# Frankfort's Energy Future

## Exploring the Benefits of Renewable Energy and Energy Efficiency for the Frankfort Plant Board

By Daniel Holder, Andy McDonald, and Nathan Shuler

August 2016

Presented by

ENVISION
FRANKLIN COUNTY

**EnvisionFranklinCounty** is a citizens' movement in Frankfort & Franklin County, Kentucky, that promotes a healthy, beautiful, and thriving community among people, the land and future generations.

## About the Authors

**Daniel Holder, M.A.** is an energy analyst residing in Louisville, Kentucky. His work includes forecasting energy commodity prices. He received his bachelor's degree from Centre College and a Master's in Applied Economics from Oregon State University. Contact: DanielRossHolder@gmail.com | 502-693-9732

**Andy McDonald, M.S.** is the Director of Sustainable Systems Programs for Earth Tools, Inc. in Owenton, Kentucky. He is the former Director of the Kentucky Solar Partnership and has served as the Chair of the Kentucky Solar Energy Society and the President of the Kentucky Conservation Committee.
Contact: andyboeke@yahoo.com | 502-484-3988

**Nathan Shuler, B.A.** is an energy consultant in Louisville, Kentucky. He received his bachelor's degree in Economics from Centre College and is a LEED Green Associate.
Contact: nshuler25@gmail.com | 859-753-0977

*Frankfort's Energy Future:*
*Exploring the Benefits of Renewable Energy and Energy Efficiency for the Frankfort Plant Board*

# Table of Contents


**List of Acronyms** 5
**Executive Summary** 6
**Introduction** 10
**I. The Risks of Continuing with the Status Quo** 11
A. Understanding the Business-As-Usual Path 11
B. Kentucky's Electricity Profile 11
C. Managing Demand: Kentucky's Current Energy Efficiency Profile 13
D. Demand Response and Peak Load Management in Kentucky 14
E. Coal Retirements and Natural Gas Switching – Updating the Business-As-Usual Model 14
1. Natural Gas Price Trends 15
2. Coal 15
F. Electric Rates Under the BAU Scenario 17
G. Health Costs 17
H. Summary of the Business-as-Usual Path 18

**II. An Electricity System for the Future: Renewable Energy and Energy Efficiency at the Foundation** 18
A. Renewable Energy Technologies 18
1. Solar Photovoltaics 19
2. Wind Energy 20
3. Distributed and Centralized Generation – Complementary Approaches to Renewable Energy 22
4. Barriers to Wind and Solar 22
5. Renewable Energy Summary 23
B. Energy Efficiency is a Key Resource 24
C. The Benefits of Renewable Energy & Energy Efficiency 25

**III. Next Steps for Moving Forward** 26
A. Developing Energy Efficiency Programs 26
1. The How$mart On-Bill Financing Program 26
2. Other Energy Efficiency Programs 27
B. Renewable Energy Development Strategies 28
1. Investing in Renewable Energy Generation 28
A. Exploring Long Distance Transmission and Importing Wind Energy 28
2. Encourage and Develop Distributed Generation 29
A. Develop and Support Community Solar Projects 29
B. Raise the cap on net metering from 30 kW to 1,000 kW 30
C. Expand Net Metering by Enabling Meter Aggregation 30

**IV. Conclusion** 31

**Appendix - Case Studies of Utilities Leading with Energy Efficiency and Renewable Energy** 32
Burlington Electric Department, Vermont 32
Midwest Energy, Kansas 32
Massachusetts - A Beacon for Energy Efficiency 33
MidAmerican Energy, Iowa 34
Glasgow Electric Plant Board, Kentucky 34
The Water Heater as a Demand Side Management Tool 35
Osage, Iowa 35
**End Notes** 36

# List of Acronyms

| | |
|---|---|
| ACEEE | American Council for an Energy-Efficient Economy |
| BAU | Business-as-Usual |
| CHP | Combined Heat and Power |
| CPP | Clean Power Plan |
| CREZ | Competitive Renewable Energy Zones |
| DEDI | Kentucky Department for Energy Development and Independence |
| DOE | U.S. Department of Energy |
| EE | Energy Efficiency |
| EIA | Energy Information Administration |
| FERC | Federal Energy Regulatory Commission |
| FPB | Frankfort Plant Board |
| GW | Gigawatt (1,000 megawatts) |
| HVAC | Heating, Ventilating and Air Conditioning |
| HVDC | High Voltage Direct Current |
| KHP | Kentucky Home Performance |
| KU | Kentucky Utilities |
| KW | Kilowatt |
| KWH | Kilowatt-hour |
| KyMEA | Kentucky Municipal Energy Agency |
| LCOE | Levelized Cost of Energy |
| LG&E | Louisville Gas and Electric |
| LNG | Liquefied Natural Gas |
| MACED | Mountain Association for Community Economic Development |
| MATS | Mercury and Air Toxics Standards |
| MW | Megawatt (1,000 kilowatts) |
| NREL | National Renewable Energy Laboratory |
| PUC | Public Utilities Commission |
| PV | Photovoltaics |
| REPS | Renewable and Efficiency Portfolio Standard |
| REV | Reforming the Energy Vision |
| TVA | Tennessee Valley Authority |

# Executive Summary

The Frankfort Plant Board (FPB) is facing some critical decisions concerning their electricity supply as they make the transition away from KU and join the Kentucky Municipal Energy Agency (KyMEA). The choices made in the coming months will have long-term impacts for the FPB, its ratepayers, and the community.

In this report we offer an overview of the energy markets that affect the FPB's electricity services, highlighting the risks and uncertainties inherent to these markets. We then explore the opportunities and benefits available to the FPB and its community by turning onto a new energy path, one dedicated to energy efficiency and renewable energy.

Continuing with an energy supply highly dependent on coal and natural gas, with minimal investment in energy efficiency, would be to follow the "business-as-usual" (BAU) path. In 2015 coal supplied 87% of Kentucky's net electricity generation, down from 92% in 2010. While coal usage declined natural gas generation increased from 3% to 7% over the same time period.[1] Based on an analysis prepared by Synapse Energy Economics in 2012, we can expect that a "business-as-usual" approach to Kentucky's energy future would continue our dependence on coal, but with substantially increasing use of natural gas generation. Synapse projected renewable energy to continue playing a very minor role in Kentucky under BAU, at least through 2022.[2]

Synapse projected what the impact on Kentucky's electric rates would be if we continued along the BAU path. They projected that Kentucky's average electric rates would increase by 50% between 2010 and 2022.[3] These projections were conservative and likely underestimate the actual rate increases that would be experienced. For example, their study did not reflect the capital costs incurred in 2015 by some utilities, including KU/LG&E, to comply with tighter emission regulations. While Synapse projected an average rate increase of 4.2% per year between 2010 and 2022, the FPB's rates have actually risen 5.5% per year, on average, from 2007 to 2017.[4] In the years to come continuing environmental compliance pressures will greatly impact the price of fossil fuel commodities and thus retail prices for the BAU path.

With regards to energy efficiency and demand-side-management, while many of Kentucky's utilities offer energy efficiency programs to their customers, much more could be done to increase energy efficiency in the state. The ACEEE ranks Kentucky 29th out of the 50 US states for an energy efficient economy.[5] Synapse's BAU scenario assumes that efficiency would continue to play a minor role to reduce overall consumption in Kentucky, but also illustrates how much could be accomplished with aggressive efficiency programs. For the FPB, business-as-usual would mean continuing to offer minimal energy efficiency services to their customers.

For the FPB and their customers, the risks of continuing with business-as-usual include:

- Increasing fuel and generation prices;
- Increasing costs from federal environmental regulations;
- Vulnerability to impending carbon regulations;
- Increasing demand due to the lack of energy efficiency programs; and
- Continuing health impacts from power plant pollution.

A diversified energy portfolio founded upon energy efficiency and renewable energy is a viable alternative to the business-as-usual path for the FPB. This alternate path offers the following benefits to the FPB, its customers, City and County government, and the local community.

- Protecting the FPB's customers against rising rates by making energy efficiency services more widely available and accessible;
- Serving the community by helping customers to reduce their bills;
- Reducing risk from volatility in energy markets;
- Decreasing regulatory risk;
- Reducing the FPB's reliance on outside energy purchases;
- Lowering demand charges and transmission and distribution costs;
- Extending the life of utility infrastructure; and
- Generating local investment and economic development.

The cost of renewable energy, particularly wind and solar photovoltaics (PV), has fallen dramatically in recent decades, while their use has expanded exponentially throughout the world. Utility-scale wind is cost-competitive with natural gas and abundantly available in neighboring states such as Indiana and Illinois, as well as throughout the Great Plains and the Midwest. Solar PV is also becoming increasingly cost-competitive with conventional power, particularly during peak daytime hours, and its steep price decline is expected to continue for years to come. Other renewable energy technologies are also available, including hydroelectric, biomass, and landfill gas.

A diversified energy portfolio based on renewable energy would allow the FPB to utilize the advantages offered by different technologies and mitigate the risks of being heavily dependent on one source. The range of renewable energy sources available enables the FPB to invest in a mix of larger centralized generation (e.g. utility-scale wind), mid-scale centralized generation (e.g. biomass and landfill gas, hydro, utility-scale solar), and distributed generation (rooftop and community solar, smaller hydro and biomass, solar thermal water heating). Centralized and distributed generation each have their advantages and limitations. Combined in a diversified portfolio they can contribute to a cost-effective, reliable, resilient energy system. The Burlington Electric Department in Vermont is one example of a utility which meets 100% of its energy requirements using a mix of biomass, hydro, and wind.[6]

Utilizing wind and solar energy at a large scale does present challenges to the current utility grid, due to the fact that they depend on intermittent and variable resources (the wind and sunlight). However, with wind and solar becoming major contributors to our national energy system, people are working out solutions to these challenges. These solutions include dramatically improved energy storage, changes to the grid infrastructure and grid management, and the distribution of renewables across a wide geographic area. The states of New York and California are proactively working to adapt their electricity systems to integrate large amounts of renewables, distributed generation, and demand-side resources (both states aim to use 50% renewables by 2030).[7]

Germany, meanwhile, has experienced increasing levels of grid reliability as they have increased their utilization of renewables. Wind and solar met 45% of Germany's total electric capacity in 2015.[8] The existence of barriers to using wind and solar at a large scale is not halting their expansion – it's spurring people to find solutions.

Energy efficiency and demand-side management are essential components of a diversified energy portfolio, being the least expensive "source" of new energy available. Effective energy efficiency programs save utilities and their customer's money, delaying the need for new power plants, lowering peak demand charges, and reducing service cut-offs to low-income customers. They benefit the community by helping customers reduce their energy bills and help the community adapt to rising energy prices. The Burlington Electric Department calls energy efficiency the "cornerstone" of their resource acquisition strategy.[9] By integrating energy efficiency programs into a diversified energy portfolio, a utility can lower overall costs while providing a valuable service for their customers. Even after 25 years of energy efficiency programs, the Burlington E.D. is still saving their customers $11 million per year.[10]

## Next Steps for Moving Forward

In the final section of this report we recommend steps the FPB can take if it chooses to pursue the clean energy path that we have described.

1. Partner with the Mountain Association for Community Economic Development (MACED) to develop a How$mart On-Bill Financing energy efficiency program.

2. Develop additional demand-side management programs targeted to serve all segments of the community, including low-income customers.

3. Invest in renewable energy generation, using strategies such as:
   - Include renewable energy in all Requests for Proposals issued by the KyMEA;
   - Investigate importing wind energy from the Great Plains via Clean Line Energy Partners and other avenues;
   - FPB development and ownership of renewable energy generating facilities;
   - Power Purchase Agreements for renewable power from third-party developers;
   - FPB selling or leasing rooftop solar PV systems to customers;
   - Partnerships with the KyMEA and/or its members on joint renewable energy projects.

4. Encourage and develop distributed generation by:
   - Developing and supporting community solar projects;
   - Expanding net metering by enabling meter aggregation for net metering customers;
   - Raising the cap on net metering from 30 kW to 1,000 kW.

5. Avoid long-term contracts for fossil fuel resources.

6. Maintain local control of the FPB's ability to develop energy efficiency programs and pursue renewable energy options in the years ahead.

## Conclusion

As the FPB moves ahead with the KyMEA, we recommend that these organizations pursue the path of energy efficiency and renewable energy together. The risks and opportunities outlined in this report confront each of the members of the KyMEA, not only the FPB. The energy sector is in a time of great change. All municipal utilities would be wise to avoid long-term commitments to fossil-fuel resources and to maintain their freedom to develop energy efficiency programs and renewable energy resources. Contracts which bind these local utilities to coal for the next decade or more risk closing off paths to much better options for themselves and their communities.

