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Smart Lighting Policy Exploration for the City of Monterey

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Submitted by

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Abstract

How can technology be used to create innovation and benefit for society? The answer to this question has many possible solutions depending on your location and perspective, but an increasing number of collaborators are working toward solutions on some of the most challenging problems facing humanity. This paper will examine innovative smart lighting solutions which present an improvement over the current solution for the City of Monterey. Current research presents use cases and case studies which will be used as a basis for exploring a smart lighting solution for Monterey. The impacts of this study, policy evaluation and policy recommendations could create an opportunity for Monterey to position itself as leader in the region of sustainability and innovation, creating buzz, bringing collaborators and business to the area, while also decreasing expenditures on lighting, reducing emissions and light pollution, and building an additional layer of fault tolerance for Monterey.

Chapter 1 Introduction

What comes to mind when you hear the word light? Is it the something used to help wake yourself, possibly the blinding light in the sky, or maybe the moon and stars? Do you think about the objects used by communities to assist citizens in illuminating needed areas at night, such as walkways and roads? Does that artificial light used by communities have an effect on the surrounding plant and animal life, and is light pollution something with which local governments should concern themselves? This research paper set out to examine how can lighting become "smart", flexible, and more useful to communities? The concept of smart lighting is explored for its application utilizing the City of Monterey as a case model for this study.

Global warming is a phenomenon which has been agreed upon by many scientists. The recognition of this trend has been driving innovative approaches to reduce human impact on the planet. As theories and practice of corporate social responsibility evolve on the national and global level and carbon footprint reduction becomes a higher priority, many government organizations have begun lighting reduction efforts, while looking to establish themselves as leaders in the technology and social space. The social awareness of global warming has created momentum toward development of a global ecosystem of national and local governments working together to solve the environmental crisis facing the planet. This research highlights various solutions and strategies which could be deployed in the City of Monterey to reduce its energy consumption, create disaster tolerance, increase public safety, reduce budget, create future capability, and establish itself as a leader in the regional smart lighting space.

Background and History

The idea of community is an essential element in any smart initiative. A smart initiative is one which seeks to create consensus though collaboration, with the most complete stakeholder picture possible, working to create progress and innovation across communities. Manipulation of light is a concept which has been gaining momentum for its potential impact on daily life. How can lighting affect a community? Can a lighting plan be poorly executed and what would the consequences of such a failure look like? What potential positive outcomes could come from a smart lighting solution?

The idea of using technology to assist in solving problems and creating innovation has been around for quite some time. Information, communication and technology (ICT) devices as they are known are the driving force behind smart solutions. These ICT devices assist humans in solving problems which they may not otherwise be able to solve alone or it may take more time than is available. It has been said that the modern creation of the smart/intelligent community was that of a group of scientists at Bletchley Park during WWII. This group led by Alan Turing used technology in a communal form to help crack codes during the war (Komninos, 2011). Since the early days of computers, revolutionary leaps and bounds have occurred with billions of devices now online and communicating. This influx is in the midst of recreating how humans interact with machines and technology. If humans are able to effectively leverage and share the information garnered from all of the connected devices, a smart revolution will be on the horizon.

The idea of city lighting for safety and security began in the streets of London and came to the American City of Baltimore in 1817. The spread of the gas light across the early Americas was slow. Citizens in the US were fearful of the night throughout the 19th century, as many gangs

and criminal activities were carried out under the cover of darkness. Police officers were primarily only employed during the day until the late 1800's. The Night Watch is a 1642 painting by Dutch artist Rembrandt van Rijn. The painting depicts the early human security measures used to help protect the townspeople during the dark evening hours of the 15th century.

The Night Watch (Dutch: *De Nachtwacht*), is a 1642 painting by: Rembrandt van Rijn.

Night watchmen were the primary source of criminal defense at night prior to that point. These night watchmen held very little authority and were not looked highly upon, leaving the communities feeling unsafe. As lighting began to spread, albeit to predominately affluent neighborhoods, police forces also began to employ dedicated night time officers as well, creating a greater sense of safety across major US cities (Baldwin, 2012, 2011).

The rise of urban artificial lighting has had an impact on the natural habitat and night sky as well. The voices from that side of the debate have become more prevalent over the last decade. The rise of modern technology is allowing for a deeper debate on lighting of communities during night hours. Lighting design has become more integrated into many larger cities globally with an emphasis on Smart Lighting initiatives and implementations.

Smart lighting initiatives and implementation plans are a part of a larger Smart City ecosystem in the global market. Smart City plans and initiatives are meant to be citizen and future focused, ensuring inclusivity and benefit for all sectors of a given population. As the smart lighting market continue grow and mature, standardization and best practices have begun to emerge. Each city must focus on personalized needs, finding solutions which solve not only the current needs, but seek out innovative policies and solutions which are forward-looking, creating use-cases which will suit the city well into the future, while also being able to scale and integrate with solutions from other cities and regions. The interoperability of these solutions is essential in creating partnerships and collaboration at scale with technologies being emplaced to create social equity.

Problem Statement

How does a small municipality best use its resources to provide services while also encouraging multiple stakeholders to participate in a collaborative solution approach? There could be many possible answers to that question. How large of an impact on the budget is the use of electricity in support of the lighting grid? How can Monterey integrate best practices from cities around the globe which have begun implementing solutions by introducing varying lighting systems to reduce costs, quickly showing cost savings and emission reduction.

