

The Chicago Region's “Green” Economic Opportunities

An Examination of Chicago's Cluster-Based Economic Growth Opportunities Arising
from Changing Market Demand for Energy Efficient Products and Services

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Foreword

Metropolis Strategies is pleased to sponsor this report on the Chicago Region's Green Economy. It serves two of Metropolis Strategies' current interests: growing the Chicago regional economy and promoting sustainable practices in the region.

For the past several years, there has been considerable talk about the "green economy." It is driven in part by those who are working to limit greenhouse gas emissions or respond to ever higher energy costs by promoting clean energy sources and improved energy conservation practices. It is also of interest to those who are looking for new opportunities to grow the economy in the Chicago region by identifying and nurturing new market opportunities driven by increasing demand for energy and resource efficiency.

This report offers a disciplined way to analyze the green economy opportunities best suited to the Chicago region. It uses economic analysis to see where we might have a competitive advantage over other metropolitan regions in growing new firms or expanding markets for existing firms. The report identifies 12 sectors that look promising for Chicago and delves more deeply into one promising opportunity for growth -- energy efficient lighting.

The report is a first step for the Chicago region. It provides a road map for how to identify green economic opportunities, and ways to grow them. Developing these clusters of businesses requires considerably more work and a coordinated effort on the part of the leadership in the field. The authors found relatively few formal or informal industry associations or business networks in this sector of the economy. This suggests a need for more institutional capacity to identify and seize the opportunities in Chicago. This report can serve as a catalyst for discussion and action, including bringing together the disparate people and organizations working on environmental and economic development issues in the region. Several organizations have already expressed interest in following up on the action steps described in this report. We look forward to working with them, and others, to grow our region's green economy.

Thank you to the authors, John Cleveland of Innovation Network for Communities and Robert Weissbourd and Sophie Cohen of RW Ventures, for their dedication to this project. Thank you also to the **ArcelorMittal Foundation**, the **Grand Victoria Foundation** and the **Joyce Foundation** for funding and advising this important endeavor. We hope that those already working in the field, from businesses to investors to non-profits and governments, will find the report useful, and that the leaders in the field will join in taking the next steps in our continuing effort to move the green economy from idea to reality.



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A critical component of this project was our interviews with experts, first in Chicago's green landscape broadly, and then in the Energy Efficient Lighting sector. We thank all our interviewees – Amy Francetic, Christy Augustine, Dan Swinney, Dennis Vicchiarelli, Donna Ducharme, Gail Longmore, Howard Learner, Robert Whittier, Claire Woolley, Peter Locke, Chinwe Onyeagoro, Erik Birkerts, Lee Eilers, Glenn Garbowicz, Adam Gruber, Craig Hall, Michelle King, Jim Livingston, Sandra Miles, John Reagan, Bill Solomon, Steve Weiland and Jeff Winton – for their valuable insights.

Many thanks to the Brookings Institute and Battelle, and in particular Mark Muro, Jonathan Rothwell and Martin Grueber, for offering us early access to their *Sizing the Clean Economy* data. This information gave us a better understanding of Chicago's assets than we would have otherwise been able to uncover. Thanks also to Michael He for helping us to make sense of the data.

The project benefited early on from efforts by the Midwest Energy and Sustainability Leadership Alliance (MESLA), and James Cahan in particular, to survey its members on their thoughts regarding opportunities in the green economy. We also appreciate early support from Douglas Ashburn, Vishal Jain, Mariam Kittaneh and Jeff Mai, students at the IIT Stuart School of Business who conducted some early data analysis and additional research as part of a class taught by Fred Cutler.

Finally, cluster work undertaken by RW Ventures with partners in several other projects contributed to our work on this project, including the Metropolitan Business Planning initiative developed jointly with the Brookings Institute, review of the economic impacts of the Chicago Metropolitan Agency for Planning's GO TO 2040 comprehensive plan, and ongoing MacArthur-funded work to link neighborhood and cluster development. We are grateful to our partners in those projects.

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Project Purpose and Summary

High energy costs, along with concerns about climate change and energy security, are driving rapid global growth in demand for energy efficient products and services. This large emerging “green” market presents major economic opportunities for the production side of the economy (including for companies that would not themselves be considered green, such as ball bearing manufacturers in the wind power supply chain). This project focuses on uncovering some of these opportunities in Chicago:¹ it approaches the “green economy” with the primary lens and purpose of economic development (not environmental improvement, though the two often align).

The particular economic approach applied in this project is cluster analysis. Cluster based interventions offer a particularly effective and powerful way of identifying and developing strategies to build from concentrations of competitive assets in an economy, specifically of mutually reinforcing firms and related institutions and inputs (enhancing the productivity of participating firms, attracting firms and inputs, and creating new firms). The project analyzes Chicago’s economic base to identify opportunities for cluster development (as distinct from opportunities for individual firm or entrepreneurial opportunities) to meet the emerging green market demand.

The project was divided into two phases. The first phase set out to understand Chicago’s green economic landscape, identify promising sectors² for regional economic growth and select one among them for deeper analysis in the second phase. The goal of Phase II was to become more deeply acquainted with the chosen cluster and to recommend strategies for its growth regionally. It should be noted that the project was designed to be illustrative, and highly limited in scope: it did not seek to fully analyze every opportunity in the region’s green economy, but rather to illustrate *how* to identify and design tailored cluster strategies. Thus, while numerous sectors were identified in Phase I that would benefit from a cluster development strategy, only Energy Efficient Lighting was investigated in depth in Phase II. Applying the same process, cluster development strategies could be developed for the other sectors in subsequent projects.

The economic opportunities for responding to expanding green market demand were divided into 39 different sectors.³ Of these, 12 appeared to be especially promising avenues for economic development in Chicago: Biofuels/Biomass; Green Chemicals; Organic Farms & Food Production; Recycled Content Products; Smart Grid; Solar Thermal Energy; Vehicle Electrification; Water Purification and Treatment; Wind Energy; Green Building; Building Energy Management; and Energy Efficient Lighting. As mentioned earlier, Energy Efficient Lighting was eventually chosen as the “deep dive” sector. Given the limited scope of this project, choosing only one sector necessarily

¹ “Chicago” will be used interchangeably with “region” and “metro” throughout this report to mean the fourteen-county Chicago metropolitan region. If the City or any other geography is intended, that will be specified.

² The terms sector and cluster are used repeatedly throughout this report and should not be confused. “Sector” generally refers to all or part of an industry, generally as defined by data sources (such as NAICS codes). “Cluster” is defined in depth in Part I, Section 1, and generally consists of firms in one or more sectors, along with related institutions, that are economically connected. The two can empirically coincide, but often do not. Sector is more often a categorization of firms by what they make or do, whereas cluster is a grouping based on the economic co-dependency and benefits of agglomeration.

³ The project adopted the sectors introduced by Brookings and Battelle in *Sizing the Clean Economy*.

leaves out many others; key findings related to each of these other sectors are summarized in Section 2 of Part I and may serve as a useful starting point for future cluster development work.

As the project delved into the Energy Efficient Lighting sector (discussed in Part II), it became clear that the cluster development opportunity was likely different than expected. Rather than narrowly focused on EE Lighting, the analysis revealed that a promising cluster appears to be emerging in “Integrated Lighting and Building Energy Systems” (ILBES). The lighting industry is in a state of turbulence, spurred by the arrival of disruptive LED technology. As LEDs make up an ever greater share of the lighting market, lighting production is becoming increasingly integrated with lighting design, controls and management and with other energy efficiency products and services. The distribution process is changing, giving energy management integrators, designers, utilities and building managers a greater role.

Given these changes, Chicago has an opportunity to build on its unique assets in the commercial building sector – a large network of existing manufacturers, designers, architects and engineers, energy management companies and others – to support the development of the ILBES cluster. Chicago could develop an applied R&D network that would: provide manufacturers with an opportunity to prove their quality in demonstration sites; develop relationships with emerging and increasingly important distribution channels such as lighting/building designers, ESCOs, utilities and commercial building managers; and use these relationships to build trust and gain market acceptance. It would also provide an opportunity for manufacturers of related products to integrate with one another. This system would benefit the customers and distributors by allowing them to easily compare products and work with the manufacturer to get the desired customization. Overall, this strategy would use close-knit relationships between building designers, owners and managers, and providers of energy efficiency products and services, to shorten the time between innovation development and its penetration into the market. Leveraging Chicago’s unique assets in the commercial building sector, such a system could make Chicago the place to go to do real world applied R&D and accelerate commercial viability of energy efficient building technologies.

In order to make the vision of an applied R&D network for Integrated Lighting and Building Energy systems a reality, Chicago needs to improve its institutional infrastructure in green economic development. Unlike in other sectors of the economy, such as information technology, few business and market-driven networks exist of firms, institutional partners and investors in the green economy. Even considering the emergent nature of the green economy, and with one or two significant exceptions, Chicago’s green economic institutional infrastructure is less developed than that of many other cities. To get to the on-the-ground, firm-level knowledge and relationships necessary to do cluster development, an ongoing dedicated staff capacity that works directly with business leaders in specific sectors should be developed. Over time, this capacity would build knowledge and relationships that could enable practical business development strategies, allowing for ongoing cluster development in multiple sectors of opportunity.

Structure of the Report

This report is divided into two parts, reflecting the project’s two phases. The first part describes the project’s cluster approach, outlining the theory behind cluster-driven economic growth and identifying the particular criteria used to select promising clusters for the project. Using these

criteria, the report narrows from many green sectors of opportunity to the one—energy efficient lighting—ultimately chosen to illustrate green cluster development.

The second part of the report digs deeper into the energy efficient (EE) lighting sector, providing an overview of the industry and its current trends and dynamics, based on further data, research and extensive interviews with lighting experts. The report ends with recommendations for development of Chicago’s EE Lighting sector as well as strategies for regional green economic development more broadly.

Part I: Cluster Development Opportunities

1. The Cluster Development Approach

1.1. What are Clusters and how do they Drive Economic Growth?⁴

A cluster is a group of firms and related economic actors and institutions that are located near each other⁵ and “draw productive advantage from their mutual proximity and connections.”⁶ A cluster can consist of hundreds, and even thousands, of firms of various types and sizes—from Fortune 500 corporations and large professional service firms (advertising and accounting businesses, for instance) to highly specialized R&D operations and small supplier businesses—along with related entities such as business associations, research universities, community colleges, worker training providers and professional development entities that support and connect firms to each other. To constitute a cluster, these firms and institutions must be interdependent actors linked economically, socially and technologically within a region—a sort of production “ecosystem.”⁷

Clusters drive regional economic growth by enhancing firm productivity, which they do by:

- Reducing transportation costs due to firms’ close proximity to one another;
- Enabling the development and sharing of specialized labor pools and other inputs common across the cluster firms;
- Providing cluster firms more efficient access to customers, who may also be geographically concentrated (either as a cause or effect of firm clustering); and
- Facilitating innovation through “knowledge spillovers” – the informal learning and knowledge exchange that results from in-person interactions among employees of clustered firms and the movement of employees from one firm to another.

⁴ This section draws significantly on two papers: Kosarko, Gretchen and Robert Weissbourd, “Economic Impacts of GO TO 2040,” prepared for the Chicago Community Trust, January 2011 (see Chapter IV: Enhancing Performance of Existing and Emerging Clusters); and Wolman, Hal and Diana Hincapie, “Clusters and Cluster-Based Development,” working paper produced for the Surdna Foundation, 2011 (forthcoming).

⁵ The degree of geographic proximity exhibited by firms in clusters varies widely from one cluster to another, ranging from a few blocks (e.g., Manhattan’s garment district) to several states (e.g., the Great Lakes’ auto industry cluster). For the purposes of this paper, the primary unit of geographic reference is the metropolitan area, though the question is an empirical one: any given cluster will have a specific geography of its members, which will often be sub-regional in scale. Joseph Cortright, “Making Sense of Clusters: Regional Competitiveness and Economic Development,” The Brookings Institution, March 2006, 6.

⁶ Cortright, “Making Sense of Clusters,” 1. For further definition and discussion of the literature on clusters, see Edward Bergman and Edward Feser, “Industrial and Regional Clusters: Concepts and Comparative Applications,” in *Web Book of Regional Science*, Regional Research Institute, West Virginia University, available at www.rri.wvu.edu/WebBook/Bergman-Feser/contents.htm.

⁷ Note that a cluster ecosystem is not the same as a membership organization or trade association – the cluster is defined by the economic interactions of its members, not their formal association (or not). “The organizations that represent members and individuals are...one of the key organizations in a cluster but their membership does not constitute a cluster.” Stuart Rosenfeld, “Industry Clusters: Business Choice, Policy Outcome, or Branding Strategy?” *Journal of New Business Trends and Ideas* 3(2) (November 2005): 5-6.

In addition to making existing firms more productive, clusters grow the local economy by attracting firms and workers from outside the region that are seeking greater opportunities, in the form of profits and growth, or a wage premium, respectively. Clusters also foster the creation of new firms, as existing employees split off from one company to form another or entrepreneurs recognize an opportunity to fill an unmet need of the cluster.

Recent evidence suggests that the emergence of a global and knowledge-based economy is affecting what economic activities most benefit from clustering. As transportation costs for goods have declined and the importance of interactions between the human capital embedded in firms and institutions has increased, regions are experiencing the emergence of new “functional” clusters that specialize in different parts of production processes.⁸ Functional concentrations, such as corporate headquarters, back-office or R&D capacities are thus becoming more important. In effect, functional clusters arise from the proximity of facilities that perform the same functions for different firms, rather than from the proximity of firms that operate in the same or related industries.⁹ As a result, firms previously organized as a single unit or vertically clustered within an industry (or set of related industries) may now tend to organize themselves as multi-unit organizations or benefit more from the co-location of horizontal functions. Units performing different functions then tend to locate in places where those functions are best supported (in terms of cost efficiencies and productivity factors).¹⁰

Though the benefits and behaviors of clusters are nothing new—agglomeration economies and “industrial districts” have been a part of economic literature for over a century—the term “cluster” was first popularized in mainstream business literature by Michael Porter in his 1990 book *The Competitive Advantage of Nations*. Since then, an explosion of cluster studies and a multitude of cluster definitions have sparked some scholars to lament that “it is one of those rare terms that has gone from obscurity to meaninglessness without any intervening period of coherence.”¹¹ Despite the sometimes messy definition, clusters are a useful framework for thinking about regional economies. More than that, clusters are a real phenomenon that exist in the production side of the economy and can be identified and strengthened with the right tools.¹²

Part of what makes clusters a messy concept is that each one manifests differently and draws its advantages from different shared benefits and circumstances. For this reason, the basic “cluster

⁸ See, e.g., Rosenfeld, “Industry Clusters: Business Choice, Policy Outcome, or Branding Strategy?” 11-12.

⁹ At the same time, the information technology innovations associated with the knowledge economy reduce the cost of sharing, managing and communicating certain types of information across disparate geographies, allowing firms to separate functions that previously needed to be located in the same place.

¹⁰ Specifically, Duranton and Puga maintain that firms tend to locate their headquarters in places that offer a wide array of business services, while production plants are moved to more sector-specialized cities. An example of this trend is provided by the decision of the Boeing Company to move its corporate headquarters to Chicago, while its primary production facilities remain in Seattle. Duranton, Gilles and Diego Puga, “From Sectoral to Functional Urban Specialisation,” *Journal of Urban Economics* 57(2) (2005), 343-370.

