group is markedly worse than that of ComEd pilot footprint customers overall: 13.7% are homebound, 33.3% have asthma or chronic obstructive pulmonary disorder and 70.6% have high blood pressure or heart disease, all risk factors for adverse outcomes related to temperature exposure. About one-quarter report health problems related to cold weather (25.5%) and 41.2% health problems related to the heat.
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a. Baseline Conditions Analysis

Using data from various sources, Table 1 describes population characteristics of interest when assessing the health impacts of AMI deployment, especially related to fuel poverty and substandard housing.¹⁵ For the purposes of this HIA, factors that make an individual more susceptible to illness or premature death in connection with fuel poverty and housing include poverty itself, access to utility service, and adequacy of housing.

¹⁵ Using these data sources to develop estimates of the number and proportion of households at risk introduces biases of unknown size and extent. These biases reflect the fact that the American Housing Survey (AHS) and the Behavioral Risk Factor Surveillance Survey (BRFSS) offer estimates at the county level, not specifically of household served by Commonwealth Edison, and that the National Energy Assistance Directors' Association (NEADA) survey offers estimates specifically for low-income households that receive LIHEAP grants nationally, not in Illinois or in the Commonwealth Edison service territory.

Table 1. Health Impacts Linked To AMI:
Indicators of Fuel Poverty and Substandard Housing

Determinant/Indicator(s)	Data Source	Size of At-Risk Population in Pilot Footprint	Size of At-Risk Population in Service Territory
<i>Poverty/Income</i>			
Households<100% FPL	Claritus	15.7%	11.8%
Households<200% FPL	Claritus	37.1%	27.4%
Households that are food insecure	USDA		12.2%
Adults reporting limited access to physician due to cost	BRFSS	11.2%	10.2%
Adults reporting limited access to prescription RX due to cost	BRFSS	13.7%	12.4%
Households with housing costs>30% of income	AHS	50.5%	47%
<i>Access to Utility Service</i>			
Low-income households reporting shutoff (gas or electric) for nonpayment	NEADA		12%
<i>Heating Problems Due to Cost</i>			
Low-income households reporting keeping heat at unhealthy level due to cost	NEADA		26%
Households using stove for heat	AHS	0.2%	4.6% use stove; 0.1% specify cook stove
Low-income households using oven/stove for heat	NEADA		33%
Households reporting heating problems due to cost ¹	AHS	12.9%	10.9%
Low-income households reporting heating problems due to cost ²	AHS/Households<100% FPL		16.2%
	NEADA		27%
<i>Cooling Problems Due to Cost</i>			
Low-income households reporting cooling problems due to cost	NEADA		17%
Households without access to central a/c	AHS		37.9%
Households<100% FPL without access to central a/c	AHS		56.6%
<i>Reliance on Electricity</i>			
Households reporting electricity as main heating fuel	AHS	13.6%	11.3%
Households<100% FPL reporting electricity as main heating fuel	AHS		20.3%
Households reporting use of portable electric heaters	AHS	14.5%	13.3%
Low-income household uses medical device requiring electricity	NEADA		25%
<i>Adequacy of Housing</i>			
Households reporting moderate/severe housing problems (plumbing, electrical, maintenance, heating)	AHS		5.2%
Households reporting overcrowding	AHS		2.8%
Households<100% FPL reporting overcrowding	AHS		8.8%

Key: AHS (American Housing Survey), BRFSS (Behavioral Risk Factor Surveillance Survey), CHR (County Health Rankings project at the University of Wisconsin), Claritus (Census data product provided by ComEd to project team, data for 2008 unless otherwise noted), NEADA (annual telephone sample survey of LIHEAP recipient households in participating states, National Energy Assistance Directors' Association), USDA (U.S. Department of Agriculture's Economic Research Service, survey on food insecurity prevalence by state).

POVERTY: In addition to the measures of poverty described in the previous section, based on Claritus and County Health Ranking findings, related indicators capture the

difficulty experienced by these households in meeting basic needs. About 12.2% of Illinois households are food insecure, and 47% of households in the region have high housing costs (greater than 30% of their income). For counties within the ComEd service territory, 10.2% of adults report limited access to health care due to cost and 12.4% of adults report limited access to prescription medications due to cost.

ACCESS TO UTILITY SERVICE: Nationally, about 12% of LIHEAP-eligible households report having had their service (either gas or electric) shut off for nonpayment; primary data related to ComEd pilot households will be reviewed in a subsequent section of the HIA. Other indicators of access include the prevalence of heating or cooling problems related to the cost of utility service. Among metro Chicago region households, 10.9% report heating problems due to cost, with 16.2% of households living in poverty reporting cost-related heating problems. About 26% of LIHEAP-participating households nationally report keeping the heat at an unsafe or unhealthy level due to cost and 33% report having used an oven or stove for heat. Only 4.6% of all metropolitan Chicago area households report having used a stove for heat; primary data related to low-income AMI pilot households will be reviewed in a subsequent section, starting on page 39. Across the region, 37.9% of households do not have access to central air-conditioning, a percentage that jumps to 56.6% of all households living in poverty.

RELIANCE ON ELECTRICITY: For metro Chicago region households, 11.3% report electricity as their main heating fuel, including 20.3% of households living in poverty. About 13.3% report using portable electric heaters, which represent a fire risk if incorrectly used. Nationally, 25% of LIHEAP-participating households report using a medical device that requires electricity.

ADEQUACY OF HOUSING: Across the region, 5.2% of households report moderate to severe problems with major systems in their homes, which can affect moisture or mold levels, and the capacity to heat or cool. Overcrowding is another risk made worse by fuel poverty, which can lead households to close off part of their homes that are too expensive to heat or cool. Approximately 2.8% of metro Chicago area households report overcrowding, and 8.8% of households live in poverty.

b. Literature Review and ComEd Pilot Studies

As with any new investment in a utility's distribution system (metering, poles, wires, and local substations and transformers), a regulated public utility seeks to include

new capital costs and operating expenses in rates paid by customers. A utility obtains revenues from its customers through retail prices regulated by state regulatory commissions, at least for the distribution portion of its bill.¹⁶ The regulated rates or prices include the utility's expenses plus a rate of return on the utility's cost of capital. While AMI investments may not be different from a utility's historical investments in new poles, wires, and generation facilities to serve its customers, the scope and scale of the proposed new investments, the manner in which utilities have sought to recover these costs, and the disputes surrounding the analysis of costs and future benefits from these investments have all contributed to substantial controversies in several states.

Utilities have proposed to recover the costs of AMI in rates in several different ways. In Illinois, electric utilities will include the costs associated with AMI deployment in formula rates that are adjusted annually for changes in operating revenues, expenses and capital investments. The key question is whether benefits of AMI in the reduction of utility operating costs or projected impacts on generation supply prices due to pricing programs are passed directly through to utility customers in a timely manner. The short-term impact on customer bills is typically a bill increase because the operational efficiencies and other savings appear after AMI deployment has reached full-scale throughout a utility service territory and the utility has implemented the various programs that it describes in its proposal for AMI deployment.

The Electric Power Research Institute (EPRI) recently published a report on the estimated costs and benefits associated with the implementation of AMI technologies nationally, and identified the cost to deploy AMI for 83% of the U.S. customers estimated at \$15.5 billion to \$41.9 billion. EPRI included in its cost estimates new metering, communications, and meter data management systems as well as estimated maintenance costs. The range of costs translates into a national estimate of \$80-\$166 per meter.

¹⁶ Approximately 20 states, including Illinois, have adopted retail competition or restructuring in which the generation supply portion of the customer bill is no longer directly regulated by the state utility commission. Utilities operating in these states pass through the costs of the generation portion of the bill, typically based on wholesale market contracts. The wholesale market is subject to the jurisdiction of the Federal Energy Regulatory Commission (FERC). In those states in which restructuring or retail competition has not been adopted, the cost of the utility's generation supply portfolio is regulated by the state commission. In every state, the distribution or delivery portion of the customer bill remains fully regulated by state commissions. AMI is typically presented as an investment in the distribution or delivery service and, therefore, the analysis of costs and benefits is under the authority of state regulators.

States that have approved cost recovery for the full deployment of AMI have typically done so with a bill impact of \$2 to \$3 per month for residential customers, such as Texas and California. Utilities that have requested approval of an AMI deployment have also estimated the potential bill impacts at these levels, such as Maryland, Delaware and the District of Columbia. For example, according to its original filing, “Baltimore Gas & Electric (BGE)’s Smart Grid proposal¹⁷ would result in an approximate average monthly charge to residential electric customers of \$0.38 beginning in January 2010 that would reach a peak of \$3.78 by 2013.”¹⁸ In Pennsylvania, the regulatory commission approved a full AMI deployment for PECO Energy in Philadelphia that was estimated to result in an increase in the monthly bill by 1% in the early years of deployment and peak at 2.1% in 2014.¹⁹ It should be noted that the utilities in Pennsylvania, Maryland, and the District of Columbia received federal grants to offset some of the AMI costs to customers.

Given multiple variables, the best estimate for cost recovery for AMI deployment in Illinois should be consistent with previous estimates of at least \$2-3 per month additional cost per residential customer for the purposes of our HIA. It has not been possible to provide a more specific estimate of the cost of AMI deployment for ComEd’s customers for a number of reasons. ComEd’s evaluation of its AMI pilot did project estimated costs and potential benefits to customer in a report on the AMI pilot commissioned by Commonwealth Edison from the independent firm Black and Veatch (discussed in more detail in the Report Appendices), though the report did not isolate bill impacts for residential customers. For a more detailed discussion of what would be needed to estimate the impact on customer bills, see Appendix 5.

¹⁷ While BGE referred to its application as for Smart Grid, it was actually an AMI deployment and did not include other investments in the distribution and transmission system.

¹⁸ Application of Baltimore Gas and Electric Company for Authorization to Deploy A Smart Grid Initiative and to Establish a Tracker Mechanism For the Recovery of Costs, Maryland Public Service Commission, Case No. 9208, Direct Testimony of David Vahos on behalf of BGE (July 13, 2009), at 27. Of course, BGE also alleged that future operational cost reductions and changes in customer usage behavior would offset these costs after the new AMI system was fully deployed and operational over a 15-year period.

¹⁹ The PECO AMI deployment plan was approved by the Pennsylvania PUC as a result of an agreement among the parties. The evidence concerning customer bill impacts was reflected in PECO’s application: Petition of PECO Energy Co. for Approval of its Smart Meter Technology Procurement and Installation Plan, Pennsylvania PUC Docket No. M-2009-2123944 (August 14, 2009), Testimony of Alan B. Cohn, PECO Statement No. 5, Exh. ABC-5.

c. Primary Data Analysis

1. COMED DATA

To better understand the impact of AMI deployment on customers, HIA project partners estimated how much more or less households with smart meters paid for their electrical consumption when compared to the system-wide average. First, it was determined how much households with smart meters paid for their electricity consumption. Second, it was determined how much households representing the system-wide average paid for their electricity consumption during the same time period. Third, there was a comparison of the two values to arrive at a savings or loss calculation.

The first question was to examine “How much did households with smart meters pay?” For this analysis, the total billed revenue for residential accounts received using smart meters was divided by the total number of bills issued for those accounts. These values were plotted for each month from March 2009 to February 2011 to produce average revenue per monthly bill for households with smart meters. Several assumptions were made: the total billed revenue equaled the total paid by consumers (assumes that total amount collected equals what was billed); and the number of bills issued for residential accounts that received smart meters equaled the number of households with smart meters (assumes one bill per month per household).

For the second question “How much did the system-wide average household pay,” it was assumed that the per customer monthly projected billing amounts were weighted to reflect the mix of classes proportionate to the mix in the smart meter sample by using the number of bills per customer class in proportion to the smart meter sample total number of bills.

Last, for the question of whether there were “savings or loss calculated for the account,” the monthly total average bill was calculated based on the same rates as those in effect for the smart meter pilot and was subtracted from the monthly average bill for households with smart meters for May 2010 to February 2011, then summed to arrive at the final savings or loss calculation. Again, this calculation assumes that the proper timeline for comparison for the smart meter pilot is May 2010 to February 2011, the time period during which the smart meter pilot was fully installed and in effect. Customers in the AMI pilot were assigned to one of many different dynamic pricing programs or to a flat rate.

Figure 1 illustrates homes without AMI (blue) have on average higher bills than AMI customers irrespective of pricing programs. Figure 2, presents the usage patterns for each of the pricing programs. Figure 3 shows that bill amounts varied by pricing program. Among the pricing programs, Critical Peak Pricing (CPP) customers had the highest usage spikes and the highest bills during the summer among the pricing options, but the Flat Rate (FLR) customers with a smart meter had higher bills in the winter months.

Figure 1. Revenue Generated per AMI (Red) and Systemwide (Blue) Bills

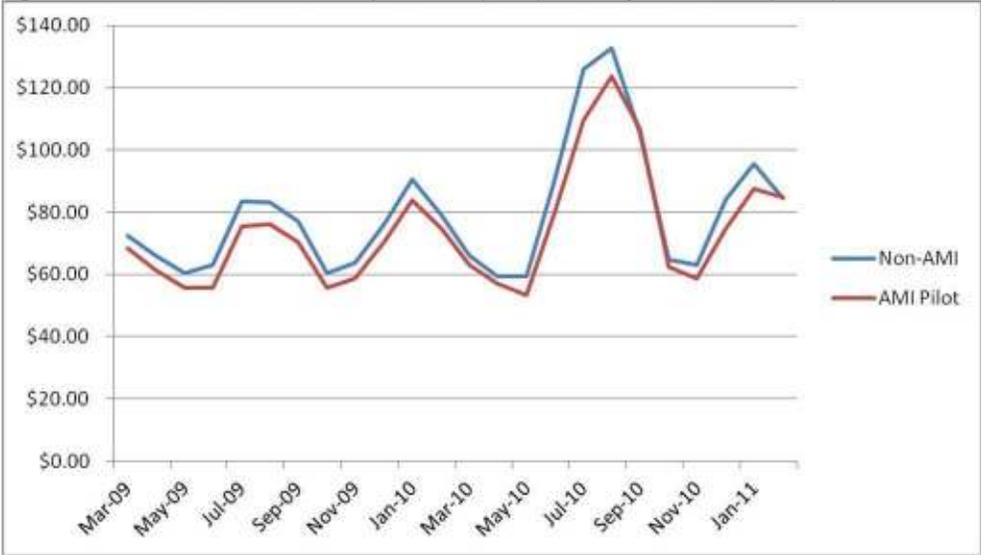


Figure 2. Energy Usage of Households with Smart Meters by Rate Design (KWHs)

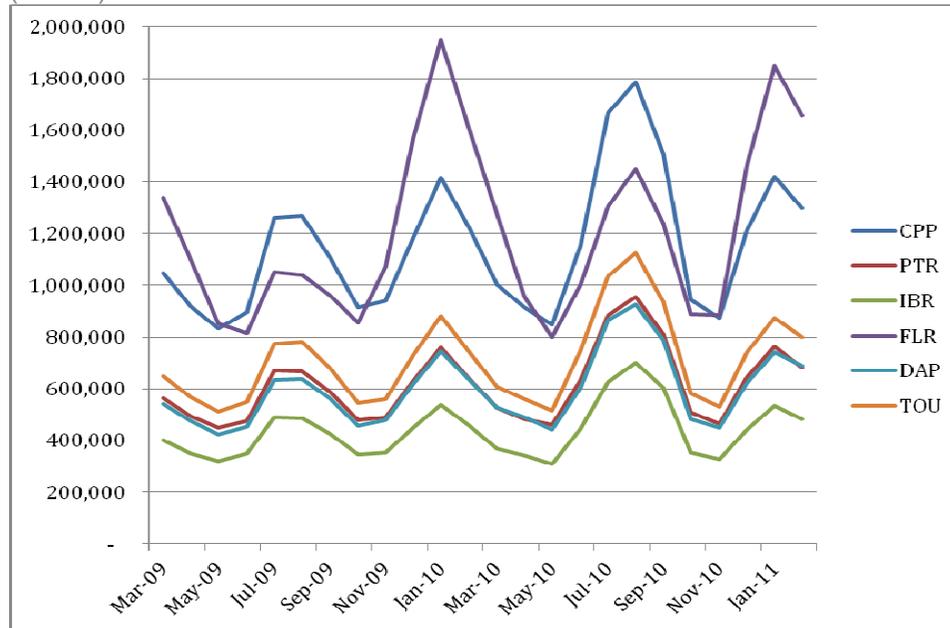
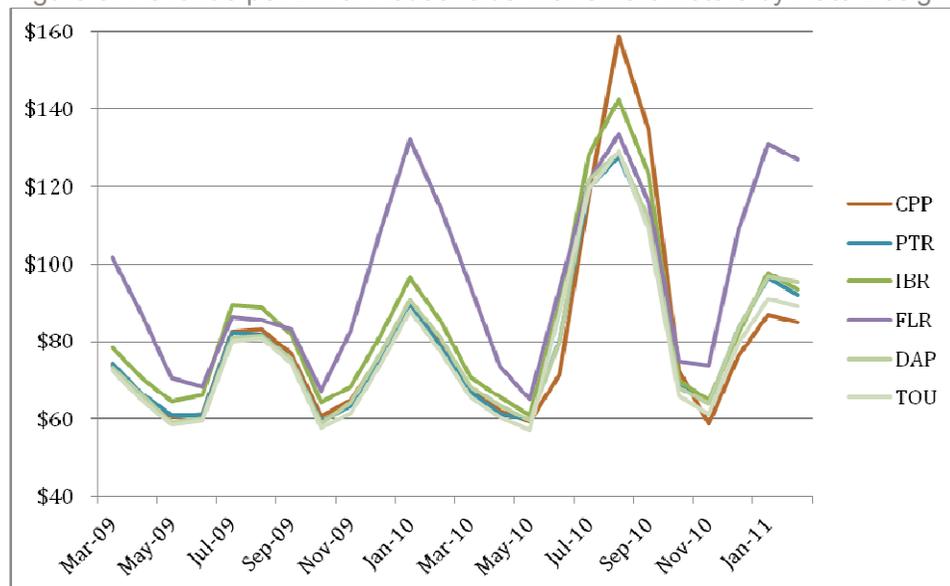


Figure 3. Revenue per Bill of Households with Smart Meters by Rate Design



In analyzing bills, it was important to analyze the AMI versus the average bills of non-smart meter customers to see if there was a difference attributable to AMI. Table 2 illustrates that, on average, non-AMI bills were higher.

Table 2. AMI Bills Compared to non-AMI Pilot Bills

Month	AMI Bill	Non-AMI Bill	Non-AMI Bill (weighted)	Difference
May 2010	\$53.24	\$62.63	\$59.49	\$6.25
June 2010	\$79.77	\$95.22	\$90.16	\$10.39
July 2010	\$109.71	\$133.20	\$125.93	\$16.22
August 2010	\$123.57	\$140.09	\$132.67	\$9.10
September 2010	\$107.05	\$111.26	\$105.64	-\$1.41
October 2010	\$62.55	\$67.83	\$64.77	\$2.22
November 2010	\$58.62	\$66.60	\$63.06	\$4.44
December 2010	\$74.66	\$90.49	\$84.20	\$9.54
January 2010	\$87.57	\$103.20	\$95.44	\$7.87
February 2011	\$84.82	\$91.11	\$84.64	-\$0.18
TOTAL	\$841.56	\$961.63	\$906.01	\$64.44

ComEd provided the actual revenues and numbers of customers, by customer class, for the customers participating in the AMI pilot and those not participating in the AMI pilot. The average revenue per bill in each month was calculated by dividing the revenue per class by the number of customers in that class. These average revenues were weighted to reflect the mix of customers by customer class. The data shows that, from May 2010 to February 2011, the average bill for those not participating in the AMI pilot was \$64.44 more than the average AMI Bill. The average bill for the flat rate customers with a smart meter from May 2011 through February 2012 was \$1,045.56, which was higher than the average unweighted residential non-AMI bill of \$961.63.

Overall these findings suggest that while the average bill for customers on dynamic pricing programs was slightly lower than the average bill for all residential customers without an AMI meter, the average bill for customers on the flat rate, which we expect will be used in the AMI deployment, was higher. The costs for deploying AMI could lead to increased delivery services rates to pay for AMI prior to the realization of any benefits in the form of potential reductions in utility costs. Any increase in customer bills will exacerbate the impact of higher prices to pay for AMI for vulnerable customers. In the short term, if the AMI technology and pricing programs were deployed as they were in the pilot, there is no certainty that these pricing programs and in-home technologies would result in lower customer bills to help offset the

higher costs to pay for AMI, though operational benefits recognized by the utility are to contribute to the majority of cost savings from AMI.

2. SURVEY DATA

To address information on any trade-offs households make based on the cost of energy and the cost of other basic needs, the HIA included two original surveys of AMI pilot households focused on low-income ComEd customers. The first survey targeted applicants for LIHEAP grants, administered by intake staff or online by means of Survey Monkey. The second survey was conducted by a field epidemiology team in the Maywood neighborhood, sampling a cohort whose characteristics put them at greater risk of adverse health and safety outcomes. Both surveys were designed as exploratory, given the time and budget limitations of the HIA, and aside from the sampling frame used in the Maywood survey did not capture a representative or statistically validated sample of customers

LIHEAP Customers: Part of the HIA's engagement with community partners involved designing and conducting a computer-aided survey using Survey Monkey to gather information from individuals who were applying for energy assistance, a predominantly low-income group. The survey was administered by the South Austin Coalition, Age Options, and the Community and Economic Development Association of Cook County (CEDA). The objective was to capture household experiences with trade-offs between energy costs and basic needs. A convenience sample of 157 people completed the survey.

Compared with all households in the pilot footprint, survey respondents were much more likely to identify themselves as a member of a racial or ethnic minority group, with 43 percent self identifying as Hispanic and over 20 percent identifying as African American. They were predominantly from households earning less than \$40,000 annually (reflecting the pool of potential respondents, most of whom would be expected to be income-eligible for energy assistance). Table 3 highlights the health findings: compared with all households in Cook County, respondents were markedly more likely to report that a household member lives with a temperature-sensitive condition including asthma (42%, compared with an estimated 10.6% of adults and 11.6% of children in Cook County) and high blood pressure (35%, compared with 23.2% of adults in Cook County); 14% of respondents report a household member with chronic obstructive pulmonary disorder (COPD), a much higher percentage of the population than the 0.1% reported as hospitalized with a COPD diagnosis across the state (American Lung Association, 2011).

Table 3. Characteristics of Survey Respondents Applying for LIHEAP

	Respondents	
	#	%
Someone in the home has		
Symptoms of asthma, including coughing, wheezing, shortness of breath, chest tightness, or a phlegm problem	65	42
Chronic bronchitis, emphysema, or chronic obstructive pulmonary disorder (COPD)	22	14
High blood pressure (hypertension), heart disease, heart attack, or stroke	55	35

Survey questions concerned the cost of electricity and responses to the actual or perceived cost of electricity. With respect to the cost of electricity, 59.9% respondents indicated that their bill this year was higher compared to their bill last year, with “higher prices in general” being the most commonly reported cause; 71.3% reported that greater difficulty paying their energy bill this year compared to last year and 35% indicated that their increased energy bill contributed to the difficulty with paying bills. Survey respondents were much more likely than a nationally representative group of energy assistance recipients to report stresses related to paying their utility bill and to making bill-related trade-offs that put their health and safety at risk. Table 4 summarizes these findings.

The overall trend for households responding to high energy bills on almost a monthly basis indicates several health and safety hazards: 54% reduced purchases of household basics, compared with 41% nationally; 31% closed off part of their home in the face of heating or cooling expenses, compared with 12% nationally; 28% kept their home at an unsafe or unhealthy temperature, compared with 6% nationally; 11% left their homes for part of the day because it was too hot or too cold, compared with 1% of respondents nationally; and 18% used their kitchen stove or oven to heat, compared with 2% nationally, while 8% reported using candles for light. In addition, 40% of respondents indicated that a household member had gone without medical or dental care, failed to refill a prescription, or took less than a prescribed dose of medication because of their increased energy bills, compared with 41% (going without needed medical or dental care) and 33% (not filling a prescription or taking less than a full dose) nationally, and 33% indicated that a household member became

Table 4. Reported Impacts of Home Energy Bills

How often did you...	Survey	worry that you wouldn't be able to pay your home energy bill?	reduce your expenses for what you consider to be basic household utilities?	close off part of your home because you could not afford to heat or cool it?	keep your home at a temperature that you felt was unsafe or unhealthy?	leave your home for part of the day because it was too hot or too cold?	use your kitchen stove or oven to heat your home?	use candles to light your home?
Almost every month	ComEd	68% (86)	54% (66)	31% (37)	28% (34)	11% (12)	18% (22)	8% (9)
	NEADA	30%	41%	12%	6%	1%	2%	n.d.
Some months	ComEd	22% (27)	28% (35)	28% (33)	26% (31)	25% (29)	19% (24)	12% (14)
	NEADA	27%	27%	18%	14%	9%	15%	n.d.
1-2 months	ComEd	8% (10)	9% (11)	8% (10)	9% (11)	14% (16)	9% (11)	13% (15)
	NEADA	16%	10%	6%	6%	10%	16%	n.d.
None of the months	ComEd	2% (3)	9% (11)	33% (40)	37% (44)	50% (58)	54% (66)	67% (80)
	NEADA	26%	21%	64%	73%	79%	67%	n.d.

Note: Count of respondents is indicated by parentheses.

ill because the home was either too hot or too cold, compared with 25% nationally (NEADA, 2009 for the national survey findings).