The City of Monterey underwent an implemented plan which consisted of a replacement program, swapping out old high-energy usage bulbs for efficient LED bulbs. This has saved the City nearly $70,000 annually, but created challenges as well. Innovative cities which have implemented smart lighting systems, have seen significant savings while also building in disaster tolerance by moving the lighting grid to a system which is self-sustaining with the ability to be remotely controlled.

Purpose of Study

The purpose of this research is to assess and determine if a smart lighting solution for the City of Monterey which can improve the current municipal infrastructure and position the city's expansion and use of technological innovations for the future.

Significance of Study

This study provides a collection of data and analysis/evidence of energy and cost saving possibilities for the City of Monterey through the implementation of smart lighting solutions. A model of this nature could create economic advantages to the area through heightened exposure of the innovative approaches to solving problems in the region, positioning the city a thought leader and implementer in the region.

Main Research Question

Would a smart lighting model for the City of Monterey be beneficial for long term prospects?

Sub-Question

1. Which lighting systems could support a smart lighting model for Monterey?

2. Is light pollution an issue which the city government should consider?

3. Should the lights controlled by the city be shut off when there is no pedestrian or vehicle traffic?

4. Is there support for an integrated remotely monitored system with potential for additional capabilities?

5. Is there confidence in the local government to carry out a smart lighting project?

Dependent Variables

The dependent variable in this study is the current lighting solution across the City of Monterey.

Independent Variables

The independent variables examined in this research are:

1. Cost to power lighting grid
2. Emissions from lighting
3. Disaster tolerance
4. Lighting poles with interoperable compatibility
5. Light pollution

The independent variables were examined to determine their relationship on the impact of the dependent variable. Findings are laid-out in chapter 4, results and findings.

Research Hypothesis

An alternative energy smart lighting solution for the City of Monterey which provides cost savings, reductions in emissions, decreased light pollution, disaster tolerance and interoperable compatibility with emerging smart technologies is supported by the community.

Assumptions and Limitations

This study assumes that municipalities will want to create alliances with local and regional entities to create an environment of innovation. The limited time line and funding of this study will keep it scoped to possible solutions which could help to solve energy solutions for the city. The final limitation to this research will be the fact that this in an emerging market so a consensus on standards and topics of importance have not been agreed upon.

Definition of Terms

California Environmental Quality Act (CEQA) - is a statute that requires state and local agencies to identify the significant environmental impacts of their actions and to avoid or mitigate those impacts, if feasible

Light emitting diode (LED) bulb - A bulb which is more efficient than HPS with brighter colors having many applications

Lighting grid – A series of connected lighting devices which cover a given area

Light Pollution - Light traveling into the night sky and surrounding area which reduces darkness, creating a washed-out sky and having impact on habitat

Light Trespass - The travel of light beyond its desired area of coverage

High pressure sodium lamp (HPS) - The bulbs which have a yellowish orange hue and mostly used for street lighting and industrial purposes

Information and communication technology (ICT) – These terms together are often used to describe a means by which communities, cities and governments create innovation, development to solve problems and create opportunity

Internet of things (IOT) – A grouping of devices which are connected together or part of a larger system where the connected devices are sharing data

Smart City - This definition varies from city to city but generally refers to a city which uses information and communication technology (ICT) to help understand and solve problems faced both locally and globally.

Smart Lighting - A group of policies and initiatives which represent the plan for lighting a city or region which are adaptable and advanced, looking to reduce cost and emissions

Public private partnership - An agreement between government organizations and private sector, non-profit or education institutions

Stakeholder - An entity or individual which has an interest and input on a particular project or idea

The Ralph M Brown Act - is an act of the California State Legislature which guarantees the public's right to attend and participate in meetings of local legislative bodies.

Expected Impact of Research

In a region that is a risk for suffering from natural or other disasters, implementing a lighting system and grid which is self-sustaining, able to be remotely controlled and monitored,

and interoperable with other integrated systems is the way of the future. This research aims to show how a lighting model of this nature is both possible and beneficial in the city of Monterey.

Chapter 2 Literature Review

To get an understanding of the current literature on smart city and smart lighting research which has been emerging, various scholarly database searches were conducted with the search terms smart city, smart lighting, and off-grid lighting. The searched terms led to a number of results, from which, the abstracts were read to determine if those papers met the scope of this research topic. As this research focused on a smart lighting solution for the City of Monterey, scholarly publications and practitioner studies were selected which discussed (1) governance of smart cities and initiatives; (2) case studies from previous smart lighting implementations; (3) research being conducted on the latest scientific advancements in smart lighting capabilities and (4) research of models with intersecting definitions and principals shifting toward an environmental, social and technological approach. Each of these themes is examined and assessed in separate sections below.

Governance of Smart Cities and Initiatives

The stakeholders under taking smart city and smart lighting projects are working to openly share their experiences and practices, in attempts to create an environment where innovation and collaboration become a call to action. This environment creates a focus on designing technology roadmaps for supporting research and development of future technologies and public sector services that could improve the quality of life for citizens and enhance government legitimacy (Lee, et al, 2013).

A smart city has been defined in various ways, with innovation and collaboration being key indicators for leaders in the smart city sector (Meijer & Bolivar, 2016). Cities and regions which have adopted smart city principals are becoming models for best governmental and

operational practices, earning awards and recognition as global smart city industry leaders. As the market continues to grow and develop, the objectives and goals of smart city models are evolving, with an emphasis on encouraging working together to create shared vision and value for communities and environment.