¹¹ Cortright, “Making Sense of Clusters,” citing Maskell and Kebir 2005; see also Rosenfeld, “Beyond Clusters,” citing (in slightly different form) Robert Reich’s 1992 remarks on competitiveness.

¹² Examples of successful clusters include Portland’s Athletic and Outerwear Cluster, North Carolina’s Biotechnology Cluster, and Milwaukee’s Water Cluster.

analysis” that merely examines quantitative data to identify the concentrations and growth patterns of industries in a region relative to the nation is insufficient. Such an analysis often fails to properly identify what firms are in fact clustering, or to capture the nuances of why a particular cluster has formed, what characteristics and circumstances particular to its members and location drive its performance, and how intervention might further increase its productivity. For this reason, after conducting basic research on several sectors, the project engaged stakeholders in one cluster, in order to better understand the mechanics of the cluster, whether it is likely to be a regional economic growth driver, and what types of interventions will help the cluster prosper.

1.2. Cluster Selection Criteria

Clusters are difficult to define and identify in general, and the challenge becomes much greater when examining emerging firms and sectors whose economic inter-relationships are less clear, and often do not yet show up in the data (or even the categories of data) available. As anticipated, typical cluster analysis and categorization techniques shed some light on potentially promising emergent green clusters, but also have serious limitations, requiring additional investigation.

When analyzing Chicago’s “green” economic clusters, the project team considered two distinct questions – *what* is clustering? And is it a *promising* cluster? Table 1 describes the characteristics to look for to first understand if a cluster exists, and then to determine its potential for regional growth in the context of this project. A group of firms need not demonstrate every characteristic in order to be considered a cluster, nor must a cluster exhibit every criteria to be a worthy development enterprise. However, the more criteria met, the more likely it is that the sector will be a good choice for the project. More importantly, the specific characteristics of the cluster will influence the appropriate tools to use for its development.

Table 1. Identifying clusters.

Characteristics of a Cluster	Criteria for a <i>Promising</i> Cluster for this Project
Is geographically concentrated	Is expected to grow regionally, nationally or globally
Shares suppliers	Exhibits a large employment and firm base
Shares markets and customers	Has above average concentration of employment and/or gross product compared to the nation (and is not already dominated by another region)
Exhibits relationships between competitive firms	Builds from strong, underlying regional assets
Has related, supporting institutions	Exhibits export potential
Shares “commons assets” such as R&D institutes and specialized infrastructure, technologies, labor pools or financing sources.	Exhibits existing organization and leadership
	Industry structure is well balanced between large and small firms
	Provides quality jobs for all skill levels
	Will derive added value from intervention (in other words, the cluster is not already the focus of other efforts or market dynamics that would make intervention by this project redundant)
	Contributes to reducing greenhouse gas emissions, or otherwise benefits the environment
	Is supported by policy and local institutional environment

In a perfect world, one would first determine what clusters exist in the region and then analyze them based on potential to impact economic growth. In the real world (with data constraints), the process is iterative, usually starting with a list of sectors or industries (which may or may not be clusters), then evaluating the growth potential of *those*, and then through interviews determining whether the sector does in fact demonstrate characteristics of a cluster.¹³

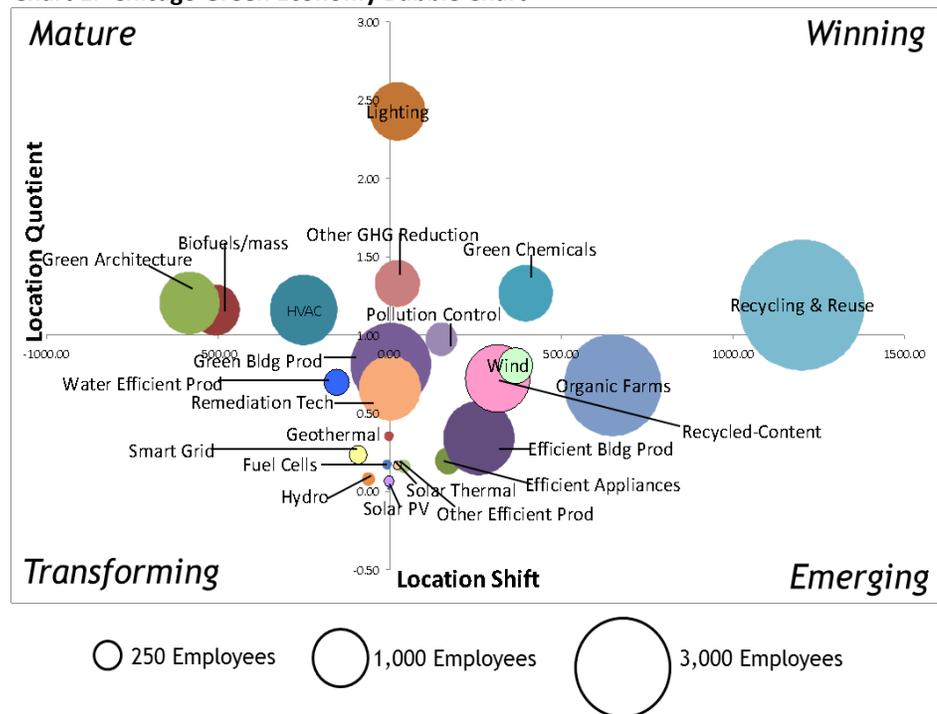
The characteristics and criteria outlined here were used to guide the selection of a growing green sector that would illustrate the process of cluster development.

1.3. Cluster Selection Process

An extensive, separate Phase I Memo describes in detail the methodology and data used in the cluster selection process. This includes standard analysis of NAICS data and “clean economy”-specific data from Brookings & Battelle,¹⁴ industry research, review of proprietary firm level data and interviews with experts. Some key data conclusions are summarized below. For a detailed description of methodology, see Appendix A, and for a fuller discussion of the findings, see the Phase I Memo.

The universe of potential clusters for this project began with Brookings and Battelle’s list of 39 sectors from their *Sizing the Clean Economy* report (see Appendix B). The bubble chart to the right illustrates the absolute size, the relative concentration and the regional growth of the sectors. The subsequent “heat map” presents the same and additional information in another way, grouping the sectors into five categories based on commonalities in the data.¹⁵

Chart 1. Chicago Green Economy Bubble Chart

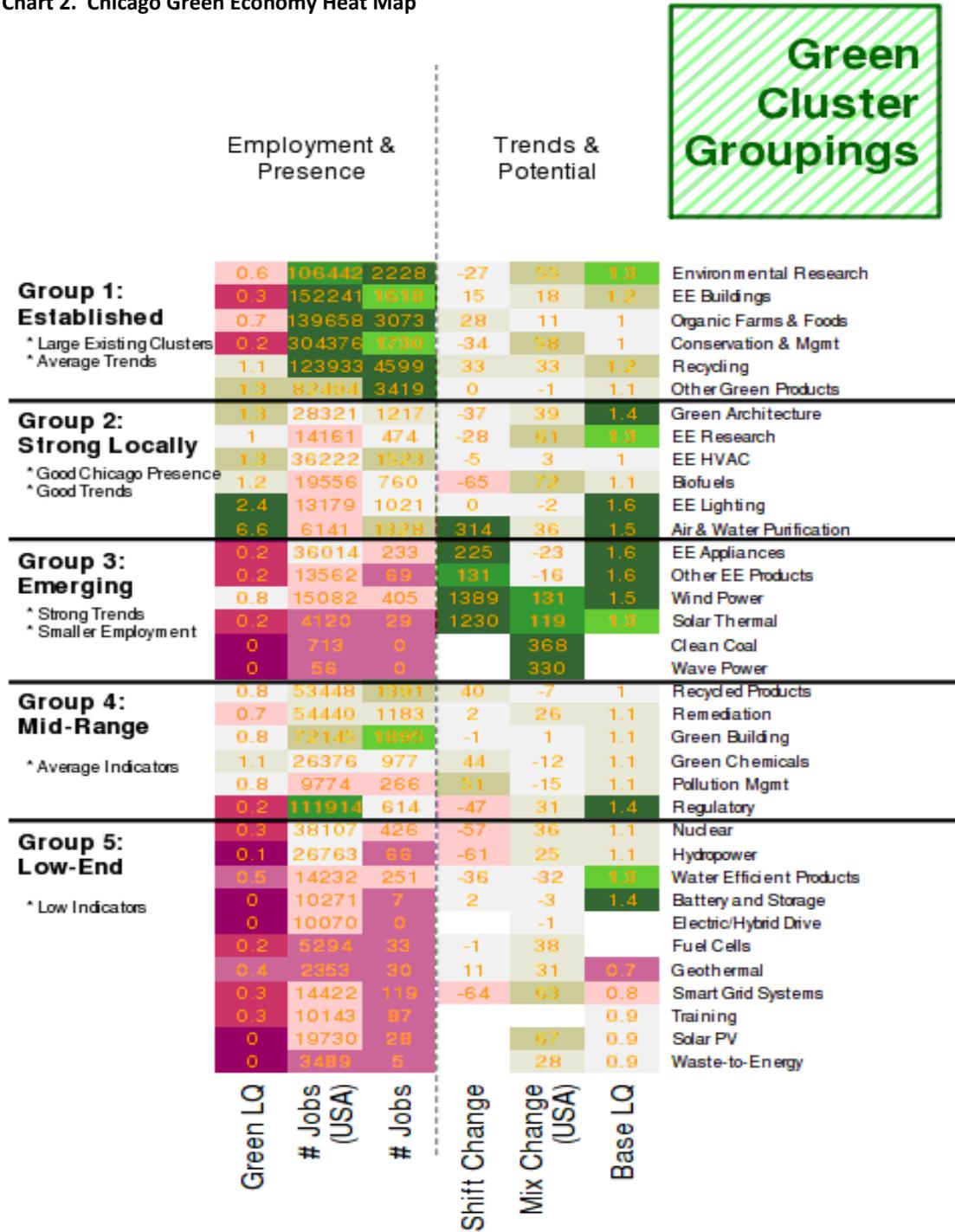


¹³ This process is further confounded by the fact that some measures, such as location quotient, can be used both to suggest that a cluster exists *and* that it is a promising cluster.

¹⁴ Note that the data used in this process (and reflected in Charts 1 and 2) was preliminary, and may not perfectly match the version of data released by Brookings and Battelle in July 2011. The overall trends remain accurate.

¹⁵ Though the heat map looks complex, it is actually relatively straightforward to interpret. Sectors are presented in rows, while the indicators are in columns. Appendix A describes the indicators and how they were calculated. Each cell is shaded according to its relative value compared across sectors, where pink indicates a low relative

Chart 2. Chicago Green Economy Heat Map



value and green represents a high relative value. The actual values of the indicators for each sector are written in orange text. The visual nature of the heat-map is useful for analyses like this one, in which the exact values of the data are not as important or reliable as the general relationships between data. The heat map automatically groups data that score similarly across indicators, exposing commonalities that may not have been obvious otherwise. Based on these commonalities, the sectors are broken down into five identifiable groups and given a label according to the characteristics observed in the data.

A few sectors included in the Brookings-Battelle data do not show up in these charts either because there were no Chicago firms listed or because the data were judged misleading or inaccurate.¹⁶

From this quantitative analysis, which is described in more detail in Appendix A and in the previous “Phase I Memo,” the following clusters emerged as potential growth opportunities for Chicago:

- Green Architecture
- Biofuels/Biomass
- Energy Efficient HVAC
- Energy Efficient Lighting
- Green Chemicals
- Recycling & Reuse
- Recycled Content Products
- Organic Farms & Food Production
- Wind Energy
- Air and Water Purification
- Solar Thermal Energy
- Energy Efficient Building Products
- Other Greenhouse Gas Reduction
- Conservation & Management
- Environmental Research
- Other Green Products
- Energy Efficient Research

Of these, a few were removed from consideration for this project based on unique project criteria (which, recall, seek not only high potential areas of green economic activity, but ones likely to lend themselves to and illustrate well cluster approaches). “Other Greenhouse Gas Reduction” and “Other Green Products” were too general to constitute a meaningful cluster. “Energy Efficient Research” and “Environmental Research” may include firms that are part of other clusters, but they do not themselves make interesting clusters as defined here. “Conservation & Management” and “Recycling & Reuse” were both dominated by the public sector.

Two promising clusters—*smart grid* and *vehicle electrification*—did not show up well (or at all) in the data, most likely due to their highly emergent nature, but were added for consideration because the interviews revealed potential that the data had not yet captured. Information from the interviews also caused the adjustment/combination of some sectors. For example, Air & Water Purification was changed to Water Purification and Treatment, and Green Building emerged as a broad mega-cluster that encompasses Energy Efficient Appliances, Energy Efficient Building Products & Materials, Energy Efficient HVAC & Building Control Systems, Energy Efficient Lighting, Green Architecture, Building Design, & Construction, and Other Energy Efficient Products. While most people interviewed did not distinguish between the subparts of the Green Building cluster, research for this project suggests that these subparts may represent multiple, overlapping clusters.¹⁷ Within the Green Building mega-cluster, Energy Efficient Lighting and Energy Efficient HVAC & Building Control Systems (relabelled Building Energy Management) stood out as having stand-alone potential worth researching further.

¹⁶ For example, Public Mass Transit included only the employment associated with Amtrak, and none with CTA, Metra, PACE, etc.

¹⁷ This subject is discussed in Part II.

2. Cluster Opportunities

After considering the data and the interviews, but before looking deeply at additional research, the list of promising sectors for cluster development stood at 12:

- Biofuels/Biomass
- Green Chemicals
- Organic Farms & Food Production
- Recycled Content Products
- Smart Grid
- Solar Thermal Energy
- Vehicle Electrification
- Water Purification and Treatment
- Wind Energy
- Green Building
 - o Building Energy Management
 - o Energy Efficient Lighting

A brief description of each of these, including employment data from Brookings and Battelle and insights gained from interviews and industry research, is included below. This review serves both to highlight the potential that each of these sectors has to grow the regional economy, and to describe why it was or was not selected for further analysis in Phase II.

Biofuels/Biomass

The Biofuels/Biomass sector includes those firms engaged in the production of energy from biological material such as plants, trees, and even waste. A variety of firms make up the sector, from farmers to forest trimmers to corn and cellulosic ethanol producers. This sector is still relatively small in Chicago (approximately 760 employees), although it has a higher than average concentration in the region. In addition, biomass was one of the four main sectors that a 2008 Bain/WBC study identified as promising, although a lack of Chicago-based R&D and funding hampered its potential. There is some biofuels research taking place at Argonne National Labs, as well as at (mostly downstate) Illinois universities. One potential concern regarding biofuels is the uncertain environmental benefits of corn-based ethanol, although next generation advanced biofuels show far greater promise environmentally and economically. This potential cluster demonstrates potential and deserves further attention outside this project.