In addition to the survey of energy assistance applicants throughout the ComEd pilot footprint, the HIA also generated original data to document experiences of at-risk residents in the pilot footprint neighborhood of Maywood.²⁰

²⁰ To be eligible to participate, potential respondents had to be at least 18 years old, live within the ComEd pilot footprint, be residential customers of ComEd and pay their own electrical bill. The first 50 respondents who met the criteria were offered \$40 in exchange for completing a 30-minute interview. Interviews were transcribed and coded by the research group. Summary findings are reported in Table 5.

Table 5. Key Characteristics of Maywood Survey Participants

	All Respondents (N=51)		Respondents < 65 Years of Age (N=24)		Respondents ≥65 Years of Age (N=27)	
	#	%	#	%	#	%
Housing						
Homeowner	44	86.3	26		18	
Heating Fuel is Electricity	3	5.9				
Cooling/Central Air Conditioning	28	54.9				
Cooling/Window Unit(s)	19	37.2				
Cooling/No Air Conditioning	1	2.0				
Health/Disability Status						
Homebound	7	13.7	1	4.2	6	22.2
Homebound, Asthma or COPD	4		57.1% of all homebound			
Asthma or COPD Condition	17	33.3	11	45.8	6	22.2
High Blood Pressure or Heart Problems	36	70.6	11	45.8	25	92.6
Diabetes	15	29.4	7	29.2	8	29.6
Other Conditions	29	56.9	11	45.8	18	66.7
Health Related to Temp Exposure						
Problems Related to Cold Weather?	13	25.5				
Problems Related to Hot Weather?	21	41.2				
Missed Work Days As A Result?	5	9.8				
Missed School Days for Child As A Result?	3	5.9				
More Doctor Visits by Household Member As A Result?	4	7.8				

Housing Status: Most respondents own their own homes (86.3%), a higher proportion than households in Cook County overall. About half as many residents rely on electricity as their primary heating fuel (5.9%), compared with the 13.6% of Cook County residents who heat using electricity (Table 1); as a result, sampled Maywood residents may be less sensitive to the price of electricity when used for heating, compared with pilot footprint households overall. In the case of summertime cooling, however, Maywood residents are more likely than the general population surveyed in the American Housing Survey to rely on window air-conditioning units (37.2%) and just over half have access to central air-conditioning (54.9%), less than the 62.1% of Cook County households that report access to central a/c (data from American Housing Survey for Metropolitan Chicago, 2009) Maywood respondents are at higher risk for adverse effects of summertime heat, compared with pilot footprint households overall, given the demonstrated importance of central air-conditioning.

Health/Disability Status: The Maywood respondents are significantly less healthy than Cook County residents as a group and exhibit key risk factors for vulnerability to adverse health outcomes related to fuel poverty, substandard

housing, and temperature exposure. Seven of Maywood’s 51 respondents reported being homebound (13.7%), comparable to the percentage (13.5%) of senior households in Cook County that include a member with limited mobility (American Housing Survey for Metropolitan Chicago, 2009; see technical appendix). Of these homebound residents, 4 of the 7 report having asthma or chronic obstructive pulmonary disorder (COPD), considerably higher than the 10.6% of all Cook County adults reported to have an asthma diagnosis, both homebound and non-homebound, (see Table 5), reflecting the age and disability status of the Maywood respondents. About one-third of the Maywood cohort overall report symptoms of asthma or COPD (33.3%). Rates of cardiovascular disease (70.6%) and diabetes (29.4%) are over three times as high among Maywood respondents, compared with Cook County residents

(23.2% for high blood pressure or heart disease, 9% for diabetes; see Table 5).

“And I guess for me I think what would be more helpful is understanding more about how to change things in the home so that you’re not forced to use so much electricity or things like that. And I know that they send little notes in the bills about... I don’t find them that helpful. ”
- Maywood Resident ID #28

Health Status Related to Temperature Exposure: Given that the sample was more likely to have a chronic condition and be elderly, for many Maywood residents, the excess costs of electricity drove potentially

unhealthy temperature conditions, as they struggled to pay either heating or cooling costs. Many Maywood respondents report experiencing *health problems related either to cold weather (25.5%) or to heat (41.2%)*, of particular concern given the importance of access to electrical service to maintain an air-conditioned indoor environment in summertime. Small proportions of respondents report missing work days as a result (9.8%), that a child misses school as a result (5.9%), or that more doctor visits by a household member occur as a result of these problems (7.8%); having fewer than 5 respondents limits the statistical meaning of these survey responses. In comparison, NEADA’s national telephone sample survey of energy assistance recipients in 13 states finds a comparable proportion (25%) report a household member becoming ill on account of cold indoor temperatures (NEADA, 2010).

Table 6. Reported Impacts of Home Energy Bills

	All Respondents (N=51)		Respondents <65 Years of Age (N=24)		Respondents >65 Years of Age (N=27)	
	#	%	#	%	#	%
Digital meter experience						
Know what rate plan	44	86.3				
Noticed increase in bill	26	51.0	12	50.0	14	51.9
Noticed decrease in bill	7	13.7				
Contacts with ComEd staff	14	27.5	8	33.3	6	22.2
ComEd Contacts/Arrears	11	21.6	11	45.8	0	0.0
ComEd Contact/Creating Payment Plan	15	29.4	11	45.8	4	14.8
ComEd Contact/Avoiding Service Shutoff	9	17.7	8	33.3	1	7.4
Responses to household expenses						
Leave home for part of the day to avoid heat or cold?	9	17.7				
Turn down a/c in summer?	38	74.5				
Trouble paying household bills?	21	41.2	14	58.3	7	25.9
Lose sleep due to worry over bills?	23	45.1	15	62.5	8	29.6
Paying bills affect respondent at work?	13	25.5	8	33.3	5	18.5
Ever worry about how going to pay bills?	31	60.8	18	75	13	48.2

Tables 6 and 7 list findings related to the impacts of home energy bills and household financial stresses, relevant to a consideration of potential health and safety effects of new digital metering.

Knowledge/Perceptions about Digital Meter: Maywood respondents were more likely than Survey Monkey participants to know the rate plan for their household (86.3%, compared with 62% of Survey Monkey respondents). Respondents also expressed concern regarding understanding the

“I think that our community does need a better outreach or understanding how to downsize energy, okay. We’re not... we’re not real educated on using the better style light bulb or our seniors... our community is like 60 percent senior, so and then the other 40 is unemployed, okay? So then here we go. So we do need that educational piece.”- Maywood Resident ID 37

purpose of dynamic pricing programs and how to decrease usage from a practical perspective. About *half noted an increase in their electricity bill since the installation of a digital meter (51%)* and a smaller percentage (13.7%) reported a decrease in their electricity bill; an increase presents the threat of greater fuel poverty, accompanied by a host of potential ills.

Contacts with ComEd: About one-quarter of the Maywood cohort report contacting ComEd about their account (27.5%). The proportion with contacts varies by the purpose of the contact: 21.6% acknowledge contacting ComEd as arrearages on their electrical account accumulate, almost one-third (29.4%) contact the utility to arrange a payment plan, and 17.7% are in touch with ComEd to attempt to avoid the shutoff of service for nonpayment. In comparison, energy assistance recipients nationally are more likely to be in communication with their gas or electric utility to try to negotiate a payment plan (51 percent of respondents; NEADA, 2009). Qualitative findings suggest that ComEd customers would benefit from educational outreach from ComEd around better practices for energy usage reduction, and also to introduce newer, energy-reducing technologies to this predominately elderly population.

Responses to Household Financial Pressures: Maywood respondents are less likely to report leaving their homes for part of the day to avoid excessive heat or cold indoors (17.7%, compared with 50% of the Survey Monkey cohort and 21% of energy assistance recipient households nationally). However, three-quarters of the Maywood cohort report turning down their air-conditioning in summer due to the cost of utilities. This trend puts Maywood residents at a greater risk of adverse health outcomes due to higher prices for electrical service, as well as the influence of the perception of higher prices and greater fuel poverty. The Maywood households report considerable stress in connection with their household expenses, with 41.2% reporting trouble paying the bills, 60.8% worrying about how bills will be paid, 45.1% reporting losing sleep over concern about bills, and 25.5% reporting that such fears affect workplace performance. See Table 7 for Findings related to respondents' perceived behavior changes in response to hypothetical bill increases.

Respondents were asked how they cope with a higher bill. As noted above in Table 7, many explained that they turn off their air conditioner during certain times of day, layer their clothing during the winter, use CFL light bulbs, encourage family members

Table 7. Budgetary Trade-offs In Face of Hypothetical Increase in Electrical Bill

<i>I would cut back on...</i>	<i>If my electric bill increased by...</i>		
	10% increase	20% increase	50% increase
Cut back on food, gas, or heating	30%	14%	20%
Cut back on medicine or health care	4%	2%	0%
Cut back on leisure activities	12%	20%	10%
Don't know or would do something else, such as ask someone else for help paying bill	54%	64%	70%

to turn off lights, and they limit their leisure activities. More extreme examples of how people nationally cope include cutting down on food, gas, and other utilities, using no air conditioning at all, and failing to pay other bills (NEADA, 2009).

“... The last bill I got a couple of days ago was \$230 and I have to pay it on time and so something is going to have to go missing. So it is a...I hate that by me being on so many medications that I have to juggle either to pay my utilities, buy my food or get my medication. So, I'm not going to cry [starts crying]... I have to juggle it. I have to have the lights, I have to have the medication, and I have to...to be honest with you I have cut back on the food. I mean, the refrigerator gets cut off and I just cannot deal with it. So I mean I have to... I think their rates have gotten a lot higher but the economy, living on a fixed income of seven hundred dollars a month, how far does that go?”
 - Maywood Resident ID 44 (COPD, asthma, diabetes)

Participants were also asked about health related issues that they were facing. A third of respondents reported that someone in their home had a chronic respiratory disease, such as asthma or chronic obstructive pulmonary disorder (COPD). Of note, 57% of those who reported having asthma or COPD were homebound. 71% of participants reported that someone in their home had high blood pressure and/or heart problems, and 29% reported that someone in their home had diabetes.

Relating to energy, 26% of those surveyed noted that they were often uncomfortable in their home due to the cold weather, and as a result, their osteoarthritis, rheumatoid arthritis, and asthma were negatively affected. As well, 41% reported

discomfort in their home related to the hot weather, exacerbating asthma, COPD, and diabetes.

d. Impact Analysis

Household reliance on electricity for heating or cooling connects those residents and their health more closely due to the monetary costs and benefits associated with AMI deployment. If AMI deployment increases fuel poverty, it increases the chances of adverse health and safety outcomes. To the extent that the new pricing programs associated with digital meter deployment results in less electricity usage, decreasing fuel poverty and improving housing quality as a result (for example, by lowering

monthly utility bills), AMI lessens the likelihood of adverse health and safety outcomes.

Based on the literature review, findings from ComEd's own studies, analysis of ComEd data, and survey data, the HIA finds that a net cost of \$2-3 per month for the deployment of AMI, as projected, will have a negative impact on vulnerable populations who are very sensitive to small price changes. This population includes elderly adults, young children, and people with chronic diseases (asthma, COPD, diabetes). Vulnerable populations are subject to a number of risks in their lives due to their economic status and these risks could be exacerbated as a result of AMI deployment. These risks include:

- Inability to pay for housing, health care and/or food
- Difficulty paying for heating/cooling, and consequently, an inability to heat or cool their home during extreme weather conditions
- Unreliable electricity for heat or to power medical devices
- Foregoing needed healthcare, including medication and healthcare visits, can result in costly health crises, representing a large potential negative impact.

The HIA also found that customers faced with making decisions regarding trade-offs, especially trade-offs that would put their health and safety at risk, experienced greater stress related to paying utility bills when compared with energy assistance recipients across the nation. AMI alone is not the "prime" mover of causing underlying fuel poverty, but can exacerbate it with potential health consequences.

2. WILL DYNAMIC PRICING PROGRAMS RESULT IN DECREASED USAGE AND/OR A SHIFT IN USAGE, OR WILL IT NOT HAVE ANY IMPACT ON USAGE?

Summary of Findings

- Changes to pricing programs that charge much higher prices during certain times of day can cause some customers to reduce usage to avoid higher or unaffordable bills, resulting in under-usage of electricity resulting in extremes in temperatures indoors. Exposure to temperatures outside of a moderate range increases the likelihood of hospital emergency department visits, hospitalizations, and premature death. ComEd's residential customers include households with young children (7.2%) and seniors (11.2%), all more likely to develop symptoms of heat- and cold-related illness such as hypothermia or heat stroke, while persons who are socially isolated (an eightfold greater risk for death during a heat wave), and those living with a mobility-limiting disability (nearly six times the risk of death during a heat wave) are also at greater risk.
- Nationally, there is evidence of peak load reduction due to dynamic pricing programs using both critical peak pricing and peak time rebates using volunteers. However, among low income households with dynamic pricing programs there is only limited peak load reduction. Evidence also suggests that customers on a critical peak pricing plan did not lower overall energy usage, instead shifting usage to lower priced time periods.
- ComEd's AMI pilot found no statistically significant reduction in usage overall or at times of peak load for the electrical grid, for any of the tested combinations of pricing and technology options. As cited in the EPRI report Section 6-15, the pilot did show a reduction in peak load of 32-37% in a small group (5-6%) of respondents but this was not statistically significant and cannot be generalized to the larger population. There was little demographic difference between the survey customers who responded to the pricing programs (the 10% who did respond) and those who did not respond to the pricing programs.²¹

²¹ EPRI Final Report, Table 6-4, page 6-11.

- ComEd’s AMI pilot also found only small predicted reductions in greenhouse gas emissions. Deployment is likely to result in reduced emissions from ComEd vehicles no longer needed to conduct premise visits to read meters or connect and disconnect meters. However, the potential health impacts of reduced vehicle emissions are at best negligible, removing approximately 25,000 tons of CO₂ from the roughly 40 million tons in total CO₂ emissions for the Chicago metropolitan areas.
- A separate analysis of the AMI pilot conducted for ComEd by Black and Veatch estimated that 30,000 MWh of electric generation would be avoided from programs that ComEd did not test in the pilot, such as exposing customers to more detailed usage information on the company’s website and educating customers on how to reduce energy by analyzing the customer’s usage profile and stimulating voluntary changes in usage behavior.²² Even this estimate, however, is a very small amount of energy savings (0.03% of ComEd’s total of 91.1 million MWh in sales in 2010).²³ This energy savings translates to an estimated CO₂ reduction of 23,000 tons per year.²⁴
- The opt-out nature of ComEd’s pilot also suggests, as shown nationally, voluntary dynamic pricing programs are likely to have better results. Since the pilot, as shown nationally, did not show any meaningful difference in response between critical peak pricing and peak time rebates, a peak time rebate should be used since it would not adversely penalize low-income customers.
- Customer adoption of dynamic pricing programs may result in reduced demand for power generation at peak times from fuel sources associated with air pollution, including emission of greenhouse gases. Current education, during the ComEd pilot, did not demonstrate this, but other studies in other states have shown more reduced usage with volunteers. Improved customer education, including improvements in energy efficiency and demand

²² Section 14.1.

²³ Greater - but still modest - reductions in consumption are attributed to reducing unaccounted for energy (UFE, 350,000 MWh annually). We do not consider these energy savings to result in actual emission reductions because as discussed in Section 7.9 of Black & Veatch report, most customers found to be receiving unmetered power are expected to begin paying for power.

²⁴ Using Black and Veatch’s CO₂ emission factor in Section 9.5

response programs, is necessary to ensure customers are interested and able to take advantage of pricing programs and technology investments that will shift and reduce energy usage.

a. Baseline Conditions Analysis

Pricing: In Illinois, the price of the electricity itself, or the supply price, is set through regional electricity transmission organizations which act as clearinghouses between electricity generators who create the power and electricity utilities who deliver the power. Prices vary by demand, such that electricity generated at peak times when usage is high is more expensive than, for example, at night when demand and usage is low. In Illinois, like most U.S. states, all residential customers have as their default pricing rate a “bundled” fixed rate, which means usage is billed at the same price per kWh every month regardless of what time of day the kWh is used. ComEd customers can opt-into a residential real-time pricing plan (RRTP), which passes through wholesale supply costs based on the time of day electricity is used.²⁵

AMI allows a wider variety of pricing plans which can be designed to capture hourly usage information because pricing and usage data can be captured in real time between the utility and the household. **Typical dynamic pricing rates include:**

- **Time of Use:** A TOU rate charges customers a different price per kWh during different times, generally structured in blocks of hours. For example,
- **Critical Peak Price:** A CPP rate charges customers a higher price per kWh during peak usage times, typically hot summer afternoons.
- **Peak Time Rebate:** A PTR offers customers who lower their usage during critical peak times a rebate based on the amount of kilowatthours the customer avoids using.

²⁵ Residents opting into the RRTP program receive a digital mechanical meter to capture the more detailed usage necessary for RRTP billing.

Health Outcomes Related to Usage: Health outcomes related to exposure to excessive heat or cold are an important concern in this HIA. The literature on the relationship between temperature exposure and health is voluminous, encompassing retrospective longitudinal observations of mortality differentials by season or weather event (deep freeze, heat wave) over years and decades, case studies of health services utilization during heat waves, and clinical studies detailing the physiological changes that accompany exposure. For the purposes of this HIA, the most relevant studies are those that document indoor temperature exposure, its relationship to energy use and to health and safety outcomes; a much smaller universe of literature makes the link to home energy and very few studies connect temperature exposure directly to energy.²⁶

Exposure to cold: A meta-analysis of studies linking winter outdoor temp to excess cardiovascular and respiratory disease deaths, for the most part based on data from the United Kingdom, Europe, and New Zealand, concludes that between 30% and 50% of premature deaths in winter reflect exposures to indoor cold (Rudge, 2011, based on Keatinge and Donaldson, 2000 for upper bound and Wilkinson et al., 2001 for lower bound). These otherwise avoidable deaths are associated with lower temperatures in bedrooms and living rooms (adults age 50+) (Eurowinter Group, 1997).

Exposure to heat: Recent published summaries of the literature on heat exposure and heat waves highlight dozens of peer-reviewed studies documenting elevated rates of hospitalization and premature deaths. One such review identifies 29 studies where short-term rises in outdoor temperature are associated with greater risk or likelihood of premature death (Basu, 2009).

Another review specifically concerning the experiences of seniors finds 6 peer-reviewed studies where a heat wave or summertime hike in temperature is associated with greater morbidity, and 24 peer-reviewed studies linking heat waves of higher ambient temperature with higher mortality rates (Astroma et al., 2011). Young or advanced age, disabled status (especially a disability that limits mobility), African American ethnic identity, and social isolation or lack of social capital are each indicators of greater vulnerability to adverse impacts related to heat or cold exposure

²⁶ For elders, this literature is reviewed in some detail in Snyder and Baker, *Affordable Home Energy and Health: Making the Connections*. Washington, DC: AARP Public Policy Institute, 2010.

(Bouchama et al., 2007; Kilbourne, 2008; Schwartz, 2005, Medina-Ramon et al., 2007).

With respect to chronic illness and temperature exposure, various studies have found the following relevant results.

- *Heart Disease.* Among adults and seniors, both heat and cold are associated with greater risk of hospitalization and premature death from cardiovascular and cerebrovascular (stroke-related) diseases (Alanitis et al., 2008; Medina-Ramon et al., 2006, Ostro et al., 2010, Semenza et al., 1999, Naughton et al., 2002).
- *Respiratory Disease.* For elders, chronic obstructive pulmonary disorder is made worse by indoor cold: in wintertime, patients whose living rooms are warm (at least 21 degrees C, or approximately 70 degrees Fahrenheit) fewer than nine hours per day have worse respiratory health than those who have at least nine hours of indoor warmth on a daily basis (Collins, 2000; Osman et al., 2008). Children are more than twice as likely to experience respiratory symptoms when they live in cold homes, compared with those who live in warm homes (Marmot Review Team, 2011).
- *Diabetes, Kidney Disease, Neurological and Movement Disorders.* Heat represents a particular threat for diabetes patients, who are more likely to be hospitalized or die prematurely during a heat wave or non-extreme summer temperatures, as well as those living with kidney disease, who are more likely to be hospitalized for or die from acute renal failure (Schwartz, 2005; Ostro et al., 2010; Semenza et al., 1999, Medina-Ramon et al., 2006; Naughton et al., 2002). Heightened risk for persons with psychiatric disorders or with movement disorders including Parkinson's have been documented.

Table 8 summarizes population characteristics related to the risk of exposure to hot or cold temperature – issues that are particularly important to questions of dynamic pricing. For the purposes of this HIA, factors that make an individual more susceptible to illness or premature death related to temperature exposure include age (young or old), degree of social isolation, disability status, and the presence of pre-existing chronic health conditions likely to be made worse by exposure to temperatures outside of a moderate range. Poverty amplifies the impacts of these determinants.

Table 8. Health Impacts Linked to AMI and Dynamic Pricing: Indicators of Temperature Sensitive Characteristics and Conditions

Determinant/Indicator(s)	Data Source	Pilot Footprint	Service Territory
<i>Age</i>			
Households including child < 5 yrs	Claritus	7.8%	7.2%
Households including elder 65 yrs +	Claritus	9.8%	11.2%
<i>Social isolation</i>			
Seniors living independently	AHS	11.2%	9.2%
Seniors living independently, < 100% FPL	AHS	31.6%	
Adults reporting social isolation/lack of social support	BRFSS/CHR	25%	18%
<i>Disability</i>			
Adults reporting functional disability	BRFSS	16.4%	15.7%
Household includes member with disability	AHS	15%	17.2%
Household includes member living with disability that limits mobility	AHS	6.2%	5.6%
Senior household including member with limited mobility	AHS	13.5%	
Household < 100% FPL including member with limited mobility	AHS	10.2%	
<i>Temperature-Sensitive Condition</i>			
Adults reporting fair/poor health	BRFSS/CHR	18%	13.7%
Adults with asthma	BRFSS	10.6%	13.4%
Children with asthma	BRFSS	11.6%	14.5%
Adults with diabetes diagnosis	BRFSS/CHR	9%	8%
Adults with high blood pressure /cardiovascular disease	BRFSS	23.2%	28.9%

Key: AHS (American Housing Survey), BRFSS (Behavioral Risk Factor Surveillance Survey), CHR (County Health Rankings project at the University of Wisconsin), Claritus (Census data product provided by ComEd to project team, data for 2008 unless otherwise noted), ALA (American Lung Association, unpublished data for Illinois), NEADA (annual telephone sample survey of LIHEAP recipient households in participating states, National Energy Assistance Directors' Association, data for 2009), USDA (U.S. Department of Agriculture's Economic Research Service, survey on food insecurity prevalence by state).

Age: As described in the preceding section, about 8% of households in census tracts that include ComEd residential customers include children no more than 5 years old, and 11% include an elder at least 65 years of age. At both ends of the age spectrum, thermoregulation of body temperature is more difficult, leaving young children and elders more vulnerable to temperature-related ailments.

Social Isolation: Seniors who live independently, especially on limited incomes, are more vulnerable to temperature-related health effects when they lack social supports or connections (defined by social scientists in terms of social capital, a measure of civic relationships and functioning). About 9% of seniors in the Chicago region live independently, a number that jumps to 31.6% of seniors who live in poverty and also live alone. Lack of regular social contact can put these residents at greater risk for premature death or illness in the case of a heat wave or the loss of electrical heat in winter. Another way to measure such vulnerability is that 25% of Cook County adults and 18% of service territory county adults report a lack of social support.

Disability Status: Within ComEd's service territory, 15.7% of adults report a disabling condition, and 17.2% of households include someone with a disability. Of particular concern are disabilities that limit mobility, or the ability to leave housing conditions that are too hot or too cold; 10.2% of households living in poverty include a member with a mobility-limiting disability and 13.5% of households comprised of seniors include someone with such a disability.

Temperature-Sensitive Conditions: Data on the range of chronic ailments affected by temperature are limited. For Illinois counties served by ComEd, 13.7% of adults report their health to be fair or poor, 13.4% of adults report an asthma diagnosis and 13.4% report a child with asthma, 8% of adults report a diagnosis of diabetes, and 28.9% of adults report having high blood pressure, which is a risk factor for heart (cardiovascular) disease and stroke (cerebrovascular disease). Chronic obstructive pulmonary disorder (COPD) and renal (kidney) disease also mean an increased risk of adverse outcomes in the case of exposure to heat or cold, but there are insufficient data to estimate prevalence rates for this population.

b. Literature Review and ComEd Pilot Studies

Published studies, including the two reports on ComEd's AMI pilot, present a mixed set of findings regarding the capacity of dynamic pricing under AMI to dampen usage and, in turn, improve both air quality and energy efficiency.

AMI Pilot Program and Air Quality Benefits²⁷: Programs that encourage energy efficiency and conservation can reduce the amount of air pollution from power plants if they reduce the total consumption of electricity. Demand response programs can also reduce emissions when peak loads are avoided (peak shaving) or when load is shifted in time from higher-emitting peaking power plants to lower-emitting base load or intermediate-load power plants (a condition that does not always obtain, in which case load shifting would increase emissions).