Smart governance has been described as smart urban collaboration between the various actors in the city (Shahidehpour, et al, 2018). Some leading smart cities are utilizing updated lighting solutions which have the capacity to function as the backbone of city services. This backbone is a grid which has a much greater capacity to provide multiple services, not merely providing light to a given area. A modern smart lighting system can integrate and exchange information with surrounding devices and sensors, creating a network used to control and monitor the entire ecosystem.

City officials are looking to align with citizen concerns by reducing their environmental impact and decreasing energy consumption. Smart lighting projects have become a foundational aspect along the smart city journey. The scope of a smart lighting solution can be varied from simple bulb replacement to an entire integrated system, with the solutions needing to be tailored to each individual implementation. Some solutions have created secondary concerns, facing challenges from communities and advocacy groups around environmental and legislative transparency concerns. Despite those challenges, momentum continues to build as cities and regions are using this window of opportunity to upgrade infrastructure and capabilities of their communities. A well thought-out smart lighting solution is capable of how a lighting system can interact with and create value in society.

Case Study

Cities across the globe have launched smart lighting projects. Although domestically in the United States, these lighting projects are confined to smaller areas, often not spanning city or county boundaries, European countries are much further ahead when exploring current and future lighting needs for communities.

The city of Monterey is responsible for its own lighting system, which differs from some other municipalities which often partner with local power agencies such as Pacific Gas and Electric. The City of Monterey when initiating their smart lighting plan, choose the option of simply replacing the bulbs. In 2011 Monterey began replacing the old HPS bulbs with new LED lights. Shortly after the project had begun, the city of Monterey faced a lawsuit from a community organization Turn Down the Lights. They claimed the city failed to properly notify and explain the scope of the lighting project under the Brown Act, also failed to conduct appropriate environmental impacts under CEQA, and should be responsible for fixing light trespass created by the installation of LED lighting (Rahaim, 2017). The judge sided with the petitioner and Monterey has been working on an updated plan since.

Current Research

Research conducted on remote smart light control systems which have the capacity to control the output of the LED light both in color and intensity has shown its capability in areas such as cost reduction, safety, natural habitat protection, and eye health. Certain blue lighting colors have been shown to have negative effects on eye health, so being able to reduce blue light exposure is important based on current health research (Huang, et al, 2017). Research has been conducted showing the ability to control and replicate lighting parameters accurately across varying lighting methods, meeting the needs and desires of communities. Among the methods and systems studied, the LED bulb has emerged as the leading solution. The LED has been used

as a replacement for the old HFL and other bulb technologies. The LED's ability to consistently control the color emittance and power output is key to reducing light pollution, ensuring eye health for humans and limiting impact to wildlife.

Globally there is a trend for research into alternatives to artificial lighting. Entities such as the Department of Energy are sponsoring research into these areas with some success. A research group from Massachusetts Institute of Technology have applied for a patent on a light emitting plant which was developed through this research effort. They have developed plants which are able to emit light and are hoping to develop this technology into a viable alternative for outdoor lighting (Kim, et. al, 2010). Technologies such as this and other emerging research such as concrete is luminescent at night are on the horizon of possibilities for future advances in lighting technologies.

Gates of Light – Netherlands, Daan Roosegaarde

Global Shift toward Environmental, Social, and Technological Solutions

The smart city models which have emerged embrace the interplay between environmental, social, and technological solutions, with individual solutions being tailored to a particular area or region, but also looking to be compatible for varying types of alternative connections as well. Smart model approaches may differ, but generally have similar goals in-mind, those of creating increased value their communities and increasingly environments as well. Contributors and researchers in the space are building best-practices and knowledge sharing across the smart city community.

Solar energy is becoming cheaper while battery storage capacity has also been increasing making photovoltaic a viable alternative source for smart lighting solutions globally. This type of off-grid solution has been implemented in parts of Asia and Africa with great success. One key for this type of solution has been power management of the system. Research conducted suggests that intelligent systems which are able to monitor its battery and usage levels are most effective at handling the needs of large systems (Lawder, et. al, 2015). As technologies advance to control and create efficiencies, cities must look to ensure these systems are being integrated into their future lighting plans.

Another area of research which is being used in remote areas as well as in urban setting is that of Solar/Wind combination for power generation. Research conducted by the Illinois Institute of Technology (Burgess, et. al, 2017) showed that a hybrid style smart lighting solution is able to provide sufficient lighting, even during the winter months in Chicago under less than ideal weather conditions. A hybrid style approach to alternative smart lighting solutions offers flexibility to local lighting planners and highlights the horizons of possibility with off-grid solutions.

Studies have shown there are nearly 280 million street lights globally (Sedziwy, 2015). As data and knowledge continues to grow as to the extend which street lights consume energy and put off emissions, a global effort is being undertaken to update and modernize the lighting systems for improved efficiency and benefit. The future interconnectedness of devices, including lighting, will reshape the remaining static models with one which is interactive and adaptable.

Conclusion

The future of lighting appears to be moving toward integrated systems. Integrated lighting control systems are able to adjust several inputs including mode, intensity and color of the LED light, while also monitoring system status. A smart lighting solution is capable of connecting with other monitoring systems (i.e. weather sensing, camera enabled) helping to make more accurate decisions. The addition of having accurate data from which to help make more accurate decisions is crucial for the cities of the future. Cities are looking to build fault tolerance through developing off-grid and alternative power lighting solutions. According to International Energy Agency (IEA) estimates, more than 114 TWh of electricity is consumed globally on road/street lighting per year (International Energy Agency 2006). Road and street lighting costs on average 11.4 billion US dollars per year (Todorović & Samardžija, 2017). This of course varies greatly based upon local energy costs, usage of system, efficiency of current system. Overall costs can be greatly reduced with an integrated system. A solar and wind hybrid powered self-sustaining system with remote monitoring would have the ability to generate its own power while effectively managing the lighting needs of the community, providing reduced load to the grid and increased disaster tolerance.