Green Chemicals

The Green Chemicals sector includes companies making a wide variety of chemicals – from paint to machine lubricants to cleaning products to food and beverage chemicals. One of the only sectors that stood firmly in the top-right “winning quadrant” of the bubble chart, Green Chemicals has both an above average LQ and positive growth trends in the region. Still, the distinct inputs and markets of the many different types of chemicals makes it less likely that a unified cluster strategy could readily be developed, especially in the limited timeframe of this project. The green chemicals sector undoubtedly merits additional analysis outside the scope of this project in order to reach a deeper understanding of its cluster development potential.

Organic Farms & Food Production

Organic Farms & Food Production companies are engaged in the growing, processing or selling of organic food – Chicago area firms tend to manufacture or sell food, with only a few farmers. This sector overlaps with, but is distinct from, the local foods movement. While some organic food is sourced or sold locally, other firms may participate in a broader market. Chicago has the fourth highest number of employees in this sector (2,800), but its employment growth and comparative concentration rank much lower. While Chicago’s longstanding strengths in food production make this sector a natural fit, its transition to organics has been slower than competitors on the West Coast, preventing the region from fully capturing the opportunity.¹⁸ Regional growth in this sector is likely to be driven by existing firms recognizing the market opportunity in organics and adding/converting some of their production capacity accordingly. A comprehensive industry strategy could be developed outside of this project to accelerate that process.

Recycled Products

Companies in the Recycled Products sector are those that use recycled materials (paper, metal, glass) to create new products and materials. Though its location quotient is low, Chicago has the fifth largest employment base in this field. In addition, Chicago’s Waste to Profit Network is a national model of “byproduct synergy,” helping businesses save money by turning one company’s trash into another’s products. This is a growing sector – recycled materials used in packaging went from around 150 million pounds in 2002 to over 400 million in 2009. Chicago’s large manufacturing base in recyclable materials provides the region with an opportunity to lead innovation in recycled products, which should be investigated further outside the scope of this project.

Smart Grid

The Smart Grid sector refers to those companies engaged in the improvement of the electrical grid, bringing it into the 21st century through two-way, real-time communication technologies. A robust smart grid will enable many other green sectors by providing opportunities for building energy efficiency, facilitating the integration of renewable energies into the power supply, and making it easier and cheaper to recharge electric vehicles and maintain reliability. Smart Grid technologies are so new that many companies have not yet been picked up by the data. Thus, while Brookings-Battelle found only 3 companies and around 100 jobs in the industry, it is clear from other work that this sector is far more active in the region than the numbers suggest. Indeed, the Illinois Institute of Technology (IIT) is managing a \$600,000 grant from SBA to develop a Smart Grid Regional Innovation Cluster (SGRIC). As of several months ago, this cluster already had over 100 participants, including non-profits, utilities, midsize firms, and small IT and software companies. IIT and its partners (Clean Energy Trust, Illinois Science and Technology Coalition and O-H Community Partners) will help firms grow by identifying financing tools, pursuing advanced research, and creating new market opportunities. Due to recently passed state legislation, elements of a smart grid will soon begin to be deployed in Illinois. This legislation also provides for a “smart grid test bed,” a unique provision with potential to spur innovation in hardware, software, and applications. With help from SGRIC, Illinois could become a national leader in this sector. Given the cluster work already being done by the SGRIC partners, it did not make sense for this project to also focus on the smart grid sector.

¹⁸Altman, Durbin, Felt, Hazlett and Lopez-Silva, “The Chicago Processed Food Cluster,” 2006.

Solar Thermal Energy

Solar Thermal Energy companies, distinct from Solar Photovoltaic companies, are those that capture and distribute heat from the sun for energy consumption. Solar Thermal systems typically work by harnessing the sun to heat water either for direct use or to turn it into steam that drives an electricity generator. Solar Thermal Energy is still very small in Chicago, but has grown significantly over the last seven years, a trend that is expected to continue. Most support for a potential solar thermal cluster in Chicago is due to the location here of the company Solargenix. While possible that Solargenix will jumpstart a solar thermal cluster here, Chicago is competing with regions that already have a strong base of solar companies, more sunlight, and greater local demand.

Vehicle Electrification

The Vehicle Electrification sector, as considered for this project, primarily concerns activities related to the electrification or hybridization of traditional vehicles, particularly heavy-duty trucks and machinery and other fleet vehicles. This includes the firms related to the creation of high capacity batteries that make hybrid and electric vehicles possible. Though Chicago's opportunity in this sector is not apparent from the Brookings-Battelle data, Chicago has research and manufacturing assets that make a Vehicle Electrification cluster possible here. The presence, in particular, of Navistar (and to a lesser extent Caterpillar and Deere) could be an industry driver, given Navistar's status as a leader in the field of hybrid trucks. While several companies in this field have headquarters in Chicago, fewer locate their manufacturing plants here; many more manufacturing facilities related to electric vehicles are in nearby states Michigan and Indiana. That being said, some Chicago companies may have an opportunity to supply the larger clusters in these neighboring states. In addition, the Chicago area is investing heavily in fast-charge infrastructure for electric vehicles. Further support could make the region a very attractive early test site for electric vehicles and promote cluster growth.

Water Purification & Treatment

The Water Purification and Treatment sector includes firms that are researching, manufacturing, and distributing water-related technologies, as well as firms that provide related services. Water technologies initially showed up well in the data—indeed, in the final release of the Brookings and Battelle data, Chicago ranked #1 in employment in “Air and Water Purification Technologies.” However, when looked at more carefully, the picture gets murkier—Brookings and Battelle found only a handful of air and water purification firms and one of them dominated the total employment and job growth.¹⁹ Still, research for this project revealed many more water technology companies than appeared in the data. While clear that Chicago has many important assets for a water cluster (an existing firm base, research institutions, companies with large purification needs, and access to clean water), there is some concern that Milwaukee is already well known as the “place to be” for water firms. Over the last few years, Milwaukee's Water Cluster, which formed in part out of their historical strength in breweries, has become a leading example of the possibility of cluster development, leading to questions of whether there is room for another major Water Cluster so close to Milwaukee. The jury is still out, with some of the belief that the short distance between

¹⁹ Based on initial Brookings and Battelle data, in which sector as a whole had around 1300 jobs; more recent data released shows around 2000 local jobs in the sector. These may be concentrated in one or a few companies, or they may reflect more distributed employment.

here and Milwaukee could be an asset to development of another water cluster in Chicago. At the very least, Milwaukee's proximity presents an opportunity for Chicago companies to grow as *part* of their northern neighbor's cluster.

Wind Energy

At the core of the Wind Energy sector are wind turbine OEMs, wind farms, and suppliers of thousands of different parts. In the Brookings-Battelle data, Wind Energy stood out for its trends, but not for its existing size or concentration in the area. Interviews and industry research revealed that Chicago is home to many wind energy headquarters, which benefit from the same array of business and financial services as other headquarters. Likewise, Chicago's manufacturing base includes many companies that are already supplying wind companies and even more that may be able to transition to the wind market supply chain. The Chicago Manufacturing Renaissance Council, in partnership with the Great Lakes Wind Network, is leading efforts to help interested companies make this transition. Chicago's proximity to the Plains states, the windiest parts of the country, makes it an especially attractive location for wind companies to locate their headquarters and their manufacturing facilities. Market forces, state renewable energy mandates, and actions by other organizations are already turning the Windy City into the Wind-Energy City, leading this project to focus on a sector receiving less attention.

Green Building

The Green Building sector encompasses a wide array of economic activity—green architect and construction firms, energy efficiency appliances, lighting and HVAC manufacturers, green material producers, etc.—that may actually constitute several distinct clusters or sub-clusters. An increasing number of new buildings now have “green” elements in their design, especially in Chicago, which leads the country in the number of LEED certified buildings.²⁰ Energy efficient retrofits of existing buildings are also growing in popularity, aided by efforts like Energy Impact Illinois, a DOE-funded and CMAP-led initiative in support of more efficient buildings. However, this aspect of the Green Building sector is primarily local, (i.e. not a “traded” sector that exports its goods and services beyond the metro), and thus offers a less appealing economic growth opportunity. For the purposes of this project then, the sectors that provide the energy efficient materials, systems and products for green buildings to companies located both here and elsewhere are more interesting and are receiving less attention from other actors. Especially promising opportunities are those that link the local market for green buildings with the traded market for efficient products. Two traded sectors— building energy management systems and energy efficient lighting—show particular promise to do that in Chicago and are discussed in more detail below. As Part II illustrates, the manner in which the subsectors of Green Building will emerge and operate as one or several related clusters is actively at play in the marketplace, and as yet an open question.

Building Energy Management

Building Energy Management companies reside at the intersection of information technology and building management, and make products like heating, cooling and lighting controls systems and energy monitoring software. Chicago already has an above average concentration of jobs in this

²⁰ Kamin, Blair, “Chicago ranks first in LEED-certified buildings, but Washington and New York are gaining fast,” *Chicago Tribune*, February 16, 2011.

field (LQ=1.2) and also has the R&D capacity, entrepreneurs, software talent, and other assets required to build a competitive cluster in this area. Indeed, Chicago is already home to several major companies in this field, including Enablon, SAP, IHS, Johnson Controls, Siemens Building Technologies, Schneider Electric and Honeywell International. Demand for Building Energy Management is on the rise, presenting a real growth opportunity for Chicago. However, other regions, notably Seattle and Philadelphia, already have sophisticated plans in place to develop next generation technologies and compete globally in this market. To compete, Chicago will need to develop something similarly sophisticated that relies on the region's unique strengths. Capturing this opportunity may require a sophisticated, in-depth approach similar to Seattle's Building Efficiency Testing and Integration (BETI) Center.²¹

Energy Efficient Lighting

Energy Efficient Lighting refers primarily to LED and fluorescent lighting (the most well-known being compact fluorescent lamps), although many lighting companies work with several different types of lighting, including those not considered efficient. Chicago consistently has a very high location quotient for Energy Efficient Lighting (2.4 in Brookings-Battelle data) and related industries (Michael Porter's Lighting and Electrical Equipment cluster has a 2.5 LQ in the Chicago region; Ed Feser's Lighting Fixture Manufacturing sector has an LQ of 1.7). Industry trends support a rapid transition to more efficient lighting technologies across the board, spurred in part by federal regulations. Chicago's existing base in lighting firms and the expected growth of this sector make it a promising avenue for cluster development. For this reason, it was chosen for deeper analysis.

3. Conclusion

Each sector described in Section 2 represents a promising economic opportunity for Chicago. Unfortunately, the limited nature of this project precludes the additional analysis required to deeply understand and develop growth strategies for every opportunity. Instead, the project selected Energy Efficient Lighting as an illustrative sector to explore below the surface, in a way that could be emulated with other sectors in future projects. Through numerous interviews and extensive industry research, the project explored the sector's dynamics globally and in Chicago. Part II describes these findings and their economic development implications.

²¹ See <http://psrc.org/assets/5590/BETIBusinessPlan.pdf> for more information on BETI.

Part II: Opportunities for Green Cluster Development in the Energy Efficient Lighting Sector

The second half of this report examines the Energy Efficient (EE) Lighting sector and explores possibilities for a cluster development strategy aimed at accelerating the growth of this cluster in the Chicago region. Examination of the EE Lighting sector proceeded through review of existing industry analysis and reports²² and interviews with Chicago area firms and industry leaders, including manufacturers, designers, investors and distributors.²³

The information learned from this analysis is presented in four sections. The first summarizes the project's key findings and recommendations. Following that is an analysis of the EE Lighting industry, which describes the basic structure of the sector – the core technologies; products and services; customer segments; and the primary industry value chains and types of firms that participate in those value chains. This analysis is fundamental to understanding what might actually constitute the cluster (and whether there is one). The third section examines the primary market dynamics and their implications concerning the opportunities for cluster development. The fourth section then applies the industry research to Chicago, analyzes the local cluster characteristics and identifies growth strategies and next steps. In addition to recommending strategies specific to the EE Lighting sector (or, as it turns out, the emerging Integrated Lighting and Building Energy Systems cluster of which it is a part), the report also suggests steps to strengthen the Chicago region's institutional infrastructure around green economic development.

1. Summary of Findings and Recommendations

Key Findings about the EE Lighting Sector

- **Historically conservative sector undergoing transformation.** The lighting sector has been a traditional and conservative sector that is undergoing significant transformation.
- **High growth.** The EE Lighting sector (especially in LEDs) is a growth sector with many new business opportunities.
- **Growth burst in the next five years.** The large burst in LED growth will come in the next 2-5 years as costs continue to fall and performance and quality continue to rise. By 2020, LED lights are expected to account for up to 60% of the overall lighting market.
- **New entrants.** Many new players will enter the market, throwing industry leadership up for grabs.

²² A list of primary industry reference sources is included in Appendix E.

²³ A list of the interviewees is included in Appendix D.

- **More integrated technology.** Unlike incandescent light bulbs and other traditional lighting sources, which are sold separate from the fixture, LEDs are often integrated into the design of the fixture and sold as one product.
- **Distribution changes.** EE Lighting technology will drive changes in distribution, including distributors with more technical and design knowledge; more direct distribution; and a larger role for energy management companies and integrators of energy efficiency products and technologies.
- **Niche opportunities.** There will be many new opportunities for players with customized niche applications.
- **Growth in non-manufacturing markets.** The market for lighting design, controls and energy management will grow substantially, with much of it driven by regional players.
- **Opportunities for US manufacturing.** While most commodity manufacturing will be done overseas, the economics of domestic production are favorable for niche products with smaller lot sizes and shorter lead times.
- **Strong regional presence of firms.** The Chicago region has a large concentration of lighting firms that cover a broad range of technologies, products, services and markets. The sector has a strong location quotient. Many of these companies are actively transforming their business models to adapt to new market realities.
- **This is the right time for leadership.** Because this is an industry undergoing fundamental transformation, if the Chicago region wants to take a leadership position in the sector, this is the right time to do it.

Based on these findings, the project makes the following summary recommendations:

1. *Focus on the broader “Integrated Lighting and Building Energy Systems” cluster.* Given the state of turbulence in the EE Lighting sector, it makes sense to take Wayne Gretzky’s advice and “skate to where the puck is going to be.” In this respect, the two key trends to pay attention to are: 1) the increased integration of lighting design, controls and management in the EE Lighting sector; and 2) a greater integration of lighting with other energy efficiency products and services and an increasing role of “energy management integrators” in the lighting distribution process. These trends argue for focusing cluster development in Chicago not on the EE Lighting niche by itself, but on the larger commercial and institutional building energy efficiency market. This expanded focus would encompass a broader range of firms in the sector, including architecture/design; building engineering; property management; energy efficiency management; building controls/management systems; and Smart Grid integration.
2. *Make Chicago the easiest place in the world to do real world applied R&D on building energy efficiency technologies.* An applied R&D network would provide manufacturers with an

opportunity to prove their quality in demonstration sites; develop relationships with new/more important distribution players such as lighting/building designers, ESCOs, utilities and commercial building managers; and use these relationships to build trust that allows them to gain market acceptance without going through the cumbersome efficiency verification process. It would also provide an opportunity for manufacturers of related products to integrate with one another. This system would benefit the customers/distributors by allowing them to easily compare products and work with the manufacturer to get the desired customization. Overall, this strategy would use close-knit relationships between building designers, owners and managers, and providers of energy efficiency products and services, to shorten the time between innovation development and its penetration into the market. Leveraging Chicago's unique assets in the commercial building sector, such a system could make Chicago the place to go to do real world applied R&D and accelerate commercialization of energy efficient building technologies.