EPRI's analysis of the ComEd pilot results showed that 5% to 7% of CPP and PTR customers reduced peak, event-period load by 32% to 37%. However, EPRI reported "little evidence" of a reduction in the total energy consumed.²⁸

A separate analysis of the AMI pilot conducted for ComEd by Black and Veatch estimated that 30,000 MWh of electric generation would be avoided from customer energy efficiency or other voluntary use reductions, after full deployment of AMI to all ComEd customers.²⁹ This is a very small amount of energy savings (0.03% of ComEd's total of 91.1 million MWh in sales in 2010).³⁰

²⁷ Emissions reductions (e.g., tons of nitrogen oxides emitted at power plants) can be translated into air quality benefits (e.g., reductions in ambient ozone levels) through the use of air quality models. However, in light of the very limited information regarding the effects of the AMI pilot on electricity consumption, such an analysis was not performed as part of this HIA. EPRI reported no statistically significant effects on energy consumption or demand in the aggregate. The only effects came from a disaggregated subset of participants that exhibited peak load reductions, with no projection of the effects of full scale-up. Moreover, in contrast to prior studies, EPRI reported no observed reduction in overall energy use. If overall consumption doesn't go down, but peak demand decreases, an air quality analysis would have to be based on an evaluation of detailed power plant dispatch data. Such data not available for this HIA.

²⁸ p. 5-3.

²⁹ Section 14.1.

³⁰ Greater - but still modest - reductions in consumption are attributed to reducing unaccounted for energy (UFE, 350,000 MWh annually). We do not consider these energy savings to result in actual emission reductions because as discussed in Section 7.9 of B&V report, most customers found to be receiving unmetered power are expected to begin paying for power.

This energy savings translates to an estimated CO₂ reduction of 23,000 tons per year.³¹ Avoided vehicle emissions of 4 million miles of travel were also reported; this translates to an annual reduction of about 2,000 tons of CO₂ emissions.

The lack of observable energy savings in ComEd's AMI pilot is inconsistent with similar demonstrations, including the 2003-2006 Energy-Smart Pricing Plan in ComEd's service territory which showed a 3-4% reduction in summer electricity usage.³² This difference may owe to pricing incentives and/or inadequate information provided to AMI pilot participants and should be further examined.

The combined reduction in CO₂ emissions of 25,000 tons per year, derived from Black and Veatch's estimates of the benefits of full AMI deployment, would be roughly equivalent to the annual CO₂ emissions from roughly 4,400 passenger vehicles or the energy consumed in 2,000 homes.³³ For comparison, the Chicago metropolitan area's total CO₂ emissions have been estimated to be about 40 million tons.³⁴ Reductions in other pollutants including nitrogen oxides, carbon monoxide, mercury, particulate matter and volatile organic compounds would also be expected but were not calculated here due to the lack of project-specific data on energy consumption.

What has been the result of AMI pilot programs to test dynamic pricing?: The HIA considered the results of AMI pilots nationally as well as the results of ComEd's Customer Applications Pilot to assess potential health impacts associated with AMI. Most AMI pilot programs, unlike ComEd's pilot, rely on volunteers who agree to participate in alternative pricing programs and accept no-cost in-home technologies for the duration of the pilot. There is a rich literature on the results of these AMI pilots, which shows that in most instances, the dynamic pricing programs tested have resulted in statistically valid lower peak load usage in response to either high critical peak prices or the offer of a rebate or credit and deliver significant peak load reductions during the peak hours called during the pilot

³¹ Using Black and Veatch's CO₂ emission factor in Section 9.5

³² A. Faruqui and S. Sergici, "Household response to dynamic pricing of electricity: a survey of 15 experiments," *J. Regul. Econ.* (2010), **38**, 193-225.

³³ <http://www.epa.gov/cleanenergy/energy-resources/calculator.html>

³⁴ 2005 emissions, as reported in: Center for Neighborhood Technology, "Chicago's Greenhouse Gas Emissions: An Inventory, Forecast And Mitigation Analysis For Chicago And The Metropolitan Region," (2008); available at http://www.cnt.org/repository/CNT_Climate_Research_Summary_9.17.08.pdf

period.³⁵ However, most of these pilot programs have documented that customers are more likely to shift usage from peak periods to off-peak periods rather than reduce total energy consumption, even when customers were given in-home devices to actually see their usage information in a more detailed manner at the time of their usage. As a result, there is little evidence that dynamic pricing programs, even when accompanied by in-home devices, will result in lower usage overall (for more details see APPENDIX 3). Furthermore, the results document that customers will respond to the peak time rebate offer with significant peak load reduction and that relying on critical peak pricing is not necessary to obtain valuable results in the form of lower usage during peak periods.

Do Low Income Customers Respond to Dynamic Pricing?: Most of the pilot programs have not identified low income customers or other customers that are more vulnerable to higher electricity prices, such as elderly Americans, those disabled, or those with medically necessary electrical powered devices. However, some pilots specifically gathered some data on known low income customers due to their enrollment in utility-sponsored low income discount or bill payment assistance programs. As indicated in APPENDIX 3, the California pilot specifically enrolled known low income households and their responsiveness to various dynamic pricing was much lower than non-low income households. This same result was documented in the Baltimore Gas & Electric pilot in Maryland. However, this does not mean that low income customers may not be interested in optional pricing programs if they are viewed as a means to lower the monthly bill. Furthermore, even though low income households have documented a lower level of response and lower level of dollar amount of bill savings in these pilot programs, it is still important to recognize that some level of peak load reduction may occur for some of these customers.

The issue in many of these pilot evaluations remains, however, clouded by the lack of valid data due to the low number of participating low income customers, the lack of a uniform method of identifying which pilot customers are in fact “low income”, as well as the fact that the costs of AMI deployment itself is not included in the bill savings and analysis of bill impacts for these volunteer pilot program participants. Finally,

³⁵ See Memo prepared by Barbara Alexander for Citizen's Utility Board and National Center for Medical Legal Partnership summarized in Appendix 3.

very few if any pilots have evaluated the response and bill impacts on older customers or those with young children.

In September 2010, IEE³⁶ released a Whitepaper entitled *The Impact of Dynamic Pricing on Low Income Customers* that attempted to assess the impact of dynamic pricing on low-income customers in two ways. First, the authors conduct simulations of dynamic pricing using assumptions drawn from a large urban utility. Second, the authors collect the results of evaluations of 4 pilots and one ongoing dynamic pricing offering, comparing what is known from these evaluations about the response of the average customer and that of the low-income customer. The authors state that their "core finding" is that "low income customers are responsive to dynamic rates and that many such customers can benefit even without shifting load."³⁷ However, several other experts took issue with the low-income threshold used in the IEE report³⁸ and have criticized the IEE Report on a number of grounds, emphasizing the need to evaluate the potential impacts of a particular dynamic or time-based pricing program with utility-specific data.³⁹ The IEE analysis also excluded from its analysis costs of implementing dynamic pricing, such as the costs of smart meters, which have an impact on customer bills.

AMI Metering and Energy Efficiency: Energy efficiency is about reducing a dwelling's energy usage by making that dwelling more efficient. Energy efficiency measures can include a number of different appliances or upgrades. From more efficient refrigerators and furnaces to lighting or insulation, there are a variety of upgrades available to improve the efficiency of a dwelling. In many states utilities run energy efficiency programs. These programs usually include rebates for purchasing energy efficient equipment or behavior modification programs to encourage people to think about how they use energy. Currently it is difficult and expensive to measure the impacts of utility energy efficiency programs. The evaluation process as it stands relies heavily on estimating savings based on algorithms and interviews or surveys of program participants. Even if consistent

³⁶ The Institute for Electric Efficiency (IEE) is a sister program to the Edison Electric Institute which represents investor-owned utilities in policy debates at the federal level.

³⁷ *Id.*

³⁸ The IEE Whitepaper defines income classifications with incomes as high as \$50,000 per year as "low income", and resulted are not adjusted for household size, a key factor when evaluating poverty or financial hardship.

³⁹ Internal Memo, Barb Alexander, prepared for the National Center for Medical-Legal Partnership. 2011.

values for energy efficiency measures could be delineated through custom surveys and monitoring, the costs would be prohibitive. ComEd will be spending \$3.6 million a year for the next 3 years on the costs for their energy efficiency programs. (Final Order Docket 10-0570, pg 16-17) AMI metering will allow evaluators, stakeholders and utilities more complete data to analyze the experiences of residential consumers who participate in energy efficiency programs, to evaluate whether savings are achieved. Because utility programs are funded by ratepayers, having more complete data will enable the utility to run more cost effective programs and save ratepayers money in the long run but only if consumers understand the data and are educated how to reduce their usage.

Customer Education: Customer Education around AMI should be an ongoing process. There is very limited evidence of the effect consumer education has on usage in the context of AMI. The primary data from the ComEd pilot in the next section indicates that most vulnerable consumers did not make many changes to their usage. The data from Maywood participant surveys (in next section below) does not indicate a high level of awareness about the meters themselves. Consumer interest focuses on the programs facilitated by AMI metering, related to understanding their bills and identifying ways to reduce usage. These programs could be the focus of customer education efforts, not the meters themselves. In the long term, “smart appliances” could enable even more participation in programs such as a “peak time rebate,” however it will take time for smart appliances to find their way into people’s homes, and the relevance of this market for low-income households is unclear. In the mean time, coordinated effort by the utilities, stakeholders, and municipalities should communicate the opportunities provided by AMI metering. Possible strategies could include a “bill protect” program where utility will notify customer by text message or email when their bill is approaching a customer chosen level, say \$100, so the customer knows where they stand before their bill shows up the mail, or a program to provide monetary credits to customer for reducing usage during peak times, or even a program where children of elderly parents can be sent a text message if their elderly parent loses electricity.

c. Primary Data Analysis

The ComEd pilot included pre- and post- surveys of pilot customers, capturing a range of identifying information as well as self-reported behavior change related to energy use. While ComEd used this information to look more closely at the characteristics of subgroups that appeared to respond to price signals and education,

it is important to note many limitations to the data. First the response rate was 33%, which for some epidemiologic surveys would be considered low, but for energy consumption surveys is reasonable. The loss to follow up was also high, with complete data on people who did pre-survey to post-survey less than 50%. The characteristics in the survey are described in Table 9.

Table 9. Characteristics of Survey Respondents

	<i>Respondents</i>	
	<i>#</i>	<i>%</i>
<i>Race/Ethnic Identity</i>		
Hispanic or Latino	550	18.5
Black non-Hispanic	554	18.7
White non-Hispanic	1615	54.5
Asian Pacific Islander	77	2.6
American Indian or Alaskan Native	4	0.1
Other	90	3.0
NA	76	2.6
<i>Annual Household Income</i>		
Less than \$20,000/year	552	20.1
\$20,000 - \$39,999/year	667	24.3
\$40,000 - \$79,999/year	829	30.2
\$80,000 - \$120,000/year	381	13.9
Greater than \$120,000	318	11.6
NA	219	8.0
<i>Highest level of education completed</i>		
Graduate or Professional School	630	21.2
Trade or Technical School	126	4.2
Graduated College	775	26.1
Some College	595	20.0
Graduated High School	513	17.3
Some High School	178	6.0
Elementary School	100	3.4
NA	49	1.7
<i>Housing Type</i>		
Detached single family home	1570	52.9
Condominium	283	9.5
Townhouse, Duplex or Rowhouse	163	5.5
Apartment	829	28.0
Mobile Home	15	0.5
Other	106	3.6

The HIA team prepared an original analysis of ComEd's survey data, to focus on how at-risk groups reported their likely changes in energy use. There was insufficient data to examine usage changes among non-English speakers, but the HIA did examine three groups of vulnerable populations that could be measured: elders 65 years or older, families with children and people with low incomes, defined here as incomes less than \$40,000. Individuals living with a disabling condition, including temperature sensitive conditions, and individuals with social isolation were not tracked in the survey. Language was asked but had too many missing values to be analyzed. It was postulated that these vulnerable groups would be very price sensitive and therefore would be most motivated to see changes in behavior. Interestingly, very few statistically significant changes were seen. Tables 10, 11, and 12 highlight the findings.⁴⁰

⁴⁰ Three demographic factors are dichotomized among 2423 unique post-survey participants in order to examine whether elders, families with young children and low income populations reported differently at post intervention survey about how they use utilities at home to conserve energy. The three dichotomous categories were born before 1946 vs. born after 1946; having zero kids vs. any kids at home; and income less than \$40,000 vs. \$40,000 or more.

Chi-square tests were conducted to test whether these three dichotomous demographic factors have significant differences on a series of questions: whether they:

- "used appliances at a non-peak time",
- "replaced light bulbs with energy efficient CFLs",
- "used cold water for laundry",
- "set the thermostat to 78 degrees or higher",
- "turned off lights and electronics when not in use",
- "purchased a more efficient appliance",
- "used timers to run appliances during non-peak times",
- "charged re-chargeable devices during non-peak times",
- "asked household members to use less electricity", and
- "did not take any actions".

Participants who have valid information on three factors or more were included in the analyses. SAS 9.1.3 was used to complete the analyses.

Table 10. Changes In Usage By Elders (65 Years Or Older) vs Non Elders (Less Than 65 Years)

	Age 65+ and said YES	Less than 65 and said YES	OR	Age 65+ and said NO	Less than 65 and said NO
Used appliances at a non-peak time	236 (44.6)	663 (39.4)	1.24 * (1.02-1.51)	293 (55.4)	1020 (60.5)
Replaced light bulbs with energy efficient CFLs	321 (60.7)	990 (58.8)	1.80 (0.88-1.32)	208 (39.3)	693 (41.2)
Used cold water for laundry	190 (35.9)	605 (35.9)	1.00 (0.81-1.22)	339 (64.1)	1078 (64.1)
Set the thermostat to 78 degrees or higher	173 (32.7)	446 (26.5)	1.34 (1.09-1.67)	356 (67.3)	1237 (73.5)
Turned off lights and electronics when not in use	383 (72.4)	1233 (73.3)	0.96 (0.77-1.19)	146 (27.6)	450 (26.7)
Purchased a more efficient appliance	121 (22.9)	377 (22.4)	1.03 (0.81-1.30)	408 (77.1)	1306 (77.6)
Used timers to run appliances during non-peak times	41 (7.8)	110 (6.5)	1.20 (0.83-1.74)	488 (92.2)	1573 (93.5)
Charged re-chargeable devices during non-peak times	88 (16.6)	190 (11.3)	1.57 (1.19-2.06)	441 (83.4)	1492 (88.7)
Asked household members to use less electricity	204 (38.6)	850 (50.5)	0.62 (0.50-0.75)	325 (61.4)	833 (49.5)
Other	20 (3.8)	106 (6.3)	0.58 (0.36-0.95)	509 (96.2)	1577 (93.7)
I did not take any actions	42 (7.9)	177 (10.5)	0.73 (0.52-1.04)	487 (92.1)	1506 (89.5)

Note: Counts are reported in each cell, with column percentage in parentheses for respondent tabulations and confidence intervals reported in parenthesis for the estimated odds ratios.

Overall, participants who completed a survey at the conclusion of the ComEd pilot reported few significant changes in energy use behavior, except for the increased odds that seniors would set their thermostats to 78 degrees Fahrenheit or higher, representing a potential health hazard in summertime. Respondents were less ethnically diverse than were all pilot footprint households (in terms of the percentage reporting themselves to be white) and more likely to be poor, compared with households in the pilot footprint. Aside from the higher likelihood that seniors would keep their homes at a higher temperature in summer, the survey finds limited evidence of greater energy efficiency, with seniors 24 percent more likely to use non-peak hours to use appliances and 57 percent more likely to re-charge appliances during non peak times, and low-income respondents 19 percent more likely to replace light bulbs with compact fluorescents and 28 percent more likely to turn off lights and electronics when not in use.

Table 11. Changes in Usage By Having At Least One Child vs No Children In Home

	No children in the house and said YES	1 or more child in the house and said YES	OR	No children in the house and said NO	1 or more child in the house and said NO
Used appliances at a non-peak time	628 (42.0)	284 (38.2)	1.17 (0.98-1.40)	869 (58.0)	459 (61.8)
Replaced light bulbs with energy efficient CFLs	870 (58.1)	461 (62.0)	0.85 (0.71-1.02)	627 (41.9)	282 (38.0)
Used cold water for laundry	547 (36.5)	266 (35.8)	1.03 (0.86-1.24)	950 (63.5)	477 (64.2)
Set the thermostat to 78 degrees or higher	449 (30.0)	180 (24.2)	1.34 (1.10-1.64)	1048 (70.0)	563 (75.8)
Turned off lights and electronics when not in use	1076 (71.9)	560 (75.4)	0.84 (0.68-1.02)	421 (28.1)	183 (24.6)
Purchased a more efficient appliance	350 (23.4)	163 (21.9)	1.09 (0.88-1.34)	1147 (76.6)	580 (78.1)
Used timers to run appliances during non-peak times	100 (6.7)	48 (6.5)	1.04 (0.73-1.48)	1397 (93.3)	695 (93.5)
Charged re-chargeable devices during non-peak times	207 (13.8)	67 (9.0)	1.62 (1.21-2.17)	1290 (86.1)	676 (91.0)
Asked household members to use less electricity	619 (41.4)	458 (61.6)	0.44 (0.37-0.53)	878 (58.6)	285 (38.4)
Other	85 (5.7)	42 (5.6)	1.00 (0.69-1.47)	1412 (94.3)	701 (94.4)
I did not take any actions	159 (10.6)	70 (9.4)	1.14 (0.85-1.54)	1338 (89.4)	673 (90.6)

Note: Counts are reported in each cell, with column percentage in parentheses for respondent tabulations and confidence intervals reported in parenthesis for the estimated odds ratios.

Table 12. Changes in Usage By Low Income (<40,000) vs Non Low Income (>40,000)

	Low-income and said YES	Not low-income and said YES	OR	Low-income and said NO	Not low-income and said NO
Used appliances at a non-peak time	349 (38.3)	545 (42.2)	0.85 (0.72-1.01)	562 (61.7)	748 (57.8)
Replaced light bulbs with energy efficient CFLs	564 (61.9)	746 (57.7)	1.19 (1.00-1.42)	347 (38.1)	547 (42.3)
Used cold water for laundry	319 (35.0)	468 (36.2)	0.95 (0.80-1.13)	592 (65.0)	825 (63.8)
Set the thermostat to 78 degrees or higher	264 (29.0)	351 (27.1)	1.10 (0.91-1.32)	647 (71.0)	942 (72.9)
Turned off lights and electronics when not in use	692 (76.0)	920 (71.2)	1.28 (1.06-1.56)	219 (24.0)	373 (28.8)
Purchased a more efficient appliance	198 (21.7)	311 (24.0)	0.88 (0.72-1.07)	713 (78.3)	982 (76.0)
Used timers to run appliances during non-peak times	64 (7.0)	84 (6.5)	1.09 (0.78-1.52)	847 (93.0)	1209 (93.5)
Charged re-chargeable devices during non-peak times	118 (12.9)	159 (12.3)	1.06 (0.82-1.37)	793 (87.1)	1134 (87.7)
Asked household members to use less electricity	432 (47.4)	625 (48.2)	0.96 (0.81-1.14)	479 (52.6)	668 (51.7)
Other	54 (5.9)	74 (5.7)	1.04 (0.72-1.49)	857 (94.1)	1219 (94.3)
I did not take any actions	74 (8.1)	145 (11.2)	0.70 (0.52-0.94)	837 (91.9)	1148 (88.8)

Note: Counts are reported in each cell, with column percentage in parentheses for respondent tabulations and confidence intervals reported in parenthesis for the estimated odds ratios.

In general tables 10, 11, and 12 demonstrate that the three vulnerable populations analyzed have very little capacity to change their energy usage. It highlights that some vulnerable populations are likely to make changes that may be detrimental to their health, such as elders over 65 years of age using temperatures over 78 degrees, when many elders have temperature sensitive conditions such as chronic obstructive pulmonary disease or heart disease. Given the potential increased cost related to AMI deployment, the decreased likelihood that vulnerable populations can change their usage, the variable pricing programs will more likely lead to increased bills rather than decreased bills for the population most at risk.

d. Impact Analysis

To the extent that AMI deployment facilitates maintaining moderate indoor temperatures (through greater reliability of service, for example, that shortens the periods of time when households are without service due to a storm-related outage), AMI lessens like the likelihood of adverse consequences related to temperature sensitivity. If AMI deployment makes it more difficult for customers, particularly in low-income households, to maintain moderate indoor temperatures (for example, through a higher cost for electricity during peak summer hours that discourages consumers from using their air-conditioning), AMI increases the likelihood of adverse health and safety outcomes. This HIA concludes:

- Dynamic pricing programs have the potential to decrease usage and reduce air pollution, but that they did not do so as ComEd deployed them in the AMI pilot.
- It is unclear from this pilot that the implementation of AMI technology will actually result in a reduced usage and significant peak load reduction. In fact, other dynamic pricing programs show that while there is typically an overall peak load usage reduction of 5-6%, overall energy consumption does not change.
- Findings also show that none of the dynamic pricing plans implemented by ComEd demonstrated a statistically significant overall usage reduction. Even though peak load was reduced by 32-37% in a small group (5-6%) of Critical Peak Pricing and Peak Time Rebate customers as cited in Section 6-15 in the EPRI report, these results were not statistically significant and therefore difficult to generalize across the entire population. As a result, this evidence

gives little basis for concluding that AMI will significantly lower greenhouse gas emissions from electricity plants.

- For meaningful reduction in overall usage and therefore greenhouse gas emissions, consumer education is needed to lower usage and therefore lower bills. There is little evidence that the education done during the AMI pilot to date has been sufficient to see a meaningful reduction and suggests a greater investment in using AMI technology to better educate the consumer is needed.

3. HOW WILL DIGITAL METERING TECHNOLOGY AFFECT RELIABILITY OF SERVICE, INCLUDING CONNECTIONS, DISCONNECTIONS AND INTERRUPTIONS OF SERVICE? HOW WILL REMOTE DISCONNECTION OF SERVICE FOR NONPAYMENT AFFECT VULNERABLE POPULATIONS?

Summary of Findings

- Interruptions or loss of service jeopardizes the safety of those who rely on electrically-powered medical devices such as nebulizers, and sleep apnea devices (CPAP). In addition, carbon monoxide poisonings, residential fire injuries, and related deaths are much more likely in homes where electricity has been disconnected for nonpayment.
 - There were no measurements of actual outage duration and response time during the ComEd pilot, though the new system was deemed to be able to provide such data in the future. As a result, the HIA cannot draw specific conclusions on service improvements associated with the deployment of AMI.
 - Reductions in the use of ComEd trucks to obtain meter readings, and connect or disconnect service, will likely result in lowering of ambient air pollution load and greenhouse gas emissions.
 - Remote connection and disconnection of service was not tested in the ComEd pilot, although ComEd's business case for AMI depends on implementation of remote disconnection and calculates potential cost savings in avoiding premise visits for this function. If this functionality disconnects customers remotely for nonpayment, current consumer protections associated with a premise visit and attempted contact may be threatened. Analysis of ComEd billing records from 2009 (the year before the pilot) and 2010 (the pilot year) for customers enrolled in the CAP (dynamic pricing rate design) component of the ComEd pilot indicates increasing numbers of households who would otherwise be eligible for disconnection in 2010, likely due to the cost of AMI deployment, compared with 2009 when there was no AMI infrastructure in place.
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a. Literature Review

Typically, electric service quality is measured by regulatory commissions through utility reported information using indices that have been developed throughout the industry: CAIDI or Customer Average Interruption Duration Index (measuring the average customer outage length), SAIDI or System Average Interruption Duration Index (measuring the average duration of interruptions), and SAIFI or System Average Interruption Frequency Index (measuring the entire system's frequency of interruption). All of these metrics exclude widespread interruptions that are due to extreme weather or major disaster, with the result that the typical reliability metrics do not capture lengthy and harmful outages that are typically associated with major storms and widespread outages.

Deployment of AMI can result in service improvements since the utility will be able to detect service interruptions and outages at a meter level, with the potential to lower the duration of outages since the utility can see outages in real time and conduct restoration activities more promptly. This feature will also potentially result in operational savings to the utility which can be passed through to all customers in the form of lower rates. AMI pilots nationally have not quantified the value of any reliability improvements or tracked system improvements due to deployment of AMI alone, though utilities have presented information and projections of such improvements. For example, Baltimore Gas and Electric identified improved reliability as a customer benefit that would result from AMI installation but did not quantify or monetize that benefit in its cost/benefit analysis.⁴¹ San Diego Gas & Electric Co. in California (SDGE) included some calculated benefits to customers due to improved outage management as a result of AMI, though information on the specific dollar amount calculated as a customer benefit to offset improved reliability costs is not available. SDGE's projections of reliability improvements are typical of those offered nationally:

SDG&E contends deploying AMI will improve customer service in several ways. First, it will transform the meter reading process by improving the accuracy and timeliness of utility bills. Second, it will provide near real time energy usage

⁴¹ BG&E's AMI application was filed under Case No. 9208 before the Maryland PSC in 2009.

information empowering customers to make informed choices about their energy usage. Third, by providing customer premise endpoint information, SDG&E will be able to monitor its system continuously, speeding detection of gas leaks and electric system outages. Fourth, AMI will improve safety and provide greater service reliability through superior outage response and service restoration.⁴²

Reliability of service for the HIA also encompasses connection and disconnection of service. In particular, the HIA considers whether the use of a remote service switch to disconnect customers for nonpayment would negatively affect the health of vulnerable populations. As a result of the concerns about potential health and safety impacts of loss of electricity service for non-payment, every state regulatory commission regulates the disconnection of electric service. Consumer protection regulations typically require, at a minimum, advanced written notice and an attempt to contact the customer by telephone to discuss payment terms, handle disputes or complaints, and respond to a declaration of medical emergency, all designed to avoid disconnection where possible. Health and safety figure directly into such consumer protections; over 40 states, for example, prohibit involuntary disconnection of gas or electrical service for nonpayment during the winter months, a growing number of states prohibit disconnection for nonpayment during periods of high summertime heat, and many states offer delays in disconnection for seniors, persons living with serious illnesses or life-threatening conditions that are certified by physicians. The issue of whether remote connection and disconnection functionality should be used for involuntary disconnection of service (typically for nonpayment) has been controversial in many state reviews of AMI investment proposals by electric utilities since it potentially eliminates a visit to the customer's premise by utility personnel. Many states require such a visit not only as a matter of practicality for the disconnection but also as a last attempt to contact the customer at the time of disconnection.