Chapter 3 Research Methodology

Introduction

This research was designed by synthesizing current relevant information and documentation in the smart lighting arena. An emphasis was placed on the history of artificial light, light pollution, off-grid solutions, and smart lighting system integration. The research design for this study incorporates a combination of qualitative and quantitative collection. All survey and interview participants were informed that information collected would be used as part of a research capstone. Data was collected during the period, November 1 - 30, 2018

A survey of 19 questions (Appendix B) was developed through SurveyMonkey for distribution though social media outlets. The survey used a Likert scale for 12 question, 5 questions were collecting demographic information, 2 questions were open response. The Survey was developed and intended to gain an insight from the community in the following areas:

- Determine understanding of smart lighting solutions
- Determine areas of importance for a smart lighting project in Monterey
- Determine community desire for smart lighting projects in the City of Monterey
- Determine opinions on efficacy of varying lighting technologies
- Determine public sentiment on government capability to fulfill a smart lighting project

A key to successful completion of the research for the project was conducting key informant interviews. The author conducted 7 key informant interviews (Appendix C) with individuals from several individuals from city departments, lighting industry professionals, and smart lighting researchers. The interviews were semi-structured focusing on the relevance of a smart lighting project to the individual being interviewed.

Site visits were also conducted with visits to Monterey city council meetings and attendance of a Smart City summit in Washington, DC. During the site visits several short semi-structured interviews were conducted with decision makers from various cities with varying levels of experience in smart city and smart lighting planning and implementation.

Research Hypotheses

The research hypothesis examined in this study was: the implementation of a smart lighting solution will improve the City of Monterey's ability to provide a lighting system which creates cost savings, reductions in emissions, decreased light pollution, and interoperable compatibility with emerging smart technologies.

Operational Definitions

Kilowatt hour (kWh) – This is a unit of measure used for tracking electricity

Implementation roadmap – A plan which includes future planning items which be put into place

Cross-functional collaboration – Having work teams which are comprised of individuals from varying functional areas

Population Sampling Strategy

This study was conducted by sampling individuals from departments within the city and community members. The key informant interviews with varying city employees was meant to represent varying stakeholders from across the city employee landscape.

Procedure

The research was conducted through surveys, which were disturbed through social media outlets attempting to target varying demographics, face-to-face interviews conducted with key stakeholders, and site visits to Monterey city council meetings and a national smart city conference in Washington, DC. The interviews, survey data, and discussions from the smart city conference were tallied and interpreted with the report of findings included in chapter 4.

Variables

Dependent Variable

Dependent variable in this study is the lighting solution in place across the City of Monterey.

Independent Variable

The independent variables explored in this research were:

6. Cost to power lighting grid
7. Emissions from lighting
8. Disaster tolerance
9. Lighting poles with interoperable compatibility
10. Light pollution

These independent variables were examined to determine whether or not their relationship to the dependent variable affected the efficacy in providing power to the lighting grid within Monterey.

Controlling for External and Internal Validity

Solutions which may be implemented by the City of Monterey can be evaluated against cities and regions which have already implemented smart lighting solutions. These comparisons can help to build best practices across cities and regions of varying sizes.

Internal validity of this research will be evaluated by acceptance of criteria and initiative idea which are supported by the decision makers within the City of Monterey.

Summary

Upon research conclusion and information collection, all data points coming from surveys and key informant interviews were collated and analyzed helping to demonstrate the benefit and importance of implementing a smart lighting solution for the City of Monterey.

Chapter 4 Results and Findings

This section provides an examination and analysis of the raw data collected for the study and the researcher's findings related to the hypothesis of a smart lighting solution for the City of Monterey. With the following questions in mind: What does the information collected indicate? What does it mean? This chapter provides the reader with the essential elements to answer the main subject of the research.

Overview of Results

This research project consisted of two components: the first component consisted of individual interviews with key informant subject matter experts and city employee to discuss and examine smart lighting solutions. The second component consisted of a survey which was used to collect and analyze opinions from the local community members on smart lighting solutions.

Results and Findings from Interview Data

Interviews were conducted through several methods: first being face to face and over the telephone discussion. The interviews were semi-structured with an agreed upon set of discussion topics, with the ability to cover other topics as well. The other interview method consisted of written correspondence with a pre-determined set of questions.

Interview 1

The first interview was with Terry Yates, a Smart City & IT Project Manager from the Town of Cary, North Carolina. The Town of Cary in early 2018 was selected as a smart city grant

winner. Mr. Yates reported that winning the grant and working on smart city solutions has “had a very positive impact on the town and the community”. Mr. Yates was asked 3 questions with regard to public smart lighting. A paraphrase of his responses to the questions are below:

Question 1 – What role has smart lighting played in your town?

The Town of Cary did not initially see lighting as an important consideration for projects. After beginning the process of deciding upon projects, a smart lighting system was seen as one which would have a quickly seen and measurable value. The town has set out to deploy a smart lighting platform to monitor and control the lighting system.