# Introduction

The Frankfort Plant Board is facing some critical decisions concerning their electricity supply as they make the transition away from KU and join the KyMEA (Kentucky Municipal Energy Agency). The choices made in the coming months will have long-term impacts for the FPB, its ratepayers, and the community.

In this report we offer a brief overview of the energy markets that affect the FPB's electricity services, highlighting the risks and uncertainties inherent to these markets. We then explore the opportunities and benefits available to the FPB and its community by turning onto a new energy path, one dedicated to energy efficiency and renewable energy.

Continuing with an energy supply highly dependent on coal and natural gas, with minimal investment in energy efficiency, would be to follow the "business-as-usual" (BAU) path. The risks of continuing with business-as-usual include:

- increasing fuel and generation prices;
- increasing costs from federal environmental regulations;
- vulnerability to impending carbon regulations;
- increasing demand due to the lack of energy efficiency programs; and
- further health impacts from power plant pollution.

Recognizing these risks, we point towards an alternate path that offers substantial opportunities and benefits - an energy portfolio founded on energy efficiency and renewable energy. This alternate path offers the following benefits to the FPB, its customers, City and County government, and the local community.

- Protecting the FPB's customers against rising rates by making energy efficiency services more widely available and accessible;
- Serving the community by helping customers to reduce their bills;
- Reducing risk from volatility in energy markets;
- Decreasing regulatory risk;
- Reducing the FPB's reliance on outside energy purchases;
- Lowering demand charges and transmission and distribution costs;
- Extending the life of utility infrastructure; and
- Generating local investment and economic development.

This report concludes with tangible next steps the FPB can take to begin moving along this alternate path. There is a wealth of examples from across the region and country of how utilities and communities are seizing these opportunities. We share a few of these examples in the Appendix to this report.

# I. The Risks of Continuing with the Status Quo

For many decades Kentucky has been heavily dependent on coal for electricity generation. While in the past this has helped Kentucky offer some of the lowest electric rates in the nation, the benefits of being so dependent on coal are dwindling. An energy transition is underway, but what form will it take? This section describes the current status of Kentucky's electricity market and explores the vulnerabilities and risks of trying to continue with the status quo for another decade or more.

## A. Understanding the Business-As-Usual Path

A report produced by Synapse Energy Economics, Inc. in 2012 entitled *Potential Impacts of a Renewable and Energy Efficiency Portfolio Standard in Kentucky* provides a basis for projecting how Kentucky's electricity system could develop in the years to come.[11] The report builds out two scenarios for Kentucky's energy future: one based on business-as-usual (BAU) and one on the adoption of a proposed Renewable and Efficiency Portfolio Standard (REPS). These scenarios provide a useful reference point for assessing what a business-as-usual energy future would look like for Kentucky and, by extension, the Frankfort Plant Board. The Synapse report primarily utilizes data from 2010 to construct its BAU scenario. In this report we have combined Synapse's analysis with more current data and trends to explore what the BAU scenario looks like today. The BAU scenario that we explore assumes the following holds true into the future: Kentucky enacts no REPS, the US EPA's Clean Power Plan remains on-hold in court[12], and the trajectory of Kentucky's energy mix does not change.

## B. Kentucky's Electricity Profile

In 2010, Kentucky's power generation was 92% coal and 3% natural gas. Under their BAU scenario Synapse expected coal to drop to 71% in 2022 and natural gas to reach 25%.[13] Data from the Energy Information Administration's (EIA) *2015 Kentucky Energy Profile* shows that Kentucky's transition from coal towards natural gas is actually proceeding faster than Synapse projected. By 2015 coal was down to 87% of Kentucky's net electricity generation and natural gas was at 7% (ahead of Synapse's projection of 5% for 2015).[14] Synapse also projected that renewables would meet less than 5% of Kentucky's electricity generation and capacity in 2022. Data from the EIA shows that by 2015 renewables had already reached 5.1% of Kentucky's total electricity consumption.[15] Figure 1 shows Synapse's BAU Scenario for annual electricity requirements and sources in Kentucky. Figure 2 shows where Kentucky stands relative to the other fifty States on energy-related measures, as of 2015.

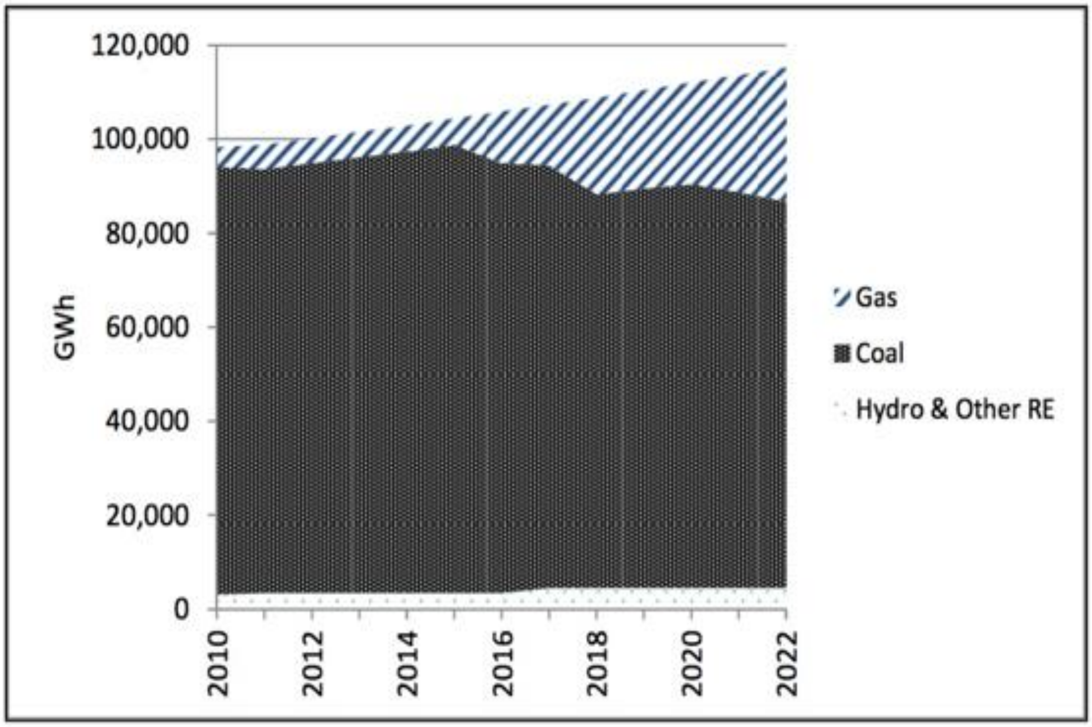
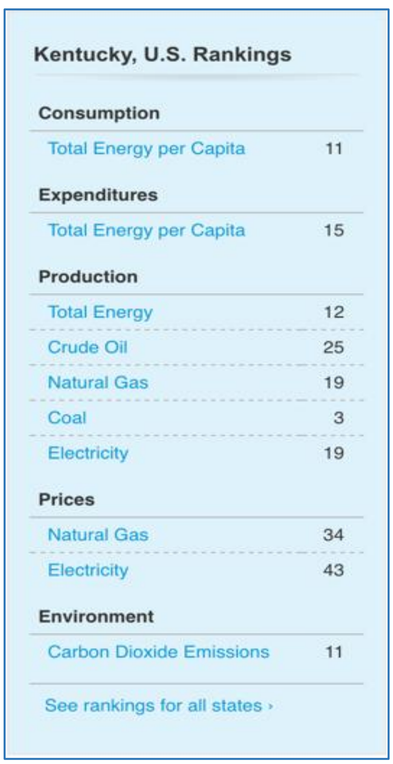



**Figure 1** – Business-As-Usual Scenario for Kentucky's Annual Electricity Requirements and Sources, from Synapse Energy Economics, Inc.[16]


Kentucky, U.S. Rankings

| | |
|---|---|
| **Consumption** | |
| Total Energy per Capita | 11 |
| **Expenditures** | |
| Total Energy per Capita | 15 |
| **Production** | |
| Total Energy | 12 |
| Crude Oil | 25 |
| Natural Gas | 19 |
| Coal | 3 |
| Electricity | 19 |
| **Prices** | |
| Natural Gas | 34 |
| Electricity | 43 |
| **Environment** | |
| Carbon Dioxide Emissions | 11 |

See rankings for all states ›

**Figure 2**- EIA Ranking of Kentucky Energy Profile.[17]

# C. Managing Demand: Kentucky's Current Energy Efficiency Profile

The American Council for an Energy-Efficient Economy (ACEEE) currently ranks Kentucky at 29th out of all 50 US states for an energy efficient economy. Kentucky received 14 out of 50 points on the ACEEE scorecard.[18] ACEEE reports that in 2014 Kentucky spent 0.63% of statewide electricity revenue on energy efficiency programs, about one-tenth as much as the states with the highest spending (Rhode Island, Massachusetts, and Vermont).[19] Synapse's BAU scenario expected energy efficiency to play a minor role in Kentucky's electricity profile, based on the state's historically low energy efficiency. Figure 3 below shows Synapse's projection of the growth in annual electricity sales in Kentucky through 2022 under their BAU and REPS scenarios. The BAU scenario illustrates that without sufficient support from state and utility programs, energy efficiency will continue to play a minor role in Kentucky's energy landscape.[20]

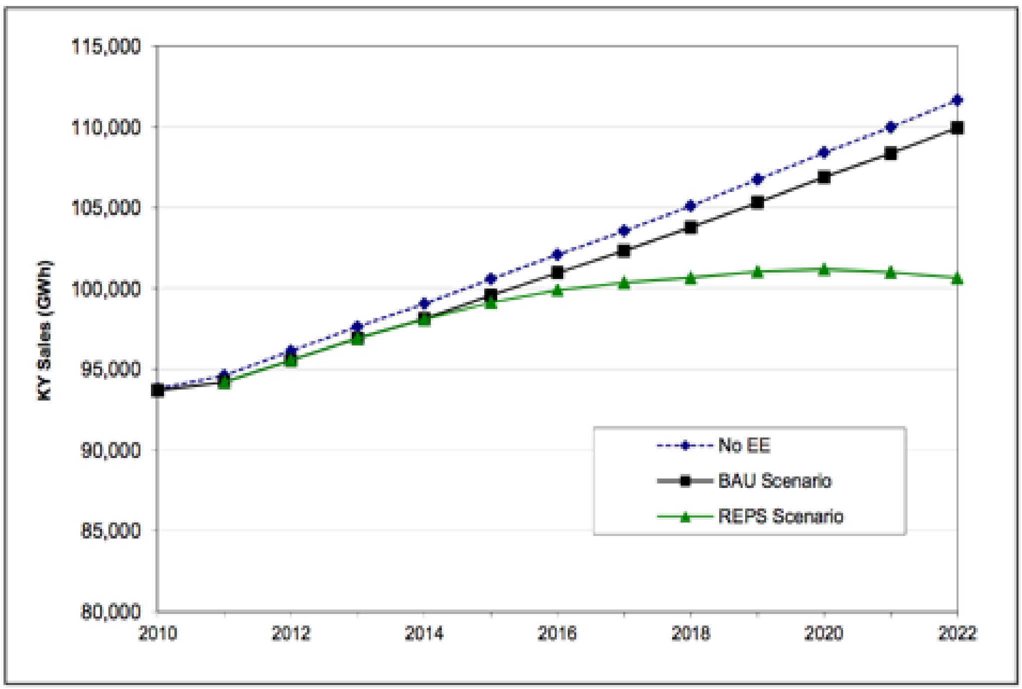



**Figure 3** – Projected total annual electricity sales in Kentucky with No Energy Efficiency (EE), in the BAU scenario, and in the REPS scenario, from Synapse Energy Economics, Inc. 2012.[21]

The BAU scenario recognizes that there are existing programs to promote energy efficiency in Kentucky and that these would continue in some form under BAU. Figure 3 illustrates that efficiency programs can have a measureable impact on electricity consumption (especially under the influence of an REPS).