A utility often does not complete the number of legally allowed disconnections of service on any day or week since utilities schedule their field resources to reflect other

⁴² California PUC, Application of SDG&E Co. for Adoption of an Advanced Metering Infrastructure Deployment Scenario and Associated Cost Recovery and Rate Design, Order Approving Settlement, Application 05-03-015, Decision 07-04-043, April 12, 2007, at 12. This benefit was a portion of a \$15.6 million in benefits associated with various T&D benefits.

obligations and needs for both the employees and the vehicles. If there are insufficient trucks and employees to accomplish all potential disconnections, utilities will defer, delay, or simply not accomplish the disconnection for all eligible customers. Some utilities prioritize disconnections for nonpayment based on the amount of the overdue balance, for example, opting to first disconnect customers owing in excess of \$100 even if customers owing \$50 could be disconnected as well. This targets disconnections to those most likely to cause a higher uncollectible amount or who have broken numerous payment plans.

Utilities typically include the benefits associated with reduced expenses to connect and disconnect electric service in AMI proposals. Such expense reductions result from the elimination of the use of utility vehicles and the use of utility employees to implement a disconnection. In a recent compliance filing with the Maryland Public Service Commission, Potomac Electric Power Co. (Pepco) estimated that a continuation of the obligation to conduct a premise visit and attempt to contact the customer at the time of disconnection for nonpayment would eliminate \$45.9 million in projected savings over the 15-year project plan.⁴³

Given the AMI technology capabilities, remote disconnection for nonpayment is likely to increase the volume of disconnections. According to a study issued by the California Division of Ratepayer Advocate, the rate of disconnection of residential customers increased in PG&E service territory once the remote disconnection switch was used with the new metering system:

As stated during the recent report in AMI deployment in California “The increase in digital or “smart” meter shutoffs using AMI technology appears to be disproportionately large compared to shut-offs of homes with traditional meters that require a premise visit. There are now three times more digital or “smart” meters installed, but smart meter disconnections have increased 12-fold in one year.”⁴⁴ In

⁴³ Pepco's Amended Business Case was filed in Case No. 9207 on December 13, 2010 in response to the Commission's Order No. 83571 (September 2, 2010) in which the Commission ruled that Pepco's AMI investment could be implemented under certain conditions, one of which was the elimination of any savings associated with remote disconnection of service for nonpayment. Marty Ahrens, Home Candle Fires, National Fire Protection Association (June 2010)(particular risk of fatalities where candles used in absence of electricity) Exec Summary at ii.

⁴⁴ Division of Ratepayer Advocate, Status of Energy Utility Service Disconnections in California (November 2009), available at: http://www.dra.ca.gov/NR/rdonlyres/2A0C5457-56FC-4821-8C4D-457F4CF204D1/0/20091119_DRAdisconnectionstatusreport.pdf

the first five months of 2009, 46 percent of all customers who lost their power remotely were enrolled in CARE, the California low income bill payment assistance program.

Any increase in disconnections of service has an adverse impact on the customers who are disconnected, since customers without essential electricity service may incur the higher risk of health impacts and potential harm due to the use of unsafe alternatives. Customers may also be forced to sacrifice other necessities to restore service or seek financial assistance. A significant increase in disconnections for nonpayment by lower income customers will adversely impact the financial service organizations that respond to lower income customers who are eligible for aid in the form of emergency grants, since such agencies are likely to be overwhelmed with a significantly increased caseload if remote disconnection is allowed to operate without regulatory oversight.

Opponents of remote disconnection of service maintain that a utility's premise visit at the time of disconnection allows the utility to respond to customer statements at the time of disconnection, detect a medical emergency, or other conditions that may result in forbearance by the utility from effectuating the disconnection of service, and consider the customer's dispute allegations (e.g., "I made a payment this morning down at the payment agent.") if made orally at that time. Several states require a utility to attempt contact and avoid the disconnection upon certain situations, including the option to allow the customer to pay via credit card or other electronic means. Central Maine Power Company's (CMP) submitted evidence to its regulatory commission concerning the actual actions taken by the Company to effectuate its disconnections of service, noting that of the over 54,000 notices that were "worked" in 2008, almost 30,000 (almost 60%) were left connected. A majority were not disconnected because they were not home, but other reasons included collection of funds, check, customer showed receipt, customer made arrangements, declaration of medical emergency, leaving a "green card", etc. Consumer advocates are concerned that such discretion on the part of field personnel could be eliminated if service disconnections are done remotely.

Proponents of remote disconnection argue that any utility service that remains unpaid for becomes a burden on the overall system. Avoiding ongoing bills and the greenhouse gas emissions and costs from needing to send staff to a home for a site visit are cited as efficiencies that can be gained and reduce overall cost as well.

Even though ComEd did not use the remote disconnection feature of the new meters in its AMI pilot, it has stated that it intends to make use of this feature when AMI is deployed throughout its service territory.

An evaluation of ComEd's pilot did address various factors related to this research question, including whether or not deployment of AMI will improve outage management, disconnections of service and air quality, and is discussed below.

Outage Management: The AMI system has the ability to provide near real-time outage status for the electric meters since the meters provide power status information in two ways—automatically and upon request. The automatically generated information includes the power fail indication upon loss of power by the electric meter and power restoration indication upon restoration of power at the meter. Additionally, the AMI system provides the capability for a user or application, such as the Outage Management System (OMS), to generate an on-request service to query the power status of a particular meter or group of meters. Because of this, it is anticipated that ComEd will experience fewer "OK on Arrival" occurrences (i.e., customers that had a power outage that was restored on a separate, previous outage ticket) and will not need to send a first responder to the field needlessly to address customer outage tickets that result in positive power status verification. ComEd will now be able to ascertain near real-time power status via a query to the AMI system or via automatically provided power status indication that will more accurately reflect the current state of restoration activity and allow resources to be utilized more efficiently. This will also reduce costs to call customers to confirm power restoration. With the ability to automatically, or on-request, receive outage information from meters throughout the system, the ComEd OMS can more effectively track and manage the actual outage conditions. Through a better understanding of the state of the system during major storms, ComEd should be able to more effectively deploy and coordinate emergency restoration resources. This should translate into decreased time allotted for storm restoration and savings in overtime and contractor expenditures. Shorter outage times should have positive impacts on health, given the well documented health effects of loss of electricity discussed in previous sections. Studies of blackouts from natural disasters document not only dangerous use of alternative sources of heating and lighting, which can be linked to fire hazards and death. Long term loss of electricity can also cause food spoilage, medication loss, and inactive medical devices that can be life threatening as well.

Bad Debt: By using new business practices in conjunction with the disconnect switch automation, ComEd estimates that it will be able to cut off services in a more timely manner because back office and field work capacity constraints will be reduced. In Illinois, bad debt is socialized among all customers, and an increase in the pace of disconnections should lower bad debt expense for remaining ComEd customers. A decrease in the time it takes for a customer to be disconnected should also lower the ultimate balance owed by the customer, improving odds of repayment and service restoration as well as avoiding potential collection activity. Through remote connection of service, service can be restored to customers disconnected for nonpayment much more rapidly as well.

Avoided Power Plant Emissions: Black & Veatch evaluated the operational aspects of ComEd's AMI pilot, and developed a conservative estimation of the potential CO₂ equivalent emissions associated with the customer use reductions observed during the pilot project and as projected due to full-scale AMI implementation. Reductions in total energy consumption will result from successful efforts to eliminate theft and tamper conditions, with additional reduction is also estimated due to voluntary customer reductions attributed to web-based presentment of energy usage information. In all, Black and Veatch estimated approximately 380,000 MWh would be reduced during a typical year once the AMI system is fully installed. To the extent that these reductions reduce power plant cycle times, air emission reductions will result also. When considering the losses associated with the transmission and distribution of energy over long distances, the result is a total avoided generation requirement of 415,000 MWh. After computing emission effects using EPA eGRID factors for calculating CO_{2e} related to electricity consumption, Black and Veatch estimated the avoided generation of 415,000 MWh/year yields avoided CO_{2e} per year of 650,000,000 pounds avoided CO_{2e}, or approximately 325,000 tons CO_{2e}, roughly comparable to the output of a modest sized (750 MW) power plant operating for approximately 10% of its hours based on a 60% duty cycle.⁴⁵

⁴⁵ According to Black and Veatch, Exelon Corporation, the parent company of ComEd, is implementing a business and environmental strategy — Exelon 2020 — to reduce, offset, or displace 15.7 million tons of CO_{2e} by 2020, which includes accounting for customer abatement of emissions due to energy efficiency and demand reduction programs. Black and Veatch's estimations were developed using a different methodology than Exelon uses for its Greenhouse Gas (GHG) accounting which may not be fully representative of Exelon's internal GHG Inventory Management Plan or Customer Abatement protocol. For Illinois, which is in eGRID region RFC West, the CO_{2e} emission factor is 1,559.94 lbs/MWh.

Avoided Vehicle Emissions: AMI implementation means fewer vehicles travelling to support meter reading and field meter service operations. Black and Veatch used data from ComEd to estimate 4.4 million miles of travel would be eliminated each year on average.⁴⁶ While the reduction is positive, the total emissions reduced are negligible in comparison to the regions total Vehicle Miles of Travel VMT, and the emissions are also hard to quantify given the wide range of duty cycles and emission factors for the vehicle fleet. VMT reduction of approximately 4 million is a very small percentage of the estimated billions of miles of travel by households in the greater Chicago area each year.

b. Primary Data Analysis – ComEd Data

In approving the ComEd Pilot, the ICC ruling stated Illinois law:

“clearly contemplates a site visit by a utility employee upon disconnection. While we acknowledge that the language in this regulation may have contemplated the world as it existed before AMI technology, a site visit upon disconnection affords a valuable service to consumers, and, in certain circumstances, (e.g., when a safety issue is detected upon the site visit) to ComEd. ComEd shall not remotely disconnect a program participant unless such disconnection is in accordance with 83 Ill. Adm. Code 280.130(d) and any other pertinent regulations.”

While the terms of the Commonwealth Edison AMI pilot included an agreement not to activate the remote disconnection functionality of AMI, residential customers remained subject to potential disconnection for nonpayment. Given the potential increased costs on the bill impacts described previously, it is important to examine the number of customers eligible for disconnection. Using primary data provided by ComEd, the HIA assessed the number and proportion of customers eligible for disconnections.

⁴⁶ This represents a net change since there are some increases in vehicle miles of travel within the Field Meter Services due to new types of inspection activities. The reduced Vehicle Miles of Travel (VMT) are principally in passenger and light duty vehicles.

Table 13. Annual total and monthly number of accounts that were eligible for service disconnections in the billing months of 2009 and 2010

Actual Disconnection for Non-payment Among Residential Accounts who Received Smart Meters in the ComEd Pilot		
	2009 (TOTAL)	2010 (TOTAL)
Single Family Without Electric Space Heat	4068	9
Multi Family Without Electric Space Heat	3332	20
Single Family With Electric Space Heat	34	0
Multi Family With Electric Space Heat	332	1
Disconnections Among Accounts Assigned to CAP		
CPP (5 treatment cells)	91	0
PTR (4 treatment cells)	53	0
IBR (3 treatment cells)	24	0
FLR (6 treatment cells)	41	17
DAP (4 treatment cells)	43	0
TOU (5 treatment cells)	49	0
Disconnections Among Accounts Enrolled in CAP		
CPP (5 treatment cells)	65	0
PTR (4 treatment cells)	42	0
IBR (3 treatment cells)	23	0
FLR (6 treatment cells)	33	12
DAP (4 treatment cells)	35	0
TOU (5 treatment cells)	37	0

Table 14. The annual monthly average of accounts ELIGIBLE to have their service cut in the billing months of 2009 and 2010.

Residential Accounts who Received Smart Meters & Are Eligible Have DISCONNECTED service		
	<i>2009 MONTHLY AVG Across treatment cells</i>	<i>2010 MONTHLY AVG Across treatment cells</i>
Single Family Without Electric Space Heat	1658	1979
Multi Family Without Electric Space Heat	1542	1915
Single Family With Electric Space Heat	12	10
Multi Family With Electric Space Heat	111	119
Eligible Disconnections Among ALL Accounts Assigned to CAP		
CPP (range of 5 treatment cells)	10.52 (4.5-14.3)	17.1 (9.5-22.8)
PTR (range of 4 treatment cells)	7.2 (4.5-7.0)	10.0 (6.9-17.6)
IBR (range of 3 treatment cells)	4.2 (3.5-4.6)	6.2 (5.7-6.5)
FLR (range of 6 treatment cells)	4.2 (1.9-6.3)	7.6 (2.5-14.2)
DAP (range of 4 treatment cells)	6.2 (4.3-11.6)	10.8 (6.3-17.9)
TOU (range of 5 treatment cells)	5.0 (2.3-9.1)	8.9 (4.5-18.7)
Eligible Disconnections Among Accounts CONTINUOUSLY Enrolled in CAP throughout Pilot		
CPP (range of 5 treatment cells)	7.6 (3.3-11.3)	13.5 (7.6-19.6)
PTR (range of 4 treatment cells)	6.1 (4.1-9.0)	8.4 (5.8-14.4)
IBR (range of 3 treatment cells)	3.7 (3.1-4.5)	5.5 (5.3-5.9)
FLR (range of 6 treatment cells)	3.4 (1.9-4.4)	5.8 (2.5-10.5)
DAP (range of 4 treatment cells)	5.3 (3.3-10.4)	9.1 (3.3-10.4)
TOU (range of 5 treatment cells)	4.2 (1.3-7.8)	7.4 (3.4-15.0)

The disconnection rate among residential accounts with digital meters was examined for the years 2009 (the year prior to the pilot) and 2010 (the year of the pilot). Table 13 is broken down to reflect actual disconnections for nonpayment by house-type and heating system, and also by dynamic pricing plan enrollment. To determine the total number of disconnections based on rate plan, disconnections for each treatment cell within a rate plan were summed to provide the total number of disconnections in 2009 and 2010 for that particular rate plan. The chart shows that the number of actual disconnections that ComEd implemented dramatically decreased in 2010 for the pilot participants even though an increasing number were eligible for disconnection.

The HIA examined both the number of people in each treatment cell that were originally assigned to the CAP pilot and the smaller group of customers that actually

stayed in the CAP pilot continuously. Given ComEd's decision not to disconnect pilot customers, it is not unexpected to see the dramatic decrease in disconnection. However in Table 13, there was a change from 2009 to 2010. After enrollment in the Customer Applications Pilot, it appears that at much higher rate of homes would have been eligible and disconnected. Remote disconnection for non-payment using AMI technology could result in more disconnections than previously seen before AMI, placing vulnerable populations at risk of adverse health impacts associated with disconnected service.

For this specific analysis of accounts eligible for disconnection, an average of eligible accounts was taken for each billing month in 2009 and each billing month in 2010, and was broken down by housing type and heating system. To determine the average number of eligible accounts by rate plan, the average number of eligible accounts for each treatment cell within each rate plan was summed and divided by the total number of treatment cells. Table 14 shows the monthly average and also the minimum and maximum average numbers of eligible accounts within each rate plan. With the exception of Single Family with Electric Space Heat, the number of eligible accounts increased between 2009 and 2010

Some of the data above does not have comparisons, but suggest that remote disconnection could be increased under an AMI deployment based on the CAP pilot programs. However, there is no data available for non-CAP families.

c. Impact Analysis

The HIA does find that AMI deployment could result in faster reconnection of service, such as during a storm, though there was no evidence presented in ComEd's pilot around that potential benefit. It is certainly true that the loss of electricity would have an adverse impact on vulnerable customers who depend on electrically-powered medical devices, such as nebulizers, and refrigeration for insulin. With regard to reliability of service, the HIA also finds that it is difficult to quantify reliability as these metrics are not generally captured regularly by regulators. As a result of this, it is difficult to assess reliability of determining storm or disaster-related outages.

Loss of electricity, whether from a storm or disconnection of service, poses a risk to customers. Carbon monoxide poisonings, fire injuries and related deaths are more likely in homes where utility service has been disconnected for non-payment. Utilizing a remote service switch for the connection and disconnection of service is

more likely to result in an increase in the pace and frequency of disconnections for nonpayment. Though ComEd did not utilize this feature, when comparing the number of ComEd customers from the year before and year of the pilot it appears there were more accounts eligible for disconnection, which is consistent with data from previous sections suggesting higher costs for pilot accounts relative to the average customer in ComEd service territory at large. Given the AMI technology and ease for remote disconnection, this increase in eligible accounts is important to consider in evaluating the potential impacts associated with AMI deployment where remote disconnection is proposed to be implemented.

C. Summary of Impacts

The findings detailed above follow from the hypotheses and research questions assembled by the HIA team and stakeholders regarding the relationship between AMI deployment and population health in the Chicago region. Findings from the literature (including ComEd’s own studies), existing datasets on health and the vulnerabilities of Chicago residents, and the HIA’s analysis of primary data from ComEd’s AMI pilot in Cook County informs the understanding of the relationship between the decision to deploy AMI and the terms of deployment on the health of the population served by Commonwealth Edison.

Table 15 places the key findings from the HIA assessment into the context of the health determinants that were the focus on the HIA: fuel poverty, adequacy of housing, and AMI’s enhanced two-way functionality, unintentional injuries and premature deaths, vulnerability to heat or cold, and ambient air pollution. Findings are presented according to the direction of impact, magnitude of impact, severity and likelihood of impact, distribution of impact, and the quality of evidence. While the average bill for customers on dynamic pricing programs was slightly lower than the average bill for all residential customers without an AMI meter, the average bill for customers on the flat rate, which we expect will be used in the AMI deployment, was higher. Therefore, this table characterizes the health impact of higher electric bills. If the recommendations are implemented, and electric bills decrease, the direction of many arrows will change.

PREDICTED HEALTH IMPACTS OF AMI IN COMMONWEALTH EDISON SERVICE TERRITORY

Health Determinants and Outcomes	Size of At-Risk Group (Direction Negative Unless Otherwise Noted)	Severity/Likelihood	Quality of Evidence
FUEL POVERTY FROM HIGHER ELECTRICITY COSTS			
Pressure on Household Budgets	All households with AMI	▼▼▼	●●●●
Poor Nutritional status	12% of Illinois households that are food insecure	▼▼▼	●●●●
Decreased Access to Health Care	10.2% of adults report limited access to physician due to cost	▼▼▼	●●
	12.4% of adults report limited access to prescription Rx due to cost	▼▼▼	●●
Poor Housing Quality	5.2% of households report moderate/severe housing problems	▼	●●●●●
HEALTH IMPACTS RELATED TO AMI TECHNOLOGY			
Reduced Air Pollution from Fewer Emissions	28.9% of adults report high blood pressure or cardiovascular disease	=	●●●●
	14% children, 13% adult population with asthma		
Remote Connection After Disconnection	All households with AMI	=	●
Remote Disconnect for Nonpayment	47% of households have housing costs > 30% of income	▼▼	●●
Exposure to Non-ionizing Radiation	All Households with AMI	=	●
UNINTENTIONAL INJURIES & PREMATURE DEATHS FROM DISCONNECTED SERVICE			
No Access to Electrically Powered Devices for Medical Uses	25% of low income households use electrically-powered medical device	▼▼	●
Use of Alternative, Risky Sources for Heat & Light	0.2% of poor households nationally heat home with cook stove	▼▼	●●●●
	13.3% of households use portable electric space heater		
TEMPERATURE-SENSITIVE CONDITIONS MADE WORSE BY EXPOSURE TO HEAT OR COLD			
Decreased Access to Cooling	56.6% of low income households report no central a/c (37.9% of all households)	▼▼▼	●●●●●
Decreased Access to Heating	20.3% of low-income households report electricity as main heating fuel (11.3% of all households)	▼▼	●●●●●
Heat and Cold-related Illness (e.g., heat cramps, hyperthermia, hypothermia)	Age (7.2% of households include child < 5 yrs, 11.2% of households include elder 65 yrs +)	▼▼▼▼	●●●●●
	Social isolation (18% adults report no social support; 31.6% of low-income seniors live independently)		
	Disability status (5.6% households include member living with mobility-limiting disability; 10.2% of low-income households include member living with mobility-limiting disability)		
Heart Disease	28.9% of adults report high blood pressure or cardiovascular disease	▼▼▼	●●●●●
Respiratory Disease	14% children, 13% adult population with asthma	▼▼▼▼	●●●●●
Diabetes	8% of adults report diabetes diagnosis	▼▼	●●●●

LEGEND:

- ▼▼▼▼ Strong impact on many
- ▼▼▼ Strong impact for medium number or moderate impact on many
- ▼▼ Moderate impact on medium number or strong impact on few
- ▼ Moderate impact on few
- 10+ Strong studies
- 5-10 + Strong studies or data analysis
- < 5 Strong studies OR 5 or more studies of moderate quality
- < 5 studies of moderate quality OR studies with mixed results
- There is evidence to suggest impact, however none was found during the pilot or there was insufficient evidence to comment

IV. RECOMMENDATIONS

The HIA makes the following set of recommendations based on the analyses presented in the preceding chapters and the findings summarized above. The recommendations focus on: 1) the increase in AMI-related costs to consumers during the years of deployment; 2) what are anticipated to be the likely dynamic pricing programs associated with the deployment of AMI; and 3) impacts on the reliability of service associated with the deployment of AMI, including the use of remote connection and disconnection of service.

Because the cost recovery for these AMI projects are typically started early, such as the first five to seven years, it is important to focus on the potential health impacts during this time. Since most customers will see a rise in the cost of electricity before the cost savings can be appreciated, it is important to estimate health impact in that window. Even small changes in cost will have a potential negative health impact on vulnerable populations. Vulnerable populations are an importance focus of this HIA since the health literature documents well how sensitive they are to small swings in prices if they are low income. Therefore, recommendations #1 and #2 focus on remedies to minimize this negative health impact.

However, not all vulnerable populations are low income. Elders can be vulnerable because of social isolation, placing them at risk for illness related to swings in temperature if they are unable to heat or cool their homes sufficiently and cannot seek help. Children can be vulnerable because of their sensitivity to temperature as well and therefore any pricing plan that discourages these vulnerable populations to use electricity to heat in cold weather or cool in hot weather has potential for negative health impact. Recommendation #3 focuses on which variable pricing programs and deployment methods are most health protective.

Given that falling behind on an electricity bill, the precursor to remote disconnection, makes it very likely that a customer is starting to make trade-offs between heating, cooling, food or medicine, it becomes imperative that these vulnerable customers receive education and regulatory protections. The negative health impacts of loss of electricity are extreme, with documented deaths from temperature sensitivity or fires from using alternative heating fuels such as kerosene, propane or wood. Recommendation #4 addresses how these populations might benefit if the utility makes use of the enhanced information from the AMI system to develop new and potentially innovative programs.

Lastly, given the importance of electric service and the importance of its affordability for vulnerable customers, programs must be developed to assist lower income and vulnerable customers to identify safe and effective means to reduce usage and the monthly bill. Engaging the public in that endeavor is part of recommendation #5.

Recommendations

1. Analyze proposed terms of deployment with respect to clearly defined groups and at-risk residential customers, including an analysis of the likely impacts on health and safety.

Regulators and policy makers should carefully review and evaluate the costs and the benefits from the perspective of vulnerable customers and include a consideration of health impacts for not only the average customers, but those most vulnerable to higher prices for essential electricity service. This analysis should focus on ensuring that AMI deployment delivers the expected customer benefits in the form of reduced operational costs within the period of AMI deployment, and review of any proposed cost recovery mechanism to determine the adverse implications of higher bills for vulnerable customers. Pertinent information should be analyzed as described in section III, in which this HIA analyzes the primary data collected from the ComEd pilot program. In addition, data must be collected about characteristics or indicators of vulnerability for residential customers to permit designating of their accounts for analysis of AMI impacts. Data parameters should include indications of hardship, such as missed payments, delayed payments, or non-payments. Applications for utility financial assistance should also be considered an indicator of vulnerability, as should any appeal made by a residential customer to the utility company for assistance, including application for medical considerations including but not limited to the submission of a 30 day Certificate of Illness in accordance with Illinois Administrative Code Part 280.130(j) or an application for the Life Support Registry in accordance with the Public Utilities Act (220 ILCS 5/8-204) (from Ch. 111 2/3, par. 8-204). Periodic surveying of residents should take place to determine the prevalence of disease, changes in the disease status, and the presence of increased hardship across the board. Surveys should also be used to determine whether there has been any widespread changes in the general population (including job status, health developments among children, or any new injuries/disabilities) to determine if cost recovery practices are appropriate.

2. Proposed cost recovery from electric customers should link benefits and costs for vulnerable customers specifically, in addition to linking benefits that are documented and realized for all customers.