Question 2 – What are the main goals for smart lighting in the town?

The Town of Cary intends for the smart lighting program to reduce costs, emissions and light pollution, and also increase public safety.

Question 3 – Could you see smart lighting as a foundation on which you could build out additional services and capabilities?

Yes. The smart lighting system is seen as “one which could have services built out upon it”. The Town of Cary is starting with monitored and controlled lighting areas and working to expand the capability and services.

Interview 2

The second interview was with Mehdi Ganji, PhD Electrical and Electronics Engineering, and Adjunct Professor at Illinois Institute of Technology (IIT). IIT is part of a research program in conjunction with the Department of Energy studying smart lighting solutions. IIT has received more than 65 million dollars in support of various areas of research including micro-grid, wind turbine and smart grid workforce training. IIT has also helped the City of Chicago with a smart lighting deployment. Doctor Ganjij was asked 3 questions about smart lighting projects.

Question 1 – How should smart lighting projects be used by cities?

Doctor Ganji reported that a “smart lighting initiative can be a great way to begin innovation projects for a city. Lighting systems which provide multiple services and capabilities for small towns and cities is a key element in supporting future development goals.”

Question 2 – What has been the most effective off-grid smart lighting system?

Through research conducted to date the method with both solar and wind-turbine power has provided the best results.

Question 3 – What challenges do you see to implementing a smart lighting system?

One major hurdle is deciding upon placement and type of connection, either off-grid or connected to the local energy grid. There can be weather challenges if using off-grid technology to power the lights as conditions may not be ideal for long periods of inclement weather.

Interview 3

Interview number 3 was with Fanny Soulard a lighting designer at Concepto in France. She has worked internationally on lighting projects with industry thought leaders and has deep knowledge of industry standards and practices.

Question 1 – What are your thoughts on the sustainability of outdoor lighting?

"We haven't developed any wind solution for outdoor lighting yet. We began to use solar paving or solar decorative luminaires only. We have not seen any solar projectors with enough autonomy to provide enough luminous flux for a peaton pathway."

Question 2 – What outdoor lighting methods are on the horizon?

"On some cycle paths we are testing phosphorescent and we are pretty convinced about the potential this material can provide in the future."

Question 3 – How does light pollution play into urban lighting plans?

“Instead of providing light, we usually prefer to switch off as much lighting equipment as we can, drawing "dark infrastructures" where we find necessary. (protecting nocturnal wildlife and creating some breaks in night panoramas).”

Interview 4

Interview number 4 was with a key informant within the Information Resources Division (IRD), City of Monterey. The idea of a smart lighting project and potential roadblocks were discussed.

Question 1 - Does the organization play any role in support of the street lighting system?

The IRD does not currently play a direct role in supporting the street lighting system in Monterey. However, there is interest and capacity for the department to manage the system if it were to be approved.

Question 2 - What roadblocks, if any, could impede an integrated street lighting system?

Sometimes in a city it can be hard to gain consensus on projects and technology. There are those in the community who may not understand and therefore oppose new technologies. Getting to an agreement on a project is often times about education on the technology and its capabilities.

Question 3 - Is there a roadmap for an upgrade of the lighting grid?

That is not an item currently on the agenda but open to hearing ideas.

Interview 5

The fifth interview was with a key informant from the Administrative Division, City of Monterey. The discussion was around smart city and lighting initiatives in the City of Monterey.

Question 1 - Does this organization play a role in planning for the street lighting system?

The Administrative Division does not play a role in with street lighting for the city.

Question 2 – Could a smart lighting project be successful in Monterey?

Depending on the technology chosen and the support from the community and city council it could be possible. The city is working to modernize its capabilities and services to meet the needs of the citizens.

Interview 6

Interview number 6 was conducted with a key informant from the Fleet and Streets Operations Division, City of Monterey. The discussion focused on street lighting and smart lighting potential for Monterey.

Question 1 - What role does this organization play in the upkeep of the street lighting system?

The city is responsible for the upkeep of 3127 street lights within the city limits. The upkeep includes maintenance to the pole and lighting unit. This includes replacing a pole if knocked down and replacing bulbs as they go out.

Question 2 - What is the current budget for street lighting?

The budget for the department is $127,100. This includes all labor cost and equipment.

Question 3 - Is there a roadmap for upgrades to the lighting grid?

The city moved to replace a majority of the old HPS bulbs in 2012. There are still a few parking lots which have the old HPS bulbs, but most of the lights which the city is responsible for have been replaced. There is not a plan to connect the streetlights through monitoring hardware, but it could improve response time to maintenance actions required if there were a monitoring system which could notify administrators of a problem when detected.

Significant Findings / Conclusions from Interview Data

Based on the interviews conducted, the following conclusions about a smart street lighting solution were determined:

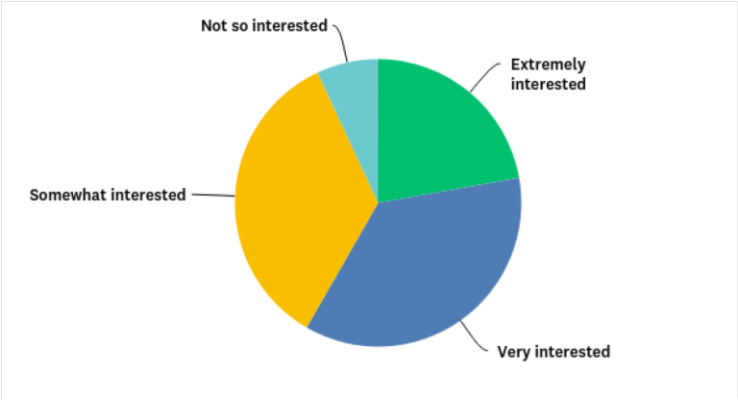
- Have capacity to be remotely controlled and monitored for support needs.
- Light reduction and energy grid demand decrease should be key priorities for any smarty lighting solution

- Mandatory feedback cycle with the community about concerns and interest with any smart lighting solution
- Collaboration is an essential element for successful smart lighting solutions
- Off-grid smart lighting solutions offer disaster tolerance and increased grid resiliency

Results and Findings from Survey Data

Q1: What is your relationship with technology?