2. Energy Efficient Lighting Sector Overview

2.1. Introduction to the Energy Efficient Lighting Sector

There is no precise definition of what constitutes “energy efficient” lighting, but it is generally used to denote lighting systems that are significantly more efficient over their life cycle than traditional incandescent and less efficient fluorescent lighting systems. The two most common types of EE Lighting are compact fluorescent lights (CFLs) and light emitting diodes (LEDs). The more efficient T5 and T8 fluorescent bulbs are also sometimes included in this category. Energy efficient lighting is a subset of the overall lighting industry, and thus shares its market dynamics (which are changing as the energy efficient subset becomes more popular).

Lighting is a major source of electricity use in the US. The Energy Information Administration (EIA) estimates that in 2010, about 507 billion kilowatt-hours (kWh) of electricity were used for lighting by the residential and commercial sectors. This was equal to about 18% of the total electricity consumed by both of those sectors and 13.5% of total U.S. electricity consumption.

- Residential lighting consumption was about 207 billion kWh, equal to about 14% of all residential electricity consumption.
- About 300 billion kWh was consumed for lighting by the commercial sector, which includes commercial and institutional buildings and public street and highway lighting, equal to about 22% of commercial sector electricity consumption.

Higher energy costs and interest in protecting the environment from climate change are causing consumers to demand lighting products that use less energy. Companies big and small have risen to the challenge, and now new lighting technologies have the potential to significantly reduce the electricity used for lighting. A recent Navigant Consulting report for USDOE projects that LED

market penetration could reduce lighting electrical consumption by 25% below 2010 levels by 2030.²⁴

Compared to many other market segments, the lighting industry is very complex and highly fragmented.²⁵ To understand the industry, it is useful to look at it from several different perspectives. Three of these are summarized in Table 2.

Table 2. Lighting Segmentations.

Lighting Technology	Application Environments	Types of Industry Players
<ul style="list-style-type: none"> • Incandescent • High intensity discharge (HID) • Fluorescent • Light Emitting Diodes (LEDs) 	<ul style="list-style-type: none"> • General lighting <ul style="list-style-type: none"> ○ Residential lighting fixtures ○ Commercial and industrial lighting fixtures ○ Outdoor lighting fixtures • Portable electric lamps • Vehicle lighting fixtures • Backlighting for electronics 	<ul style="list-style-type: none"> • Manufacturers • Material & Component Suppliers • Architects, Engineers, Designers • Software and Controls • Distributors and Installers • Energy Management Integrators • Utilities • Federal Government R&D

Each of these aspects of the EE Lighting industry is discussed in more detail below.

[2.2. Different Types of Lighting Technology](#)

Table 3 provides some basic information on the four primary types of light source.

The level of lighting efficiency is measured by a combination of the lumens (a measurement of light intensity) produced per watt of electricity, and the life expectancy of the light source. These two factors add up to the overall life-cycle costs of the lighting source.

²⁴ Navigant Consulting, "Energy Savings Potential of Solid-State Lighting in General Illumination Applications 2010-2030," February 2010, p. 42, http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/ssl_energy-savings-report_10-30.pdf.

²⁵ A recent McKinsey report notes: "In contrast to typical electronics products, the lighting industry is very fragmented and complex, as lighting is used in so many different ways." McKinsey & Company, "Lighting the Way: Perspectives on the Global Lighting Market," McKinsey & Company, Inc., 2011, p. 17, <http://img.ledsmagazine.com/pdf/LightingtheWay.pdf>.

Table 3. Primary light sources.

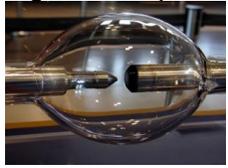
Light Source	Description
	<ul style="list-style-type: none"> • The incandescent light bulb makes light by heating a metal filament wire to a high temperature until it glows. The hot filament is protected from air by a glass bulb that is filled with inert gas or evacuated. • In a halogen lamp, a chemical process returns metal to the filament, extending its life. The light bulb is supplied with electrical current by feed-through terminals or wires embedded in the glass. • Most bulbs are used in a socket which supports the bulb mechanically and connects the current supply to the bulb's electrical terminals.
	<ul style="list-style-type: none"> • HID lamps are a type of electrical lamp which produces light by means of an electric arc between tungsten electrodes housed inside a translucent or transparent fused quartz or fused alumina arc tube. This tube is filled with both gas and metal salts. • Mercury vapor lamps and metal halide lamps are two common variations of the HID technology. • HID lamps are typically used when high levels of light over large areas are required, and when energy efficiency and/or light intensity are desired. These areas include gymnasiums, large public areas, warehouses, movie theaters, football stadiums, outdoor activity areas, roadways, parking lots, and pathways.
	<ul style="list-style-type: none"> • A fluorescent lamp or fluorescent tube is a gas-discharge lamp that uses electricity to excite mercury vapor. The excited mercury atoms produce short-wave ultraviolet light that then causes a phosphor to fluoresce, producing visible light. • A fluorescent lamp converts electrical power into useful light more efficiently than an incandescent lamp. Lower energy costs typically offset the higher initial cost of the lamp. The lamp fixture is more costly because it requires a ballast to regulate the current through the lamp.
	<ul style="list-style-type: none"> • A compact fluorescent lamp (CFL) is a fluorescent lamp designed to replace an incandescent lamp; most types fit into light fixtures formerly used for incandescent lamps. • Compared to general-service incandescent lamps giving the same amount of visible light, CFLs use less power (typically one fifth) and have a longer rated life (six to ten times average). Despite a higher purchase price than an incandescent lamp, they can save over five times its purchase price in electricity costs over the lamp's lifetime. • Like all fluorescent lamps, CFLs contain mercury, which complicates their disposal.
	<ul style="list-style-type: none"> • Light-emitting diodes (LEDs) are semiconductor devices that convert electricity to light. LED lighting is also called “solid state lighting” because the light is emitted from a solid object— a block of semiconductor material—rather than from a vacuum or gas tube, as in traditional incandescent or fluorescent lights. • Unlike incandescent or fluorescent lights, LEDs are not inherently white. “White” light is actually a mix of wavelengths in the visible spectrum, whereas LEDs emit light in a very narrow range of wavelengths, and so are ideal for producing colored light. • An organic light-emitting diode (OLED) is an LED that uses a layer of organic compounds which emit light in response to an electric current. The advantages of OLEDs are that they can be printed on inexpensive flexible plastic substrates; they have better power efficiency; and faster response times. Currently, however, they suffer from very high production costs; short life spans; poor efficiency under some circumstances; and lack of robustness in outdoor environments. They are not expected to be a significant technology in general illumination for some time.

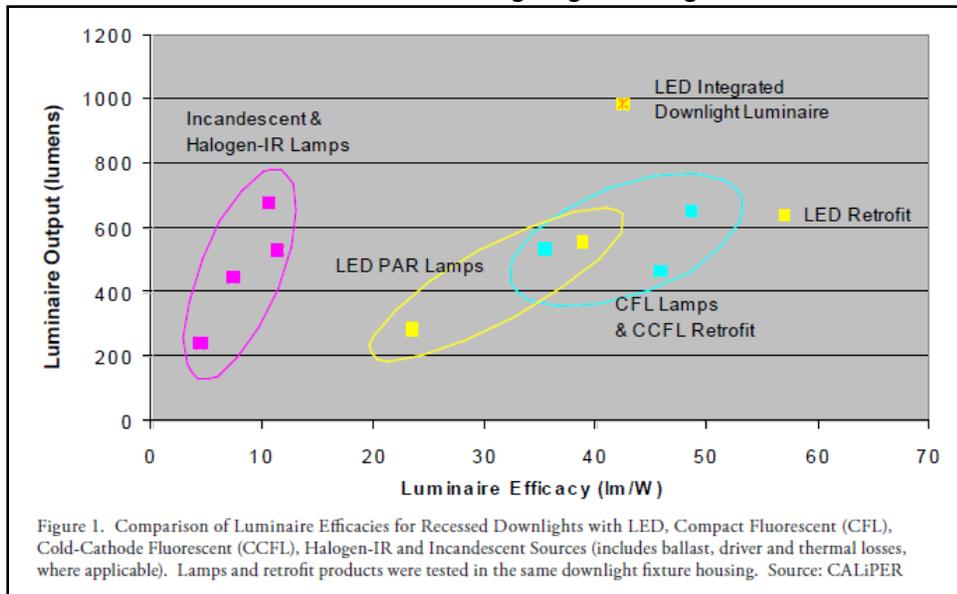
Table 4 compares different features of LEDs, CFLs and incandescents.²⁶

Table 4. Comparison of Common Light Sources.

Aspect	LEDs	CFLs	Incandescents
Frequent On/Off Cycling	no effect	shortens lifespan	some effect
Turns on instantly	Yes	slight delay	yes
Durability	Durable	fragile	fragile
Heat Emitted	low (3 BTUs/hr)	medium (30 BTUs/hr)	high (85 BTUs/hr)
Sensitivity to temperature	No	yes	some
Sensitivity to humidity	No	yes	some
Hazardous Materials	None	5 mg mercury/bulb	none
Replacement frequency (over 50k hours)	1	5	40+

Chart 3, from USDOE, provides a graphic display of the performance variations of different lighting technologies.²⁷

Chart 3. Performance variations of different lighting technologies.



2.3. Application Environments

The lighting market is typically segmented into three categories of product application – general lighting; automotive lighting and backlighting.

²⁶ Eartheasy, “LED Light Bulbs: Comparison Charts,” http://eartheasy.com/live_led_bulbs_comparison.html#d.

²⁷ U.S. Department of Energy Building Technologies Program, “Comparing White Light LEDs to Conventional Light Sources,” October 2008. http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/comparing_white_leds.pdf.

- **General Lighting** covers the use of lighting products in homes, office buildings, factories, streets and other common uses. It is the largest lighting market segment (75% of total global sales) and is heavily driven by trends in the real estate sector. It includes several sub-categories of application:
 - Residential
 - Commercial
 - Outdoor (streets, stadiums, parking lots, etc.)
 - Portable Lamps (flashlights, etc.)
- **Automotive Lighting** covers the use of lighting products in the car, truck and off road vehicle markets. It constitutes less than 20% of the total global market.
- **Backlighting** is the use of lighting for computers, appliances, hand held devices and other electronics. It is the smallest portion of the lighting market.

The technologies, products and sales and distribution channels for these application segments are very different. Some of these variations are described in Table 5 below.

Table 5. Lighting application environments.

Application Segment	Dominant Technology	Typical Customers	Distribution Channels
<i>Residential</i>	Incandescent	<ul style="list-style-type: none"> • Homeowners • Builders 	<ul style="list-style-type: none"> • Home stores (Home Depot, Lowes) • Electrical contractors
<i>Commercial</i>	Fluorescent	<ul style="list-style-type: none"> • A& E firms • Contractors • Building owners 	<ul style="list-style-type: none"> • Property management companies • Lighting designers • Electrical contractors • Supply houses • Manufacturers reps • Energy management companies
<i>Outdoor</i>	HID, Fluorescent	<ul style="list-style-type: none"> • Municipalities • Utilities • Retailers 	<ul style="list-style-type: none"> • Manufacturer reps • Public bid • Contractors
<i>Automotive</i>	Incandescent, Halogen, LED	<ul style="list-style-type: none"> • Auto manufacturers • Tier 1 suppliers 	<ul style="list-style-type: none"> • B2B
<i>Backlighting</i>	LED	<ul style="list-style-type: none"> • Device & appliance manufacturers 	<ul style="list-style-type: none"> • B2B

This report and analysis focuses on the **general lighting** segment and does not address the automotive and backlighting markets, which have a smaller opportunity and distinct value chains and market dynamics. In particular, it centers on commercial and residential lighting,²⁸ which can be thought of as a part of the larger building sector, with energy efficient general lighting part of the *green* building sector. Green building is the practice of creating structures and using processes that

²⁸ While energy efficient Outdoor Lighting is a growing market, a *cluster* opportunity around Outdoor Lighting was less obvious, given the market dynamics and nature of the existing firms in Chicago (to be described more in sections 3 and 4).

are environmentally responsible and resource-efficient throughout a building's life-cycle from siting to design, construction, operation, maintenance, renovation and deconstruction.²⁹

While there is no formal definition of the elements of the building sector, it can be broken down into three basic categories, with several sub-categories (see Table 6). Of these categories and subcategories, the lighting sector interacts most with the building services category and the building controls subcategory.

Table 6. Building Sector Categories.³⁰

Building Services	Building Products	Building Materials
<ul style="list-style-type: none"> • Architecture, engineering and design services • Construction and Construction Management • Building Services <ul style="list-style-type: none"> ○ Property management ○ Energy management ○ Janitorial services ○ Landscaping services ○ Waste management 	<ul style="list-style-type: none"> • Cleaning products • Furnishings • Windows • Doors • Flooring • Insulation • Roofing • HVAC • Lighting • Plumbing • Building controls 	<ul style="list-style-type: none"> • Asphalt • Concrete • Metals • Paint and coatings • Plastics • Textiles • Wood

The building sector can be further segmented by building type. The major categories of building types are single family residential; multi-family; commercial/institutional and industrial.³¹ Segment differentiations are important for many aspects of the building sector, since product configuration, sales and distribution, and pricing vary significantly by segment. The commercial building sector is especially relevant to the energy efficient lighting sector, as these building managers are more likely to be willing to make the upfront capital investment necessary to convert traditional lights to LED.

2.4. Types of Industry Players

There are many different kinds of companies that participate in the lighting sector. Some of the major types of players are summarized below.

Manufacturers

Three companies dominate the global lighting manufacturing sector – Philips, GE and OSRAM Sylvania (a subsidiary of Siemens). These companies together have constituted 60-70% of the total

²⁹ <http://www.epa.gov/greenbuilding/>

³⁰ Partly based on the taxonomy in Green Building Alliance, “Green Building Products and Services – Market Analysis for Pennsylvania and Benchmark States,” March 2009.

³¹ For a more complete segmentation of the building sector, see the recent reports on the Building Retrofit Industry and Market (BRIM) initiatives, posted on the Rockefeller Foundation web site at:

<http://www.rockefellerfoundation.org/news/publications/building-retrofit-industry-market-brim>

market for several decades.³² The large integrated producers manufacture, distribute and service every type of light source for all end use environments.

The remainder of the market is occupied by a very wide variety of smaller niche manufacturers. Most specialize in one lighting technology or another, but many are also expanding their product line to include new technologies like LEDs. Examples of US based companies include Acuity Brands, Cooper Lighting, Hubbell Lighting, Juno Lighting, and Leviton.

Material and Component Suppliers

The material and component suppliers vary widely by type of lighting technology. For incandescent and fluorescent bulbs, the primary components are the glass bulb; filaments; metal base; gases (argon and mercury); ballasts; starters; and metal and plastic fixtures. For LEDs, there is a more complex supply chain. The most important component is the LED chip itself. Other components include connectors, diodes, drivers, substrate, lenses, wires, and circuit boards.