Costs should not be imposed on vulnerable customers unless the benefits are realized at the time that costs are imposed. The cost recovery method should consider the potential for eliminating rate increases to pay for AMI for low income customers if the benefits cannot be delivered at the time of imposing the costs. Utilities should be required to make enforceable commitments concerning costs and benefit estimates, and penalized for the failure to meet specific performance requirements during AMI deployment. Utilities should be required to enhance and further develop their ability to identify and respond to the needs of their vulnerable populations. Specific cost indicators should be monitored throughout the first years of deployment, such as reporting on utility bill impacts for vulnerable customers.

3. Proposed time-based pricing programs for AMI should offer incentives for vulnerable households to optimize their use of electricity from the perspectives of health as well as of energy efficiency.

Programs that reward customers for reduced usage (such as a Peak Time Rebate) rather than charging very high prices for certain times of day (such as Critical Peak Pricing) will benefit vulnerable customers. Components of this recommendation include:

- a. All dynamic pricing programs should be offered on an opt-in basis to improve customer response.
- b. A Peak Time Rebate program should be offered to all customers. Any other time-based pricing programs should be offered as an option and not imposed on customers as a mandatory or “default” price design.
- c. Customers must be allowed to revert back to flat rate pricing at any time without penalty.
- d. Customers on a dynamic pricing plan must be given timely information regarding their cost and usage status, including insight as to what their bill would be if they were on an alternative plan offered by that utility.

4. The remote connection and disconnection functionality of AMI, especially in the case of involuntary loss of service for nonpayment, must be deployed to promote and not endanger the health and safety of vulnerable customers.

There was not full agreement among the HIA analytic team as to the optimal way to implement this recommendation.

All HIA team principals agree that, at present, Illinois does not have consumer protections that offer a targeted means to prevent disconnection remotely when health or safety is at risk for “vulnerable” customers because those customers, as defined in our HIA, are not identifiable in the utility’s billing system. The HIA analysis of the ComEd pilot documented a potential for an increase in the incidence of disconnection for nonpayment among the households eligible for disconnection for nonpayment during the pilot period. It is likely that greater numbers of low-income households will lose their access to electrical service more quickly if a utility uses remote disconnection for nonpayment because (1) bills will be higher to pay for the new AMI and smart grid investments in the early years of deployment; (2) the elimination of the need for a truck and field personnel to disconnect will mean that larger numbers of customers with overdue bills can be disconnected earlier in the collection cycle.

Currently in Illinois there are limited temperature based proscriptions on utility shutoffs (220 ILCS 5/8-205) (from Ch. 111 2/3, par. 8-205) and a date-based proscription on shutoffs for LIHEAP recipients (280.136) This represents an inadequate patchwork of consumer protections that allow vulnerable households to suffer disconnects during dangerous temperature conditions even under traditional circumstances.

Best practices from other states include shutoff prohibitions for nonpayment during winter, either proscribing shutoff between specified dates (seasonal moratorium) or when temperatures drop below specific readings; prohibition of shutoff of electrical service for nonpayment during extreme heat, when ambient temperatures reach a specific reading or when the National Weather Service issues a heat advisory; and the delay of shutoff for nonpayment for consumers who obtain medical certification that a household member is an infant or young child, an elder, or someone living with a serious or life-threatening illness (specific provisions vary from state to state). In the case of remote disconnection, several states, including New York, Ohio, and

Maryland, have mandated that AMI deployment not eliminate the requirement of a premise visit and attempt to contact the customer at the premises prior to disconnection for nonpayment, on health and safety grounds.

This HIA recommends that:

- Utilities should first attempt to promote efficiency programs that might reduce the size of the electric bill and reduce the potential for arrears balances that are unaffordable, and be required to develop targeted messages and new programs that specifically make use of the AMI system to offer no cost or low cost efficiency and conservation programs. While lower income customers typically cannot afford additional investments for efficiency (such as weatherization or more efficient appliances), utility programs should include a robust and well-funded program for no cost and low cost efficiency programs for qualified low income customers.
- Any approval for the deployment of AMI technology should be accompanied by a requirement that the utility sponsor and submit a community education and outreach plan that will integrate the programs that are enabled by AMI deployment and associated communication capabilities into existing programs that target isolated elderly, who may not have the means or understanding of how to contact their utility company, and medically vulnerable customers with options to respond to loss of power for essential heating and cooling and unaffordable electricity bills. For example, California regulations require a premise visit so that the customer has an opportunity to make a noncash payment for households where a member is flagged as being on life support (with a specific list of life support equipment included in the regulation) or having medical certification of a number of conditions (compromised immune system, life-threatening illness or other condition for which additional heating or cooling is medically necessary to sustain the person's life or prevent deterioration of the person's medical condition). Such medical certification may be specified for a set time period or be classified as permanent, with renewal every 2 years.
- Any approval for the deployment for AMI technology should also require the utility to analyze usage data to assist targeting of education, efficiency and demand response programs for all customers, but particularly those identified as low income as a result of their participation in utility-sponsored low income bill payment assistance programs, or those who receive state and

federal energy payment assistance. The utility’s education and outreach programs should provide individually tailored usage and bill impact information, including usage reduction and conservation information to such customers, using the communication methods preferred by the customer. For those customers without high-speed internet access, such information should be provided through the mail and, where the customer agrees, through smart phone applications and text programs.

The current obligation of Illinois consumer protection regulations regarding customer contacts and the requirement of a premise visit prior to disconnection for nonpayment should not only be maintained, but expanded. In approving the ComEd Pilot, the ICC ruling states Illinois law:

“Clearly contemplates a site visit by a utility employee upon disconnection. While we acknowledge that the language in this regulation may have contemplated the world as it existed before AMI technology, a site visit upon disconnection affords a valuable service to consumers, and, in certain circumstances, (e.g., when a safety issue is detected upon the site visit) to ComEd. ComEd shall not remotely disconnect a program participant unless such disconnection is in accordance with 83 Ill. Adm. Code 280.130(d) and any other pertinent regulations.”

All HIA principals agree that remote disconnection when requested by the customer, and remote re-connection are important uses of AMI technology. All HIA principals agree that any disconnection for nonpayment must be done in accordance with current Illinois consumer protections. In particular, however, not all principals agreed that a premise visit would continue to be necessary and valuable in the “AMI world” contemplated by the ICC in 2009. Some principals (NCMLP, consultants B. Alexander, L. Snyder) believe the evidence in Illinois and nationally show that a premise visit and customer contact affords a service to customers, most often because customers can arrange for payment options or other programs that would prevent the disconnection of service. Other principals (CUB) question whether there is evidence in Illinois that a premise visit in an AMI regime would offer the benefits it might in other states, and that with AMI, payment troubled customers may well be better served. During the time it takes to schedule a premise visit, these customers can accrue large unpaid balances, which are beyond what existing low-income assistance programs can address. Without large unpaid balances, these customers can pay their bill and be remotely re-connected quickly using AMI technology. Customers that

remain connected with unpaid bills potentially endanger their credit score and the balance is collected from all other ComEd customers.

This requirement for a site visit and customer contact prior to disconnection of service is only one of a wide range of consumer protections that could be adopted to ensure that disconnection is the last resort and not the first resort in the collection of overdue bills, especially for low-income or vulnerable households. It is appropriate to recognize that the prohibition on the use of remote disconnection without compliance with the current premise visit and customer contact requirement is a blunt tool in response to the over-arching issue of fuel poverty and the need for essential electric service for vulnerable customers. Though it is not possible to consider a wide range of potential improvements in consumer protection policies in the context of a proposal for AMI deployment at this time,⁴⁷ in the long run it may be possible to craft more targeted consumer protection and assistance programs to vulnerable customers so that an elimination of the premise visit requirement may be more appropriate to consider. Until such time as Illinois consumer protection regulations devise alternate means to address the health and safety issues connected with remote disconnection, all HIA principals agree that the current Illinois rule should be maintained. Most HIA principals agree this requires a premise visit and customer contact and prohibits the use of remote disconnection for nonpayment.

⁴⁷ Such protections could include a more expansive use of medical certifications to prohibit disconnection for customers with ongoing medically certified conditions, summer and heat-related moratoria on service disconnection that are strengthened and enforced, more liberal payment arrangement terms, and fully funded low-income weatherization that could include appliance replacement and bill payment assistance programs.

5. Any AMI deployment and programs that seek customer engagement to make use of the new metering and communication system should be accompanied by robust consumer education and outreach to customers to obtain their awareness of and participation in approved programs.

An approval of AMI deployment should require the development of a Customer Education Plan that focuses on AMI-enabled programs with the input of stakeholders and include specific performance requirements to measure the utility's implementation of the approved plan, including the following requirements:

- a. Outreach and education for any specific pricing or conservation program should target groups at higher than average risk for adverse impacts, including seniors during the summer months and low-income households that rely on electricity for their primary heating fuel in wintertime. The Customer Education Plan should be coordinated with the City of Chicago's heat health response plan, to ensure that access to adequate home cooling, or a centrally air-conditioned environment, is maintained for seniors within ComEd's service territory. This plan should include tutorials describing how new pricing programs and conservation initiatives can be helpful to such customers. Additionally, the utility's outreach program could include replacing old inefficient air conditioners with new energy efficient ones for vulnerable households, enrollment in energy saver plans and referrals to weatherization agencies.
- b. This education and outreach should include participation and delivery of educational messages and information by local and neighborhood organizations that are mostly likely to interact with vulnerable customers. These organizations could include utility assistance locations, healthcare practices, legal aid offices, etc. By having this information available, these organizations will be able to offer advice and resources for vulnerable customers should they require assistance with the any new programs that take advantage of the AMI technology.

V. MONITORING

The purpose of a Health Impact Assessment is to bring a data-driven, systematic approach to understand the ways in which a policy or program decision is likely to affect health, in order to ensure that the decision promotes health to the greatest extent possible. The monitoring section of the HIA is designed to track the impact that the assessment has on the decision in question, the implementation of the decision, and how any of the determinants of health may change as a result of implementation. Has the HIA influenced the decision making process and its outcomes? What impacts has AMI deployment had on the health determinants, characteristics and indicators of population health? Have there been changes in AMI deployment that reflect the HIA?

Monitoring goes hand in hand with dissemination of findings. HIA partner Citizens Utility Board has the primary role in monitoring, together with other local and state partners in consumer protection related to residential utility service within Illinois.

For this Health Impact Assessment, evaluating the ComEd AMI pilot, the following monitoring plan has been developed:

1. *Summary of Impacts:* The HIA finds that AMI implementation could result in higher residential energy costs for vulnerable populations. There would be economic incentives for customers to use less electricity when it is most needed for central air conditioning (i.e., critical peak pricing). Disconnections and reconnections for nonpayment, and remote disconnections, would likely be expedited.
2. *Description of Mitigation Measures:* This HIA makes the following policy recommendations:
 - c. Clients should be able to opt-in to a pricing plan, rather than having it be made mandatory for AMI and for pricing
 - d. Peak time rebate should be offered over the critical peak pricing design
 - e. Consumer education about health and safety aspects of energy usage and indoor temperatures should be integral to AMI deployment.
 - f. With oversight by the state regulatory body (the Illinois Commerce Commission), Commonwealth Edison should monitor the experience of at-risk populations through flags on accounts, to identify these

accounts to be protected by a prohibition of remote disconnection for nonpayment.

3. *Monitoring the Impact of this HIA on the decision:* Consumer groups, such as Citizen’s Utility Board or others, can track ComEd’s progress on implementing the recommendations made by this HIA.
4. *Monitoring AMI Implementation:* The ICC should require ComEd to monitor and report bill impacts and disconnection eligibility of at-risk households whose accounts have been flagged (information provided voluntarily by customers), and will make this data public so that it can be tracked over time. CUB will track consumer issues related to the cost of energy and regulated consumer protections. This should include public reporting to stakeholders about AMI deployment in the form of a report card, scoring the terms of deployment against the HIA recommendations
5. *Monitoring health outcomes:* The ICC should gather information on a regular basis regarding health indicators, such as respiratory disease, described in this HIA for review and discussion in its proceedings. This would include tracking and reporting at the national level, by NCMLP and EPC, on Chicago’s experiences with AMI from the perspective of population safety and health.
6. *Implementation Schedule and Reporting:* This will depend on the ICC decision regarding how best to deploy AMI.

VI. CONCLUSION

This HIA addresses the health and safety implications of one aspect of AMI, digital metering, that is being tested by utilities across the United States. Commonwealth Edison's piloting of a year-long study of AMI, including a study of consumer behavior around energy use, presented a unique opportunity to identify the range of ways in which electrical service influences health and safety, in order to develop a set of recommendations to ensure that future decision-making around AMI, specifically in the Chicago region, takes the health and safety implications of access to electrical service into account. The HIA explores both the deployment of AMI as a new technology from an operational standpoint, apart from the rate pricing, as well as the implications of different rate designs (critical peak, peak time rebate, and time of use, as well as flat rate) facilitated by deployment.

The HIA finds that fuel poverty is likely to be increased by AMI deployment, with likely adverse impacts on low-income households, in terms of reduced affordability of housing and increased pressure on household budgets. These pressures translate into diminished nutritional status for young children and elders, reduced access to necessities that involve cash payment (household basics, health care, medically necessary prescriptions) and a decline in the adequacy of housing quality, as reflected in increased exposure to temperature extremes, greater accumulation of moisture and growth of mold, and deterioration in indoor air quality related to the more frequent use of gas ovens or stoves for heat (e.g., higher levels of nitrogen dioxide, greater risk of carbon monoxide exposure). With a sizable proportion of the metropolitan region population including persons with temperature-sensitive conditions (heart disease, respiratory disease, diabetes), disproportionately likely to be members of low-income households, it is likely that the burden of chronic illness will increase as households, particularly those where a senior lives independently, respond to higher prices for electricity by electing not to use air-conditioning during hot days or by maintaining homes at colder temperatures in wintertime. The HIA also makes recommendations to mitigate these anticipated adverse outcomes, both in terms of tracking potentially vulnerable households for enhanced consumer protections and in deploying AMI in terms that protect at-risk consumers.

Given the rate and pace that AMI is being deployed in other states across the country, these findings and recommendations should be incorporated into future policy decisions on AMI. Since the cost of electricity, variable pricing programs and other aspects of AMI can impact vulnerable populations and these groups exist in all states,

the principals believe this HIA answers many questions relevant to the debate for policy-makers in Illinois and beyond.

At the time the ComEd pilot was approved and designed, stakeholders in Illinois had many questions on whether or not the benefits of AMI would outweigh the costs, given that AMI systems are very expensive infrastructure investments. Furthermore, the residential customer response to – and satisfaction with– new pricing programs for electricity was also a matter of speculation. Whether or not residential customers would see a net benefit if AMI was deployed across ComEd’s service territory was, and continues to be, the subject of much debate in Illinois as it is in other states. This HIA provides an important and novel addition to this debate by focusing on the identification of potential health impacts associated with the deployment of AMI and the identification of consumer protection policies that might ameliorate adverse health impacts where they are likely to occur.

APPENDIX 1: PROJECT PRINCIPALS

Project Principals:

- National Center for Medical-Legal Partnership
- Energy Programs Consortium
- Citizens Utility Board
- Barbara R. Alexander, Consumer Affairs Consultant

Stakeholder Advisory Group members:

- AARP
- ABA Medical-Legal Partnership Project
- AgeOptions (Suburban Cook Area Agency on Aging)
- CEDA
- City of Chicago Department of Environment
- CNT Energy
- Environmental Defense Fund
- Health and Disabilities Advocates
- Illinois Office of Energy Assistance
- Legal Assistance Foundation of Metropolitan Chicago
- Loyola Health Justice Project
- National Consumer Law Center
- South Austin Coalition
- University of Chicago/Friend Family Health Center

APPENDIX 2: SCOPING PATHWAYS

Four scoping pathways inform the HIA. The first pathway depicts health outcomes associated with the deployment of digital meters with no change in the pricing or rate for electrical service (flat rate), aside from the cost to install and maintain new metering infrastructure, and the other three pathways illustrate a set of hypotheses about health outcomes predicted to accompany the use of variable rates for pricing of electricity. The ComEd pilot tested 24 different combinations of rate design and communications devices in connection with digital meter deployment, which the HIA summarizes and simplifies in terms of a second set of pathways, each identical in analyzing the health impacts for three dynamic pricing programs: critical peak pricing (or charging more for electricity consumed during predetermined high-demand periods), peak time rebate pricing (offering a rebate for lowered electrical consumption during high-demand periods), and time-of use (with different rates charged depending on the time of day).

The HIA scoping pathways depict a set of influences or determinants of health linked to digital metering. These determinants put residents at greater risk of impact from digital metering deployment, and include:

For Flat Rate Deployment:

- Affordability of housing
- Household budget or poverty
- Nutritional status
- Access to health care and to medications
- Adequacy of housing (this includes issues of reliability of service and exposure to non-ionizing radiation from digital meter radio transmitters)
- Unintentional injuries and deaths
- Vulnerability to indoor heat or cold
- Air pollution (related to substitution of remote meter reading and meter connect/disconnect for real-time transportation of meter readers in the field),

For Deployment with Variable Rate Pricing (Critical Peak, Peak Time Rebate, or Time of Use)

- Determinants listed above for flat rate deployment
- Air pollution (related to peak load shifting or reduction, potentially reducing generation by coal fired power plants)

For all of the scoping pathways (flat rate and dynamic rate deployment), the HIA explores the impacts of a set of proximate effects related to pricing (influence on fuel poverty and energy use behavior related to the perception of price), the reliability of service, and the physical effects of the meter itself (radio-frequency radiation and remote disconnection capacity). For the dynamic pricing pathways, an additional set of proximate effects is related to the objectives of changing how consumers are charged for electricity, namely, the shifting of demand or load for electricity from peak to non-peak hours and the reduction of demand for electricity in response to price signals.

Scoping Pathway #1: Flat Rate Deployment

Pricing:

The anticipated increase in the net price of electricity reflects the costs of purchasing and installing the infrastructure and software for digital meters, maintenance and troubleshooting, and customer service (with the ICC deciding on the extent to which these costs are passed on to consumers). Higher utility rates are likely to increase fuel poverty or energy insecurity, which makes housing less affordable and puts greater pressure on household budgets. Energy insecurity is linked to diminished nutritional status for young children and for elders, lessened access to health care and medications, and also influences the quality of housing (in terms of indoor temperature, presence of moisture or mold, and other housing-related health concerns). Through the health determinants of nutritional status, access to care, and housing quality, energy insecurity is linked to changes in hunger and growth in children, increased stress and related mental health symptoms, and a worsening of pre-existing chronic illnesses that are temperature-sensitive. Higher rates for electricity are also likely to result in increased incidents of nonpayment, decisions by customers to forgo the use of needed electricity on account of the anticipated cost,

and greater numbers of disconnections of service for nonpayment. Reduced usage of electricity needed for heating, cooling, and lighting, and shutoffs for nonpayment, are likely to lead to greater exposure of at-risk customers to extremes of heat, cold, and humidity, all of which have health implications for households that include children, elders, and others who are medically frail or otherwise disabled.

Non-Ionizing (Radio) Frequency Radiation:

Digital meters communicate wirelessly by means of two radio-transmitters. An anticipated increase in exposure to non-ionizing radiation is expected, with the extent of exposure reflecting the design and shielding of the meter, the configuration of meter installation with respect to dwelling spaces, the calibration of the meter (the extent to which it functions as intended), and the power density and frequency of transmissions. Given the potential exposure to non-ionizing (EMF) radiation from other devices (cell phones and WiFi routers), and the lack of studies specific to smart meters, there is a need for better evidence to inform any conclusions.

Reliability of Service:

The new metering and two-way communications system has the potential to detect outages more quickly and pinpoint restoration activities more effectively, resulting in faster restoration times and shorter outages. Greater reliability would reduce the likelihood of consumers' use of risky, alternative means to heat (i.e. indoor use of barbeque grill or unvented kerosene heater) or light (i.e. use of a candle), which would improve the quality of housing and lower the incidence of unintentional injuries and deaths from residential fires and carbon monoxide poisoning, as well as health crises brought on by the loss of power to medically necessary devices.

Remote Disconnection of Service:

Two-way communications also facilitates the expedited shutoff of service for nonpayment, as disconnection can be effected by the flip of a switch, rather than by sending a truck and crew to physically shut off service at the dwelling. Shutoff of service for nonpayment increases the likelihood that consumers will use risky, alternative means to heat or light their homes, degrading the quality of housing, influencing the rate of unintentional injuries and deaths, and increasing homelessness and instability of housing for elders and persons living with a disability.

Greenhouse Gas Emissions:

Digital metering is likely to reduce vehicle emissions (hydrocarbon pollution) due to the reduced need to physically visit customer premises to read the meter or to connect or disconnect service.

Scoping Pathway #2: Dynamic Rate Deployment

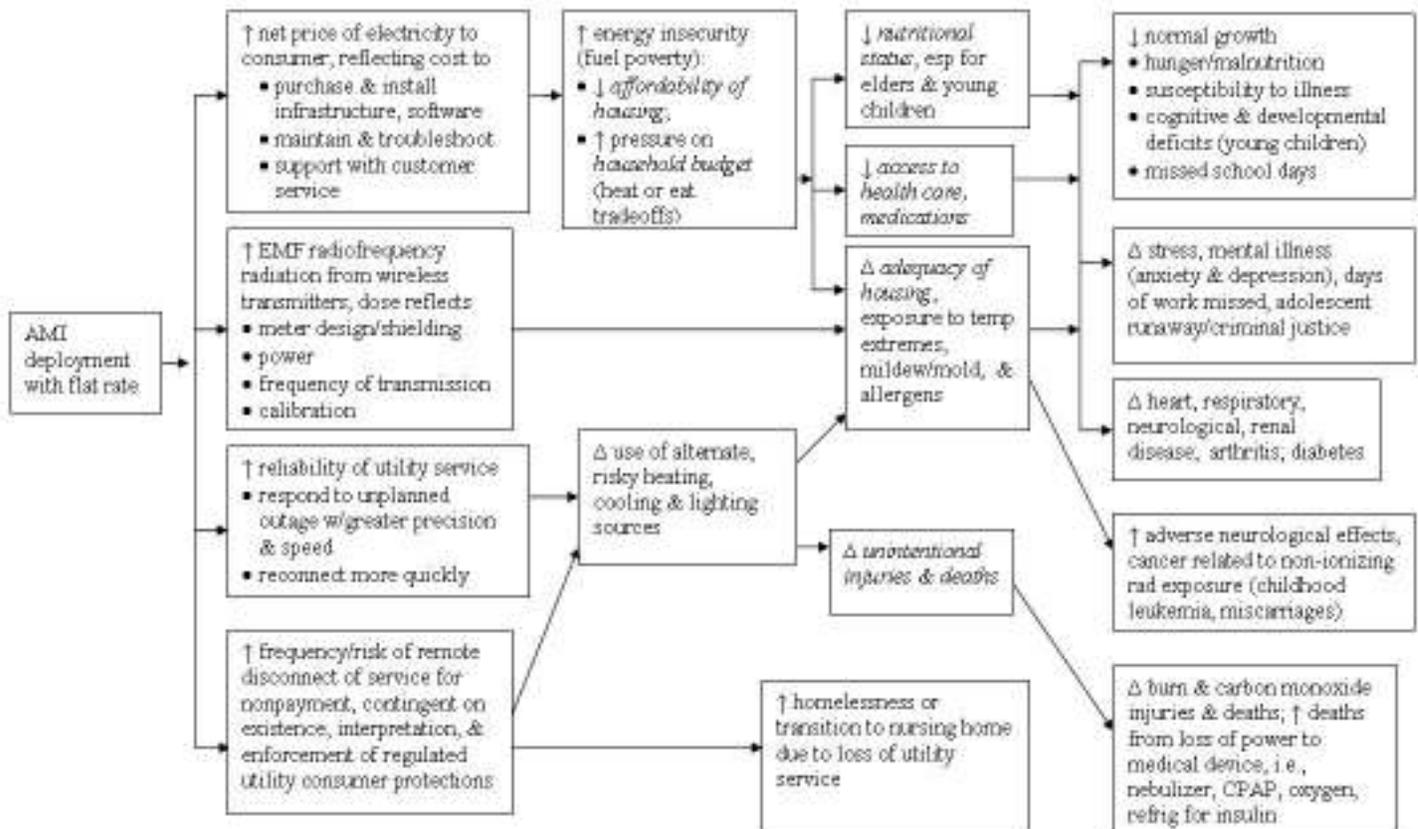
Greenhouse Gas Emissions:

When rates for electricity change according to time of day or pre-determined periods of time, particularly when rates are designed to discourage use of electricity during hours of peak collective demand for power, the intent is to influence consumer behavior. To the extent that consumers shift their demand away from peak hours, it is likely to result in cost savings on their electric bill (lower net price for electricity), with implications for energy insecurity. If demand for electricity is lowered absolutely, it may (depending on the wholesale market for electricity generation in Illinois) lead to the shutdown or decommissioning of the dirtiest power generators, which would reduce air pollution levels in the region from coal-fired electrical plants (such as particulate, acidic compounds that attack the ozone layer, and greenhouse gases) and lower both the incidence of respiratory disease, heart disease, and cancer, as well as lessen the progress of climate change.