Answered: 72 Skipped: 0



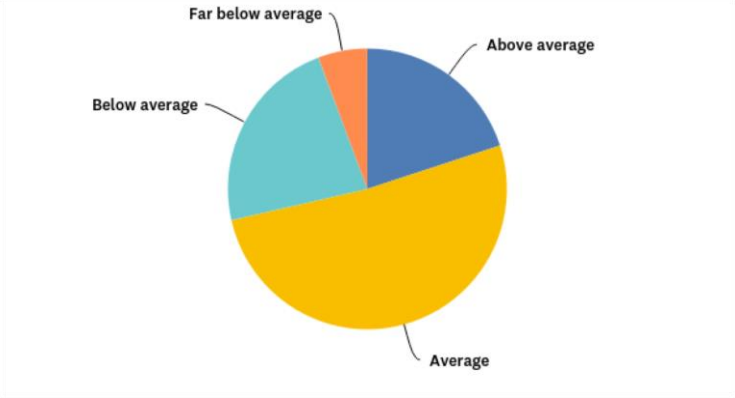
Q1: What is your relationship with technology?

Answered: 72 Skipped: 0

ANSWER CHOICES	RESPONSES	
Extremely interested	22.22%	16
Very interested	36.11%	26
Somewhat interested	34.72%	25
Not so interested	6.94%	5
Not at all interested	0.00%	0
TOTAL		72

Q2: To what extent, if any, do you feel the local government effectively uses technology to understand and solve problems?

Answered: 70 Skipped: 2



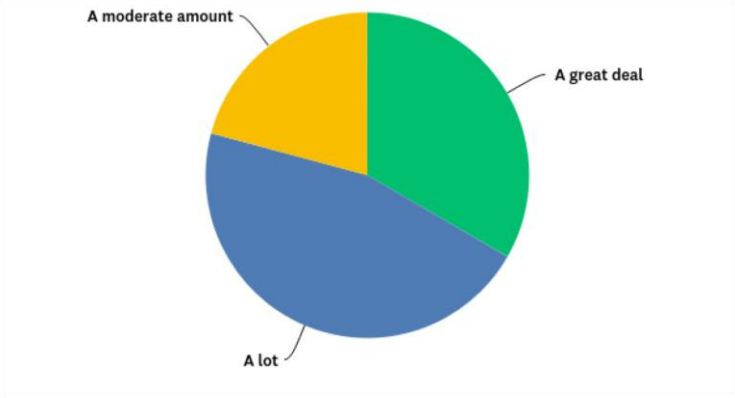
Q2: To what extent, if any, do you feel the local government effectively uses technology to understand and solve problems?

Answered: 70 Skipped: 2

ANSWER CHOICES	RESPONSES	
Far above average	0.00%	0
Above average	20.00%	14
Average	51.43%	36
Below average	22.86%	16
Far below average	5.71%	4
TOTAL		70

Q3: To what extent, if any, do you feel local government should use technology to understand and solve problems?

Answered: 72 Skipped: 0



Q3: To what extent, if any, do you feel local government should use technology to understand and solve problems?

Answered: 72 Skipped: 0

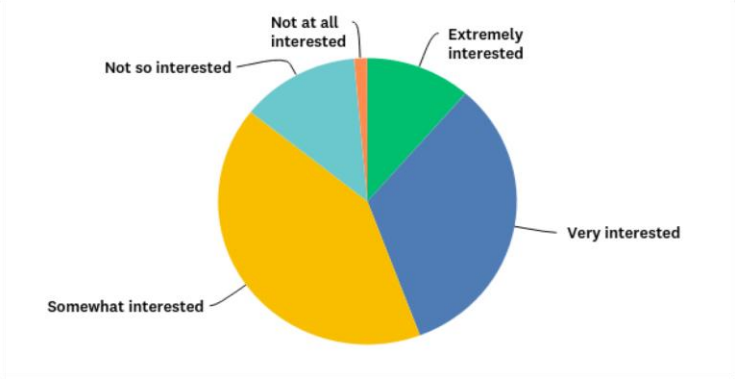
ANSWER CHOICES	RESPONSES	
A great deal	33.33%	24
A lot	45.83%	33
A moderate amount	20.83%	15
A little	0.00%	0
None at all	0.00%	0
TOTAL		72

Question 4 – In what areas would you like to see the local government focus in term of innovation, technology and community improvement (Optional)?

There were 43 respondents to this question with a varied number of responses. Approximately 23.26% of respondents stated street lighting and general outdoor lighting as primary areas for government focus. Communication came in next position with 13.95%. No other comments on this question reached above a 10% threshold.

Q5: What is your level of interest in Smart Lighting initiatives?