Architects, Engineers and Designers

The architecture and engineering industry plays an important role in influencing lighting choices, primarily in the commercial building sector. Architectural firms frequently have a lighting designer on staff. In addition, a sub-industry of lighting designers typically works in small practices and specializes in the design of lighting systems for large building contractors and owners.

Software and Controls

As energy efficiency becomes more important, and as LED technologies offer a wider range of dimming options, lighting control systems are becoming a more important part of the lighting industry. Controls are typically sold through three different kinds of venues:

- Some controls are integrated into the lighting fixture and sold by the lighting manufacturer.
- A separate set of firms sells independent controls products for the lighting sector.
- Some lighting controls are designed into integrated building management systems that control overall building systems.

Distributors and Installers

Many different kinds of firms distribute and install lighting products, including:

- Big box retail stores like Home Depot, Lowes and Walmart. (Home Depot is the largest single buyer of light bulbs in the world.) These retailers typically serve residential customers and residential contractors.
- Manufacturers' reps are used for sales in the commercial and industrial sectors.

³² McKinsey, 2011.

- Electrical contractor and electric supply houses are a key distribution source. Some of these are large national players like Grainger; in addition, there is a robust network of independent regional and national electric supply houses.

Energy Management Integrators

Energy management companies are playing an increasingly important role in the lighting market. This is driven by two primary factors:

- An increased interest in opportunities for comprehensive energy efficiency strategies as a cost saving and greenhouse gas reduction strategy.
- New lighting technologies like LEDs have high up-front costs that can be a barrier to customer acquisition. Energy Performance Contracting (EPC), where a third party Energy Services Company (ESCO) covers the capital cost of installation in return for compensation through savings, can be an effective way of overcoming this barrier.

This niche includes traditional “super ESCOs” such as Siemens, Ameresco, Johnson Controls and Honeywell (many of whom also sell their equipment as part of the EPC deals), as well as specialized energy management companies (e.g. Lime Energy), and companies that are focused only on lighting management (such as Sylvania Lighting Services). All of the Big Three lighting producers offer lighting services products to their customers.

Utilities

Utilities are increasingly important players in this sector as Energy Efficiency Portfolio Standards (EEPS) generate capital to subsidize energy efficient lighting technology installation. EEPS programs use ratepayer funds to pay for part of the cost of energy efficiency measures for residential and commercial customers. In the top five states alone, these expenditures exceeded \$2.2 billion in 2009 and are expected to increase in the future.

A recent report of the American Council for an Energy Efficient Economy (ACEEE) noted how important lighting technology was to the success of these programs:

“Electric utilities see the rolling improvement of efficient lighting technologies as creating substantial energy savings opportunities. One utility called the opportunities almost endless’. With the evolution of program management and delivery, Connecticut’s United Illuminating could meet their savings goals with lighting alone.”³³

³³ Nowak, Seth, Martin Kushler, Michael Sciortino, Dan York and Patti White, “Energy Efficiency Resource Standards: State and Utility Strategies for Higher Energy Savings,” American Council for an Energy Efficient Economy, June 2011, p. 10, <http://aceee.org/research-report/u113>.

Government

Many countries, including the US, are investing in R&D to advance their lighting industries. In addition to the US, Japan, South Korea, Taiwan and China have made significant national investments in LED R&D.

The US Department of Energy's Building Technology Program sponsors a Solid State Lighting (SSL) initiative³⁴ that was established by the Energy Policy Act of 2005. The goal of this program is to:

"By 2025, develop advanced solid-state lighting technologies that, compared to conventional lighting technologies, are much more energy efficient, longer lasting, and cost-competitive by targeting a product system efficiency of 50 percent with lighting that closely reproduces the visible portions of the sunlight spectrum."³⁵

The SSL initiative supports a broad range of strategies to advance the SSL sector, including:

- Basic energy science research that supports SSL
- Core technology research
- Product development research, including the development of industry "technology roadmaps"
- Manufacturing R&D to improve the efficiency of US SSL manufacturing
- Support for technology commercialization, including product testing, design competitions, and technical information
- Development of standards for the industry
- Strategic partnerships, including:
 - Next Generation Lighting Industry Alliance (NGLIA)
 - Partnership with the Illuminating Engineering Society (IES)
 - Partnership with the International Association of Lighting Designers (IALD)

"Current LED market share in outdoor lighting is estimated at around 5 percent. It is expected to be close to 40 percent in 2016, rising to around 70 percent in 2020. Government initiatives are key to adoption. Governments are the chief owners of most outdoor lighting and are therefore the prime decision makers on LED installations. The current pressure on governments to reduce CO2 emissions will push LED market share in this segment."

(McKinsey, 2011)

In addition to R&D investments, governments also act as a major customer for EE Lighting.

³⁴ U.S. Department of Energy, "Solid-State Lighting," <http://www1.eere.energy.gov/buildings/ssl/about.html>.

³⁵ Bardsley Consulting, Navigant Consulting, Inc., Radcliffe Advisors, Inc., SB Consulting, and Solid State Lighting Services, Inc., "Solid-State Lighting Research and Development: Multiyear Program Plan," May 2011, http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/ssl_mypp2011_web.pdf.

3. Energy Efficient Lighting Trends and Industry Dynamics

The lighting industry has historically been a mature, conservative industry with relatively few dramatic changes in structure and technology. The first light bulb was invented in the 1870s, and another technological innovation didn't emerge until the invention of the fluorescent light bulb in the 1920s. The industry has operated without any fundamental technology changes until the introduction of commercial scale LEDs in the latter decades of the last century.

The most important dynamic in this market will be the increased market share of LEDs. While LEDs now have a relatively small share of the general lighting market (7% in 2010), they are expected to grow to dominate the market over the next decade, potentially achieving a 60%+ market share by 2020.³⁶ In the process, they will drive a radical restructuring of the lighting sector and its value chain, creating many opportunities for new value creation and growth.

The advantages of LED lighting that will drive this market growth include:

- **Life span.** LEDs can last up to 10 times as long as CFLs, and 50-100 times longer than incandescent bulbs. This also reduces the significant labor costs of bulb replacement.
- **Efficiency.** LEDs are three to four times more efficient than incandescent and halogen sources.
- **Durability.** Without a filament, LEDs are more durable and less prone to damage than traditional lighting sources.
- **No Mercury.** Mercury disposal is a major issue for fluorescents of all types.
- **Less Heat.** LEDs produce 3.4 BTUs per hour, compared to 85 for incandescent bulbs, therefore avoiding heat buildup in living and working spaces.

See Table 7 for a comparison of the costs over time for LED, CFL and incandescent light sources in a residential setting.³⁷

Table 7. Comparison of light source costs for 60-watt Incandescent or LED and CFL comparable alternatives

	LED	CFL	Incandescent
Light bulb projected lifespan	50,000 hours	10,000 hours	1,200 hours
Watts per bulb (equiv. 60 watts)	10	14	60
Cost per bulb	\$35.95	\$3.95	\$1.25
KWh of electricity used over 50,000 hours	500	700	3000
Cost of electricity (@ 0.10per KWh)	\$50	\$70	\$300
Bulbs needed for 50k hours of use	1	5	42
Equivalent 50k hours bulb expense	\$35.95	\$19.75	\$52.50
Total cost for 50k hours	\$85.95	\$89.75	\$352.50
COST SAVINGS OVER 50,000 HOURS, IN A HOUSEHOLD WITH 25 BULBS			
Total cost of bulbs and energy	\$2148.75	\$2243.75	\$8812.50
Savings to household by switching from incandescents	\$6663.75	\$6568.75	0

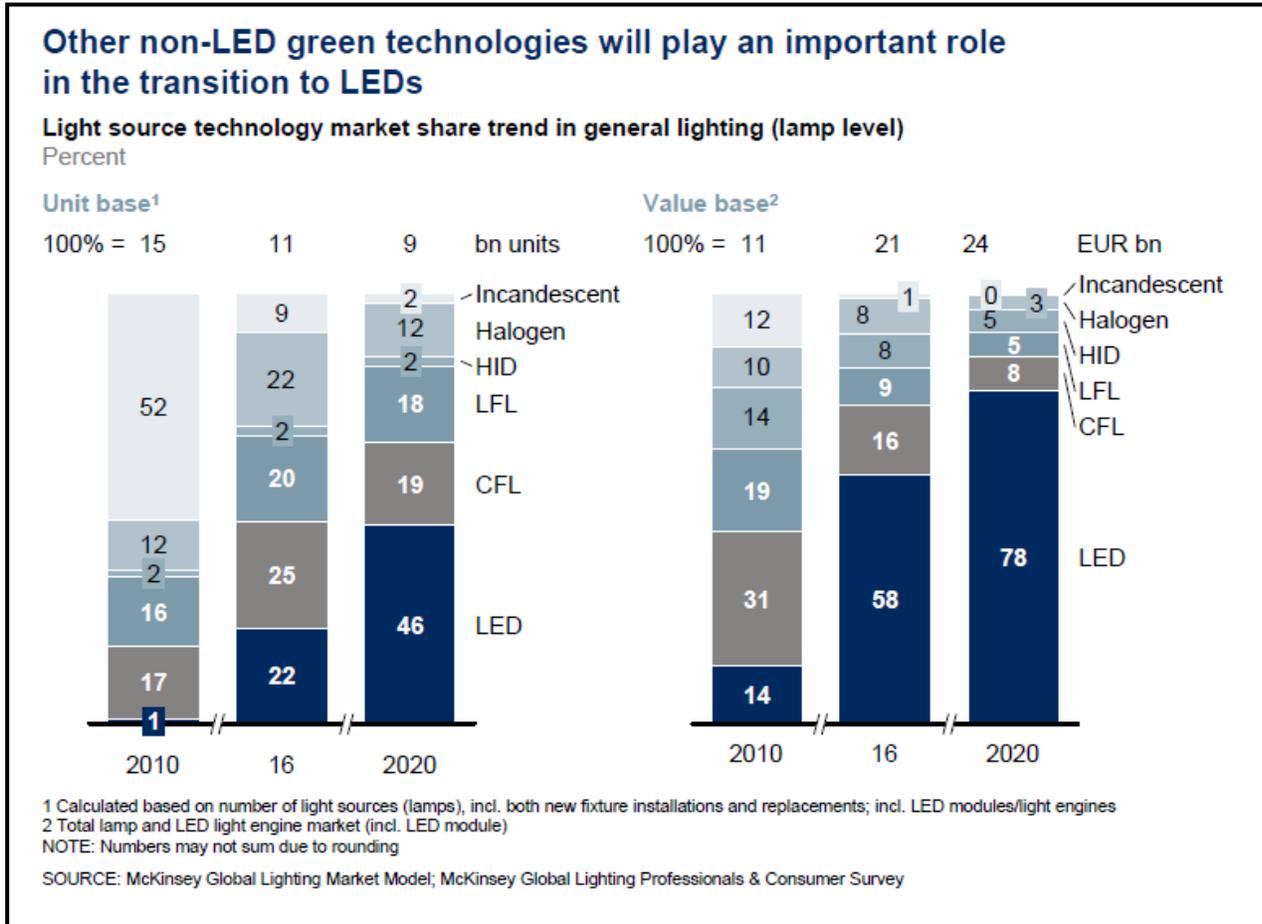
³⁶ McKinsey, 2011, p. 17.

³⁷ Eartheasy, "LED Light Bulbs: Comparison Charts," http://eartheasy.com/live_led_bulbs_comparison.html. Note that costs per bulb vary considerably for each type of light source, and that LED prices in particular may already be considerably below those reflected in the chart.

3.1. Dramatic Market Share Gains Forecast for LEDs

McKinsey and Company forecasts a fundamental shift in market share for different light technologies over the next nine years. Chart 4, below, shows expected global shares for both units (number of lights installed), and value (dollar value of the light units in Euros).

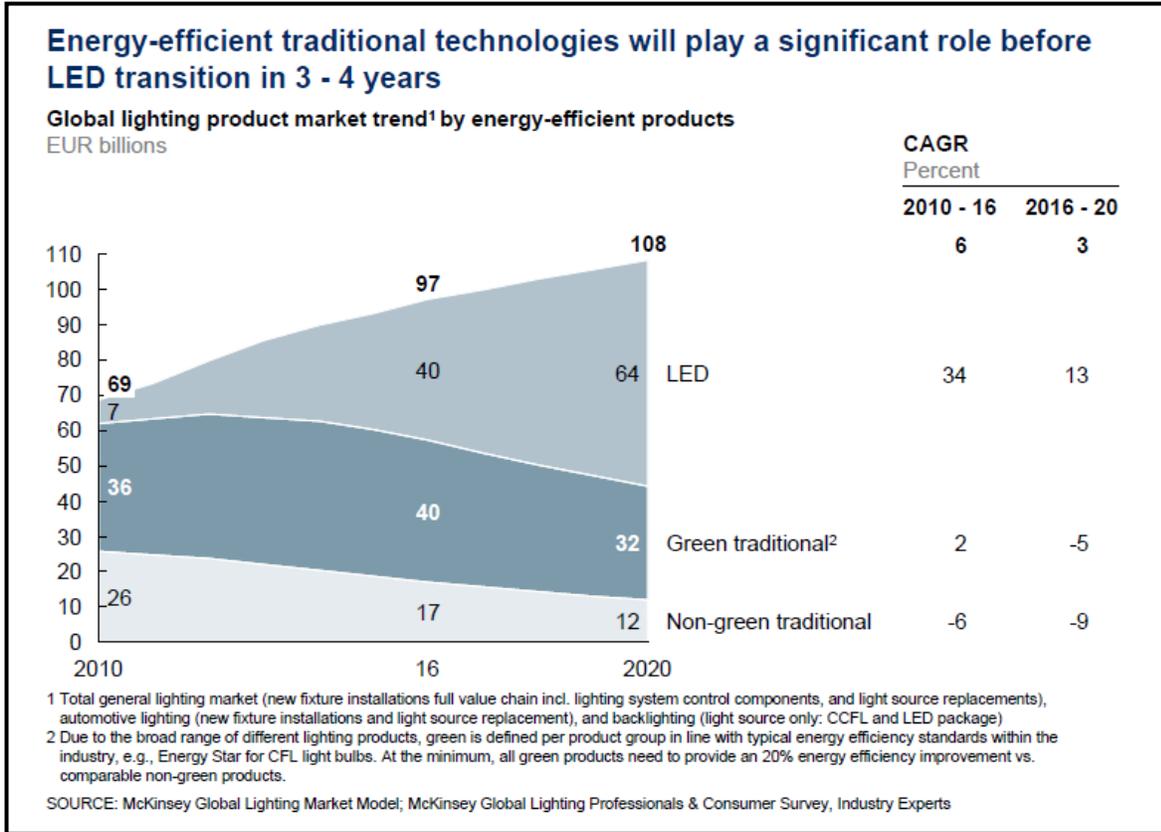
Chart 4.



The level of disruption this kind of shift can produce should not be underestimated. It projects the value of the LED market will more than quadruple in the next five years.

Chart 5 shows how “traditional” energy efficient sources such as CFLs and high efficiency fluorescents (e.g. T8 and T5 lamps) will play a transitional role in this market shift.

Chart 5.



Several interviewees emphasized that the large-scale shift to LED lighting technology will not happen until additional improvements in the cost/performance ratio are achieved, but they see its eventual ascendance as inevitable. Representative quotes include the following:³⁸

“LED costs need to come down 8-10 fold to be competitive.”