Among Kentucky's existing energy efficiency programs is the KY Home Performance Program (KHP). KHP was initially funded through the American Recovery and Reinvestment Act. As of July 2016, KHP has completed nearly 1,200 single-family energy efficient retrofits resulting in a total development cost and investment of nearly $11 million across Kentucky.[22] Many of Kentucky's electric utilities offer energy efficiency services to their customers, with widely varying programs across the state. The Kentucky Department for Energy Development and Independence (DEDI) has provided leadership in energy efficiency for many years, with various initiatives aimed at improving energy efficiency in the state. One of their most successful programs has targeted energy efficiency in public schools. Energy conservation services are also available to lower-income families in many communities through the weatherization programs offered by local Community Action Agencies.

Despite these many programs, Kentucky has much more potential for increasing energy efficiency, as the Synapse report and ACEEE's research shows. Unlike many other electric utilities in Kentucky, the FPB offers minimal energy efficiency services to its customers, and therefore has even greater potential for improvement than the rest of the state.

## D. Demand Response and Peak Load Management in Kentucky

"Demand response" and peak load management are used to reduce the use of electricity by customers at times of peak demand rather than bringing in new energy supplies. Demand response helps to improve system reliability, reduces costs, and can defer the need for new infrastructure and generation capacity. Demand response programs are used in many states, including Kentucky, with LG&E/KU, TVA, Duke Energy and other utilities providing such services. The benefits of demand response are clear; in one week in 2006, for example, customers in PJM's territory saved an estimated $650 million from voluntary curtailments in electric use by business and residential consumers.[23] Demand response lowers the cost of electricity by avoiding the use of the most expensive generators. Keeping peaking power plants idle helps to lower the price of power especially as the "last-in" unit of power often determines power prices.

Peak load management programs support customers in reducing their loads by shutting down non-essential equipment, turning on back-up generation, and adjusting HVAC, lighting, and water heater usage. Demand response programs are often incentive-based programs that reward customers for not using electricity or shifting its use to preferable times of day.

## E. Coal Retirements and Natural Gas Switching - Updating the Business-As-Usual Model

While the 2012 Synapse report provides a foundation for understanding the business-as-usual path, it's important to know that much has changed in the energy world over the last four years. For example, most analysts widely missed the production boom of natural gas that was spurred by hydraulic fracturing. Nonetheless, the Synapse report remains relevant to this conversation due to its comprehensive and thorough analysis. This section aims to revise our understanding of the BAU scenario by taking into account the speed at which natural gas has penetrated Kentucky's electric generation market and the speed at which coal power plants are retiring.

## 1. Natural Gas Price Trends

The Synapse report assumed that the price of natural gas delivered to gas-fired units in Kentucky would increase from $5.29/MMBtu in 2010 to approximately $6.50/MMBtu (in 2010$) by 2022.[24] The largest component of that price is the projected Henry Hub price, with the other component being an estimate of the basis differential between the Henry Hub price and Kentucky. By May 2016, the spot price for Henry Hub was $1.92/MMBtu, a sizable shift from Synapse's projection.[25] The record high production of natural gas over the last five years coupled with generally mild peak seasons over the last two years have led to this precipitous drop in the price of Henry Hub natural gas.

In the US natural gas market, prices have recently seen lows not witnessed since the 1990's. This is in large part due to the technological advancements in extraction of shale gas and oil. The low price environment has incentivized the construction of more than 40 GW of natural gas-fired power plant capacity in the US since 2011, including the 640 MW Cane Run conversion from coal in Louisville and the 1 GW Big Sandy conversion in Eastern Kentucky.[26]

Even though gas prices are currently low, the growing ability to export gas will increase price volatility going forward. As Mexico deregulates its electricity sector, the country will demand more US gas, and the past two years have seen a tripling of total natural gas exports, to 3 Bcf/d (billion cubic feet per day). We expect to see approximately 4.6 Bcf/d exported to Mexico by the end of 2024.[27] While exports via pipeline to Mexico are increasing, so too are inter-continental exports via liquefied natural gas (LNG). By the end of 2018, it is expected that liquefied natural gas (LNG) export terminals will have the capacity to ship 8 Bcf/d of US gas overseas.[28] The potential demand from LNG will make up about 10% of total US demand for natural gas by 2018. Because LNG connects the US gas market to the global natural gas marketplace, US prices will begin to be affected by global price spikes and price trends.[29] While the global marketplace for LNG over the next three years looks to be bearish, global demand will begin reacting to the low price environment and will eventually catch up.

## 2. Coal

Coal prices in the US have been relatively stable since 2008, with Illinois Basin coal trading around $2/MMBtu (roughly in line with current natural gas prices) for the past 6 years. [30] However, the combination of low natural gas prices and increased cost of compliance to federal regulation has caused 14 GW (gigawatts) of coal-fired power plants to retire in 2015 and will result in another 5 GW of coal-fired power plants to retire in 2016.[31] While the price of coal is likely to remain low for the coming years in order to compete with other sources of fuel, further regulation will increase the cost of coal-fired generation. The EPA's Clean Power Plan (CPP), which seeks to regulate carbon dioxide emissions from existing power plants, is expected to cause an additional 50 GW of coal-fired power plants (about 1/4 of the US total) to shut down by 2030, and will bring additional compliance costs to the plants that remain. [32] Beyond the US regulatory landscape is a much larger trend in the global coal market: China. Responsible for half of the world's consumption and nearly half of the world's production, the realization that Chinese coal demand decreased for the past two years helped bring global coal prices to decades-long lows. On the flip-side, government action to reduce total Chinese production by 9% (4% of global production) by 2020 has begun lifting prices again.  It is clear that US regulation is only one part of the larger coal story.[33]

Low natural gas prices coupled with increased environmental regulation (such as the MATS mercury rule of April 2015) have  had a major impact on power markets in the Southeast and Midwest, where coal remains a high portion of the energy mix. Large quantities of coal-fired generation have been retired in recent years, as Figure 4 illustrates. In 2015 alone 10% of Kentucky's coal-fired capacity was retired.[34]  About 30% of US coal retirements in 2015 occurred in April due to the MATS rule and the remaining plant closures were caused by economic pressures such as the low price of natural gas.

Nearly 5.4 GW of coal-fired generating capacity in Kentucky have recently been retired or will be retired before 2020. Kentucky has a total of 145 power generating units of all types with a capacity of 17 GW. Of those,  32 are coal-fired plants, averaging 45 years of age, and they account for 65 percent of the state's total  capacity.[35] These 1960s and '70s-era plants are receiving major reinvestment from utilities like LG&E/ KU to bring them into compliance with existing laws.

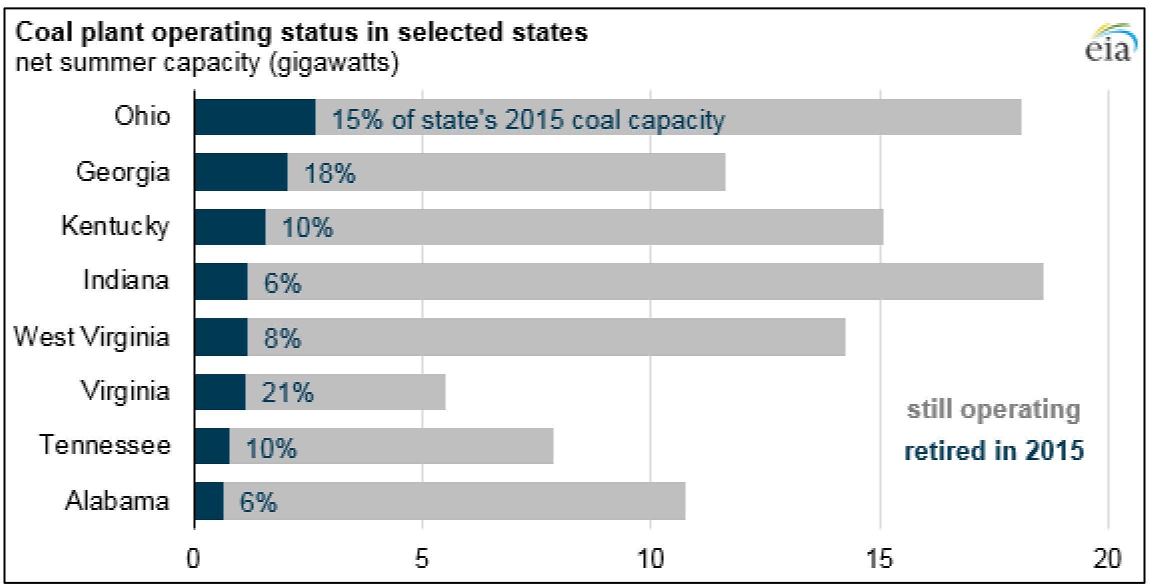



**Figure 4** – Coal plant operating status and retirements in 2015. U.S. EIA.[36]

The Synapse report had originally estimated that 5% of Kentucky's coal-fired capacity would retire by the end of 2015, a conclusion largely based on environmental compliance and already planned retirements. The more rapid movement away from coal to natural gas and the retirement of larger coal-fired assets raises important questions about which resources will best fit into Kentucky's future. If Kentucky continues with BAU new generation will need to match a steadily increasing electricity demand in a state with high energy consumption and low energy efficiency.

## F. Electric Rates Under the BAU Scenario

The Synapse BAU scenario projects that, between 2010 and 2022 statewide average electric ***bills*** would increase by approximately 47%, while ***rates*** would increase by 50%.[37] Figure 5 shows how rates and bills would change under BAU for different rate classes. It is important to note the difference between electricity ***rates*** and ***bills***. Higher electricity rates do not have to result in proportionally higher bills if customers consume less energy, which is why energy efficiency programs become even more important as rates continue to rise. One's actual bills depend upon the amount of energy used, which is why many states with higher electricity rates have lower average monthly bills than Kentucky.[38] For example, while Massachusetts' average residential rates are $0.17/kWh - substantially higher than Kentucky's average of $0.10/kWh- Massachusetts residents pay $12 less per month than Kentuckians on their electric bills.[39]

| Average Electric Rates ($/kWh) (2010$) | 2010 | 2015 | 2020 | 2022 | Increase from 2010 |
|---|---|---|---|---|---|
| Total (All Sectors) | $0.067 | $0.070 | $0.095 | $0.101 | 50% |
| Residential | $0.086 | $0.088 | $0.114 | $0.120 | 40% |
| Commercial | $0.079 | $0.081 | $0.106 | $0.113 | 43% |
| Industrial | $0.051 | $0.053 | $0.078 | $0.085 | 67% |
| | | | | | |
| **Average Electric Bills ($) (2010$)** | **2010** | **2015** | **2020** | **2022** | **Increase from 2010** |
| Residential | $1,249 | $1,319 | $1,727 | $1,834 | 47% |
| Commercial | $5,198 | $5,384 | $7,185 | $7,658 | 47% |
| Industrial | $325,409 | $342,448 | $513,290 | $557,989 | 71% |

**Figure 5**- Forecast statewide average rates and bills by sector under the BAU Scenario, from Synapse Energy Economics, Inc.[40]

The increases in rates and bills projected under the BAU scenario were conservative. Synapse did not reflect the capital costs that some Kentucky utilities, such as LG&E/KU, incurred in 2015 in order to retrofit certain existing coal units to comply with tighter emission regulations, namely the MATS rule. In the years to come continuing environmental compliance pressures will greatly impact the price of fossil fuel commodities and thus retail prices for all ratepayers.

# G. Health Costs

Power plant pollution has significant impacts on human health and quality of life. As reported by the Clean Air Task Force, "Among all industrial sources of air pollution, none poses greater risks to human health and the environment than coal-fired power plants. Emissions from coal-fired power plants contribute to global warming, ozone smog, acid rain, regional haze, and—perhaps most consequential of all from a public health standpoint — fine particle pollution."[41] In 2010 the Clean Air Task Force commissioned Abt Associates to perform an in-depth analysis on the burden of death and disease from coal-based electricity production. Their analysis concluded that nationwide over 13,000 premature deaths per year could be attributed to the fine particle pollution from coal plants. "Additional impacts include an estimated 9,700 hospitalizations and more than 20,000 heart attacks per year. The total monetized value of these adverse health impacts adds up to more than $100 billion per year."[42] Kentucky had the fourth-highest mortality risk among all states, due to the large number of coal-fired power plants in our region.

A more comprehensive accounting of the health and environmental impacts of power generation is beyond the scope of this report. Without exploring in-depth the effects of ozone smog, mercury emissions, other air pollutants, water pollution, and global warming, we can conclude that the BAU path would have significant impacts on human health and the environment.