Answered: 70 Skipped: 2



Powered by SurveyMonkey

Q5: What is your level of interest in Smart Lighting initiatives?

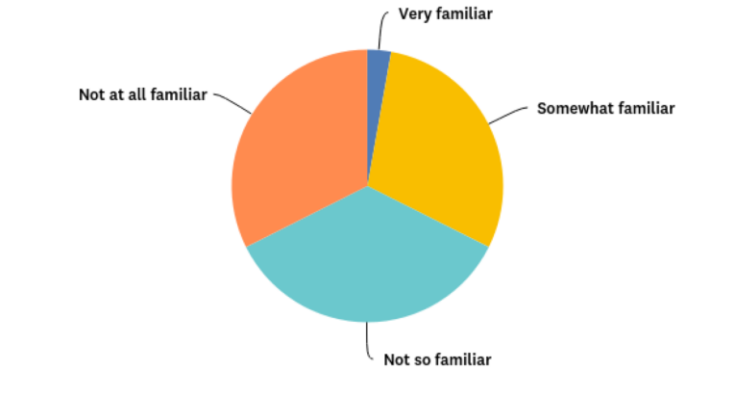
Answered: 70 Skipped: 2

ANSWER CHOICES	RESPONSES	
Extremely interested	11.43%	8
Very interested	32.86%	23
Somewhat interested	41.43%	29
Not so interested	12.86%	9
Not at all interested	1.43%	1
TOTAL		70

Powered by SurveyMonkey

Q6: What is your level of knowledge in Public Smart Lighting initiatives?

Answered: 71 Skipped: 1



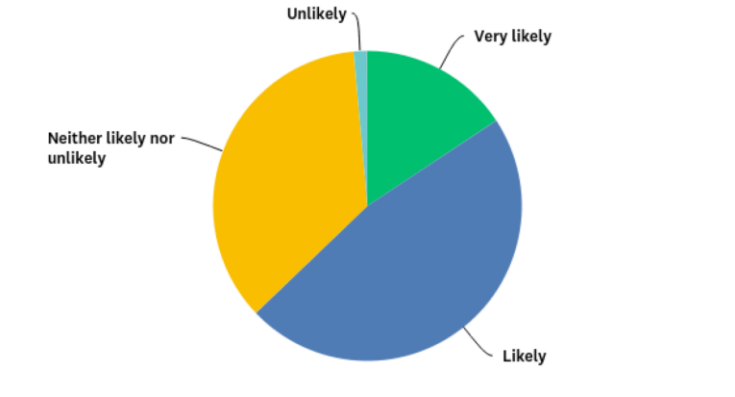
Q6: What is your level of knowledge in Public Smart Lighting initiatives?

Answered: 71 Skipped: 1

ANSWER CHOICES	RESPONSES	
Extremely familiar	0.00%	0
Very familiar	2.82%	2
Somewhat familiar	29.58%	21
Not so familiar	35.21%	25
Not at all familiar	32.39%	23
TOTAL		71

Q7: How likely would you be to support a "Smart Lighting" initiative?

Answered: 70 Skipped: 2



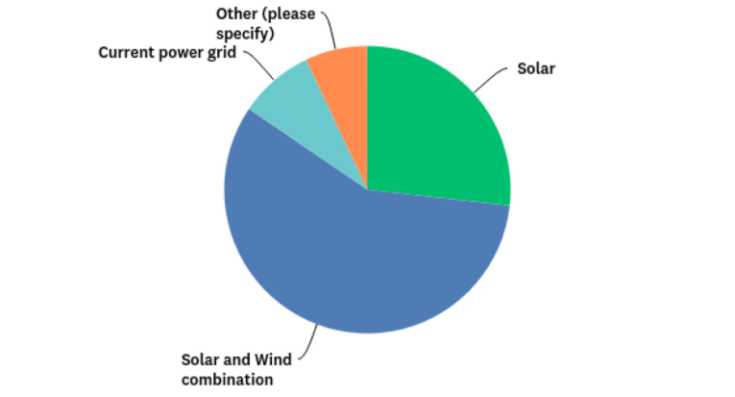
Q7: How likely would you be to support a "Smart Lighting" initiative?

Answered: 70 Skipped: 2

ANSWER CHOICES	RESPONSES	
Very likely	15.71%	11
Likely	47.14%	33
Neither likely nor unlikely	35.71%	25
Unlikely	1.43%	1
Very unlikely	0.00%	0
TOTAL		70

Q8: If a "Smart Lighting" initiative were brought for discussion, which do you feel would be the best option for providing power to that system?

Answered: 71 Skipped: 1



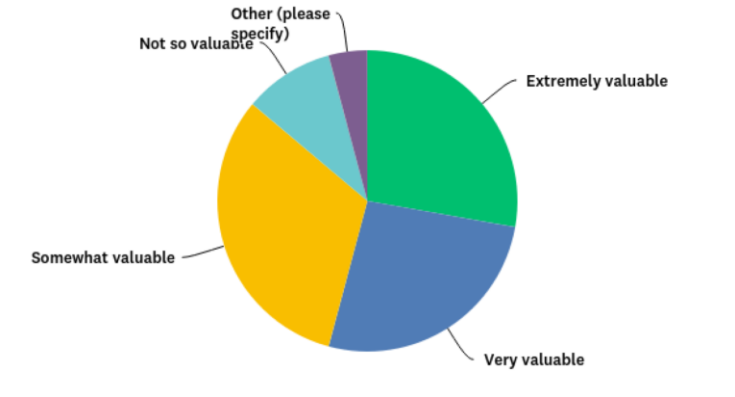
Q8: If a "Smart Lighting" initiative were brought for discussion, which do you feel would be the best option for providing power to that system?