“By and large in general illumination, LED is still too expensive and doesn’t put out the value of light required on a cost effective basis. Frankly, T-5 and T-8 fluorescents still offer efficient high quality of light and are quite inexpensive.”

“LED is not yet ready for prime time. The real market for LEDs in the short term is the commercial/institutional sector. There the lights get used for more hours, so the payback is faster.”

“Right now there is a price issue with LEDs. They are selling for 2-3 times traditional lighting costs. But the LED performance is improving rapidly. Right now we only have 5% LED market penetration. But in 2 years or more it will really take off.”

³⁸ All quotations are from interviews with individuals in the energy efficient lighting sector. Attribution is not included because interviewees were assured confidentiality.

“LEDs are going to quickly take over the lighting world. The offices of the future will be lit with LEDs. Pretty soon, we will have \$20 LED replacement bulbs. In 2-4 years the price/performance curve will cross and the market will really move.”

“One of the best markets for LEDs is outdoor lighting. The economics there already make sense. There are 56 million cobra-head lights in the US. At \$400 a fixture, that is a \$20+ billion market. The indoor market, however, is 2-4 years off. Bulbs still cost \$30-\$40.”

“LED has been getting much more efficient and cost effective, even in the last 18 months. The price of chips has dropped from \$2.40 to \$1.20. I think it will eventually go to \$0.05.”

“LED development is a bit all over the place. There isn’t yet broad acceptance of the LED platform – so I agree that we’re still a few years away before new installations are majority LED. But there is no question that that is where things are heading.”

“I see the LED market changing dramatically. It is happening a lot faster than I ever imagined. Quality is improving and price is coming down. I think within the next 3-4 years, the market will be 30% or more LED.”

These market changes will be accelerated by federal regulations. The Energy Independence and Security Act (EISA) of 2007 sets minimum standards of performance for light bulbs beginning in 2012. These standards are high enough that the incandescent bulbs commonly used by consumers will not meet these standards. The EISA will essentially eliminate 40W, 60W, 75W and 100W medium screw base incandescent bulbs by 2014.³⁹ These regulations are expected to accelerate the replacement of traditional bulbs by CFLs, halogens and LEDs.

3.2. Barriers to LED Market Growth

Although there appears to be a very strong consensus that the LED lighting market will eventually grow rapidly and eclipse other forms of lighting, there also are a number of factors that represent potential barriers to that growth. These help to explain why the market has not already reached its projected height:

- **Cost to Performance Curve.** As noted above, LEDs are still considered to have high upfront costs relative to lighting performance. Costs are rapidly dropping, however, and quick improvement in the cost to performance curve is expected.

³⁹ As this report nears completion, these standards face uncertainty in Congress. The omnibus spending bill passed by Congress on December 16, 2011 includes in it “a provision that prevents the Department of Energy from spending any money to implement or enforce the energy efficiency standards for light bulbs” for nine months. It is not yet clear exactly what effect this will have on the lighting industry, which supported the standards, but it will not change the underlying economics that make more efficient lighting, and particularly LED lighting, the technology of the future. See <http://www.chicagotribune.com/business/breaking/chi-incandescent-light-bulb-ban-put-on-hold-20111216,0,805622.story>

- **Product Quality.** Several interviewees noted that in the early stages of the LED market, substandard products “polluted” the market and slowed consumer acceptance. As quality standards become more rigorous; customers become more sophisticated; and producers improve their manufacturing quality, some of this concern is diminishing.
- **Distribution Barriers.** Many of the existing lighting distribution channels are ill-equipped to sell a technically more complex product that requires higher levels of customized design and a more sophisticated ROI analysis. While the “re-engineering” of the distribution network appears to be in full swing, it still requires time to build this capacity at scale.
- **Speed of Commercial Viability.** Changing standards for efficiency verification in lighting (e.g. EnergyStar) make it difficult for firms to quickly change their technologies and then obtain the “efficient” label, which is often critical to market acceptance.

3.3. Changes in Market Share Will Drive Industry Restructuring

These shifts in market share will drive a fundamental restructuring of the lighting industry over the next decade. It is important to understand that the future shape of this industry is not yet clear, and many aspects of the sector are undergoing transformation in real time. However, several general trends in this restructuring were emphasized both in industry reports and in interviews. These include the following:

- Entrance of many new players into the market.
- More versatile and integrated technologies.
- Changes in distribution, including an increased role for energy services companies.
- Growth opportunities for players with niche applications.
- An increased share of the industry profit pool going to players other than lamp and bulb producers.
- Primary manufacturing done overseas, but many opportunities for US-based production, especially in custom and niche products.

“The penetration of LED technology is driving a far-reaching change to the industry’s structure. This transformation is affecting every stage of the value chain, from upstream, where altered production methods are driving new capabilities and entrants, to downstream, where the fixtures market is expanding in multiple directions.”

(McKinsey, 2011, P. 22)

Each of these key trends is discussed in more detail below.

New Players Will Disrupt the Industry Structure

The disruptive nature of the new lighting technology is succinctly summarized in Sanderson et al’s report on the structure of the Solid State Lighting industry:

“Solid state lighting is challenging incumbents and throwing leadership in the future industry up for grabs.... Which firms will successfully ride this new wave of innovation and what impacts these changes will have on incumbents is not yet determined. Although the first wave of lighting innovation in the early 20th century spawned the development of global companies like GE, OSRAM and Philips, these 21st century innovations will create challenges for incumbents. New firms are emerging at all levels of the value chain to address the opportunities presented by solid-state lighting technologies.”⁴⁰

This view was reinforced by interviewees, many of whom represent some of these new value chain players.

New technology challenges traditional players:

“The Big Three (Philips, OSRAM, GE) are trying to find their way in this market and exploit it without cannibalizing their traditional market. They are all making moves in the LED market. I think what they really fear is a foreign competitor (LG, Toshiba, Samsung) coming after the US market in a big way.”

“The LED and energy efficiency markets are a big challenge for traditional lighting businesses. They are used to being “order takers” with repeat business every 6 months based on how many light bulbs they know are going to burn out. If they embrace LED, there will be no bulb turnover, no predictable repeat sales.”

Many new entrants, followed by consolidation:

“I’ve never seen so many new companies pop up in so short a time. Our customer base has almost tripled in number. The pattern seems to be that these small companies are acquired by the larger players.”

“Last year I think there were close to 200 new LED firms that popped up. I think the big players depend on the small ones to duke it out and figure out where the successful new innovations are. Then they go buy them.”

“LED companies are very capital intensive. There are at least 200 VC-backed startups in this space. Like the early PC players, they are all just a bit different. I believe we will see lots of consolidation in the future. The VCs are really struggling to make many of these deals work.”

New players are not expected to take over any of the traditional high volume bulb manufacturing business, which is a highly cost sensitive business, with high capital intensity. However, there is no guarantee that the traditional Big Three will retain the commodity component position in the LED market, which is a fundamentally different manufacturing value chain, especially considering the

⁴⁰ Sanderson, Susan Walsh, Kenneth L. Simons, Judith L. Walls, and Yin-Yi Lai, “Lighting Industry: Structure and Technology in the Transition to Solid State,” Sloan Foundation, April 2008, <http://web.mit.edu/is08/pdf/Lighting%20to%20distribute%2010Apr2008.pdf>

tension between their existing business model (e.g. lots of repeat orders to replace conventional bulbs) and an LED model. Kodak developed the first digital camera in 1975, but failed to successfully promote it and capture the digital market (perhaps because it competed with their existing products and business model). Of course, as the new technology gained market share, Kodak's traditional film market and business eroded. Whether the Big Three will remain on top of the lighting industry, or go the way of Kodak, is still to be seen. While all of the large players are participating in this market, the traditional electronics firms are expected to have a leg up on LED chip production and eventually LED bulb production. Given the uncertainty of the major commodity lighting market, the greatest opportunity for new firms is likely to be in customized products and niche applications.

More Versatile and Integrated Technologies

LED technology differs from its predecessors not only in its level of efficiency but in its versatility. Though each LED is very small, they can be combined in any shape or size to create the desired amount of light, including for applications that require only a tiny light source. LED light sources are easily dimmable due to their ability to use all or only a portion of the individual LEDs in the fixture. Producing a virtually unlimited number of colors (without any filters), LED light sources also make color changing effects possible by relying on LEDs of multiple colors in the same fixture. These possibilities, as well as the capacity for point source lighting, backlighting and similar features provide opportunities for design innovation unimaginable with traditional lighting.

In order to take advantage of features such as dimming and color changing, LED fixtures often have built in controls. Not only is the control integrated into the technology, but the light source and the fixture are often integrated. While there are LED replacement bulbs that will fit into traditional incandescent sockets, LEDs' optimal performance is achieved when integrated with the fixture and a power supply designed to last as long as the light source itself. Indeed, a major nexus of future activity and innovation in the lighting market will be around LED-based fixtures, rather than simply the LED chips.⁴¹

The emphasis on integration of controls, fixtures and LEDs represents a model very different from the traditional bulb replacement paradigm.

Restructuring and New Players in Distribution

Distribution systems in the lighting industry have been configured for a high volume, commodity pricing business with little customization and low engineering content. The greater integration of LED technology with controls and fixtures fundamentally changes this equation. The economic equation is more complicated – upfront costs are higher, but life-cycle costs are lower, requiring a more sophisticated ROI analysis.

⁴¹ Kanellos, Michael, "The Hidden Story in Solid State Lighting," Greentech Media, May 13, 2011, <http://www.greentechmedia.com/articles/read/the-hidden-story-in-solid-state-lighting/>.

All of this means the sales process needs to be more of an “engineered sales” transaction and less of a commodity sell – which means different distribution channels and different sales strategies. Interviewees predict that this will drive several kinds of changes in distribution, including:

- More direct distribution
- Less role for commodity distributors like electric supply houses due to need for more technical knowledge
- More of a role for energy services companies and other energy management “integrators”
- An increased role for utilities in promoting EE Lighting
- A stronger role for design firms

These trends are reflected in the following interview quotes:

More direct distribution:

“My plan is to sell more of my product direct in order to take costs out of the distribution channel.”

“LEDs will drive change in the distribution model. Traditional distributors are avoiding the LED market because it is too technical. I think you will see more direct distribution.”

More technical knowledge required:

“The LED lighting sector requires a new selling paradigm. It is much more of a technical sell. Sales used to be based just on cost because all the products were commodities and there was very little performance difference between them. Now there are big differences in performance and many of those are driven by how you design the lighting systems. This requires a different selling and buying process. Customers need to be smarter and sales staff need high levels of technical knowledge.”

“The existing points of distribution in the traditional lighting industry are not well positioned to sell these new lighting technologies. They are used to high volumes of commodity products – shipping “pallets of products” based on low cost. The channels that can sell these more sophisticated solutions will have more value.”

Increased ESCO role:

“You will also see ESCOs playing a larger role in the market. The big sales opportunity is in replacements and retrofits. There are tens of billions of dollars of lights that need to be upgraded.”

“A big challenge with this market is its archaic distribution system. You need to make same sale several times, to the architect, to the engineer, to the building owner. There needs to be a new model. I think more and more distribution will get taken up by ESCO players. Lighting reps go the way of real-estate agents and get pretty squeezed.”

“We think the most interesting investment opportunities in EE Lighting are on the integration side. This means finding companies who have the network and customer base that has demand for EE products broadly speaking, and capabilities to sell and make money on a broad range of products for the customer who wants to upgrade all lighting systems – plus controls, insulation, solar, etc. The company that has a broad enough network to execute on all of that would be an EE problem solver.”

Utilities as important players:

“The utilities are playing an increasing role in the energy efficient lighting market. The growth of Energy Efficiency Portfolio Standards with utility incentives linked to lighting replacements is helping to drive demand. The vast majority of what I spend my time on is getting our products into utility programs.”

More design emphasis:

“LEDs totally change the lighting market. The design of fixtures is completely different, with a different type of optics. There are things we can now do from a design point of view that we could never imagine before.”

“There will be a lot more design content in LED niches. What you can do with LEDs is just enormous compared to traditional lighting. But this also means you have to provide much more technical support. The customers are often confused by the options.”

Growth Opportunities for Players with Niche Applications

On the product manufacturing side, the best opportunities for domestic players and new market entrants will be in customized niche applications of new lighting technologies. Because of its high design content and flexible application technology, LEDs are well suited to these kinds of applications. For example, Radionic (a Chicago area firm and interviewee) developed the first UL rated LED exit sign retrofit kit produced in the US. The signs have a payback of one year in many cases. He is selling the product direct to large building owner and managers.

“I think you will see lots of new products for niche applications. To be profitable you will have to get into these markets. You will have to have something someone else doesn’t have.”

“There will be lots of opportunities for high levels of customer service and customized products. Quickness to market will be key.”

One interesting implication of this shift to niche markets is that it increases the logic of on-shore vs. off-shore production. Niche products, especially customized ones, are often sold in smaller lot sizes on shorter lead times. The requirements of small lot size; variability in design; and short lead times are difficult to satisfy with offshore production.

Business Opportunities Outside of Product Manufacturing and Distribution

The emergence of the LED market will create more value capture opportunities outside of the traditional lighting manufacturing and distribution value chain. These primary opportunities will be in lighting design, lighting controls and lighting management.

This trend was highlighted in many quotes from the interviews:

Opportunities are outside of product manufacturing:

“I don’t see that there is that much economic value on the distribution side of the market. Margins there will always be slim. There is more value in the technologies that are outside of the lighting fixture – controls, drivers, design.”

“The secondary and niche markets are where the opportunities are – sensors, software, controls, design. This secondary market will be \$12-\$20 billion in size.”

Increased role for integrated energy management:

“More of this market will get linked to energy efficiency systems – how you manage your lighting overall. It will be connected to building systems and driven by efficiency players.”

Design will play a larger role:

“Design is a big part of the industry. It typically happens one of three ways – large A&E firms will often have their own internal lighting designer; there is also an industry of smaller lighting design firms, many of them just a few people. Finally, as a manufacturer we are often asked to provide design services to our large customers.”

Controls (including wireless) will be a big market:

“Controls are also becoming a big part of the industry. There are many ways controls get sold into a project. In some cases the sensors are freestanding; in others they are integrated into the lighting fixture. In some cases the software is sold separately; or it can be part of the overall building control system.”

“We think the next big thing in controls will be wireless. Wireless allows you to remotely control a large number of fixtures, and provides instant usage, outage and other information to managers. With wireless your controls system can also monitor overall energy consumption.”

“The industry is still sorting out the integration of fixtures with lighting design and controls. There are lots of different players and lots of different configurations. It is all organized around getting the maximum quality and quantity of light. That end result will drive the market more than specific products.”

Opportunities for Increased US-based Manufacturing in Some Niches

The project asked all interviewees about the prospects for US versus offshore manufacturing. The consensus was that future growth in commodity production of components in the traditional and LED markets will likely be offshore. On the other hand, the interviewees saw an opportunity for domestic production for customized products produced in smaller batches and with shorter lead times. In particular, high volume products with direct labor cost of 10% or lower can competitively be produced in the US because of increased labor costs in Asia, logistics costs, and quality control concerns.