PATHWAY: AMI DEPLOYMENT AND FUNCTIONALITY (FLAT RATE)

HIA of AMI: Figure for Assessment, Scoping Pathway for Flat Rate

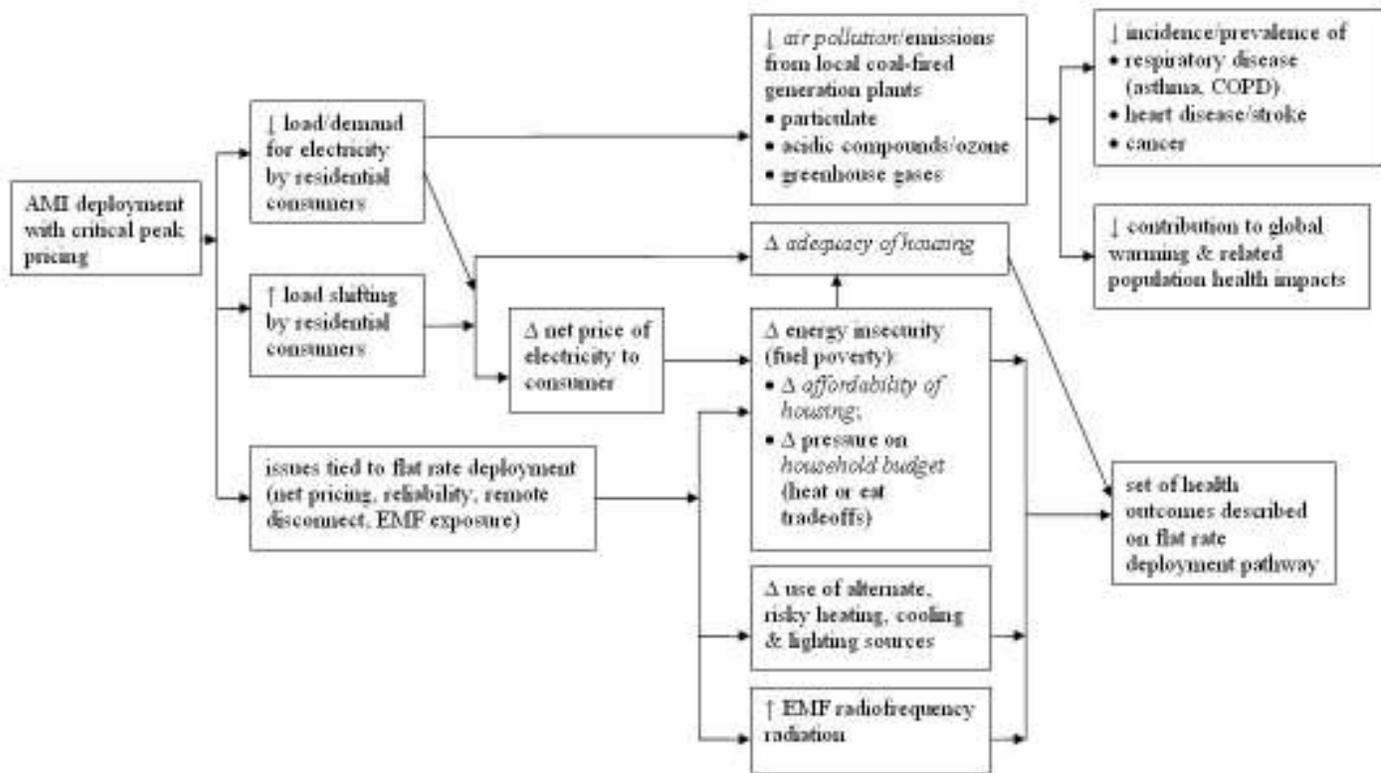
Policy → Proximate Effects → Outcomes viz. *Determinants of Health* → Health Outcomes



PATHWAY: CRITICAL PEAK PRICING

HIA of AMI: Figure for Assessment, Scoping Pathway for Critical Peak Pricing

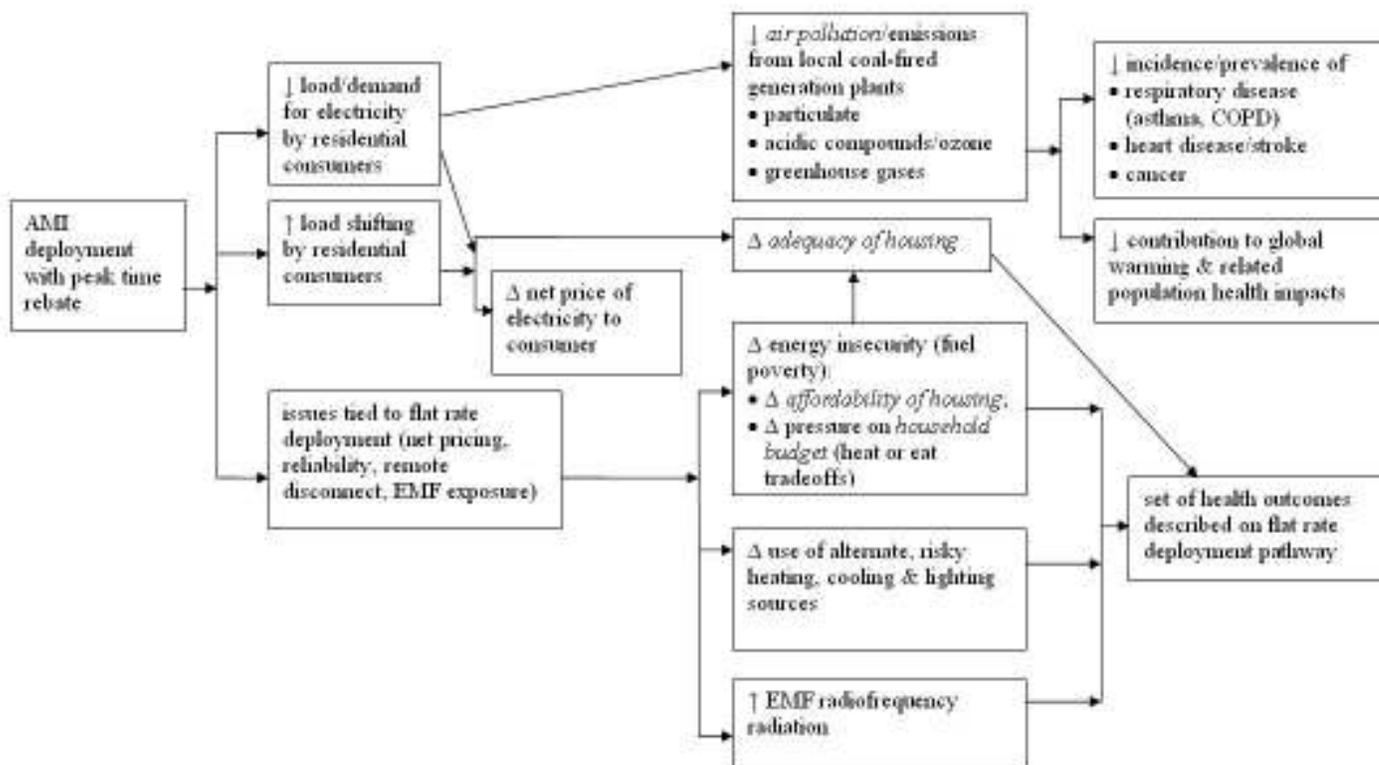
Policy → Proximate Effects → Outcomes viz *Determinants of Health* → Health Outcomes



PATHWAY: PEAK TIME REBATE

HIA of AMI: Figure for Assessment, Scoping Pathway for Peak Time Rebate

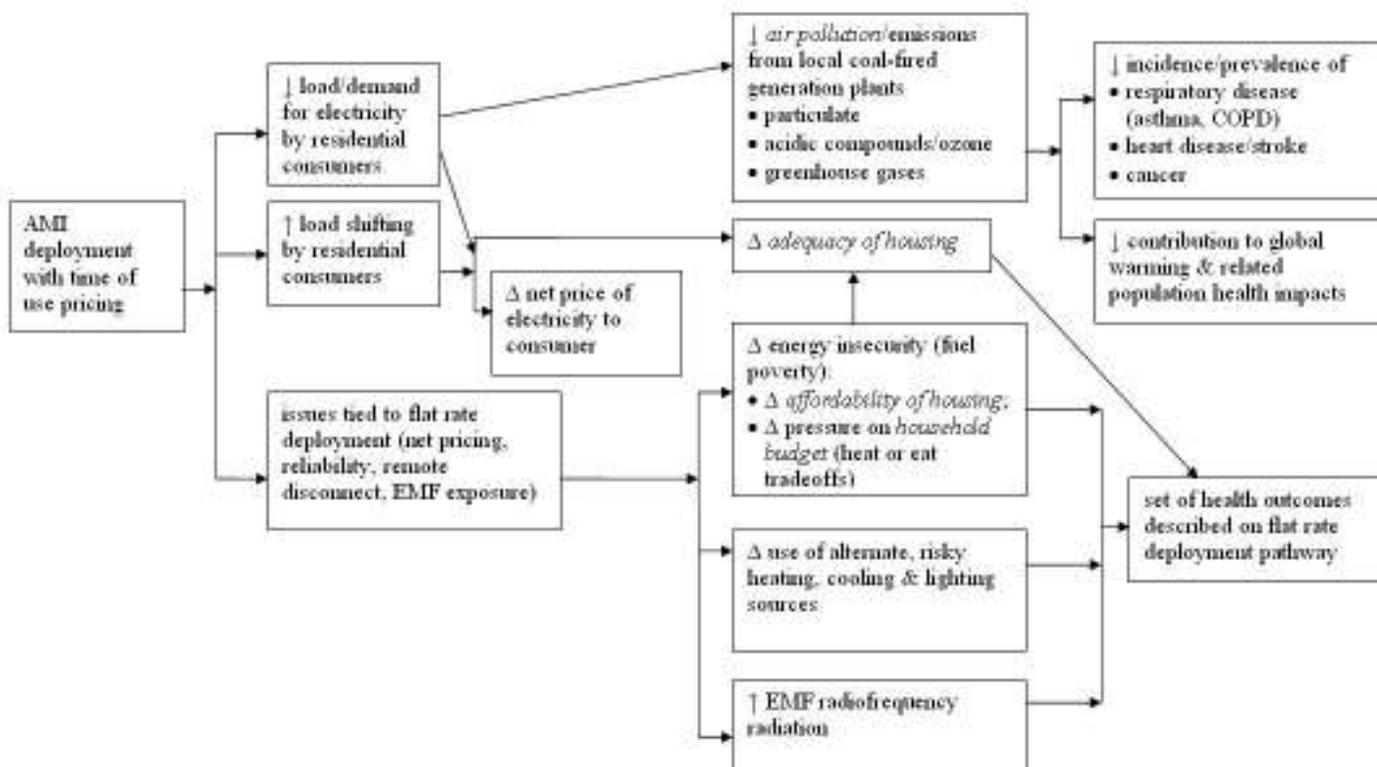
Policy \longrightarrow Proximate Effects \longrightarrow Outcomes viz *Determinants of Health* \longrightarrow Health Outcomes



PATHWAY: TIME OF USE PRICING

HIA of AMI: Figure for Assessment, Scoping Pathway for Time of Use Rate

Policy \longrightarrow Proximate Effects \longrightarrow Outcomes viz *Determinants of Health* \longrightarrow Health Outcomes



APPENDIX 3: EXPERIENCE IN AMI DEPLOYMENT IN OTHER STATES

The HIA evaluated pilot results from around the country where various forms of dynamic pricing and in-home technology were used. Among these, two examples stood out in terms of length of study and comprehensiveness of evaluation: California and Baltimore.

California: California conducted a statewide pilot program in 2003-2004 and gathered data for voluntary customer participation in a variety of dynamic rate options over a 15-month period. The pilot tested a Time-of Use (TOU) rate with a very high peak period price, a fixed price Critical Peak Price (CPP) component grafted onto the existing inverted block rate structure (the default rate structure for all residential customers in California) and a variable price CPP. The pilot documented a significant reduction in peak load usage with the CPP options, as well as modest overall usage reduction for TOU-only customers during the first year which almost completely disappeared by the second year. With regard to low-income customers, the evaluation determined that the elasticity of demand for these customers was essentially zero because these customers exhibited very little response to higher electricity prices. These limited findings, if replicated elsewhere, could be troubling because where there is inelasticity of demand for any subset of customers, the costs of the new metering system may not be offset by any customer benefits from lower supply charges.⁴⁸

Baltimore Gas and Electric: The BG&E pilot conducted in 2008 (and continued in 2009 and 2010 with similar results) enrolled volunteers into a test of AMI and dynamic pricing. This pilot also tested CPP and PTR rates, as well as in-home displays to alert customers to high price periods. This pilot documented that customers exposed to dynamic peak pricing, such as critical peak pricing and peak time rebates, as well as an in-home display to alert the customer to the onset of more expensive power hours did reduce critical peak usage on average in response to these educational programs and price signals. However, the average usage for the customers participating in the dynamic pricing programs did not decrease. Instead,

⁴⁸Charles River Associates, "Impact Evaluation of the California Statewide Pricing Pilot." 2005.

customers typically shifted, rather than reduced, their overall usage, the same result found from the California statewide pricing pilot. Customers responded just as favorably in terms of peak load reduction to PTR compared to CPP. As a result, BG&E's AMI proposal approved by the Maryland Public Service Commission relies on offering PTR to all its customers after the new metering system is deployed in 2013.⁴⁹

Other recent pilot programs conducted by Connecticut Light and Power pilot in Connecticut⁵⁰ and Pepco in the District of Columbia⁵¹, confirmed these overall results in that customers responded to both critical peak pricing and peak time rebate offers, and reduced usage during critical peak periods on hot summer days, but there was no statistically valid overall usage reduction by participants in the pilot programs. This result was also true whether or not the pilot customers were given (at no cost) in-home displays.

It is possible the new technologies under development will make overall usage reduction a reasonable objective, such as smart thermostats or other residential energy management systems coupled with appliance automation, as will the use of storage technologies such as off peak cold storage to address air-conditioning usage. Furthermore, other customer feedback studies have documented overall usage reduction, some relying on dynamic pricing, but most of these studies rely on direct load control technologies or educational initiatives that are not necessarily dependent on the installation of AMI. Nonetheless, it is likely that additional enhancements beyond the metering system itself will be needed to reduce overall electricity consumption. Additional devices (such as in-home displays) may increase the costs to consumers and may threaten the ability of lower income customers who cannot afford to purchase, install, and maintain such devices to actually experience bill savings to offset the AMI costs.

⁴⁹ Faruqi Ahmad and Sanem Sergici (2009): BGE's Smart Energy Pricing Pilot Summer 2008 Impact Evaluation, The Brattle Group Inc., April 2009.

⁵⁰ Connecticut Light & Power. Connecticut Light and Power AMI Pilot Project: Plan-it Wise Energy Program. 2009. Available at: <http://www.cl-p.com/downloads/Plan-it%20Wise%20Pilot%20Results.pdf?id=4294986558&dl=t>

⁵¹ PowerCentsDC. PowerCentsDC Program Final Report. 2010. Available at: <http://www.powercentsdc.org/ESC%2010-09-08%20PCDC%20Final%20Report%20-%20FINAL.pdf>

AMI DEPLOYMENT AND REMOTE DISCONNECTION

AMI's two-way functionality enables remote disconnection of service for nonpayment. A handful of states have developed regulations that consider the health and safety implications of remote disconnection specifically.

Maine: In a proceeding held before the Maine Public Utilities Commission concerning Central Maine Power Company's (CMP) compliance with consumer protections obligations in an alternative rate plan, CMP submitted evidence concerning the actual actions taken by the Company to effectuate its disconnections of service. Of the over 54,000 notices that were "worked" in 2008, almost 30,000 (almost 60%) were left connected.⁵² The reasons for those left connected include collection of funds, check, customer showed receipt, customer made arrangements, declaration of medical emergency, leaving a "green card", etc. Thousands of customers avoided disconnections by having contact with the field worker at the time of disconnection. The Company exercised its discretion to not disconnect service based on what occurred at the time of physical disconnection of service. This discretion could not be exercised with the use of remote disconnection.

California: In a tragic example of the risks of using alternative sources of lighting after loss of electricity, four children died in a fire sparked by a candle in a Fairfield, California apartment without electricity after PG&E remotely disconnected service in April 2010. A candle set atop a TV, with combustible materials nearby, started the blaze, according to Fairfield assistant fire marshal Jerry Clark. Two other candles had also been used. The Solano County District Attorney's Office continues to review the fire—ruled accidental—to determine whether any crime occurred and whether it would file any charges, said Al Garza, chief of that office's bureau of investigations. The mothers of the children, two sisters in their 20's, were not inside the home at the time of the fire but were outside in the nearby parking lot. One of the mother's stated that the home lacked electricity for about five days and that she and her sister had stepped outside to the laundry room next door to try to charge their cell phones.⁵³

⁵² CMP Response to Oral Data Request 01-15, attachment 1 in Docket No. 2009-217 before the Maine PUC.

⁵³ Anthony, Laura. "Investigators: Fairfield fire started with candles." ABC News, April 29, 2010. Available at: http://abclocal.go.com/kgo/story?section=news/local/north_bay&id=7412580

Some states have prohibited the implementation of remote disconnection and refused to amend existing premise visit and contact requirements, including New York, Ohio, Maryland, and California, particularly because of the risks cited from alternative sources of heating and lighting.

New York: A 2007 decision of the New York Public Service Commission explicitly provided that current consumer protections relating to disconnection would be retained in the event that smart metering was implemented, thus preventing New York utilities from relying on any savings associated with remote disconnection of service.⁵⁴

The New York Commission stated,

“Finally, we remind the companies that termination of service for nonpayment is subject to Home Energy Fair Practices Act (HEFPA) regardless of whether that disconnection is performed by physical (on site) or electronic (remote) service shut off. No utility may utilize AMI for remote disconnection of service for nonpayment unless it has taken all of the prerequisite steps required by HEFPA, including the requirement of 16 NYCRR §11.4(a)(7) that customers must be afforded the opportunity to make payment to utility personnel at the time of termination. This process requires a site visit, even where a remote device is utilized.”

Ohio: Duke Energy filed for a series of waivers from Ohio’s consumer protection rules to accommodate its smart grid pilot. The Company requested exemption from the rules requiring a premise visit from company personnel on the day of disconnection for nonpayment. The rules require a written notice be delivered to the named customer or an adult at the home, or posting of a notice providing information on assistance programs and other options to delay disconnection. Most importantly, the utility representatives are required to accept payment on the account in order to stop the disconnection. The latter requirement is also a part of Ohio statutory law.

⁵⁴ See Order Requiring Filing of Supplemental Plan, Case Nos. 94-E-0952, 00-E-0165, and 02-M-0454 (December 17, 2007).

The Commission responded by denying this waiver request:

In considering Duke's request, the Commission is aware of the purpose of Rule 4901:1-18-05(A)(5), O.A.C, which is to notify the occupants at the premise of the pending disconnection and allow the customer one last chance to prevent disconnection by making payment. Without personal notification, or the display of notice, it is possible that customers may be unaware of the pending disconnection, or may believe that the lack of service is the result of an outage. Moreover, the Commission agrees with OP&E's concern that customers who have not paid their utility bill may not have immediate access to text or electronic messaging, despite their selection of such means of notification at an earlier date. Therefore, while the Commission may be willing to discuss alternative notice processes in the future, at this time, the Commission finds that the processes set forth in this rule should remain in force. Accordingly, the Commission finds that Duke's request for a waiver of Rule 4901:1-18-05(A)(5), O.A.C, should be denied.⁵⁵

Maryland: Both Baltimore Gas & Electric and Pepco and Delmarva filed applications for AMI deployment and included the potential savings from relying on remote disconnection for nonpayment in their business cases to support this investment. The Maryland Public Service Commission rejected this proposal and required the utilities to continue to conform to the current regulation that requires the utilities to conduct a premise visit and attempt to contact the customer, including mandatory acceptance of payment when offered by credit card, to avoid disconnection where possible.⁵⁶

California: The California PUC opened a proceeding to consider the implications of a rising number of disconnections, the impact of remote disconnection of service, and the general increase in customer nonpayment as a result of economic conditions. In an Interim Decision issued in July 2010, the Commission instituted new protections

⁵⁵ Public Utilities Commission of Ohio, In the Matter of the Application of Duke Energy Ohio, Inc. for a Waiver of Certain Sections of the Ohio Administrative Code for SmartGrid Pilot Programs, Case No. 10-249-EL-WVR, Entry, June 2, 2010.

⁵⁶ In approving BGE's AMI proposal, the Maryland Commission stated, "We note that we have not approved any exemption from our regulations concerning termination of service for non-payment, and that nothing in this Order should be construed as changing this Commission's policies or regulations regarding termination of service for non-payment." Order No. 83531, Case No. 9208, August 13, 2010, at 19.

for some customers in the implementation of remote disconnection of service.⁵⁷ The Commission specifically refused to halt remote disconnection, but ordered utilities to conduct premise visits by employees with the capability of accepting non cash payment to those on “medical baseline” and “life support” customers, customers specifically identified in California. Qualified customers get additional usage to be billed at the lowest rate under their applicable inverted rate structure. A typical utility application for this program requires the customer to provide identifying information and the “medical doctor or doctor of osteopathy” must certify a specific life support device, or that the patient needs specific heating and/or cooling due to certain conditions, “compromised immune system, life threatening illness or other condition for which additional heating or cooling is medically necessary to sustain the person’s life or prevent deterioration of the person’s medical condition.” The certificate can be for a specific period of years or permanent, in which renewal every two years is required. A specific list of “life support” equipment is listed, including breathing machines, motorized wheelchairs, pressure pads and pumps, respirators, etc.

⁵⁷ California PUC, Interim Decision Implementing Methods to Decrease the Number of Gas and Electric Utility Service Disconnections, Docket No. R. 10-02-005 (July 29, 2010)

APPENDIX 4: ESTIMATES OF SMART GRID IMPACT ON RELIABILITY

A recent report funded by the National Association of Regulatory Utility Commissioners (NARUC) for the Illinois Commerce Commission (ICC) examined impacts of smart grid investment, including AMI, on customer reliability of service, but it is important to note that this HIA is focusing on AMI and not smart grid per se.⁵⁸ Smart grid reliability investments should cause changes in the average duration of interruptions (CAIDI), changes in the average frequency of sustained interruptions (SAIDI) and changes in the average frequency of momentary interruptions (MAIFI). From the point of view of evaluating the benefits of these investments, NARUC urges regulators to focus on the question of whether the expected or observed changes in these reliability indicators are large enough to justify the costs of the investments required to achieve them. To answer these questions three pieces of information are required:

- The utility costs required to achieve given levels of reliability (i.e., investment, maintenance and operating costs);
- The changes in CAIDI, SAIFI and MAIFI that will result from a given Smart Grid investment or set of investments; and
- The average economic losses resulting from the units described above (i.e., CAIDI, SAIFI and MAIFI). For example, we need to develop estimates of how much a CAIDI minute costs customers, how much a SAIFI event costs and how much each momentary is worth.

The cost of unreliability is the product of the second and third points made above. In general, the reliability benefit is calculated by comparing the outage costs that occur in a baseline condition (i.e., existing SAIFI, CAIDI and MAIFI), with the outage cost that occurs (or is expected to occur) as a result of the investment. The difference in the cost of unreliability for the baseline condition and the cost that results from the investment is the reliability benefit; and the ratio of the reliability benefit to the investment cost (1) is the relevant cost-benefit ratio.

Utilities benefit because they are able to bill and collect for more kWh when outage duration is reduced or their frequency is lowered, thus increasing their revenues. Furthermore, the report to the ICC concludes that benefits to customers are often underestimated because utilities typically do not know how to assign an economic value for avoided economic losses due to unreliability. Finally, the report assumes that reduced expenses incurred by the utility to find and fix outages (associated with the access to real time information and the ability to ping the AMI meter to determine if it is on or off) will be captured and reflected in regulated utility operating cost reductions and passed through indirectly to customers.

APPENDIX 5: BLACK & VEATCH EVALUATION OF COMED'S AMI PILOT, COSTS AND BENEFITS

ComEd's operational pilot was evaluated by Black & Veatch Corporation in the summer of 2011 and this report contains preliminary information on its estimates of AMI costs and impacts.⁵⁹ Black and Veatch estimated the costs and benefits to ComEd and its customers over a 20-year period from 2011 to 2030 for two different scenarios: deployment of AMI throughout ComEd's system over a five-year period and a ten-year period.

According to the Black and Veatch report, during a five-year deployment period (at the end of 2012 through the middle of 2016) ComEd will invest and spend \$1.042 billion or around \$260 per ComEd meter (household).⁶⁰ Total operational and pass-through benefits to customers will be less than \$400 million. According to this analysis, significant operational benefits will not begin to offset the AMI costs until 2017.⁶¹

Once the system is fully deployed, beginning in 2017, ComEd will incur annual expenditures for the AMI system of approximately \$35 million and the Report estimates that savings of approximately \$240 million annually will occur in the form of reduced operational expenses. A portion of these savings is composed of reduced operational expense relating to the elimination of manual meter reading and the use of remote functions that eliminate premise visits and field trips (\$76 million), reduced bad debt and power purchase costs (\$68 million), and higher revenues (\$78 million). Ignoring these "pass through" benefits, Black and Veatch estimates the ratio of operational benefits to costs is \$76 million to \$35 million, and notes that "the difference of [approximately] \$40 million may not represent enough cost savings to pay back the initial investment of over \$1,100 million over a reasonable time period, so consideration of the past through benefits are material." Black and Veatch conclude that the AMI investment would pay for itself in ten years,⁶² with customers seeing positive value (a decrease) in ComEd revenue requirements around year 8 of

⁵⁹ Citation to Black and Veatch Report (Version 1.0), April 2011.

⁶⁰ Black and Veatch Report at 37.

⁶¹ Black and Veatch Report at 37.