## H. Summary of the Business-as-Usual Path

Synapse projected that Kentucky's electric rates would rise on average 4.2% annually between 2010 and 2022.[43] In reality, between 2007 and 2017 the FPB's rates have risen on average 5.5% annually.[44] While the FPB's rates remain relatively low (compared with much of Kentucky and the rest of the U.S.), the utility and its customers stand at a crossroads. Should it continue on the business-as-usual path, staying with an energy mix dominated by coal and natural gas, with a minimal commitment to energy efficiency and demand-side management? Moving away from Kentucky Utilities - their current electricity supplier - could be a positive step that opens up new opportunities and helps the FPB avoid the many risks inherent to the BAU path. But that will not happen if their new energy supply looks mostly like their old supply and they commit to buying it for another ten years.

# II. An Electricity System for the Future: Renewable Energy and Energy Efficiency at the Foundation

## A. Renewable Energy Technologies

The transition the FPB is making away from Kentucky Utilities opens up new possibilities for the utility to invest in a more diverse energy portfolio. Such a move offers significant benefits and opportunities for the utility, its customers, and the wider community. There are various renewable energy options available to the FPB, both locally and in the wider region, with opportunities to develop them as both distributed and centralized generation. These renewable energy technologies are being used at a large scale by utilities and their customers throughout the United States. They include:

- Wind
- Solar photovoltaics (PV)
    - Centralized, utility-scale PV
    - Distributed PV (residential & commercial rooftops, ground mounted systems, shade structures, community solar, etc.)
- Hydroelectric
- Solar thermal (domestic & process water heating)
- Biomass
- Landfill gas
- Combined heat and power (CHP)

In this report we will take a closer look at the two renewable energy sources growing most rapidly around the world, solar photovoltaics and wind.

## 1. Solar Photovoltaics

While there are many technologies for utilizing solar energy, in this report we will focus on solar photovoltaics (PV) which generate electricity from sunlight. Solar PV costs have fallen exponentially over the past three decades, with average utility-scale installation costs lower than $1.80/watt as of early 2015, according to a study by the National Renewable Energy Laboratory (NREL).[45] The unsubsidized levelized cost of energy (LCOE) for utility-scale PV ranges from $0.05 - $0.07/kWh, according to an analysis by Lazard.[46] When Federal tax incentives are added in, this figure becomes significantly lower. Solar PV systems require minimal maintenance, the PV panels are typically warranted for 25 years, and they are expected to generate power for well beyond that time. The steep decline in prices for solar PV has been accompanied by exponential growth in installations in the U.S. and around the world, as illustrated in Figure 6.

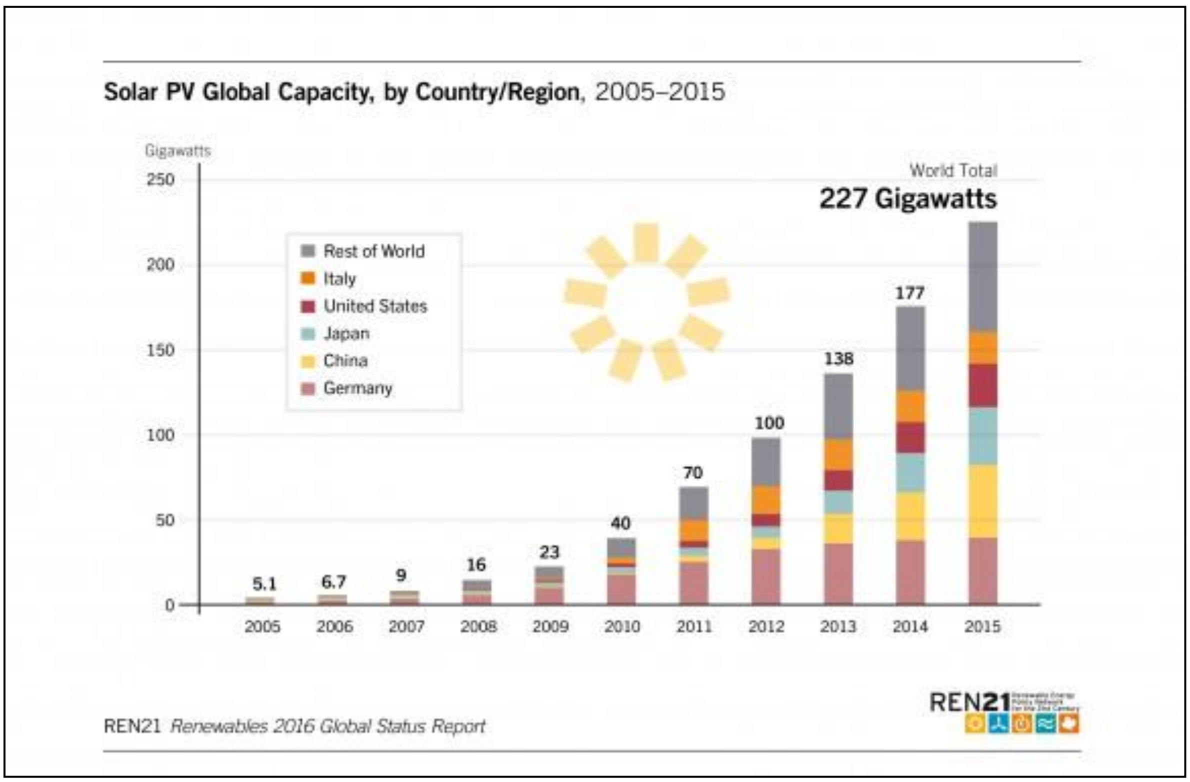



**Figure 6** – Solar PV Global Capacity, by Country/Region, 2005-2015, from the Renewables 2016 Global Status Report. [47]

## 2. Wind Energy

Utility-scale wind is very cost-competitive with natural gas and is abundantly available in neighboring states such as Indiana and Illinois, as well as throughout the Great Plains and Midwest. Lazard estimates the LCOE for onshore wind to range from $0.032 - $0.07/kWh, while their estimate for natural gas combined cycle power ranges from $0.052 - $0.078/kWh.[48] While Lazard's estimates are based on national data and actual prices for any of these technologies will depend upon numerous local factors, the lesson to be gained by their analysis is that both wind and solar PV are now being deployed in the U.S. at costs competitive with conventional fossil fuels (see Figure 7).

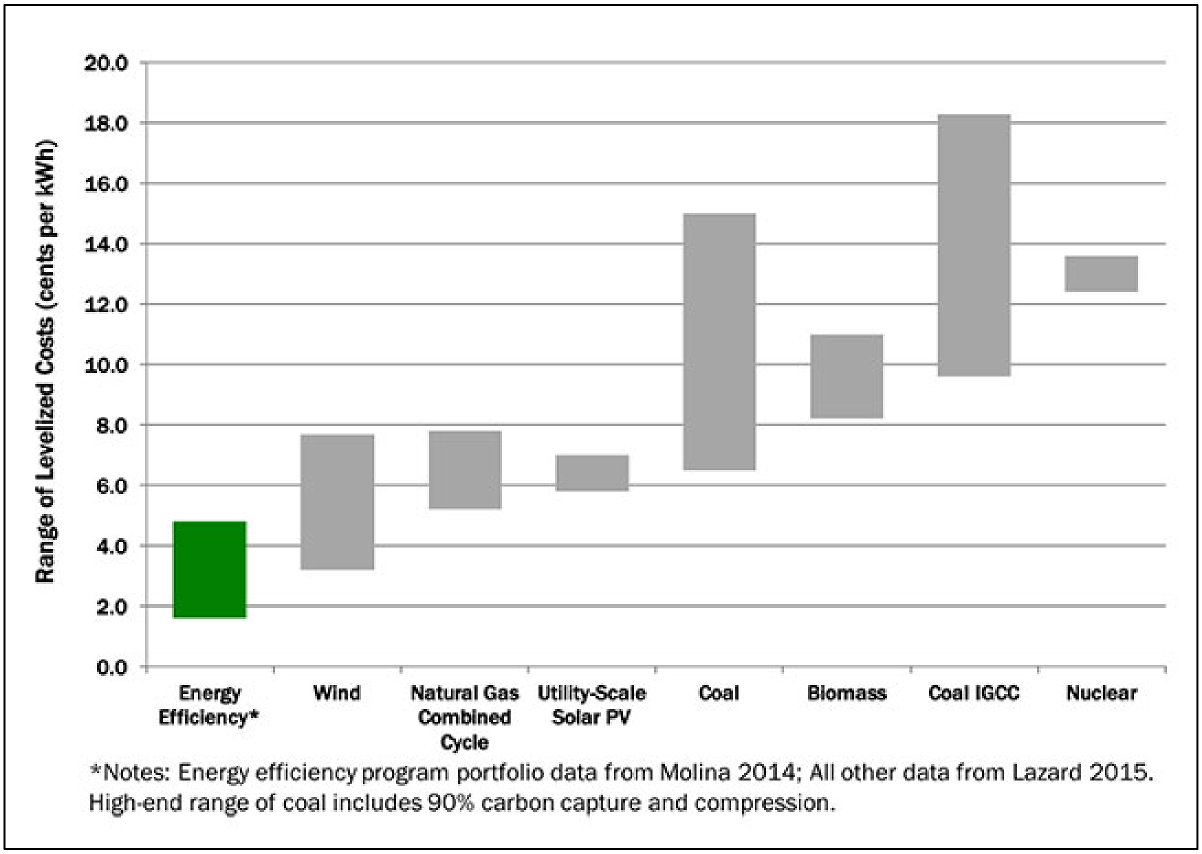



**Figure 7** – Levelized cost of energy estimates for energy efficiency and various renewable and conventional energy sources, from Molina and ACEEE.[49]

Research from the National Renewable Energy Laboratory indicates that there may be regions of Kentucky with viable utility-scale wind resources, specifically in north-central and western Kentucky. [50] There are also opportunities to import low-cost wind electricity from the Great Plains and Midwest regions via long-distance transmission lines. Section III discusses these opportunities in more detail.

According to Lazard, the levelized cost of wind generation declined by 61% from 2009 to 2015, although the price decline has flattened in recent years.[51] This trend is due in part to the engineering limits for capturing wind, yet there are advances being made to push these limits. The height of operational turbines is increasing to capture faster-blowing wind at higher elevations and the length of turbine blades is also increasing, which allows turbines to operate at lower wind speeds. These advances will allow new regions with weaker wind resources to adopt wind generation.

In many areas of the US, wind energy prices are more attractive than coal and are competitive with current natural gas prices. MidAmerican Energy, a utility with 750,000 customers in Iowa, Illinois, and South Dakota, met 41% of its generation capacity with wind in 2015 and states that its customers in Iowa have the 7th lowest rates in the U.S.[52] In Texas, the grid operator ERCOT is expected to add 12.5 GW of wind capacity to the grid in 2016 and only 2.5 GW of additional gas capacity.[53] A long-distance high-voltage direct current (HVDC) power line is being built to connect the large wind capacity of the Great Plains to the Southeast, with other HVDC lines in the planning stages.[54] Current federal incentives are also proliferating wind generation across these parts of the U.S.

Because the cost of wind is low, with current subsidies bringing it below $0.02/kWh in certain locations, the greatest challenge to wind as a generation source is the current grid design. In many parts of the world, electricity grids are designed to handle relatively stable generation from large, centralized sources of energy, whether nuclear, hydro or coal. The variability of wind and its geographic features (the resource varies significantly across regions) places extra pressure on peaking fossil-fuel plants and the existing transmission capacity network. The changes needed to the grid in order to incorporate low-cost wind energy can incur costs beyond the construction and maintenance of specific wind farms. The potential costs to the grid infrastructure are not included in the LCOE estimates provided above.