Commodity production will be off-shore:

“If you want to be stamping out light bulbs, the US is not a good place to do it. The bulbs are cost-driven commodities, even LED bulbs. They bring low margins so you need high volumes of revenue to make it make sense. We will get 2-3 huge players who will crank out LED devices by the tens of millions. The sheer size of production will lock out other players. You aren’t going to be making light bulbs in Chicago.”

“Everything will be manufactured offshore in the LED sector. Most of the intellectual property is in the chip and a lot of that will get manufactured in Asia. The Midwest will be a service and distribution market.”

“Everything is going to Solid State Lighting and the solid state electronics industry is in China, Japan and Korea.”

“There isn’t a CFL manufactured in the U.S. It is a China-made product.”

Some products can be profitably manufactured in the US:

“We make 100% of our surge protectors in the US. This is because we have pretty low direct labor costs – about 6-7%. At this level, the difference in offshore costs is not worth the additional costs of transportation; quality issues; and slower delivery time. If our labor costs were between 10-15%, we would reconsider.”

“We assemble about 60% of our product in the US. It used to be 90%. We will probably be increasing US production for two reasons – first because it gives us more flexibility and shorter lead times on customized products, which we see increasing in demand; and second because it is required for a lot of government procurement. For us, labor is not the key factor in domestic vs. offshore sourcing – it is the plating, painting and polishing processes that are too expensive here.

“Typically in this business, you have to be good at making product overseas to be successful. This means having a simple and reliable design. The products I manufacture in the US are custom or semi-custom products. With those, I have too many variations; too small lot sizes; and too short a lead time to make offshore production viable.”

“Seventy percent of our products are made here in the US. Our key outside suppliers are primarily plastic and metal fabricators.”

“We are aggressively pursuing manufacturing in the US. If you design to take labor costs out, you can get within 10% of the cost of production in China. This makes up for the disadvantages of long lead times and logistics.”

4. Economic Development Potential of the Energy Efficient Lighting Sector for the Chicago Region

This section more explicitly ties the EE Lighting sector analysis of the last two sections to the cluster criteria of Part I, Section 1.2 in order to understand the opportunities for green cluster development in Chicago, and what steps should be taken to pursue that strategy. Key questions include the following:

- What is clustering in Chicago? What are the inter-related sets of firms and economic activities, value chains and markets?
- Is it a promising cluster? Is the cluster as defined a growth cluster for the Chicago region?
- What strategies could be pursued to help Chicago capture a larger share of this changing, emerging market?

Finally, this section summarizes some key observations about Chicago's green economic development infrastructure and the nature of cluster development more broadly.

[4.1. What is clustering?](#)

In Phase I of this project, EE Lighting was identified as a sector that showed potential to illustrate a cluster development strategy. The previous two sections explored this sector in depth, identifying its primary products, markets and trends. From this analysis, it became clear that the *production-focused* EE Lighting sector initially envisioned was not in fact the emerging cluster in Chicago. While the available data revealed a concentration of lighting manufacturers,⁴² the reality that emerged from interviews with Chicago area firms was that these firms did not substantially benefit from their geographic proximity or interact in a way that made them a cluster. Chicago's firms in this sector tend to be fragmented and do not have a history of collaboration or R&D sharing. In addition, the supply chain is fairly shallow, and three large global firms dominate the industry, particularly commodity production.

Based on the inability of data to capture nuance, particularly in emerging sectors, and the dramatically transitioning state of the industry, it is not surprising that the EE Lighting sector did not translate directly into a cluster. However, analysis of the EE Lighting sector does reveal a broader cluster development opportunity for Chicago.

It is clear that the EE Lighting sector is in a state of substantial transformation. The shape of the industry will be substantially different in 10 years than it is today. Key trends are changing the nature of the industry:

1. Lighting design, controls and management are increasingly integrated with lighting production.

⁴² A list of firms in Chicago's EE Lighting sector can be found, with brief descriptions of each, in Appendix C. This list focuses primarily, although not exclusively, on the production side of the sector.

2. Lighting is more integrated with other energy efficiency products and services, opening up a greater role for “energy management integrators” in the lighting distribution process.
3. Smaller manufacturers are focusing more on niche and customized product specialization.

These trends argue for focusing local cluster development not on the EE Lighting sector by itself, but on the larger commercial and institutional building energy efficiency sector, as the lighting sector becomes more and more tightly integrated with this larger sector.⁴³

EE Lighting firms in Chicago are working more and more closely with designers, lighting/energy controls systems, and ESCOs and other energy management integrators. Together, these sectors represent an emerging cluster around “Integrated Lighting and Building Energy Systems” (ILBES). The region’s ILBES cluster consists of firms in the EE Lighting sector, including component suppliers and the many manufacturers of niche lighting products, the architecture and design sector, the commercial building management sector, the energy software and controls sector, the energy integration (including ESCOs) sector and utilities. The exact scope of products and services that will be commercially integrated as part of this cluster is not yet determined. For example, it is as yet unclear whether drivers, incentives, marketing channels and business relationships for other elements of a building’s energy system, such as HVAC, are sufficiently similar to be likely to operate primarily as part of the same cluster in Chicago.

[4.2. Is it a promising cluster?](#)

Data limitations make it difficult to comprehensively evaluate the ILBES cluster as a whole, but when broken down into some of its component parts, it is clear that the cluster has high growth potential in Chicago.

First, as described previously, the Energy Efficient Lighting Sector is a high growth industry with a sizable number and concentration of employment in Chicago.⁴⁴ Likewise, several major building energy controls firms, ESCOs, HVAC producers, etc. call Chicago home, and these fields are also projected to grow in coming years. Most importantly, the ILBES cluster builds on Chicago’s longstanding assets in design, architecture, and commercial building management.

Chicago has an authentic heritage as a center of innovation in large building design and architecture. It has served in many ways as the “skyscraper innovation incubator” for large

⁴³ The recent OECD report on Chicago green economy strategies notes the need to broaden the focus when dealing with green clusters, because the “green” dimensions often depend on interaction between multiple market segments: *“For green growth clusters, it is important to focus on a range of interconnected sectors rather than restrict efforts to narrowly defined sectors.”* OECD Territorial Review, Increasing Chicago’s Competitiveness Through Green Growth, 2011 (DRAFT)

⁴⁴ Chicago has the third highest employment of any MSA in EE lighting with 1063 employees; EE lighting is the 17th largest green sector in Chicago. Chicago also has the 12th highest specialization in EE Lighting of any MSA; at 2.3, EE lighting has the highest location quotient of any green sector in Chicago. Brookings and Battelle, “Sizing the Clean Economy: A National and Regional Green Jobs Assessment,” Brookings Institution Metropolitan Policy Program, Washington, DC, US, 2011, http://www.brookings.edu/metro/Clean_Economy/.

commercial buildings. Moreover, Chicago is home to a large headquarters and advanced business services functional cluster; these companies – from finance and legal to architecture, building management and commercial office space development and design – export advanced business services for headquarters across the globe. The existence here of this prominent cluster provides critical demand for other components of the ILBES cluster, including lighting, design, and controls.

Other regions (most notably Seattle, which has plans to develop a Building Energy-efficiency Testing and Integration (BETI) Center and Demonstration Network focused on building energy management software and automation technology, and Philadelphia, the recent winner of the DOE Energy-Efficient Building Systems Design Energy Innovation Hub and \$122 million in associated RD&D funding) have developed strategies to become “centers of excellence” in parts of this niche. In each case, there are some regional assets that they are seeking to build upon. (In Seattle, for instance, they are seeking to leverage the relationship with Microsoft and the presence of substantial software development and controls expertise.) The work of these other regions should not preclude Chicago from developing a strategy based on its own assets. Neither region has the same historical expertise in large building design, development and management as Chicago.

Despite the vast potential of this integrated cluster, a few characteristics of Chicago make development of a local ILBES cluster challenging. For example, one interviewee cited the City’s “not very business friendly” environment as a barrier to attraction of cluster firms. In addition, relatively low electricity rates and a lack of strong energy efficiency policies have not fostered the same demand for energy efficient lighting and buildings that has made California a popular location for new EE companies.

Overall, the ILBES cluster does look like a promising vehicle for regional growth, if the City and other local economic development organizations implement the right strategies.

[4.3. Recommended Strategies, Next Steps and Observations](#)

Goal: *Make Chicago the easiest place in the world to do real world applied R&D on building energy efficiency technologies.*

Section 3.2 identified four primary market barriers for LED technology. The first, the high costs relative to performance, is naturally diminishing as the price of LEDs drops. The other three barriers (product quality, distribution changes and the speed of commercial viability) will also lessen over time, but there is an opportunity to accelerate this process and help Chicago firms beat the curve.

An applied R&D network would provide manufacturers with an opportunity to prove their quality in demonstration sites; develop relationships with new/more important distribution players such as lighting/building designers, ESCOs, utilities and commercial building managers; and use these relationships to build trust, allowing them to gain market acceptance without going through the cumbersome efficiency verification process. It would also provide an opportunity for manufacturers of related products to integrate with one another. This system would benefit customers and distributors by allowing them to easily compare products and work with the manufacturer to get the desired customization. Overall, this strategy would use close-knit relationships between building designers, owners and managers, and providers of energy efficiency products and services, to shorten the time between innovation development and its penetration into the market.

Chicago's unique assets in the commercial building sector – its large network of existing manufacturers, designers, architects and engineers, energy management companies and others – make it the perfect place to test this strategy. Chicago could attract a larger percentage of startup and growing firms in this sector if it could develop this kind of sophisticated regional “distributed applied R&D” system for rapidly testing, demonstrating and commercializing innovative technologies, products and service models for the large building energy efficiency market. Such a system could make Chicago the place to go to do real world applied R&D and accelerate commercial viability of energy efficient building technologies.

Attributes of this Strategy

The applied R&D system would include the following attributes:

- Building a close consortium of architects, engineers, designers, developers, property owners, property managers, energy management companies, utilities and component providers to drive the network.
- Creating sub-sector networks around core building technologies (lighting systems; energy and building management; on-site generation and storage; HVAC and mechanical systems; smart grid connectivity; etc.).
- Proactively conducting “IP mining” for leading edge technologies developed in other regions that Chicago can implement, and developing long-term relationships with R&D institutions.
- Developing technology demonstration sites in the region.
- Creating relationships with venture and equity firms backing leading edge companies to do “field testing” of products in Chicago.
- Organizing the City and other public sector players as “lead adopters,” including regulatory provisions to make it easy to test early stage applications in municipal buildings.
- Working to build up the regional higher education assets in this niche.

Next Steps to Execute this Strategy

Building a serious cluster development strategy in this niche requires a substantial investment, and a very focused effort, institutionally and substantively. Institutionally the next steps are to:

- Convene parties interested in supporting development of the ILBES cluster.
- Identify an organization (or more than one) that will take the lead in developing the cluster.
- Identify staff and secure financial resources to support the development phase.

Once the network that will carry out the work is established, that group will need to:

- Inventory the Chicago region’s assets in the broader Integrated Lighting and Building Energy Systems cluster, to further define the scope of the cluster, the nature of relationships between the sectors and firms and the development opportunities. This would require doing the kind of sector research conducted for this project in the EE Lighting market in a number of other industries. Background research and industry interviews would have to be conducted in the following areas:
 - Architectural, design and engineering of large buildings
 - Large property management
 - Building management systems (controls and software)
 - Energy and lighting management firms (including ESCOs)
 - HVAC and mechanical systems design and manufacturing
 - Smart meters and other Smart Grid technologies
- Bring together key leaders in each of these sub-sectors to further detail the emerging market opportunity, distribution channels, product, service and design relationships and other challenges and development strategies, ultimately to shape and execute a cluster strategy for Integrated Lighting and Building Energy Systems.
- Identify key national R&D and industry collaboration initiatives related to energy efficiency in the large building sector (e.g. USDOE Commercial Building Initiative and Commercial Building Alliances) and map Chicago’s connections and relationships with these initiatives.
- Map the sector-specific energy efficiency initiatives (e.g. commercial real estate, higher education, health care, hospitality, etc.) and Chicago’s engagement with them.⁴⁵
- Conduct benchmarking research on related clusters in other regions (such as Philadelphia and Seattle) to understand their strategies more deeply and better understand Chicago’s competitive advantages.

Broader Institutional Development to Expand to Other High Potential Clusters

Execution of economic cluster strategies requires specific kinds of economic development capacities. It is important to understand what these capacities are and the degree to which they currently exist – or need to be developed – in the Chicago region.

Cluster development strategies are a very “hands on” version of economic development. They require deep “on the ground” knowledge of the cluster, the firms engaged in the cluster, the firm leadership, and the relationships between the firms themselves and between the firms and regional assets such as universities, R&D labs, and private investment groups. This networking requires network brokers who build these individual firm relationships and can use them to make connections across firms. Ideally, this leadership comes from the firms and industry organizations themselves, and they certainly take over as the activities proceed, but it is often the case in an emerging cluster that the cluster institutionalization and leadership has not yet fully surfaced.

⁴⁵ Note that much of the preliminary research on EE initiatives in these sectors is included in the [Building Retrofit Industry and Market \(BRIM\)](#) research conducted by INC, COWS and OH Community Partners.

These relationships can be developed in many ways, including through:

- Regional economic development organizations that develop these relationships as a result of transactions organized around business retention and attraction opportunities.
- Industry or sector councils focused on the growth of a particular sector.
- Specialized NGOs or trade organizations that provide services to firms.
- Large regional development projects or investments (such as specialized research and development institutes) that bring together sector leaders.

The detailed working knowledge of a cluster that is developed through these one-on-one relationships helps with the difficult and nuanced work of figuring out what are and are not promising cluster development opportunities. Those opportunities require a unique mix of both well-defined business opportunities (where a convincing case can be made that the investment in collaboration will bring a return that exceeds the investment required), and personal trust-based relationships that create confidence that working with potential competitors will yield tangible business benefits.

As the project sought to build an understanding of Chicago's green economy cluster opportunities, the robust level of activity occurring in the region was encouraging. There are a wide variety of regional economic development initiatives and a shared focus on building a strategy for regional prosperity. Regional initiatives by the Clean Energy Trust, the Chicago Manufacturing Renaissance Council, World Business Chicago, and the Midwest Economic and Sustainability Leadership Alliance (MESLA) are organizing capacity to focus on the development of green economic clusters, such as the wind industry. However, at the same time, the project found a marked absence of systematic institutional capacity and networks to develop green clusters. Chicago has few formal or informal industry associations or business networks in this sector of the economy. This absence of on-the-ground capacity in the green economy contrasts with the existing networks in other sectors of the economy, such as information technology. Even considering the emergent nature of the green economy, Chicago's green development infrastructure is less developed than that of other cities.

As a result, with a few exceptions, very few organizations have developed detailed sector knowledge or working relationships with leadership in specific firms or industries. At a very practical level, this made the simple work of identifying firms for interviews and getting the attention of CEOs and VPs very time intensive. At a broader level, this kind of institutional capacity is necessary to continually generate opportunities, and to develop and execute strategies in other green clusters.