⁶² Black and Veatch Report at 40.

deployment.⁶³ The net present value of the AMI investment was estimated at \$532 million.⁶⁴

Deployment of the meters over a ten-year period produces essentially the same results, though the “stretching out” of costs and benefits tended to reduce the overall project value by around 15%,⁶⁵ making the payback period 11 years and the net present value of the investment \$447 million.⁶⁶ Total deployment costs rose to \$1.683 million and total operational benefits dropped to \$1.563, with pass through benefits of \$2.855 million.⁶⁷ Black and Veatch notes that some investments required for AMI deployment, such as investments in information technology, are unlikely to be stretched out over a ten year period.⁶⁸ Most importantly for an operational business case, Black and Veatch noted that their assumption that meter pricing for a ten-year deployment would not change was a “somewhat speculative assumption” since meter pricing might be higher or lower depending upon the nature of ComEd’s contracts with meter suppliers and its chosen RF communication systems provider.⁶⁹

Operational Benefits

Black and Veatch included the following categories of expense in their business case which showed a reduction in cost as a result of the deployment of AMI:

- Reduced costs of meter reading through reduced labor and transportation costs since manual meter reading would be almost eliminated.
- Reduced customer care costs through the elimination of estimated bills, which is among the top three customer complaint categories ComEd handles.⁷⁰

⁶³ B&V Report at 39.

⁶⁴ B&V Report at 40.

⁶⁵ B&V Report at 38.

⁶⁶ B&V Report at 41.

⁶⁷ B&V Report at 41.

⁶⁸ B&V Report at 40.

⁶⁹ B&V Report at 40.

⁷⁰ B&V Report at 71. Black and Veatch noted that complaints about high bills, by far the most common calling reason, broke down into three general categories: complaints due to high temperatures, complaints due to estimated bills, and complaints due to inaccurate final meter reads.

- Reduced outage management costs since ComEd could determine remotely whether the customer’s power had been restored and avoid field trips for this purpose.
- Reduced unaccounted for energy (UFE) through the reduction of theft and tamper conditions, and reduced power purchase costs for empty buildings.⁷¹ Black and Veatch also noted that ComEd has distribution line losses and unbilled energy usage rates that exceed the utility industry as a whole.⁷² The evaluation estimates that theft and tamper conditions will be reduced with AMI, and so UFE will decline. Black and Veatch also included among their operational benefits increased revenues from the remote disconnection of electricity at premises where no account was associated (recorded as “Consumption on Inactive Meter” or CIM). Under current operations (prior to AMI), there are instances of metered consumption (at a premise) without an active customer account. These occurrences are usually the result of limited field work capacity to physically disconnect electricity at a premise after finalizing an account. [See fn. 2 and 3, page 1]
- Black and Veatch estimated a reduction in bad debt or uncollectible expense as a result of the use of remote disconnection of service for nonpayment, stating, “The evaluation includes estimates for the reduction in bad debt. By using new business practices in conjunction with the disconnect switch automation, ComEd estimates that it will be able to cut off customers more quickly as these customers accumulate a larger and larger uncollectible debt.”⁷³

Black and Veatch’s evaluation of the operational benefits excludes the costs and benefits associated with the impacts of premature retirement (replacement) of existing meter assets and any sunk costs associated with the AMI pilot. Finally, Black and Veatch included several statements to qualify the cost and benefit estimates in the report:

⁷¹ B&V Report at 28.

⁷² B&V Report at 64.

⁷³ B&V Report at 29.

- The estimated net customer impact and cash flows are offered as useful estimates, but are not offered as final and definitive work products for ComEd's regulatory filing requirements for cost recovery.
- Black & Veatch has no control over many variables that may influence the actual implementation and support costs, avoided costs, and other benefit categories of a proposed future deployment of AMI (e.g., actual labor costs, outcomes of vendor solicitations, price inflation, etc.) ComEd's actual implementation experience and results may vary from cost and avoided cost estimates provided in this report.

APPENDIX 6: LITERATURE REVIEW, HEALTH ASSESSMENT

This literature reviews the published evidence on potential and likely impacts of AMI, focusing on two subsets of literature as identified by the scoping pathways: fuel poverty and housing quality, and air quality and temperature (both indoor and outdoor). All four scoping pathways share the same set of health determinants and hypothesized range of health outcomes, irrespective of the type of rate plan for electrical service (flat, critical peak pricing, peak time rebate, or time of use) The search strategy began with a group of meta-reviews published since 2000 (Braubach et al., 2011; Thomson et al., 2009; Astroma et al., 2011; Liddell and Morris, 2010; Marmot Review Team, 2011; Snyder and Baker, 2010) , expanded by citation searching on Pub Med based on publications cited by the meta-reviews. NEADA’s survey of LIHEAP recipients is another important source, not only to develop a health profile of Commonwealth Edison customers but also to document the ways in which low-income households respond to high home energy costs.

Fuel Poverty

The financial pressures of trying to pay high home energy bills, and related decisions not to use needed electricity in order to avoid high bills, leads to tradeoffs among household budget items that are often labeled “heat or eat.” A national telephone sample survey across 13 states offers a window into the choices made by low-income households that receive federal energy assistance grants (LIHEAP) (NEADA, 2011): In response to high home energy bills, 72% of energy assistance recipients reduced expenses for household basics, 24% report going without food for at least one day, 37% report going without needed medical or dental services, and 34% go without the appropriate dose of a prescribed medication (NEADA, 2011). A variant of this phenomenon might be labeled “cool or eat” and refers to the influence of concern about the cost of electricity in summertime on the decision to use air-conditioning, even during a heat advisory. A survey of seniors in four cities (Dayton, OH; Philadelphia, PA; Phoenix, AZ; and Toronto, Ontario), about their responses to heat health warnings in the aftermath of hot weather events, finds that while about 90 percent of the respondents in US cities report having access to air-conditioning, and about the same percentage use their a/c during a heat event, about one-third report that the perceived cost of using air-conditioning influenced their decision about how and when to use a/c; this cost-consciousness was much higher in Toronto, where air-conditioning is less common and less commonly used (Sheridan, 2006). About 41

percent of respondents live alone, a risk factor for social isolation and heat-related injury and premature death.

Food Insecurity:

- Regional patterns in hunger among low-income senior households are likely to reflect heating and cooling costs (Nord and Kantor, 2006). In the United States, seniors living in poverty in low-income households are more likely to report going without food in late winter, while those in Southern states are more likely to go hungry in late summer.
- During the winter months, low-income households (earning less than 150% of federal poverty) spend \$11 less on food and \$37 more on fuel for every 10 degree C drop in temperature during the winter months, compared with households earning at least 300% of federal poverty (Bhattacharya et al., 1992). Adults in these low-income households took in 7.9% fewer calories and children 10.9% fewer calories during wintertime, compared with members of higher-income households.
- Infants and young children in households experiencing energy insecurity are two to three times as likely to also be facing food insecurity and hunger (adjusted OR=2.37 for households with moderate energy insecurity and adjusted OR=3.06 in the case of severe energy insecurity) (Cook et al., 2008).⁷⁴

Health and development:

- Infants and young children in families that are eligible for and not enrolled in energy assistance (LIHEAP) are more likely to need hospital admission on

⁷⁴ Household energy insecurity is measured in terms of answers to 4 questions:

- In the past 12 months, has a utility sent a letter threatening to shut off service for nonpayment?
- In the past 12 months, has the primary caregiver used a cooking stove to heat the home?
- In the past 12 months, were there any days that the home was not heated or cooled because bills could not be paid?
- In the past 12 months, has the utility shut off service or refused to deliver oil for not paying bills?

A respondent household is categorized as energy security if the answer to all four questions is no. If the first question is answered in the affirmative, the household is categorized as moderately energy insecure. If at least one other question in addition to the first one is answered in the affirmative, the household is categorized as severely energy insecure. Cook et al., 2008.

the day of a routine medical visit, compared with children in families that are enrolled in LIHEAP (Frank et al., 2006).

- Children in moderately or severely energy insecure households are more likely to be in poor health (adjusted OR=1.34 for moderate energy insecurity, adjusted OR=1.36 for severe energy insecurity), and children in households reporting moderate energy insecurity are more likely to have been hospitalized since birth (Cook et al., 2008).

Shutoff of Service:

Nationally, households that receive energy assistance grants are more likely to lose their service for nonpayment (NEADA, 2011):

- Almost half (45 percent) report home energy bills over \$2,000 annually, with energy costs averaging 12 percent of household income even after energy assistance is received, compared with a national average of 7 percent of household income
- Nearly half (49 percent) report not paying their bill in full, with one-third (37 percent) receiving notice from their utility of a planned disconnection for nonpayment and 11 percent experiencing a disconnection in the past year.

Adequacy of Housing:

The physical environment of a home itself has myriad influences on health, some related to the fiscal strains associated with energy insecurity and of poverty itself, and others related more specifically to AMI, for example, exposure to non-ionizing radiation from the meter. NEADA's survey of energy assistance recipients documents a range of ways in which energy insecurity influences how householders use their homes (NEADA, 2011):

- In response to high home energy bills, 39 percent reported closing off part of their home, 23 percent reporting maintaining an indoor temperature that they considered to be unsafe or unhealthy, and 21 percent leaving their home for at least part of the day.
- About one-quarter (24 percent) report being unable to use their primary heating source because of a disconnection for nonpayment, being unable to pay for the delivery of fuel, or being unable to pay to fix a broken heating

system, and 17 percent could not use their air-conditioning on account of disconnection of electrical service for nonpayment or being unable to pay to fix a broken system.

Overcrowding is one result of such responses. One evaluation of a British weatherization program finds that lowering home energy bills reduces overcrowding caused by the closing off of rooms that were too cold or costly to heat, in turn improving the mental health status of residents and reducing adolescent school truancy and criminal activity (Liddell and Morris, 2010). Houses that could be kept warmer more affordably improved social capital, or civic connections, as measured by reports of more time spent at home, the hosting of visitors, greater privacy, and strengthened relationships within the household (Thomson et al., 2009).

Access to heating promotes health. Evidence comes almost exclusively from studies of households in the United Kingdom.

- A survey of English working-aged adults finds that inadequate home heating has more of an influence on self-reported health than does indoor moisture (Evans et al., 2000).
- Evaluation of a Scottish weatherization program finds that the odds of indoor environmental problems decreases (OR=0.94) with the hourly increase in indoor heating duration (Walker et al., 2006).
- Seniors are more likely to die during the winter months (OR=1.016) if they live in a home without central heating (Aylin et al., 2001).
- An index of high neighborhood fuel poverty predicts the greater likelihood that seniors will be hospitalized in wintertime, compared with summertime (Rudge, 2005).

Access to cooling, and in particular central air-conditioning, is the single most significant factor predicting positive health outcomes during summer, in the United States and around the globe. Since the 1960s in U.S. cities, the number of heat-related deaths has declined, at first in southern cities (1980s) and then in northern cities (1990s), explained in part by greater access to air conditioning (Davis et al., 2003), also reflected in the decline in the risk of death from cardiovascular disease with increasing outdoor temperature (Barnett, 2007). Persons living in homes without central air –conditioning are 42 percent more likely to die, compared with

those who do have central a/c; (Rogot et al., 1992). A smaller protective effect is seen for window units in smaller homes.

- During heat waves, the odds of death are lowered almost 80 percent when a home has a working air-conditioner (OR=0.23) and about 70 percent where there is access to a cool environment (OR=0.34) (Bouchama et al., 2007). Case-control review of 63 patients hospitalized as a result of a 1999 Chicago heat-wave finds that having a working air-conditioner lowers the odds of death by 80 percent (OR=0.2), more than any other factor considered; living on top floor of building increases risk (OR=4.0) (Naughton et al., 2002).
- Even in the absence of a heat wave, air-conditioning saves lives. A study of premature summer deaths in four Midwestern cities (Pittsburgh, Chicago, Detroit, and Minneapolis-St. Paul) identifies a 5 percent higher heat-related death rate for African Americans, compared with white residents, finding that over two-thirds of this disparity reflects the lack of access to central air-conditioning reported among the African-American households surveyed in the study (O'Neill et al., 2005). A study of hospitalizations during California summer months (May-September, 1999-2005) finds that central air-conditioning, whether measured as ownership or use, reduces the risk of hospitalization, irrespective of household income (Ostro et al., 2010).

In the absence of clean, electrically-fueled central heating, unvented (gas-fueled) heaters and portable electric heaters pose respiratory health threats, especially to children, related to moisture and to accumulation of nitrogen dioxide.

- Moisture or Mold. Homes that are inadequately heated or cooled are more likely to contain moisture, from the condensation of warm indoor air against surfaces made cool by outdoor temperatures (winter) or capturing summertime heat that fosters the growth of mold. Mildew and mold-derived irritants are more likely to be result. A meta-analysis of studies derived estimates of over twice the likelihood (OR=2.2) for the development of childhood asthma where household dampness is present (Pekkanen et al., 2007) and almost two and one half times the likelihood (OR=2.4) where mold is present (Jaakkola et al., 2005, as cited in Braubach et al., 2011).
- Nitrogen Dioxide. The use of ovens, stoves, or kerosene-fueled portable heaters in lieu of electrical appliances presents hazards related to indoor air quality. A retrospective study of asthma among young children in the U.S.

finds an 80 percent greater likelihood (OR=1.8) of physician-diagnosed asthma when children live in homes where a gas stove or oven is used for heat (Lanphear et al, 2001). A study of young African American children (ages 2-6 yrs) who live in low-income Baltimore households with an asthma diagnosis finds that higher NO₂ concentrations measured in bedrooms correlate with the use of a space heater, an oven or stove for heat and that higher NO₂ levels are associated with more days with asthma symptoms such as wheezing that interfere with speech (RR=1.15), more coughing (IRR = 1.10), and nighttime waking due to symptoms (IRR = 1.09), although not with greater use of health care services (Hansel et al., 2008).

An evaluation of a New Zealand program that replaced such substandard heating sources in low-income housing finds a boost in indoor temperatures, lowering of moisture and nitrogen dioxide levels, and a reduction in health problems related to asthma: children are half as likely (OR=0.40) to visit a doctor for asthma, to be reported to be in poor health (adjusted OR=0.48) , and have fewer nighttime asthma symptoms (Howden-Chapman et al., 2008). The warmth added through weatherization alone is linked to fewer school days lost for children (OR=0.49) and fewer work days off for adults (OR=0.62) (Howden-Chapman et al., 2007).

Non-Ionizing (EMF) Radiation Exposure

Though all consumers may be exposed to some level of radio-frequency radiation in connection with the wireless communication capacity of the AMI digital meters, depending on the physical configuration of meters and the duty cycles, the health impact of these exposures remains unclear.⁷⁵ AMI digital meters emit non-ionizing

⁷⁵ In considering likely exposures for consumers in households with digital meters, a number of factors are relevant, including

- The frequency and power density of transmission: the digital meter deployed by Pacific Gas & Electric has two transmitters, one operating at 902 MHz (maximum permissible exposure of 601 microwatts/centimeter squared) that will enable automatic meter reading, and the second at a higher frequency, 2.4 GHz (maximum permissible exposure 1000 microwatts per centimeter squared, a higher limit as higher frequencies are less well absorbed compared with lower frequencies), comparable to a wireless telephone, for use with a home access network.
- The distance between the wireless transmitter and the person exposed; the extent of exposure drops off logarithmically, or rapidly with increasing distance. At a distance from the transmitter of approximately 10 feet, exposure level approaches zero. Distance would also reflect the specific configuration of a digital meter or meters, for example, whether household members would be exposed to radiation from a single meter or a row of meters in the case of a multifamily dwelling.
- The duty cycle, or length of time over which wireless transmission takes place; estimates are that digital meters may be transmitting about 50% of the time once automatic meter reading is fully enabled. In addition, digital meters may serve as relays for signals from other digital meters, increasing the total time during which transmissions are occurring.

(EMF) radiation as part of their wireless transmission of usage information and operational status between a household and Commonwealth Edison.⁷⁶ There is considerable public controversy over the potential and actual health effects of non-ionizing radio frequency radiation to which consumers are exposed by means of wireless transmission. FCC regulation of non-ionizing radiation from electronic devices concerns the thermal effects on bodies, measured either in terms of standard absorption rate (SAR) or maximum permissible exposure (MPE).

There are very few reports that focus on digital or “smart” meters and their emissions; much of the literature draws on studies of cell phones and microwave transmission towers, which are not the same amount or length of exposure.⁷⁷ Some but not all of these considerations are taken into account in a modeling exercise published by CCST in its report: in a comparison of power densities of digital meter transmitters compared with cell phones and other common wirelessly transmitting appliances, digital meters transmitting 50 percent of the time are estimated to result in an exposure of 200 microwatts/centimeter squared at a distance of 1 foot, compared with a range of 1,000 to 5,000 microwatts/centimeter squared for a cell phone exposure immediately adjacent (held to the ear), exposures of between 200 and 800 microwatts/centimeter squared for a microwave oven, and between 0.2 and 1 microwatt/centimeter squared for a home WiFi router.⁷⁸

There is no scientific consensus about the range and extent of non-thermal health effects linked to non-ionizing radio frequency radiation given off by wireless transmitters and a need for more research in this area (NRC, 2008).

UNINTENTIONAL INJURIES AND PREMATURE DEATHS

⁷⁶ Much of the discussion in this section is based on California Council for Science and Technology, Health Impacts of Radio Frequency Exposure From Smart Meters. Final Report, April 2011.

⁷⁷ Based on an expert review of studies of cell telephone usage, the World Health Organization's International Agency for Research on Cancer has labeled EMF radiation possibly carcinogenic to humans (Group 2B); a more comprehensive review is underway. According to the IARC, "This category is used for agents for which there is limited evidence of carcinogenicity in humans and less than sufficient evidence of carcinogenicity in experimental animals. It may also be used when there is inadequate evidence of carcinogenicity in humans but there is sufficient evidence of carcinogenicity in experimental animals. In some instances, an agent for which there is inadequate evidence of carcinogenicity in humans and less than sufficient evidence of carcinogenicity in experimental animals together with supporting evidence from mechanistic and other relevant data may be placed in this group. An agent may be classified in this category solely on the basis of strong evidence from mechanistic and other relevant data." (WHO/IARC, 2011).

⁷⁸ These estimates compare with the FCC limit for thermal injury of 601 microwatts/centimeter squared for devices transmitting at 902 MHz (the frequency of a digital meter's automatic meter reading radio) and the limit of 1,000 microwatts/centimeter squared for devices transmitting at 2.4 GHz (the frequency of a digital meter's radio for home access network communication). The safety standard regulated by FCC concerns the capacity of radiation to raise the temperature of body tissue (thermal effect), affecting behavior; non-thermal effects have been much more difficult to document.

Another health determinant that is the focus for this HIA is unintentional injury and death, related not only to fuel poverty and the adequacy of housing but also to how households respond to the loss of electrical service, particularly if someone in the home relies on an electrically-powered medical device, or to a consumer's decision not to use electrical service because of concerns about cost. Aside from the heightened risk of disconnection for nonpayment among low-income households, and the quicker pace of disconnections anticipated with AMI deployment, there are the fire and poisoning risks related to the use of gasoline generators, kerosene space heaters, gas stoves and ovens, and candles. Low-income households and seniors are acutely vulnerable: about one-quarter (26 percent) of households nationally that receive energy assistance grants include a member who uses a medical device that requires electricity, and one-third (33 percent) report have used their kitchen stove or oven for heat (McGwin, 1999; NEADA, 2011).

Carbon Monoxide:

Using gasoline-fueled generators to provide electricity or heat presents the threat of poisoning or death from carbon monoxide, an invisible, deadly gas. Exposure to carbon monoxide can cause effects ranging from headache and nausea to coma and death, with longterm neurological effects for those who survive exposure. Pregnant women, young children, elders, and people with cardiovascular or respiratory disease are more sensitive than average to the effects of CO. Recent studies estimate a 3% case fatality rate for CO exposure, based on data from hospitalizations (Sam-Lai et al., 2003 France; CDC, 2005) and up to 40% for neurological effects; an estimate 60% of reported CO poisonings are tied to home exposure (CDC, 2005; Clifton et al., 2001).

Fires:

A study of all single-family house fires over one year in North Carolina finds that heating equipment is the single most common cause of fires (39 percent of fatal fires and 28 percent of nonfatal) and that space heaters (for the part kerosene) cause 58 percent of fatal fires and 30 percent of non-fatal fires (Runyan et al., 1992). A number of state-level surveys conducted among similar lines, and one national retrospective analysis, find that African American elders are at higher-than-average risk of fire-related injuries and deaths, observations not directly related to poverty but hypothesized to reflect disparities in housing conditions (Bishai and Lee, 2010).

Exposure to Heat or Cold

Finally, health outcomes related to exposure to excessive heat or cold are an important concern of the HIA. The literature on the relationship between temperature exposure and health is voluminous, encompassing retrospective longitudinal observations of mortality differentials by season or weather event (deep freeze, heat wave) over years and decades, case studies of health services utilization during heat waves, and clinical studies detailing the physiological changes that accompany exposure. For the purposes of this HIA, the most relevant studies are those that document indoor temperature exposure, its relationship to energy use and to health and safety outcomes; a much smaller universe of literature makes the link to home energy and very few studies connect temperature exposure directly to energy.⁷⁹

The responses of a population to ambient and changing temperatures reflect a number of factors: two key considerations include the capacity of built infrastructure (housing stock, landscape, roads) to concentrate or buffer weather conditions and the degree to which a population, and especially vulnerable subgroups, acclimatize or adjust in terms of physiological and behavioral responses to temperature, for example, through clothing, moderating outdoor activity, and having access to adequate indoor heating or cooling (Kovats and Hajat, 2008; Marmot et al., 2011). Mortality is one crude measure of this responsiveness; deaths are at a minimum in moderate temperature ranges and increase as temperatures climb or fall from a moderate range, with what constitutes a moderate range varying from region to region. A series of studies of temperature and mortality rates among U.S. cities finds that deaths increase by 2 to 4 percent per degree Fahrenheit as temperatures climb above a city's heat threshold and up to 6 percent per degree F with a drop in temperature below the area's cold threshold (Braga et al., 2001; Medina-Ramon and Schwartz, 2007; Anderson and Bell, 2009).

Exposure to cold:

A meta-analysis of studies linking winter outdoor temperatures to excess cardiovascular and respiratory disease deaths, for the most part based on data from

⁷⁹ For elders, this literature is reviewed in some detail in Snyder and Baker, *Affordable Home Energy and Health: Making the Connections*. Washington, DC: AARP Public Policy Institute, 2010.

the United Kingdom, Europe, and New Zealand, concludes that between 30% and 50% of premature deaths in winter reflect exposures to indoor cold (Rudge, 2011, based on Keatinge and Donaldson, 2000 for upper bound and Wilkinson et al., 2001 for lower bound). These otherwise avoidable deaths are associated with lower temperatures in bedrooms and living rooms (adults age 50+) (Eurowinter Group, 1997).

Exposure to heat:

Recent published summaries of the literature on heat exposure and heat waves highlight dozens of peer-reviewed studies documenting elevated rates of hospitalization and premature deaths.

- One such review identifies 29 studies where short-term rises in outdoor temperature are associated with greater risk or likelihood of premature death (Basu, 2009).
- Another review specifically concerning the experiences of seniors finds 6 peer-reviewed studies where a heat wave or summertime hike in temperature is associated with greater morbidity, and 24 peer-reviewed studies linking heat waves of higher ambient temperature with higher mortality rates (Astroma et al., 2011).

Young or advanced age, disabled status (especially a disability that limits mobility), African American ethnic identity, and social isolation or lack of social capital are each indicators of greater vulnerability to adverse impacts related to heat or cold exposure (Bouchama et al., 2007; Kilbourne, 2008; Schwartz, 2005, Medina-Ramon et al., 2007).

Chronic Illness and Temperature Exposure

- Heart Disease. Among adults and seniors, both heat and cold are associated with greater risk of hospitalization and premature death from cardiovascular and cerebrovascular (stroke-related) diseases (Alanitis et al., 2008; Medina-Ramon et al., 2006, Ostro et al., 2010, Semenza et al., 1999, Naughton et al., 2002).
- Respiratory disease. For elders, chronic obstructive pulmonary disorder is made worse by indoor cold: in wintertime, patients whose living rooms are warm (at least 21 degrees C, or approximately 70 degrees Fahrenheit) fewer

than nine hours per day have worse respiratory health than those who have at least nine hours of indoor warmth on a daily basis (Collins, 2000; Osman et al., 2008). Children are more than twice as likely to experience respiratory symptoms when they live in cold homes, compared with those who live in warm homes (Marmot Review Team, 2011).

- Diabetes, Kidney Disease, Neurological and Movement Disorders. Heat represents a particular threat for diabetes, who are more likely to be hospitalized or die prematurely during a heat wave or non-extreme summer temperatures, as well as those living with kidney disease, who are more likely to be hospitalized for or die from acute renal failure (Schwartz, 2005; Ostro et al., 2010; Semenza et al., 1999, Medina-Ramon et al., 2006; Naughton et al., 2002). Heightened risk for persons with psychiatric disorders or with movement disorders including Parkinson's have been documented.

Heat, Cold, and Social Isolation/Social Capital

In recent years, social and biomedical scientists, as well as clinicians, have paid increasing attention to the importance of social connections in fostering health. These connections are measured by means of a construct called social capital, which refers to the capacity of relationships with neighbors and community, through social contacts, shared knowledge, and behavioral norms to promote health, much as economic capital or assets can promote health. It is a way to measure the impact on health of the connectedness of civil society, or the extent to which people identify and relate positively with their neighbors and as part of their community; it is understood either in terms of the resources that people can tap as a result of the social group to which they belong or the network of social connections that enable them to gain access to resources (Kawachi et al., 2008). Social capital has demonstrated links to health outcomes (premature disability, ill health, and death have been tied to diminished social capital) as well as measures of well-being, just as other measures of physical and mental health have implications for health status.