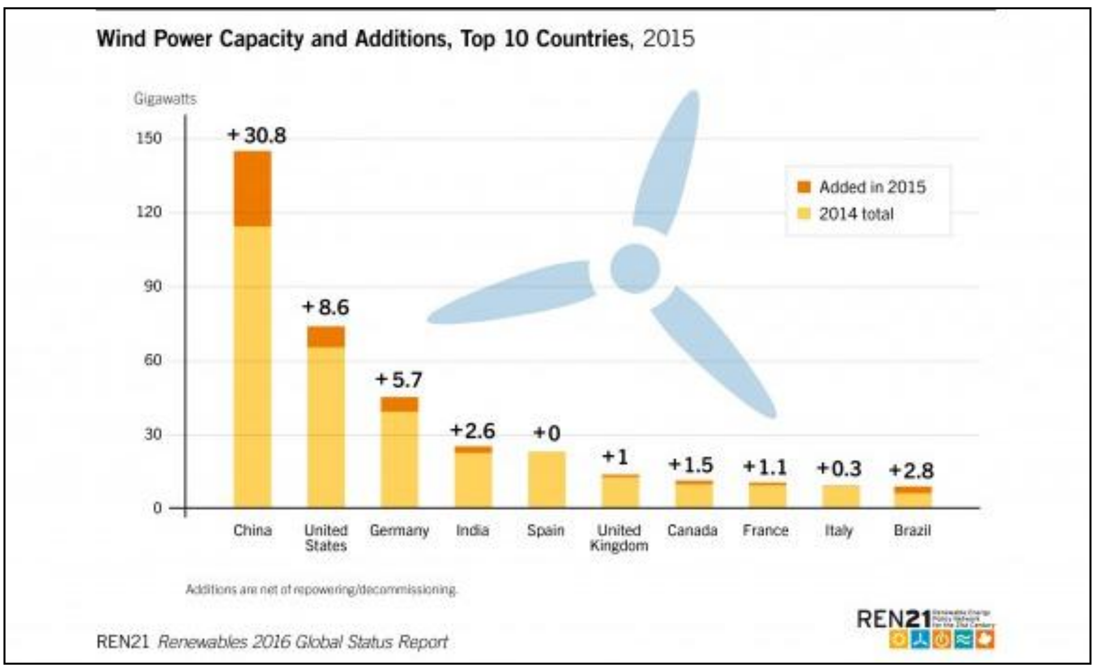



**Figure 8** – Wind Power Capacity and Additions, Top 10 Countries, from the Renewables 2016 Global Status Report.[55]

# 3. Distributed and Centralized Generation – Complementary Approaches to Renewable Energy

Renewable energy technologies provide a diverse mix of features that can benefit an energy portfolio. Biomass and landfill gas generators are fuel-based technologies, similar to coal and natural gas generators, which offer dispatchable power. Wind, solar, and hydroelectric generators operate without fuels and therefore provide protection against fuel price volatility and potential fuel supply interruptions. While wind and solar technologies are dependent upon intermittent and variable sources (the wind and sunlight), they are also very predictable and reliable. Renewable energy technologies can be developed at a wide range of scales, from small units serving individual homes to central power plants serving tens of thousands of homes.

**Distributed generation** located close to the energy consumer offers many advantages to the energy system and its users:

- Reduced energy loss in power lines by greatly reduced distances between the energy source and the user;
- Reduced wear on distribution infrastructure;
- The potential to locate generators where they can provide valuable services to the grid infrastructure;
- Economic development opportunities are distributed throughout the utilities' customer base and community;
- Customer-generators are empowered by becoming producers as well as consumers of energy. Many people value the ability to produce their own energy and have greater control of their energy supply.

**Centralized generation** of renewables offers its own advantages, which include:

- Reduced capital costs through the economies of scale and efficiencies of building at optimal sites;
- Potentially greater power generation by locating facilities at sites with optimal renewable resources;
- Lower costs of energy due to the above efficiencies.

The discussion of distributed and centralized generation highlights another important feature of renewable energy – it can be developed locally or imported from the wider region or even from outside the state. Once again there are advantages to each and both can play valuable roles in a diversified energy portfolio.

# 4. Barriers to Wind and Solar

Wind and solar energy are both intermittent and variable resources, which presents a challenge for integrating them into the power grid at a very large scale. This document outlines some of the challenges, what is being done to overcome them, and opportunities for the FPB to incorporate them into their energy portfolio.

The variability of wind and solar throughout the day and year requires changes to the grid structure as they become larger contributors to the electricity system. This challenge is being addressed through a number of strategies, including energy storage; changes to the grid infrastructure and grid management; and the distribution of renewables across a wide geographical region.[56]

It is important to note that these challenges arise as wind and solar become major components of the generation mix. For utilities in the early stages of renewables development, such as the FPB, the integration of distributed wind and solar does not pose any fundamental challenges. This is why at least 22 states can allow any eligible PV generator up to 1 megawatt capacity to connect to the grid using net metering, and states such as New Jersey, North Carolina, and California now have tens of thousands of solar PV installations.[57]

However, as places like California and New York, which are moving towards 50% renewables by 2030,[58] or Germany, which is already at 45% wind and solar,[59] achieve high levels of renewable energy, people are focusing on how to address the challenges posed by integrating high levels of intermittent and variable energy sources. In New York they have established the Reforming the Energy Vision (REV) process, which is creating a new model for the way utilities and the electric grid operate, to enable large-scale use of renewable energy, distributed generation, and demand-side resources. California's Public Utilities Commission has initiated proceedings to address similar issues. Around the world, as renewables become more and more prevalent, the electricity system is beginning to change.

Germany provides a valuable example of this process as they have been dealing with ever greater capacities of wind and solar over the past decade. While the integration of these variable resources has posed challenges for them, it is also making their overall grid more resilient. Adapting the grid to accommodate variable and intermittent renewables has also made it more resistant to other forces which cause power fluctuations, like the weather or sudden equipment failures. Germany experienced fewer than 13 minutes of power outages per consumer in 2014, 10 minutes less than they experienced in 2006. "In the same period, the share of renewable electricity production in Germany rose from 11.2 to 25.8 percent, mostly from fluctuating sources such as wind and solar power stations… Germany's security of supply is among the best in Europe." This compares to the United States, where blackouts averaged 228 minutes per year across all networks.[60]

## 5. Renewable Energy Summary

We have seen that the costs for wind and solar power have fallen dramatically over the past decade, to the point where wind is the lowest cost option in many locations and solar is becoming more competitive with conventional sources. Bloomberg New Energy Finance predicts that this trend will continue for decades to come in their *New Energy Outlook 2016*. They predict the cost for onshore wind will decline by 41% by 2040, while solar PV will be the least-cost generation technology in most countries by 2030.[61] These trends contrast with the future awaiting the fossil fuel industry, which confronts the many challenges and risks detailed in the first section of this report.

## B. Energy Efficiency is a Key Resource

Alongside the numerous supply-side energy options mentioned above, energy efficiency is now widely recognized as a significant resource for utilities and their customers, offering multiple benefits while being the least expensive "source" of energy available. Effective conservation programs save utilities money by delaying the need for new power plants, reducing peak demand charges, and reducing service cut-offs to low-income customers. These same programs benefit the community by helping customers reduce their energy bills and help the community adapt to rising energy prices.

As the ACEEE states:

> "When utilities and other groups discuss 'energy efficiency as a resource,' they are defining efficiency as an energy resource capable of yielding energy and demand savings that can displace electricity generation from coal, natural gas, nuclear power, wind power, and other supply-side resources. Investments in energy efficiency and the resulting resource benefits are factored directly into utility energy resource decision making about investing in new resources and operating existing systems.
>
> "Defining efficiency as a resource and integrating it into utility decision making is especially critical because of **the clear resource cost advantage of energy efficiency**. Energy savings from customer energy efficiency programs are typically achieved at 1/3 the cost of new generation resources. Efficiency programs can also reduce the need to install, upgrade or replace transmission and distribution equipment."[62]

Increasing the efficiency of existing homes and businesses decreases total energy demand, kWh usage, and system-wide peak demand levels. Electricity is most expensive at times of peak demand, so reducing that peak lowers costs for the utility and their customers. It's widely recognized that energy efficiency is one of the cheapest sources of power, with a study by several energy organizations finding that the cost of energy efficiency projects was $0.035/kWh saved in 2010.[63] Another study by the ACEEE that looked at the cost of running energy efficiency programs in 20 states between 2009 and 2012 found the average cost to be $0.028/kWh, about one-half to one-third the cost of new power supply options.[64]

There is a great potential for increasing the energy efficiency of homes, businesses, and buildings of all types in the Frankfort community. The opportunities include insulating and air sealing, upgrading HVAC systems, replacing old refrigerators and other appliances with Energy Star models, switching to CFL or LED lights, water heater replacement and insulation, and public education. This potential exists throughout Kentucky, which lags behind many other states in energy efficiency.

## C. The Benefits of Renewable Energy & Energy Efficiency

A diversified energy portfolio, with energy efficiency as the cornerstone and increasing amounts of renewable energy offers the following benefits to the FPB, its customers, City and County government, and the local community.

**Reduced risk from volatility in energy markets.** As described in the first section of this report, the markets for electricity from coal and natural gas are subject to numerous forces that make future prices unpredictable and very likely to increase significantly in years to come. Sourcing power from a diverse set of resources reduces risks if the prices for any one of those should spike in the future. Renewable energy resources such as solar, wind, and hydro, on the other hand, do not rely on fuels and therefore have much more stable, predictable future costs.

**Protecting customers against rising rates and serving the community.** While the FPB has provided relatively low electric rates to its customers for many years, those rates have risen over time and are expected to continue rising in the future. The FPB can help their customers control their energy costs by offering energy efficiency programs, enabling customers to use less energy and therefore reduce their bills. Helping customers to control their costs is a valuable service a utility can offer and fosters good relationships with the community. Such programs are especially helpful to low-income customers. To the extent that the FPB serves city or county government, they also save taxpayers money by reducing energy costs for these agencies.

**Reduced regulatory risk.** Federal environmental regulations have a significant impact on the cost of energy. The Clean Power Plan was developed by the US EPA to regulate carbon emissions from power plants and was intended to have far-reaching effects on the US utility industry. The future of the Clean Power Plan is uncertain as it is being challenged in the courts, but it may withstand this challenge and then be implemented. The Clean Power Plan requires Kentucky to reduce its carbon emissions by 32% by 2030.[65] The state has the option of developing its own plan for meeting this goal or allowing the Federal government to provide a plan. The Kentucky legislature has passed legislation prohibiting state agencies from taking steps to comply with the Clean Power Plan, which would result in a Federal plan being imposed. In addition to the Clean Power Plan, other Federal regulatory actions that are significantly affecting the power industry are the recently implemented "mercury rule" and coal ash disposal rules. Meanwhile, concerns about hydraulic fracturing (aka. "fracking") have led to local movements of citizen resistance across the country. The possibility of greater regulation of fracking presents further uncertainty about the future price of natural gas.

**Reduced demand charges benefit the FPB and consumers.** Energy costs are most expensive at times of peak demand (which usually occurs on hot summer afternoons when air conditioner use peaks or on cold winter mornings when heating usage peaks). A substantial portion of most utilities' costs are directly tied to their peak demand. By helping customers reduce their peak demands, the FPB's demands from their suppliers are reduced, lowering costs. Demand-side management includes energy efficiency and conservation programs but can also include load-shifting, which encourages customers to shift their energy use to times of lower demand.

**Extending the life of utility infrastructure.** Energy efficiency and distributed generation reduce the wear on utility infrastructure, delaying the need for new infrastructure and repairs to existing equipment. In 2016 the California Independent System Operator (CAISO) cancelled 13 transmission projects that would have cost ratepayers $192 million due to reduced load forecasts caused by energy efficiency and rooftop solar. The cancelled projects included "line improvements, transformer replacements, and bus upgrades."[66]

**Generating local investment and economic development.** Investing locally in energy efficiency and distributed generation can create local economic development. Investing in energy efficiency at a large scale would produce demand for insulation contractors, home energy specialists, HVAC contractors, and high-efficiency appliances, spurring local investment and economic development. The same would be true for investments in distributed generation, as local people could be employed installing solar and other renewable energy systems within their community. These investments would keep more money in the local community by reducing the amount sent out of the community to pay distant energy suppliers.

# III. Next Steps for Moving Forward

## A. Developing Energy Efficiency Programs

The FPB has a range of options if it chooses to develop energy efficiency programs to serve its customers. These include:

- Partner with MACED (Mountain Association for Community Economic Development) to develop a How$mart On-Bill Financing program (described below).
- Develop additional energy efficiency and demand-side management programs to serve all segments of the community, including low-income residents. These programs could be developed and managed in-house, with support from qualified consultants, or the FPB could hire outside contractors to develop and manage these programs.
- Explore partnering with KyMEA or other municipal utilities to jointly develop efficiency programs or hire contractors together.
- Partner with the Kentucky Home Performance Program.

### 1. The How$mart On-Bill Financing Program

"How$mart" is an on-bill financing energy efficiency program developed by Midwest Energy and brought to Kentucky in 2011 by the Mountain Association for Community Economic Development (MACED).[67] MACED began How$martKY as a pilot project with four electric cooperatives in Eastern Kentucky. Two more cooperatives have joined the program since then.