If the region wants to grow through cluster-based economic development strategies, it will need to develop this kind of institutional capacity, including a much higher level of dedicated staff capacity that works directly with business leaders in specific sectors. Over time, this capacity will build knowledge and relationships that can enable practical cluster development strategies in specific niches.⁴⁶

⁴⁶ Cluster-based capacity is especially important because no matter how sophisticated the data and analytic techniques, they cannot substitute for the on-the-ground, in-depth knowledge and understanding of the dynamics of the industry and cluster which flows from engaging cluster firms and stakeholders. Most deep cluster

Conclusion

The green economy is here and it is growing. In the last year, global revenue for just the wind, solar photovoltaic and biofuels subsectors grew 35% to a total market size of \$188 billion.⁴⁷ Likewise, the energy efficiency market hit \$200 billion in 2010 and researchers project it will top \$311 billion by 2015.⁴⁸ These numbers do not even capture major sectors like waste reduction and pollution control, nor do they account for the many non-green firms supplying green producers. The “greening” of the economy is opening up opportunities for firms of all stripes. Like in the IT industry, companies across the spectrum will adopt green products and services in order to use less (or cleaner) energy and fewer resources, allowing them to save money, increase resilience against energy price shocks, attract customers and enhance productivity. This will drive increasing demand, creating opportunities for more and more companies to participate directly in green sectors by making products or providing services that support energy and resource efficiency.

Chicago has a strong legacy in many industries that will particularly benefit from the shift to a green economy, from chemicals to metal and machinery manufacturing to building design, construction and management. These firms have a major opportunity to adapt their products and services to seize these new markets. Some firms have already made this transition or will make it on their own; others would benefit from cluster strategies through which they jointly innovate, develop new products, services and processes, and access new markets.

In the case of the Integrated Lighting and Building Energy Systems cluster, this report proposes that such strategies should take the form of a “distributed applied R&D” system. Given the expected changes in the lighting distribution system resulting from the growth of LED technology, implementation of this proposal will make it easier for Chicago area lighting and related sector firms to succeed during the transition to LED. Equivalent changes in other industries will create analogous opportunities for Chicago firms in those sectors. While the specific needs of other emerging green sectors are surely different, the process undertaken in this project can serve as a template for identifying and subsequently meeting those needs.

The firms and the regions that embrace the green economy and build on their assets to compete in it will succeed. Those that do not will be left behind. Chicago has the assets to compete in a wide range of green sectors; if the region approaches development of these assets thoughtfully and deliberately, it can become a major center of green economic activity.

development efforts start with the industry/firms themselves – stakeholders who recognize their strength and want to find a way to build on it further. The data and other secondary research is only a starting point to help identify the promising sectors to engage. Unfortunately, much current cluster work starts and ends with data and analytics, and so makes for interesting, high-level reports, but does not translate into actionable economic growth strategies. A dedicated cluster organization/staff capacity would enable ongoing research on promising clusters in emerging and existing sectors, grounded in engagement with firms.

⁴⁷ Clean Edge, <http://cleanedge.com/reports/report-download?nid=21560>

⁴⁸ BCC Research, <http://www.bccresearch.com/report/green-technologies-markets-env012a.html>

Appendix A: Cluster Selection Methodology

Information on all sectors came primarily from three sources: data, interviews, and background research. Each of these is explained in more detail below.

Data

At the outset, the project obtained a list of firms operating in Chicago's green sectors from Brookings and Battelle, as part of their forthcoming Clean Economy Project.⁴⁹ This data was preliminary and had limitations, so should not be definitively relied upon.

The firms were broken up into 39 green sectors, 36 of which listed firms in the 14-county Chicago MSA. Brookings and Battelle also provided comparison data at the national level. Using this data, the project calculated the average employment (regionally and nationally), the location quotient, the shift share, the mix share and a base industry location quotient for each green sector.

Each of these metrics is describe in more detail below:

- *Regional Employment:* Measures the regional employment by sector as a 3-year average from 2008-2010.
- *National Employment:* Measures the national employment by sector as a 3-year average from 2008-2010.
- *Green Location Quotient:* Examines sector employment in Chicago MSA, relative to the nation, averaged over 2008-2010. A location quotient of 1 indicates that Chicago's share of employment in a given sector is proportional to its share of employment overall. A location quotient of 1.2 or higher is typically interpreted as a specialization in that sector.
- *Shift Change:* Examines the growth of the sector within Chicago from 2003-(2008-2010 average). Shift change represents the portion of growth that can be attributed to growth in the Chicago region. It is expressed as a proportion of the total employment change.
- *Mix Change:* Examines the growth of the sector within the nation from 2003-(2008-2010 average). Mix change represents the portion of growth that can be attributed to growth in the industry nationwide.
- *Base Industry Location Quotient:* The project is interested not only in companies that currently are in green sectors but, for cluster development purposes, also in related companies that may not define themselves as green at all, but are foundational industrial

⁴⁹ Brookings and Battelle's Clean Economy project aims to provide an up-to-date and detailed analysis of green economy trends in the United States, broken down into local geographies. The project's definition and categorization of green sectors anticipates the Bureau of Labor Statistics' forthcoming approach, and relies on a bottom-up count of establishments and jobs. The project was able to obtain an interim set of the project's Chicago data in advance to inform the selection of a cluster. A final, public version of their data was released in July 2011, which varied some from the preliminary data relied on here.

sectors whose presence supports the green companies (for example, ball bearing manufacturers in the auto supply chain that may shift to the wind farm supply chain), or that may become green companies themselves. As a result, the project also examined the employment in Chicago MSA, relative to the nation, of broad industry sectors (at the 3-digit NAICS level) that seem likely to be foundational in this sense for each Brookings-Battelle sector. Data on the associated 3-digit NAICS came from the Metro Chicago Information Center's Chicago Economy Cluster Analysis. The assumption is that a high LQ in these existing related industries may indicate capacities suited to the green sector.

The Brookings-Battelle project is ambitious, complex and sophisticated, and provides unique data, otherwise unavailable and enormously helpful as a starting point. It provided leads on potential clusters of interest and firms to interview in the next phase. However, it was clear from Brookings-Battelle, other sources and local research that the data alone would not be conclusive. For one, the Brookings-Battelle project uses a narrower definition of green establishments than this project does, excluding non-green suppliers to green companies from their database. The Brookings-Battelle database also omits all firms with fewer than five employees because of inconsistencies in the underlying data.

Interviews

Phone interviews were conducted with eleven experts on green activity in Chicago to find out which sectors they think show potential for development, what assets Chicago has to offer in the green economy, what firms are operating in the space, and who the main players are in Chicago's green economy. For a list of interviewees, see Appendix D.

Background Research

No single, obvious cluster choice emerged from the data and the interviews. Thus, after using the data and the interviews to narrow the list of sectors, the project conducted more detailed research on the remaining candidates. The purpose of the additional research was to get a better sense of what types of firms make up each sector, what the market opportunities look like, what the local innovation assets are, and whether Chicago will be a strong competitor against other regions pursuing similar goals. Specifically, additional research topics included:

Innovation: As a measure of Illinois' innovation in the candidate clusters, the number of patents produced in Illinois was compared to other states using data from the U.S. Patent and Trademark Office. Patents are divided both by technology and by 3-digit NAICS codes; in each case, the category is broader than the green technologies and as such, the patent figures should be interpreted only as an approximate guide.

Clusters in Other Regions: Searching for information on similar clusters in other regions allowed for comparison of assets to get a sense of how successfully Chicago will be able to compete.

Rough Estimates of Industry Share: In addition to using the Brookings-Battelle data to compare Chicago's share of a particular sector with that of the nation or other regions, the project used ThomasNet to compare industries more broadly. ThomasNet is an industry search engine that

allows one to find manufacturers, distributors and service providers across a range of industrial categories. The searches can be done for all states and provinces or for a particular state or province. Using a range of search terms related to a particular sector, the number of firms that were in Illinois was compared to the number of firms in the nation. This provided an approximation of the relative concentration of that industry in Illinois. For example, a search for LED Lighting turns up 15 firms in Illinois and 211 nationwide, which translates to Illinois having 7.11% of the nation's LED lighting industry.

Like the data this metric is designed to supplement, it is imperfect: it is based on number of firms, not employment; it includes as part of a state firms that are actually well outside the state; it is based on a state-level and not metro-level geography; it is missing firms; it may categorize firms incorrectly; the information may be out of date; etc. Given these drawbacks, this metric adds to overall knowledge of the candidate clusters, but must be interpreted cautiously.

Firms: To get a sense whether one sector dominates or if there is a healthy mix of manufacturing, distribution and service providing firms, the project looked at the specific firms that make up the sector. Information on firms came from the Brookings-Battelle data, ThomasNet, association websites, firm websites, etc.

Market Observations: Information on the market conditions and opportunities in each candidate cluster was gathered through Pike Research, industry association materials, and simple Google searches.

Appendix B. List of Brookings-Battelle Sectors

Agriculture and Natural Resources

Conservation

Conservation & Management
Organic Farms & Organic Food Production
Sustainable Forestry & Related Products

Education and Compliance

Regulatory & Compliance
Training

Energy and Resource Efficiency

Battery & Energy Storage Technologies
Electric/Hybrid Drive Technologies & Vehicles
Energy Efficient Appliances
Energy Efficient Building Products & Materials
Energy Efficient HVAC & Building Control Systems
Energy Efficient Lighting
Energy Research, Engineering, & Consulting Services
Fuel Cells & Hydrogen
Green Architecture, Building Design, & Construction

Greenhouse Gas Reduction

Nuclear Energy
Carbon Sequestration
Public Mass Transit
Smart Grid Systems/Smart Metering
Other Greenhouse Gas Reduction Technologies

Pollution Reduction and Cleanup

Air & Water Purification Technologies
Air/Water/Sewage/Solid Waste Management & Treatment
Environmental Research, Engineering, & Consulting Services
Green Building Products & Construction Materials, NEC
Green Chemicals and Related Green Products
Other Green Products
Pollution Control & Prevention
Remediation Technologies & Services

Recycling and Waste Reduction

Recycled-Content Products
Recycling & Reuse
Other Energy Efficient Products
Water Efficient Products

Renewable Energy

Biofuels/Biomass
Geothermal Energy
Hydropower Energy
Solar PV Energy
Solar Thermal Energy
Waste-to-Energy
Wind Energy
Ocean/Wave Power Energy

Appendix C: Chicago's Concentration of Lighting Firms

As noted earlier in this report, Chicago has a significant concentration of lighting companies in the region. Many of the leading companies are listed in the table below.

Company	Description
Juno Lighting Group	Broad lighting product line for commercial, institutional and residential segments. Owned by Schneider Electric.
Westinghouse Lighting	Sales and distribution office for Westinghouse Lighting, which produces a broad line of bulbs, fixtures and accessories.
American Fluorescent Corporation	One of the oldest fluorescent manufacturers in the country. Produces a broad range of fluorescent and LED products.
Waldmann Lighting Corporation	Manufactures and distributes a full line of high-quality, energy-efficient LED, fluorescent and halogen lighting designs for a diverse range of architectural, office, medical and industrial applications for both interior and exterior use.
Con-Tech Lighting	Manufacturer and distributor of over 5,000, mostly energy efficient, products for a variety of residential and commercial purposes.
Aero-Tech Light Bulb Company	Manufacturer of incandescent bulbs (specializing in “rough service” applications), and distributor of fluorescent lighting including HID, CFLs, and ballasts.
Litetronics International	Manufacturer and distributor of energy efficient lighting products specializing in the commercial niches of restaurants, casinos, hospitality, retail stores and agriculture.
U.S. Way Corporation	Electronics design company focused on meeting the demand for energy-efficient lighting products that meet LEED standards.
Excelitas Technologies LED Solutions	A division of Excelitas Technologies focused on the LED market. Excelitas manufactures a broad range of opto-electronics products.
Lumex	A global optoelectronics player, with a broad range of high efficiency, high performance LED products serving industrial, medical device and general lighting markets. Lumex is a division of ITW.
iLight Technology	LED lighting for architectural and corporate markets.
Halogen Lighting Products Corp.	Manufacturers of specialized halogen and fluorescent and LED lighting for industrial applications in the industrial, machine, and manufacturing sectors.
GE Lighting	Sales for the full range of GE lighting products.
OSRAM Sylvania	Sales and distribution for OSRAM Sylvania products. Lake Zurich location works on development, marketing, manufacturing and sourcing of ballast products.
Philips Lighting	Sales and distribution for a broad range of Philips lighting products.
Marco Lighting Components Inc.	Precision sheet metal fabricator serving the lighting industry.

Company	Description
Radionic Industries	Manufactures ballasts and LED Exit Signs as well as under cabinet LED lights
QSE Inc.	Manufacturer of electronic coils and transformers
Robertson Worldwide	The largest manufacturer of compact fluorescent ballasts in the United States.
Lynk Labs	Developer and manufacturer of AC-LED technology devices, drivers and system solutions that improve and simplify the integration of LEDs into the AC Power lighting infrastructure.
TDK Corporations	Manufacturer and distributor of capacitors, inductors, coils and thermistors for LED applications.
Thomas Research Products	Produce LED drivers, transformers and controllers.
Rubicon Technology	Producer of monocrystalline sapphire for LED products.
Burnex Corp	Metal stamping and wire form supplier to the lighting industry.
io lighting	Distributor of indoor and outdoor LED architectural products. A division of Cooper Industries.
Next Generation Lighting	Distributor of solid state (LED) lighting products for residential, business and commercial signage.
Polybrite International	Manufacturer of LED light bulbs, as well as other LED specialty products such as pet collars.
Encompass Lighting Group	Distributor of multiple lighting products. Includes Tech Lighting and LBL Lighting divisions.
A.L.P. Lighting Components, Inc	Global manufacturer of HID, fluorescent and LED lighting components, including lenses, vapor-proof enclosures, unwired fixture bodies, louvers and baffles, reflectors, and extruded sheet product.
Appleton (part of Emerson Industrial Automation)	Manufacturer of lighting fixtures, both energy efficient and not, with a focus on industrial and commercial markets. Their specialty is lighting fixtures that protect against extreme conditions, such as corrosive elements and flammable gases.
Neptune Light	Manufacturer of induction lighting, LED lighting and CFL lighting bulbs and fixtures for commercial and industrial markets.

Appendix D: Interviewees

Phase I:

Christy Augustine, Bain
Donna Ducharme, Delta Redevelopment Institute
Amy Francetic, Clean Energy Trust
Howard Learner, Environmental Law and Policy Center
Peter Locke, Terralocke
Gail Longmore, Global Midwest Alliance
Chinwe Onyeagoro, O-H Community Partners
Dan Swinney, Chicago Manufacturing Renaissance Council
Dennis Vicchiarelli, World Business Chicago
Robert Whittier, Deloitte
Claire Woolley, Green Business Forum Lead, Chicagoland Chamber

Phase II:

Erik Birkerts, Orion Energy Systems
Lee Eilers, Limelight
Glenn Garbowicz, Thomas Research Products
Adam Gruber, EOS
Craig Hall, Sunovia
Michelle King, Earthtronics
Jim Livingston, Philips Lightolier
Sandra Miles, Polybrite
John Reagan, Illinois Ventures
Bill Solomon, American Fluorescent
Steve Weiland, Stifel Nicolaus Weisel
Jeff Winton, Radionic

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