In the case of access to residential electrical utility service, the key aspect of interest with respect to social capital is that of social isolation. The risk posed by social isolation during a heat wave is well-documented, for seniors and others who live independently with limited mobility (Astroma et al., 2011). Eric Klinenberg's case study of the Chicago heat wave of July 1995 identified social isolation of low-income

African American elders as a specific risk factor for hospitalization and premature death in the wake of extreme heat, compared with the lower mortality rates experienced by Latino elders of similar socioeconomic status who were less socially isolated by crime and who reported stronger networks of relatives and friends (Klinenberg, 2002). Persons who are socially isolated are at greater risk for adverse outcomes of exposure to temperature extremes.

APPENDIX 7: COMMONWEALTH EDISON AND THE AMI PILOT

To better understand the terms of the Commonwealth Edison AMI pilot, as well as the key aspects of residential utility electric service relevant to the HIA, this section offers a brief summary of Commonwealth Edison's billing practices, the cost-benefit assumptions made when planning AMI deployment, and the terms and findings of Commonwealth Edison's pilot related to dynamic pricing. ComEd delivers electricity to residential customers in northern Illinois, bills and collects bills, and provides customer service and is responsible for the reliable operation of its distribution system. However, ComEd does not own generation.⁸⁰ The ICC approves the method by which ComEd purchases generation supply power to meet the needs of its customers, but these purchases are conducted through contracts with wholesale market generators. ComEd passes through the cost of generation supply to its customers.

A typical ComEd customer receives one monthly bill that contains separate charges for delivery services and electricity supply services.⁸¹ The distribution and delivery services provided by ComEd are regulated by the ICC and any rates charged by ComEd for those services, which remain a monopoly, must be approved by the ICC. A request for AMI deployment must be reviewed and approved by the ICC and the costs to pay for AMI will be reflected in rates charged to all customers. Since most customers are residential, most of the costs for AMI are typically included in residential rates, but commercial customers will also pay for part of any approved new AMI system.

ComEd customers pay a fixed monthly customer charge, and a usage-based (that is, priced by cents per kilowatt hour actually consumed) for the distribution or delivery function. ComEd also passes through a price for generation supply service based on contracts signed through the wholesale market. As of July 1, 2011, new rates for

⁸¹ Taxes and other charges are included on customer bills in a separate section and billed on the amount of energy delivered to a customer.

ComEd delivery services went into effect.⁸² The following chart shows the current prices for residential electricity service charged by ComEd as of July 2011:

DELIVERY CHARGES	Single Family Home		Multi Family Home	
	With Electric Space Heat	Without Electric Space Heat	With Electric Space Heat	Without Electric Space Heat
Customer Charge	\$20.18	\$14.28	\$9.79	\$7.22
Distribution Charge	\$.01044 cents per kWh	\$.01949 cents per kWh	\$.01244 cents per kWh	\$.02448 cents per kWh
ENERGY CHARGES	Summer		Non-Summer	
	With Electric Space Heat	Without Electric Space Heat	With Electric Space Heat	Without Electric Space Heat
Cost Per kWh	5.690¢	7.154¢	4.319¢	6.896¢

⁸² See In Re ComEd Request for Increase in Delivery Services Rates, ICC Docket No. 10-0467, Final Order, May 24, 2011.

Energy supply costs are approximately 2/3 of a customer bill, and average customer consumption in Illinois for a single family home is 900 kWh in the summer months of June, July and August, and 600 kWh all other months. Using those averages, a single-family without electric space heat would have an average annual bill of \$929 before other taxes and fees⁸³:

- Customer Charge: \$14.28 for 12 months = \$171.36
- Distribution Charge: 8100 kWh delivered over the course of the year charged at \$.01949 per kWh = \$157.87
- Standard Meter Charge: \$2.86 for 12 months = \$34.32
- Energy Supply Charge: Annual total of \$565.54, consisting of:
 - 900 kWh for 3 months at 7.154¢ per kWh = \$193.16
 - 600 kWh for 9 months at 6.896¢ per kWh = \$372.38

Any additional costs imposed on customers to pay for AMI would increase customer bills beyond the normal rate increases that utilities need to operate their systems and bill and collect for services.

In 2007 in a proposal filed with the Illinois Commerce Commission (ICC)⁸⁴, ComEd proposed a system-wide investment in “smart grid” technology, of which AMI investments would be one part.⁸⁵ In ComEd’s last delivery services rate proceeding, the utility requested approval of a cost recovery mechanism for deployment of “Systems Modernization Projects,” a term which included a broad scope of “smart grid” projects.⁸⁶ CUB, along with other consumer advocates in the case, argued that although there may be significant benefits from smart grid technologies, those benefits will only be realized if the Illinois Commerce Commission (ICC) approaches smart grid planning strategically and with customers’ best interests in mind.

⁸³ Additional taxes and fees include, as of May, 2011, transmission services (.00760 cents per kWh), Illinois electric distribution charges (.00013 cents per kWh), environmental cost recovery adjustments (.00015 cents per kWh), energy efficiency program charges (.000160 cents per kWh), and franchise costs.

⁸⁴ The ICC regulates ComEd’s prices charges to its customers, as well as the design of the prices and the costs or charges imposed on customers.

⁸⁵ ICC Docket No. 07-0566 – ComEd proposed a new program of “system modernization” investments based around general categories of proposed “smart grid” investments.

⁸⁶ ICC Docket No. 07-0566, available at <http://www.icc.illinois.gov/e-docket/>, Final Order, September 10, 2008 at pages

The ICC rejected the utility's proposal in favor of a test of the AMI technology in a pilot program⁸⁷ of at least 100,000 meters in an area demographically representative of ComEd's overall service territory. In order to ensure that the pilot program would result in information about AMI costs and benefits that could be used to evaluate any proposal for full scale AMI deployment, the ICC ordered that an AMI workshop process be initiated to develop project goals, timelines, evaluation criteria and technology selection criteria.

After a six-month workshop process, ComEd filed its AMI pilot proposal before the ICC. In October, 2009 the ICC approved a pilot which consists of approximately 100,000 meters in the Company's Maywood Operating Area (the I-290 corridor of the Chicago area composed of suburban communities) and 30,000 meters in the Chicago metropolitan area. ComEd began installation of the digital meters and associated two-way communication system in November 2009.

During the review of the proposed pilot program, the ICC also approved a smaller subset of the meters to be used as a test of dynamic pricing programs and home energy management tools (a "Customer Applications Pilot" or CAP). This test of approximately 8,000 residential customers is one of the largest in the country, and the only one of its kind to be designed as an "opt-out" test of dynamic pricing. Customers were randomly assigned to a new rate and provided with a variety of in-home devices and different pricing programs to test whether the particular program would result in overall usage reduction (conservation), lower usage during very expensive "critical peak" summer periods, and overall customer satisfaction with the technology and pricing program assigned. While customers could choose to leave the pricing program pilot at any point, they were not allowed to choose another pricing program or technology in preference over returning to standard utility service, creating what is known as an "opt-out" pilot. The purpose of this CAP was to determine if customers would change their usage behavior, i.e., use less overall or use less during certain peak pricing periods. If one or more of the pricing and technology options could be predicted to have a significant impact if operated on a full scale basis, these actions could result in lower electricity prices for all customers.

⁸⁷ ICC Docket No. 09-0263.

- The rates that the CAP tested included: An inclining block rate, where the customer pays more for each block of use – e.g. 7.5 cents for the first 100 kWh, 9.5 cents for the second 100, 12.5 cents for the third.
- A “critical peak price” which imposes a very high price for energy use at designated “critical peak” times, such as from noon until 5 p.m. Customers using electricity during those times are charged more than they are at all other times.
- A “peak time rebate” which does the same thing as a critical peak price but instead of charging more, customers who use less energy during peak hours receive a bill credit.

ComEd provided customers with in-home display units showing energy consumption and price, as well as programmable control devices to regulate home heating and air conditioning systems. In addition, ComEd solicited pilot customers to go to their account on the ComEd website and view their usage information in more detail and learn how to respond to the specific pricing program that the customer was enrolled in.

COST BENEFIT ASSUMPTIONS FOR AMI DEPLOYMENT

To estimate the bill impact of AMI on residential customer bills, the following information needs to be provided:

- The time period over which costs are going to be recovered. Capital investments are amortized over their useful life, and utilities earn a return on those investments. AMI meters, communications equipment, etc. would be considered part of ComEd’s “rate base,” which earns a return. As of July 1, 2011, ComEd earned a return of 8.51% on its original cost rate base of \$6,548,591,000.⁸⁸
- What percentage of the capital costs are assigned to the residential class and what the amortization period and associated depreciation rate is for the

⁸⁸ ICC Final Order, Docket No. 10-0467, at 315-316.

capital costs, and finally the number of customers in each customer class. Given that ComEd has four residential delivery service classes, the breakdown between single and multi family homes, and then those with and without electric space heat must also be considered.

For the purposes of our HIA Report, the principals have assumed that bill impacts for residential customers for all AMI related costs would fall into the same range as other utilities, i.e., \$2-3 dollars per month.

Black and Veatch, ComEd's independent consultant, which assessed the operational impact of AMI deployment based on the pilot data, used a 20-year analysis period to calculate costs and benefits, which the evaluation report notes is discretionary. Estimating costs and benefits over a longer period means the cost assumptions become increasingly speculative. Given that technology changes over time, it is likely that technology will improve, and provide more capabilities at potentially lower or higher prices in future years. The final report includes a sensitivity analysis of some of the key assumptions to determine the impact of alternative assumptions on the final result, in this case, the impact on the base case of independent changes in nine key variables.

Variable	Base Case Value	Sensitivities Noted Description and Rationale
Energy and Delivery Prices	An average 3.7% escalation each year.	Future Energy and Delivery services prices ComEd charges its customers have the largest impact on the estimated Benefits since the UFE, CIM, and Bad Debt benefits (avoided costs) are all calculated based on these prices. This change would result in an unfavorable impact to the business case relative to the Base Case.
AMI Meter Price	\$122.78 / meter with no escalation during the deployment.	Meter prices are the largest single contributor to capital costs and may fluctuate. However, the unit price uncertainty is low and vendors are willing to lock in the unit price for the duration of the project. Digital meter prices have dropped since their introduction, which suggests there is a bias toward more favorable prices with scale and learning effects in manufacturing, and competitive market pressures as the market grows and matures.
UFE (Total Realizable Benefit)	50%	Based on ComEd analysis, the model assumes 0.9% of total distribution system dispatch is UFE, and that 50% of this is reducible with AMI (i.e., can be avoided and therefore estimated as a benefit).
CIM (Percent Billable Consumption)	100% Billable (Energy & Delivery)	The base case assumes 100% of the customers who are directly accountable for the current CIM losses (kWh and \$) become billable and pay their ComEd bills after AMI is implemented and CIM is eliminated. The business case will be impacted if all of these customers instead opt to simply not consume the energy they do today. In this case, ComEd would still recognize an avoided power purchase cost, but would not get the benefit out of the delivery services charges.
Reduction of Bad Debt (Remote Connect / Disconnect)	\$30.5M	An estimated \$30.5M in Net Bad Debt Expense can be avoided with use of Remote Connect/Disconnect Switch and associated new business practices to manage bad debt. A component of this benefit depends on customer behavior and specifically customer payment and re-connect choices given new knowledge of ComEd's remote switch capabilities. The sensitivity analysis evaluates both a favorable and unfavorable value to this particular estimated benefit.
AMI Meter Installation Cost	\$40.48 based on actual pilot costs and experiences.	The sensitivities suggest potential cost reductions due to the pilot costs reflecting only cold weather installations, the limited deployment period (reducing the learning curve benefit) and other lessons learned related to elimination of meter installation inefficiencies. An increased installation cost could be realized as a result of significant personnel movement and changes within the installation group causing inefficiencies, increased training costs and other associated overhead.
"Door Knock" Customer Notification Process (on Remote Disconnection for non-pay)	No Knock Required to Disconnect	Given the current "Part 280" rewrite, the disconnection rules are being rewritten to clarify the business process for disconnecting meters for non-payment using technology. ComEd does not know whether an on-premise contact (i.e., "door knock") will be required immediately prior to disconnection. Since the pending new process is uncertain, the additional costs associated with it cannot be estimated. Black and Veatch estimated the impact of having a "door knock" required in at least 50% of the circumstances where customers are disconnected.

Customer Applications and Pricing Programs

ComEd's Customer Application Pilot (CAP) was conducted from June 2010 through May 2011 with approximately 8,500 customers randomly selected from those who received a new smart meter. CAP customers were asked to participate in a pricing and technology pilot on an "opt-out" basis, that is, customers were enrolled in the CAP and only removed upon request. The experience from other similarly constructed pilots suggested that recruiting volunteers would require several months, result in high costs, or both, to achieve the participation level required to produce statistically significant results. Conversely, an *opt-out* deployment could be accomplished in relatively short order, and possibly at a lower cost. Moreover, the traditional *opt-in* recruitment process results in all participants being volunteers. Extending results to the entire population as a whole is not straightforward, because it requires establishing what distinguished volunteers and a way to identify them in the general population and the likely enrollees in a full-scale roll-out of the applications. Because opt-in customers are representative of the population, the pilot results can be used to make inferences about the full population impacts, as long as the drop-out rate is low.

The CAP tested customer use of five different rate applications with a variety of in-home devices, such as in-home displays and programmable thermostats. The pilot also tested customer response to educational and promotional strategies designed to stimulate customers to visit ComEd's website to see more detailed usage information and to use the combination of the pricing plans and in-home technologies to (1) shift usage from high cost peak periods to lower cost off-peak periods and (2) reduce overall consumption of electricity.

The five rate options tested include:

- Day-Ahead Real Time Pricing (DA-RTP), which changes the price of electricity supply through a new hourly price schedule issued each day.
- Combination of DA-RTP with critical peak prices in which the customer is either charged a very high price for usage during critical peak events (CPP) or provided a rebate or credit for reducing load during these critical peak events (PTR). Combining RTP with event-specific prices whereby the price of electricity increases to \$1.74 per kWh over the RTP price (critical peak pricing) or the customer is paid \$1.74 per kWh for load reduced during the event (peak time rebate).

- Time of Use, where the price is changed twice daily.
- Inclining Block Rates (IBR), where the more a customer consumes the more expensive the price per kWh is.
- For the CPP, RTP, PTR, and TOU rates, the peak period was defined as 1:00 - 5:00 p.m. weekdays.

All participants were invited to sign-up for an “eWeb service” that provided access to detailed information about billing data. Selected participants had access to basic or advanced in-home displays (IHD) which continuously displayed information about household electricity consumption,⁸⁹ a web-based information system, and to the means for regulating their household thermostat at times when load relief is needed through a programmable and controllable thermostat to facilitate adjusting load to price changes.

⁸⁹ The simple IHD continuously displays information, extracted directly from the AMI meter, about household electricity usage, both the current rate of energy usage and a historical comparison. Pilots that deployed this technology report a wide range of customer responses, from no change to a 5% or greater overall reduction in electric consumption. The advanced IHD incorporates electricity usage information into a device that serves a variety of roles including internet access.

These combinations of pricing programs and technology options resulted in 27 treatment cells and control groups, shown below:

		Enabling Technology Type ²				
		None	Enhanced Web (eWeb)	eWeb + Basic IHD	eWeb + Advanced IHD	eWeb + PCT/IHD (AIHD/PCT)
Flat Rate Type (1,650 Customers)	Flat Rate Existing Meter No Education	Control Group F1				
	Flat Rate Existing Meter Education		Application Group F2 (225)			
	Flat Rate AMI Meter Basic AMI Education		Control Group F3 (225)			
	Flat Rate AMI Meter Education		Application Group F5 (225)	Application Group F6 (300)	Application Group F7 (225)	
Energy Efficiency Rate Type (750 Customers)	IBR Rate AMI Meter Education		Application E1 (225)	Application E2 (300)	Application E3 (225)	
Demand Response Rate Type (3,525 Customers)	CPP/DA-RTP AMI Meter Education		Application D1 (750)	Application D2 (525)	Application D3 (525)	Application D4 (525)
	PTR/DA-RTP AMI Meter Education		Application D5 (225)	Application D6 (525)	Application D7 (225)	Application D8 (225)
Load Shifting Rate Type (2,625 Customers)	DA-RTP Rate AMI Meter Education		Application L1 (450)	Application L2 (525)	Application L3 (225)	
	TOU Rate AMI Meter Education		Application L4 (225)	Application L5 (750)	Application L6 (450)	
Total Customers: 8,550		450	2,550	2,925	1,875	750

EPRI was selected by ComEd to do an independent evaluation of the Consumer Applications Pilot (CAP), and EPRI issued a preliminary report on April 5, 2011⁹⁰ and a final analysis in October 2011.⁹¹ EPRI's reports presented findings on whether customers who were put on a variety of dynamic pricing programs and offered in-home technology options modified their energy usage and consumption patterns during the pilot which was operated from June 2010 through May 2011. As an initial matter, EPRI identified some issues relating to the implementation of the pilot which in turn affected EPRI's ability to draw conclusions about how ComEd customers would respond to these pricing programs and technologies:

- *Pilot Demographics:* EPRI found that the “load research sample,” which in the pilot was the estimated 7,000 customers, acting as the control group was found not to be representative of the residential customers located in the pilot area. For example, high usage customers were overly represented in the load research sample, with a usage level almost double the usage level of the rate treatment customers. As a result, it was not possible to give a statistically valid comparison between pilot customers and ComEd residential customers generally. Other data gathering impediments were experienced with the evaluation of the Inclining Block Rate (“IBR”) option (which required at least five years of historical usage data to create long term average usage levels from which the breaks or usage blocks of the IBR could be constructed so that IBR customers over-represent high usage and under-represent low usage customers) and the difficulties in evaluating a valid sample of customers with in-home technologies (which could not be placed in higher floors of multi-unit residences due to radio signal transmission difficulties, so that treatment cells involving in-home displays under-represented low usage customers because they exclude customers in multi-family residences above the first floor of a residential building).

⁹⁰ The Effect on Electricity Consumption of the Commonwealth Edison Customer Application Program Pilot: Phase I, EPRI, Palo Alto, CA: 2011, 1022703. ComEd selected EPRI to conduct the evaluation of its pilot program.

⁹¹ The Effect on Electricity Consumption of the Commonwealth Edison Customer Application Program Pilot: Phase 2 Final Analysis EPRI, Palo Alto, CA: 2011, 1023644 (October 2011).

- *Data Gathering:* While after 3 months only 2% of those enrolled opted out,⁹² over 1,000 participants were no longer part of the pilot at the end of the time period because the customer moved or cancelled their ComEd account during the pilot period. In addition, approximately 1,600 of the 8,000 enrolled customers were excluded from the analysis because more than 2% of the usage entries from June through August were recorded as zero and the failure to obtain the data was not explainable by outage. Because the summer of 2010 was considered cool, only a total of six critical peak event days were called in July and August, whereas during a summer with more very hot days more critical peak event days would likely be called.

Overall, EPRI found that none of the treatment cells (combinations of pricing and technology options) demonstrated a statistically valid overall usage reduction or a statistically valid peak load usage reduction. As a result, ComEd could not verify any of its hypotheses that the various pricing programs coupled with the various in-home technology options would result in a statistically valid change in customer usage behavior. However, there were a small group of customers (approximately 10% of the participating customers with valid data) in some treatment groups that did respond even if the treatment group as a whole did not respond. EPRI found that 6.7% of CPP and 4.9% of PTR customers reduced event-period load by 32% to 37% in five of the six price change events occurring throughout the summer, when prices reached \$1.70 per kWh. This was determined to be primarily due to responders shifting load from the event period (1:00 to 5:00 p.m.) to other times of the event day, since EPRI found little evidence of overall energy conservation. Of the participants on a regular real-time price, DA-RTP, 8.7% participants reduced usage during hours of high prices though their overall usage during the day increased an average of 7% on event days. These participants exhibited a higher price responsiveness according to the “substitution elasticity value” than the CPP and PTR customers, though the percentage of load change was not as significant as CPP and PTR customers.⁹³ Usage patterns among both CPP and PTR customers showed increased usage after the event

⁹² The pilot “rules” provide a bill protection feature for all customers, but this feature was not promoted and it was used primarily as a means of retaining customers who sought to opt out.

⁹³ EPRI concludes this was due in part to prices under the DA-RTP program being not nearly as high as the CPP or PTR prices.

and pre-cooling prior to the event (which is communicated to customers the previous day).

By comparison, only 2.7% of flat rate customers responded, 2.9% of IBR customers, and 4.2% of TOU customers. Moreover, the IBR rate induced no significant difference in monthly usage in the summer of 2010. A comparison of the load impacts across price and enabling technology applications did not reveal statistically significant effects attributable to TOU or to any of the enabling technology applications coupled with the pricing applications. However, at the end of the three months, only 10% of the applications had been installed or were working correctly. For other rate treatments, such as time-of-use (TOU) rates, EPRI noted it may take customers more than three months to become acclimated and respond to a change in price.

Finally, EPRI noted there was a very low uptake on the in-home devices. Less than 10% of the programmable thermostats that were intended were in fact installed. As a result, the impact of these devices on customer response to CPP and PTR is obscured. Very few customers purchased in-home devices; only 2% who were offered the device for a fee purchased it. Other customers were offered the in-home device at no additional charge, and of those, 34% installed the basic in-home display and 13% installed the advanced in-home display.

In its Final Report, EPRI included some information on demographic characteristics of the pilot customers based on the responses of two surveys conducted during the pilot, the first in March 2010 during the enrollment process and the second after the pilot was completed during April-June 2011. Customers who completed the final survey were given a \$50 credit on the ComEd bill. ComEd received 2,423 responses to the final survey, one-third of the eligible CAP customers, i.e., those enrolled in CAP as of April 2011 just prior to the end of the pilot. The survey results documented that customer satisfaction with their pricing plan was in the range of “average” (overall score of 5.6 with 0 as “extremely dissatisfied” and 10 as “extremely satisfied”), and in all pricing options, satisfaction levels were lower than satisfaction with ComEd overall as their utility.

While EPRI’s Final Report presents a table of the variety of demographic traits of the customers who returned the survey, the Report does not present any information on the response to the various treatment options by demographic characteristics, e.g., age, size of household, income, and housing type. However, the Report does confirm

that there is little demographic difference between the survey customers who responded to the pricing programs (the 10% who did respond) and those who did not respond to the pricing programs.⁹⁴ Finally, EPRI's Final Report concludes, "An opt-out recruitment strategy by itself does not appear to encourage a greater treatment response level than opt-in pilots report."⁹⁵

An analysis of the AMI pilot conducted for ComEd by Black and Veatch estimated that 30,000 MWh of electric generation would be avoided from customer energy efficiency or other voluntary use reductions, after full deployment of AMI to all ComEd customers.⁹⁶ This is a very small amount of energy savings (0.03% of ComEd's total of 91.1 million MWh in sales in 2010).⁹⁷

This energy savings translates to an estimated CO₂ reduction of 23,000 tons per year.⁹⁸ Avoided vehicle emissions of 4 million miles of travel were also reported; this translates to an annual reduction of about 2,000 tons of CO₂ emissions.

The lack of observable energy savings in ComEd's AMI pilot is inconsistent with similar demonstrations, including the 2003-2006 Energy-Smart Pricing Plan in ComEd's service territory which showed a 3-4% reduction in summer electricity usage.⁹⁹ This difference may owe to pricing incentives and/or inadequate information provided to AMI pilot participants and should be further examined.

The combined reduction in CO₂ emissions of 25,000 tons per year, derived from Black and Veatch's estimates of the benefits of full AMI deployment, would be roughly equivalent to the annual CO₂ emissions from roughly 4,400 passenger vehicles or the energy consumed in 2,000 homes.¹⁰⁰ For comparison, the Chicago metropolitan area's total CO₂ emissions have been estimated to be about 40 million

⁹⁴ EPRI Final Report, Table 6-4, page 6-11.

⁹⁵ EPRI Final Report, Abstract, at vii.

⁹⁶ Section 14.1.

⁹⁷ Greater - but still modest - reductions in consumption are attributed to reducing unaccounted for energy (UFE, 350,000 MWh annually). We do not consider these energy savings to result in actual emission reductions because as discussed in Section 7.9 of B&V report, most customers found to be receiving unmeasured power are expected to begin paying for power.

⁹⁸ Using Black and Veatch's CO₂ emission factor in Section 9.5

⁹⁹ A. Faruqui and S. Sergici, "Household response to dynamic pricing of electricity: a survey of 15 experiments," *J. Regul. Econ.* (2010), 38, 193-225.

¹⁰⁰ <http://www.epa.gov/cleanenergy/energy-resources/calculator.html>

tons.¹⁰¹ Reductions in other pollutants including nitrogen oxides, carbon monoxide, mercury, particulate matter and volatile organic compounds would also be expected but were not calculated here due to the lack of project-specific data on energy consumption.

¹⁰¹ 2005 emissions, as reported in: Center for Neighborhood Technology, "Chicago's Greenhouse Gas Emissions: An Inventory, Forecast And Mitigation Analysis For Chicago And The Metropolitan Region," (2008); available at http://www.cnt.org/repository/CNT_Climate_Research_Summary_9.17.08.pdf

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