How$martKY has now completed hundreds of home energy improvement projects. Some of the most common renovations include replacement of electric resistance heating systems with high efficiency heat pumps, air sealing, insulation, and installation of heat-pump water heaters.

On-bill financing enables customers to make energy-saving improvements to their home and pay for them through installments on their electric bills. The program is designed so the energy savings pay for the improvements and results in lower electric bills for the customer, even with the added charge to pay for the home improvement.

On-bill financing programs enable customers to make substantial home improvements with little or no up-front expense, without a bank loan, and they are not based on the customer's credit history. The utility provides the capital to pay for the home improvement, oversees the work with the support of trained building science specialists, and provides a "Quality Assurance" evaluation after the work is completed to ensure all work was properly done. The utility adds a monthly fee onto the customer's utility bill for a period up to 15 years to recover their costs. That fee remains with the meter even if the customer moves away. Future residents benefit from the home improvements and energy savings while taking over paying for the work. Once the work is paid for, the customer enjoys even lower electric bills.

On-bill financing programs offer numerous benefits. Customers benefit by reducing their energy costs, making their homes more comfortable, and increasing their home's value. The process used by How$martKY builds trust by using third-party project managers to evaluate the most cost-effective measures for the customer and overseeing the contractors. This ensures that customers achieve the most potential savings and that contractors do the work properly. By using on-bill financing to pay for the projects, the program makes home energy improvements accessible to a much wider portion of the community, including low-income families and renters.

## 2. Other Energy Efficiency Programs

Along with on-bill financing a variety of other energy efficiency programs can be offered by the FPB to meet the diverse needs of their customers.

- Home energy audits with blower door tests help residential and small commercial customers identify the best strategies for reducing heating and cooling bills.
- Rebates for energy efficient appliances (including HVAC systems, refrigerators, LED lighting, and other Energy Star-rated appliances) encourage customers to choose energy efficiency when buying new appliances.
- Buyback recycling programs for old refrigerators encourage customers who buy Energy Star refrigerators to actually stop using their old units and remove inefficient appliances from circulation.
- Through demand-response programs, customers voluntarily allow the utility to remotely regulate the on/off cycling of appliances such as air conditioners or water heaters during times of peak demand. The customer receives a monthly discount for participating in the program.
- Weatherization programs offer incentives for improving the insulation and air sealing of homes and commercial properties. Incentives can include rebates and low-interest loans.
- Educational outreach programs are used to help customers learn how to improve the energy efficiency of their homes or businesses and to make them aware of the services available from the utility.

## B. Renewable Energy Development Strategies

There are a number of steps the FPB could take to develop renewable energy within their energy supply portfolio. A diversified energy portfolio can include a mix of local distributed generation along with renewables sourced from the wider region and even outside the state.

## 1. Investing in Renewable Energy Generation

The FPB has the ability to develop renewable generation to sell directly to its customers and could also purchase renewable power through the KyMEA, if available. Investing in renewable energy generation could be accomplished using strategies such as:

- Include renewable energy in all Requests for Proposals (RFP's) issued by the KyMEA.
- Investigate importing wind energy from the Great Plains via Clean Line Energy Partners and other avenues (see below for more details).
- FPB development of its own renewable energy generating facilities.
- Using Power Purchase Agreements (PPA's) to buy renewable power from third-party developers.
- FPB could sell or lease solar PV systems to their customers.
- Form partnerships with the KyMEA and/or its members for joint renewable energy projects.

The FPB could seek qualified consultants to assist with the exploration of these options.

### A. Exploring Long Distance Transmission and Importing Wind Energy

While many of the options discussed in this report involve electricity produced within the state of Kentucky, it is important to acknowledge that other states and regions have energy resources that can complement Kentucky's. Specifically, the Great Plains states from Texas to the Dakotas and the Midwest states from Indiana to Minnesota have significantly higher wind energy potential than the Bluegrass state and have already demonstrated the technology's feasibility. Iowa, for example, generated 31% of the state's energy from wind in 2015.[68]

While wind energy is prolific in the center of the country, there are efforts being made to improve connections between the windy states and other regions. Construction is expected to begin in 2017 on a long-distance transmission line to connect Oklahoma with Arkansas and Western Tennessee with a capacity of 4 GW, which is enough to power 3 – 4 million homes. The line, called the 'Plains and Eastern', will be owned by Clean Line Energy Partners, a private company that would make money as electricity is transported through the line (like a toll on a turnpike). Clean line is currently seeking industrial customers and utilities to partner for the Plains and Eastern line's capacity.[69]

For the past two years, Oklahoma electricity at the SPP South hub has been on average $3.02/MWh less expensive than prices trading in Eastern Kentucky. During the winter, this discount actually widens to $14/MWh, while in the middle of summer days, Kentucky's prices have typically been lower than Oklahoma's. If a long-distance line were to connect the Great Plains with Kentucky, electricity would flow east during the windiest hours of the year, while electricity would flow west during the least windy hours. The overall effect would be to allow KY prices on average to fall while allowing these disparate regions to complement each other.[70]

The Electric Reliability Council of Texas (ERCOT) has created a network of long-distance lines within the state of Texas similar to Clean Line's proposal. In 2005, the Texas legislature created the concept of Competitive Renewable Energy Zones (CREZ) which is now completed. The CREZ is a network of transmission lines that connect the demand centers in the North and East, and the wind-rich Western and Panhandle regions. Of the 18 GW of wind capacity in Texas, the wind farms with the highest capacity factor are generally found in the West and Panhandle, made accessible through the CREZ network. Real-time settlement prices in Texas have averaged below $30/MWh since the beginning of 2015, in large part due to prolific renewable generation.[71]

What does this mean for the Frankfort Plant Board? Essentially, wholesale electricity prices in Kentucky have the potential to be lower if efforts are made to import cheaper electricity from wind-generating regions. Clean Line Energy is quoting prices for the TVA between $35/MWh and $38/MWh for wholesale electricity, prices which are competitive with gas and coal resources currently. As a competitive primary supply option, and as a complement to local solar resources, importing inexpensive wind energy could lower ratepayer costs and reduce pollution in Kentucky.

## 2. Encourage and Develop Distributed Generation

### A. Develop and Support Community Solar Projects

"Community Solar" projects are becoming increasingly popular around the country as they make solar energy accessible to more people. In a community solar project (also known as shared solar or virtual net metering), a single solar array is owned by multiple people and the energy generated by that array is credited to the utility bills of its owners. A community solar project can be as small as a few panels or may consist of thousands of panels totaling one megawatt or more of power. The overall project may be built and operated by the utility itself or by a private for-profit or not-for-profit developer. The individual participants in the project either buy or lease individual panels or a percentage of the total capacity of the project. They receive in return credits on their electric bills equal to the power generated by their share of the project. A critical role for the utility in community solar projects is enabling the transfer of credits from the solar array to its owners' individual accounts.

There are many potential sites where community solar projects could be developed. These include brownfields or other degraded properties; the flat roofs of commercial, government, or institutional buildings; shade structures covering parking lots or in parks; or open fields. Frankfort has many suitable sites that would be enhanced by a community solar farm.

Community solar removes many of the barriers people face to investing in solar energy. Not every home or commercial building has good solar access. Some roofs are unsuitable for mounting solar panels, whether because of their age, shading, the presence of mechanical equipment, or their location in historic districts which limit changes to architectural features. Buying into a community solar project can be much simpler than dealing with contractors and having construction work performed on your house. Community solar projects can also be built at a lower cost due to the economies of scale and the efficiencies of building large, centralized projects at sites selected for their ideal solar features.

Community solar can be a valuable investment opportunity for a utility that builds positive relations with the community. Presuming that there is a base of customers interested in investing in community solar, developing such a project demonstrates the utility's concern for their customer's interests and the environment. The project imposes no costs on non-participating customers while generating revenues for the utility. Meanwhile the project reduces the need to buy power from outside suppliers and can reduce summer peak demand charges from those suppliers.

The US DOE estimates that community solar could represent 32% - 49% of the distributed solar market in the US by 2020.[72] The first community solar project in Kentucky was developed by Berea Municipal Utilities. The 60 kilowatt array consists of 246 solar panels and was installed in 2011.[73] The East Kentucky Power Cooperative in July 2016 asked the Kentucky Public Service Commission for approval to build an 8.5 megawatt community solar farm consisting of 32,300 PV panels.[74] There are 25 states with at least one community solar project in operation and at least 16 states have policies or programs to support its development.[75]

### B. Raise the cap on net metering from 30 kW to 1,000 kW

The FPB presently limits net metering to systems no greater than 30 kW capacity. This limits the use of solar and other renewables to residential and small commercial systems. There are many potential customers who could utilize systems up to 1,000 kW in size (or greater), including commercial, industrial and governmental customers, community organizations, churches, and schools. Raising this cap could attract solar development to the Frankfort area and would establish the FPB as a statewide leader in utility policy. Twenty two states allow net metering for systems of 1,000 kW or greater capacity, including Indiana, Ohio, West Virginia, and North Carolina.[76]

### C. Expand Net Metering by Enabling Meter Aggregation

"Meter aggregation under net metering" allows for the transfer of kWh credits generated by a PV system to an account other than the one to which it is connected. Under net metering, a PV system interconnects to the utility grid through a customer's meter and the power it generates is credited against that same account. Meter aggregation enables customers to transfer those kWh credits to another account. For example, suppose a customer has an electric meter on their house and their barn, but the house is fully shaded while the barn roof is in full sun year-round. Meter aggregation would allow the homeowner to install the PV array on the barn roof and interconnect through the barn meter, but have the generation credits apply to the meter on the house. Another example would be an institutional customer like a city that has multiple meters. Meter aggregation would allow the city to place their solar array in one location that has preferable conditions for solar, while transferring the credits to another account that can benefit from the kilowatt-hour credits.

# IV. Conclusion

The Frankfort Plant Board has the opportunity to create an energy future that can avoid many of the costs and risks of the business-as-usual path.  By aggressively pursuing energy efficiency, which is commonly less expensive than even the most inexpensive generation, the FPB can reduce total demand and the corresponding peak-hour demand charges.  By adopting measures to encourage distributed renewable generation (such as rooftop and community solar), the FPB can decrease stress on existing infrastructure and avoid the need for repairs or expansions.  By sourcing electricity from large-scale renewable resources, the FPB can guarantee its members stable and predictable costs.  With expectations for increased regulation of fossil-fuel generation, energy efficiency and renewable generation can protect customers against rising rates.

In this report we have outlined the risks to the business-as-usual path and proposed feasible alternatives that can mitigate those risks.  Beyond the benefits to the electricity sector itself, investments in distributed renewable generation and energy efficiency can generate local income and promote local economic development. Money which in the past was sent out of the community to pay for power produced by KU could instead be invested locally, paying local people to produce renewable power or energy efficiency savings. There are also the quantifiable health benefits to all Kentuckians by reducing the pollution from fossil fuel power plants.

As the FPB moves ahead with the KyMEA, we recommend that these organizations pursue the path of energy efficiency and renewable energy together. The risks and opportunities outlined in this report confront each of the members of the KyMEA, not only the FPB. The energy sector is in a time of great change. All municipal utilities would be wise to avoid long-term commitments to fossil-fuel resources and to maintain their freedom to develop energy efficiency programs and renewable energy resources. Contracts which bind these local utilities to coal for the next decade or more risk closing off paths to much better options for themselves and their communities.

The Appendix to this document provides case studies of utilities and communities that have successfully implemented and benefited from the solutions we have discussed in this report.

# Appendix

# Case Studies of Utilities Leading with Energy Efficiency and Renewable Energy

## Burlington Electric Department, Vermont

### Energy Efficiency as the Cornerstone & 100% Renewable Supply

Burlington, Vermont is a small city with a population size similar to Franklin County, about 42,000, and it has a city-owned electric utility, the Burlington Electric Department (BED). The BED has been operating successful energy efficiency programs since 1990 and they describe energy efficiency as the cornerstone of their resource acquisition strategy.[77] Their programs save Burlington consumers about $11 million of retail electric costs annually. While the town's population has increased by 8% since 1990, electric use has decreased by 3.6%. The BED estimates that electricity use in Burlington was 20% lower in 2015 than it would have been without their energy efficiency programs. This compares with the dramatic increase in electricity use in the 26 years that preceded 1990, when usage increased 180%.[78]

The BED offers a range of energy efficiency programs and services, including on-bill financing, rebates and incentives, energy audits, weatherization, and a PACE program ("Property Assessed Clean Energy" financing). Between 1990 and 2015, almost $55.8 million was invested in energy efficiency projects sponsored by BED, of which $25.9 million was invested by BED and another $29.9 million invested by participating customers. "The willingness to invest their private funds in these investments is a testament to the value that BED customers place on these services," noted the BED in their 2015 Annual Energy Efficiency Report.[79]

***Along with their commitment to energy efficiency, the BED sources nearly 100% of their energy supply from renewable resources.*** As of 2013, their generation mix was 45% biomass, 32% hydro, and 17% wind, with a variety of other sources completing the mix.[80]

## Midwest Energy, Kansas

### Creators of the How$mart Program

There are other examples of utilities that have made energy efficiency and renewable energy fundamental to their energy supply strategy. Midwest Energy in Kansas is a pioneer of "On-Bill Financing," having created the How$mart program, which is now being used by MACED in Eastern Kentucky. According to Midwest Energy's 2015 Annual Report:

> "In 2015, a record 228 customers completed projects through How$mart, bringing the total to 1,496 projects completed since the program's inception. Midwest Energy's investment to date is $9.1 million ($1.39 million in 2015), while customers have added $2.4 million of their

own funds to cover improvements not offset by energy savings. Local contractors typically complete improvements, further stimulating business growth in small communities. On average, How$mart participants save roughly $53 per month on their utility bill while reducing their carbon footprint."[81]

### Midwest Energy Invests in Wind and Community Solar

On the renewable energy side, in 2015 Midwest Energy generated 13% of their power from wind and installed their first Community Solar project. This 1 megawatt solar PV installation consists of 3,960 PV panels located in one central location. Midwest Energy customers have the option of buying one or more panels in the array and then receive monthly bill credits for the power their panels produce. As of March 2016 all panels in the array had been sold, reflecting their customer's support of the program.[82]

## Massachusetts - A Beacon for Energy Efficiency

Massachusetts is a leader in energy efficiency nationwide. The ACEEE ranks Massachusetts as the number one state for energy efficiency.[83] A key element of Massachusetts' energy efficiency program is the Mass Save program.

The Mass Save Energy Savings program is a state sponsored energy efficiency and audit program that aims to be the go-to source for energy efficiency information, incentives, and technical support. The program is funded by a surcharge on electric and natural gas bills on all ratepayers in the state. The program provides ratepayers with access to free home energy assessments by professional auditors, rebates, incentives, zero-interest loans for energy upgrades, and free light bulbs. The program is administered by the Investor Owned Utilities (IOU's) of Massachusetts on both the electric and natural gas side.[84]

Between 2010 and 2012, Massachusetts' energy efficiency programs, under the statewide Mass Save brand, helped participants save 2,390 gigawatt-hours of electricity and 49 million therms of natural gas. In addition, this drop in energy consumption reduced greenhouse gas emissions by nearly 1.4 million tons.[85]

Another key component of the Mass Save program is the HEAT Loan, a 0% interest loan of up to $25,000 with terms up to 7 years. Eligible services include heating systems, domestic hot water systems, central air conditioning units, insulation, and replacement windows.[86]

Mass Save's program enabled the energy efficiency industry in Massachusetts to expand services and attract more citizens to the service providers. Regulated utilities in Massachusetts were required to streamline and standardize their rebates and incentives programs to improve efficiency of administrative processing and assessment of basic programs.

An assessment by the ACEEE of the Mass Save program highlights key successes and challenges of the program. The key successes are as follows:

1. Residential Home Energy Services – In 2011, the program accomplished 50,000 residential audits and increased the implementation rate overall.
2. Massachusetts Technical Assessment Committee – The MTAC acts as a single review board for new technologies and applications to establish rebates, policies and savings calculations for them.
3. Share Staffing and Resources – Prior to Mass Save, numerous businesses and IOUs that provided DSM services to ratepayers had administrative and service redundancies. Combining the technical support and information sharing aspect of energy efficiency programs of participants, the Mass Save program improved efficiency of the marketplace.[87]

The Mass Save program is a true example of a successful statewide program. For the FPB, the Mass Save program provides an excellent model for unlocking low- to no-cost energy efficiency services for ratepayers. While the scale of Mass Save is much greater than the FPB's size, it offers many valuable lessons that could be applied to developing effective local energy efficiency programs.

# MidAmerican Energy, Iowa

## Aiming for 100% Renewable Energy

MidAmerican Energy provides service to 752,000 electric customers in Iowa, Illinois, South Dakota, and Nebraska and is a subsidiary of Berkshire Hathaway Energy. Their vision is to provide 100% renewable energy to their customers. In 2004, 70% of their generation capacity came from coal and nothing came from wind. At the end of 2015, 41% of their capacity came from wind and 37% came from coal. MidAmerican Energy is currently seeking approval from the Iowa Utilities Board to build a 2,000 MW wind project. When completed, their annual renewable energy generation is expected to meet 85% of their customer's annual retail usage. They are continuing to evaluate options for securing the remaining 15% needed to achieve their 100% goal. MidAmerican states that they are achieving this with minimal cost impacts to their customers. "Our rates in Iowa are the 7th lowest in the US – about 38% below the national average," as stated on their website.[88]

MidAmerican Energy's website continues, "Generating energy is only part of the solution. To support the integration of renewable energy onto the power grid, we are investing in our transmission infrastructure and working with our transmission provider to ensure it can carry the new power load. All of this work helps us move toward our 100% renewable energy vision for customers in Iowa."[89] MidAmerican also offers their customers energy conservation programs and incentives, is exploring development of a community solar project, and offers net metering to their customers in Iowa and Illinois. In Iowa net metering is offered for facilities up to 500 kilowatts capacity and in Illinois it is offered for facilities up to 2,000 kilowatts capacity.[90]

# Glasgow Electric Plant Board, Kentucky

## Using Energy Storage for Demand Response

Glasgow Electric Plant Board in Glasgow, Kentucky is pioneering the use of energy storage in a demand response program aimed at reducing greenhouse gas emissions by 25%. In the fall of 2015 they installed energy storage devices supplied by Sunverge Energy in 165 homes in their service territory to strategically address issues of demand-side needs. “Sunverge's storage devices will capture power from the electric grid at night or when demand and cost are lower, and distribute it during the day when demand spikes.”[91]

# The Water Heater as a Demand Side Management Tool

A recent report authored by the Brattle Group in partnership with the National Rural Electric Cooperative Association, Peak Load Management Alliance and Natural Resources Defense Council has jumpstarted a conversation about how to use water heaters to store energy (not electricity ) to help address peak load. Similar to the Glasgow energy storage example, water heaters would capture power from the electric grid at night and store that heat to be used during the day for residential and commercial needs.[92]

Advancements in two-way control, smart meters, and the efficiency of water heaters have opened up the ability for “grid-enabled” water heaters to be a practical demand response resource. According to Robin Roy of the NRDC, “grid-enabled water heaters are large electric resistance water heaters with communication and control capability that allow them to be used in an electricity system's energy storage or demand response program.”[93]

# Osage, Iowa

## Over 40 years of Demand Side Management and Still Going

The town of Osage, Iowa (population 3,600) has its own municipal utility which began offering demand-side management programs in 1974. “The Osage program was designed to reduce the utility bills of all customers to improve the economic well-being of the community. Its other purpose was to reduce the growth rate of electric peak demand to delay the need to expand its generating capacity.” [94] Osage Municipal Utility’s (OMU) program has been highly successful, saving their customers over 90 million kWh of electricity and 8 million therms of natural gas between 1974 and 1991, at a cost of under $500,000. Through 1992 OMU had avoided the need to build additional electric generating capacity. The electricity savings over this time period amounted to $4.6 million for OMU ‘s customers, plus additional savings based on reduced rates directly related to their DSM programs.[95] OMU’s energy efficiency programs are ongoing today.

# End Notes

[1] *2015 Kentucky Energy Profile*, U.S. Energy Information Administration. Accessed online July 2016 at: http://www.eia.gov/state/data.cfm?sid=KY#Environment.

[2] Hornby, Rick, et al. *Potential Impacts of a Renewable and Energy Efficiency Portfolio Standard in Kentucky.* Synapse Energy Economics, Inc. January 2012. www.synapse-energy.com. Synapse Energy Economics is a research and consulting firm specializing in energy, economic, and environmental topics. Founded in 1996, Synapse provides analysis of the electric power sector for public interest and governmental clients.

[3] Hornby, Rick, et al. Op. cit. note 2. Page 20.

[4] *FPB Budget and Financial Plan for Fiscal Years 2016-2017*. Frankfort Plant Board, page 6.

[5] Gilleo, Annie, et al. *The 2015 State Energy Efficiency Scorecard*. American Council for an Energy-Efficient Economy. U1509. October 2015. Page 8.

[6] *Where We Get Our Power*. Burlington Electric Department. Accessed online July 2016 at: https://www.burlingtonelectric.com/about-us/what-we-do/where-we-get-our-power.

[7] *Renewable Portfolio Standard Policies*. Interstate Renewable Energy Council. June 2016. Accessed online July 2016 at: www.dsireusa.org.

See also *Reforming the Energy Vision*, New York State. Accessed online July 2016 at: https://www.ny.gov/programs/reforming-energy-vision-rev.

[8] *Energy Charts*. Fraunhofer ISE. Accessed online July 2016 at: https://www.energy-charts.de/power_inst.htm.

[9] *2015 Energy Efficiency Annual Report*. Burlington Electric Department. 2015. Page 1. Accessed online July 2016 at https://www.burlingtonelectric.com/energy-efficiency/our-commitment/our-energy-efficiency-story.

[10] Ibid, page 2.

[11] Hornby, Rick, et al. Op. cit. note 2.

[12] The US EPA's Clean Power Plan was created to take action on climate change by reducing the carbon emissions from power plants and the electricity sector. The nationwide plan aims to reduce national carbon emissions from the electricity sector by 32% by 2030. As of August 2016 implementation of the Plan is on hold pending a review from the US Supreme Court. https://www.epa.gov/cleanpowerplan

[13] Hornby, Rick, at al. Op. cit. note 2. Page 18.

[14] *2015 Kentucky Energy Profile*. Op. Cit. note 1.

[15] *Kentucky State Profile and Energy Estimates, Data*. U.S. Energy Information Administration. Accessed online July 2016 at: http://www.eia.gov/state/data.cfm?sid=KY#Environment.

[16] Hornby, Rick, at al. Op. cit. note 2. Page 18.

[17] *Kentucky State Profile and Energy Estimates*, *Overview*. U.S. Energy Information Administration. Accessed online July 2016 at: http://www.eia.gov/state/?sid=KY.

[18] Gilleo, Annie, et al. Op. cit. note 3. Page 18.

[19] Ibid, page 26.

[20] Hornby, Rick, at al. Op. cit. note 2. Page 4.

[21] Ibid.

[22] *ACEEE State and Local Policy Database, Kentucky.* American Council for an Energy-Efficient Economy. Accessed online July 2016 at: http://database.aceee.org/state/kentucky. See also www.kyhomeperformance.org.

[23] *Early August Demand Response Produces $650 Million Savings in PJM: Reducing Electricity Use Stretches Power Supplies, Lowers Wholesale Electricity Prices*. PR Newswire, from PJM Interconnection. Aug. 17, 2006. Accessed online July 2016 at http://www.prnewswire.com/news-releases/early-august-demand-response-produces-650-million-savings-in-pjm-56192937.html.

[24] Hornby, Rick, at al. Op. cit. note 2. Page 12.

[25] *Natural Gas, Data*. U.S. Energy Information Administration. Accessed online July 2016 at: https://www.eia.gov/dnav/ng/hist/rngwhhdm.htm.

[26] *Electricity Survey Data*. U.S. Energy Information Administration. EIA-860 Survey Data. Accessed online August 2016 at: https://www.eia.gov/electricity/data.cfm#gencapacity.

See also *Cane Run Generating Station*. LG&E/KU. Accessed online August 2016 at: https://lge-ku.com/our-company/community/neighbor-neighbor/cane-run-generating-station.

See also *Kentucky Power remembers Big Sandy Power Plant as transition to natural gas begins. AEP*. Accessed online August 2016 at: https://www.aep.com/environment/PlantRetirements/BigSandy.aspx.

[27] Black, Bob. *U.S. Natural Gas Exports to Mexico Taking Off*. Forbes. August 3, 2015. Accessed online August 2016 at: http://www.forbes.com/sites/drillinginfo/2015/08/03/u-s-natural-gas-exports-to-mexico-taking-off/#14d9b1b05cd9.

[28] *North American LNG Import/Export Terminals Approved*. U.S. Federal Energy Regulatory Commission. August 3, 2016. Accessed online August 2016 at: http://www.ferc.gov/industries/gas/indus-act/lng/lng-approved.pdf.

[29] Boersma, Tim, et al. *An Assessment of U.S. Natural Gas Exports*. Brookings Natural Gas Task Force. Issue Brief 4. July 2015.

[30] *Today in Energy, Prices*. U.S. Energy Information Administration. Accessed online July 2016 at: https://www.eia.gov/todayinenergy/prices.cfm.

[31] *Today in Energy: Coal made up more than 80% of retired electricity generating capacity in 2015*. U.S. Energy Information Administration. Accessed online March 8, 2016 at: https://www.eia.gov/todayinenergy/detail.cfm?id=25272.

[32] *Today in Energy: Proposed Clean Power Plan would accelerate renewable additions and coal plant retirements.* U.S. Energy Information Administration. June 5, 2015. Accessed online July 2016 at: http://www.eia.gov/todayinenergy/detail.cfm?id=21532.

See also Larsen, John and Herndon, Whitney. *Renewable Tax Extenders: The Bridge to the Clean Power Plan*. Rhodium Group. January 27, 2016. Accessed online August 2016 at http://rhg.com/notes/renewable-tax-extenders-the-bridge-to-the-clean-power-plan.

[33] *Today in Energy: China produces and consumes almost as much coal as the rest of the world combined*. U.S. Energy Information Administration. May 14, 2014. Accessed online August 2016 at: http://www.eia.gov/todayinenergy/detail.cfm?id=16271.

See also Yeo, Sophie. *Analysis: Decline in China's coal consumption accelerates*. Carbon Brief. February 29, 2016. Accessed online July 2016 at: https://www.carbonbrief.org/analysis-decline-in-chinas-coal-consumption-accelerates.

See also Wong, Edward. *Statistics from China Say Coal Consumption Continues to Drop*. NY Times. March 2, 2016. Accessed online August 2016 at: http://www.nytimes.com/2016/03/03/world/asia/china-coal-consumption-down.html?_r=2.

See also *China Puts Coal Production Capacity on Chopping Block*. Bloomberg News. February 7, 2016. Accessed online August 2016 at: http://www.bloomberg.com/news/articles/2016-02-05/china-puts-1-billion-tons-of-coal-capacity-on-chopping-block.

See also Buckley, Tim. *15.5% Drop in China Coal Production Shows Transition Gaining Speed*. Institute for Energy Economics and Financial Analysis. June 13, 2016. Accessed online August 2016 at http://ieefa.org/ieefa-note-15-5-drop-china-coal-production-shows-transition-gaining-speed/.

[34] *Today in Energy: Coal made up more than 80% of retired electricity generating capacity in 2015.* Op. cit. note 31.

[35] *Kentucky Energy Profile, 5th Edition*. Kentucky Energy and Environment Cabinet, Department for Energy Development and Independence. 2015. Page 28.

[36] *Today in Energy: Coal made up more than 80% of retired electricity generating capacity in 2015*. Op. cit. note 31.

[37] Hornby, Rick, at al. Op. cit. note 2. Page 20.

[38] *2014 Average Monthly Bills – Residential*. U.S. Energy Information Administration. Accessed online July 2016 at: http://www.eia.gov/electricity/sales_revenue_price/pdf/table5_a.pdf.

[39] Ibid, page 1.

[40] Hornby, Rick, at al. Op. cit. note 2. Page 20.

[41] Schneider, Conrad; Banks, Jonathan; and Tatsutani, Marika. *The Toll from Coal, An Updated Assessment of Death and Disease from America's Dirtiest Energy Source.* Clean Air Task Force. 2010. Page 4.

[42] Ibid.

[43] Hornby, Rick, at al. Op. cit. note 2. Page 20.

[44] *FPB Budget and Financial Plan for Fiscal Years 2016-2017*. Frankfort Plant Board. July 2016. Page 6. The FPB's rates for 2017 were set in June 2016, which is why the electricity price trend extends to 2017.

[45] Chung, Donald, et al. *U.S. Photovoltaic Prices and Cost Breakdowns: Q1 2015 Benchmarks for Residential, Commercial, and Utility-Scale Systems.* National Renewable Energy Laboratory. NREL/TP-6A20-64746. September 2015. Page vi.

[46] *Lazard's Levelized Cost of Energy Analysis – Version 9.0*. Lazard. November 2015. Page 3. https://www.lazard.com/media/2390/lazards-levelized-cost-of-energy-analysis-90.pdf

[47] REN21, 2016. *Renewables 2016 Global Status Report*. Paris: REN21 Secretariat. Page 62. http://www.ren21.net/status-of-renewables/global-status-report/.

[48] *Lazard's Levelized Cost of Energy Analysis – Version 9.0.* Op. cit. note 46. Page 3.

[49] Molina, Maggie. *The Best Value for America's Energy Dollar: A National Review of the Cost of Utility Energy Efficiency Programs*. ACEEE. March 25, 2014. Research Report U1402. Graph originally printed in ACEEE report by Molina and then updated with 2015 data. Updated graph accessed online July 2016 at: http://aceee.org/topics/energy-efficiency-resource.

[50] *WINDExchange: Kentucky Wind Resource Map and Potential Wind Capacity*. U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Wind Program. Accessed online August 2016 at: http://apps2.eere.energy.gov/wind/windexchange/wind_resource_maps.asp?stateab=ky.

[51] *Lazard's Levelized Cost of Energy Analysis – Version 9.0.* Op. cit. note 46. Page 10.

[52] *Our 100% Renewable Vision*. MidAmerican Energy. Accessed online July 2016 at: https://www.midamericanenergy.com/our-renewable-energy-vision.aspx.

[53] Trabish, Herman K. *ERCOT: Wind, solar nearly two-thirds new capacity in 2016*. Utility Dive. March 16, 2016. http://www.utilitydive.com/news/ercot-wind-solar-nearly-two-thirds-new-capacity-in-2016/415715/.

[54] Kessler, Richard. *Work set to start in 2017 on Plains & Eastern wind export line.* ReCharge News. May 24, 2016. http://www.rechargenews.com/wind/1433398/work-set-to-start-in-2017-on-plains-and-eastern-wind-export-line.

[55] REN21, 2016. Op. cit. note 47. Page 77.

[56] Jacobson, M. et al. *Low-cost solution to the grid reliability problem with 100% penetration of intermittent wind, water, and solar for all purposes*. Proceedings of the National Academy of Sciences. December 8, 2015. Vol. 112. No. 49.

[57] *Net Metering (Map of policies in U.S.)*. Database of State Incentives for Renewables and Efficiency. North Carolina Solar Center. July 2013. Accessed in August 2016 at: http://www.seia.org/policy/distributed-solar/net-metering.

[58] *Reforming the Energy Vision: Building a clean, resilient and affordable energy system for all New Yorkers.* New York State website. Accessed online July 2016 at: https://www.ny.gov/programs/reforming-energy-vision-rev.

[59] *Net installed electricity generation capacity in Germany.* Fraunhofer ISE. Accessed online August 2016 at: https://www.energy-charts.de/power_inst.htm.

[60] Schlandt, Jakob. *Germany's Electricity Grid Stable Amid Energy Transition*. Clean Energy Wire. October 26, 2015. https://www.cleanenergywire.org/factsheets/germanys-electricity-grid-stable-amid-energy-transition. https://creativecommons.org/licenses/by/4.0/.

[61] *New Energy Outlook 2016, Executive Summary, Long-Term Projections of the Global Energy Sector*. Bloomberg New Energy Finance. June 2016. #NEO2016. Page 2.

[62] *Energy Efficiency as a Resource*. American Council for an Energy Efficient-Economy. Accessed online August 2016 at: http://aceee.org/topics/energy-efficiency-resource.

[63] Cooper, Adam and Wood, Lisa. *Summary of Ratepayer-Funded Electric Efficiency Impacts, Budgets and Expenditures (2010-2011).* Institute for Electric Efficiency, 2012.

[64] Molina, Maggie. Op. cit. note 49.

[65] Op. cit. note 12.

[66] Pyper, Julia. *Californians Just Saved $192 Million Thanks to Efficiency and Rooftop Solar.* May 31, 2016. http://www.greentechmedia.com/articles/read/Californians-Just-Saved-192-Million-Thanks-to-Efficiency-and-Rooftop-Solar.

[67] *How$martKY Overview*. Mountain Association for Community Economic Development. Accessed online July 2016 at: http://www.maced.org/howsmart-overview.htm.

[68] *Iowa State Profile and Energy Estimates, Overview*. U.S. Energy Information Administration. Accessed online July 2016 at: http://www.eia.gov/state/?sid=IA.

[69] Kessler, Richard. Op. cit. note 54.

[70] Analysis based on hourly data feeds from the SNL data portal, SPP South hourly data, and EKPC hourly data.

[71] Analysis based on SNL data portal and ERCOT North hourly data.

[72] *Shared Renewables*. Interstate Renewable Energy Council. Accessed online July 2016 at: http://www.irecusa.org/regulatory-reform/shared-renewables/

[73] *Berea Solar Farm*. Berea Municipal Utilities. Accessed online July 2016 at: http://www.bereautilities.com/?page_id=348.

[74] *Application for a Certificate of Public Convenience and Necessity to the Kentucky Public Service Commission*. East Kentucky Power Cooperative. Case No. 2016-00269. July 21, 2016.

[75] *Shared Renewables/Community Solar*. Solar Energy Industries Association. July 2016. http://www.seia.org/policy/distributed-solar/shared-renewablescommunity-solar.

See also: *Updated: States Supporting Virtual Net Metering*. Institute for Local Self-Reliance. Accessed online July 2016 at: https://ilsr.org/virtual-net-metering/.

[76] *Net Metering (Map of policies in U.S.)*. Op. cit. note 57.

[77] *2015 Energy Efficiency Annual Report*. Op. cit. Note 9. Page 1.

[78] Ibid, page 2.

[79] Ibid, page 1.

[80] *Where We Get Our Power*. Op. cit. Note 6.

[81] *MWE 2015 Annual Report*. Midwest Energy. 2015. Page 5. Accessed online July 2016 at: https://www.mwenergy.com/assets/images/uploads/pages/2015_Annual_Report-compressed.pdf.

[82] *Environmental: Community Solar*. Midwest Energy. Accessed online July 2016 at: https://www.mwenergy.com/environmental/renewable-energy/community-solar.

[83] *ACEEE State and Local Policy Database, Massachusetts*. American Council for an Energy-Efficient Economy. Accessed online July 2016 at: http://database.aceee.org/state/massachusetts.

[84] *Mass Save Program*. www.masssave.com.

[85] *STAYING ON TOP: Energy Efficiency Continues to Deliver Benefits to Massachusetts Residents and Businesses.* The Report of the Massachusetts Energy Efficiency Advisory Council. November 2013.

[86] *Expanded Heat Loan*. Mass Save Program. Accessed online August 2016 at: http://www.masssave.com/en/residential/expanded-heat-loan.

[87] Halfpenny, Christina, et al. *MassSave: A New Model for Statewide Energy Efficiency Programs*. ACEEE Summer Study on Energy Efficiency in Buildings. 2012.

[88] *Our 100% Renewable Vision*. Op. cit. Note 52.

[89] Ibid.

[90] *Customer Generation, Net Metering Rate*. MidAmerican Energy. Accessed online July 2016 at: https://www.midamericanenergy.com/customer-generation.aspx?aid=1.

[91] Walton, Robert. *Kentucky utility installs home storage for demand response pilot program*. Utility Dive. October 9, 2015. Accessed online August 2016 at: http://www.utilitydive.com/news/kentucky-utility-installs-home-storage-for-demand-response-pilot-program/407084/.

[92] Hledik, Ryan, et al. *The Hidden Battery: Opportunities in Electric Water Heating*. NRECA, NRDC, and PLMA. January 2016.

[93] Roy, Robin. *A Positive House Hearing on Grid-Enabled Water Heaters*. Natural Resources Defense Council, Expert Blog. March 23, 2015. Accessed August 2016 at: https://www.nrdc.org/experts/robin-roy/positive-house-hearing-grid-enabled-water-heaters.

[94] *Osage Municipal Utility, Comprehensive DSM Program*. EcoMotion, The Results Center. Profile #5, 1992. Page 2. Accessed online August 2016 at: http://ecomotion.us/results/5.htm.

[95] Ibid, page 11.