Answered: 71 Skipped: 1

ANSWER CHOICES	RESPONSES	
Solar	26.76%	19
Solar and Wind combination	57.75%	41
Wind	0.00%	0
Current power grid	8.45%	6
Other (please specify)	7.04%	5
TOTAL		71

Q9: Is light pollution (light which encroaches upon the darkness of the night) an issue which city government should address?

Answered: 72 Skipped: 0



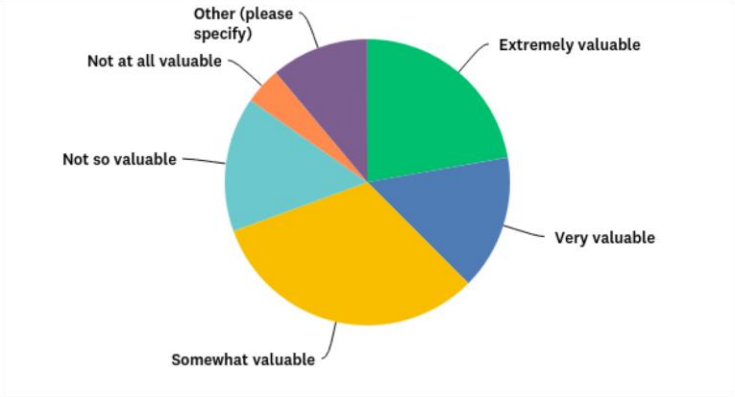
Q9: Is light pollution (light which encroaches upon the darkness of the night) an issue which city government should address?

Answered: 72 Skipped: 0

ANSWER CHOICES	RESPONSES	
Extremely valuable	27.78%	20
Very valuable	26.39%	19
Somewhat valuable	31.94%	23
Not so valuable	9.72%	7
Not at all valuable	0.00%	0
Other (please specify)	4.17%	3
TOTAL		72

Q10: How valuable is it, if at all, that public outdoor lighting be shut off when there are no people or traffic in the area?

Answered: 72 Skipped: 0



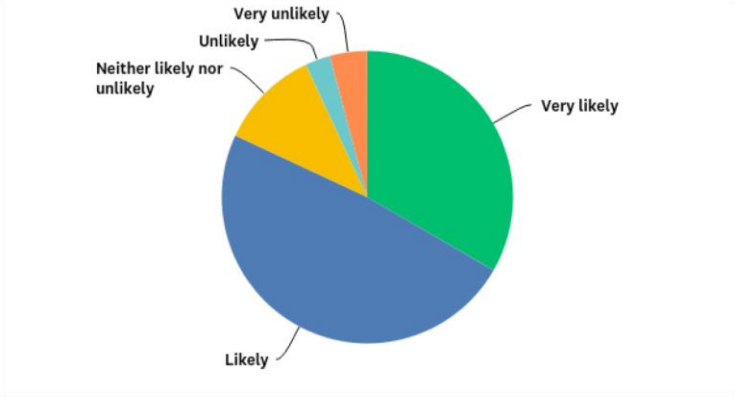
Q10: How valuable is it, if at all, that public outdoor lighting be shut off when there are no people or traffic in the area?

Answered: 72 Skipped: 0

ANSWER CHOICES	RESPONSES	
Extremely valuable	22.22%	16
Very valuable	15.28%	11
Somewhat valuable	31.94%	23
Not so valuable	15.28%	11
Not at all valuable	4.17%	3
Other (please specify)	11.11%	8
TOTAL		72

Q11: To what extent, if any, would you support a public lighting system which could be integrated with other capabilities (i.e. weather monitoring, traffic/pedestrian monitoring)?

Answered: 72 Skipped: 0



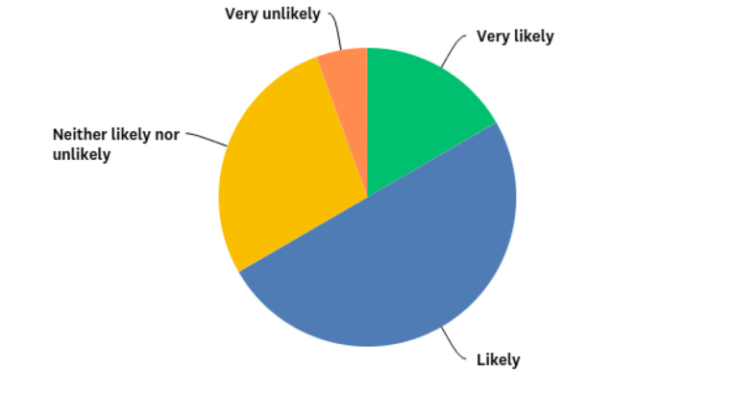
Q11: To what extent, if any, would you support a public lighting system which could be integrated with other capabilities (i.e. weather monitoring, traffic/pedestrian monitoring)?

Answered: 72 Skipped: 0

ANSWER CHOICES	RESPONSES	
Very likely	33.33%	24
Likely	48.61%	35
Neither likely nor unlikely	11.11%	8
Unlikely	2.78%	2
Very unlikely	4.17%	3
TOTAL		72

Q12: To what extent, if any, would you support a connected public lighting system which could be monitored and controlled remotely?

Answered: 72 Skipped: 0



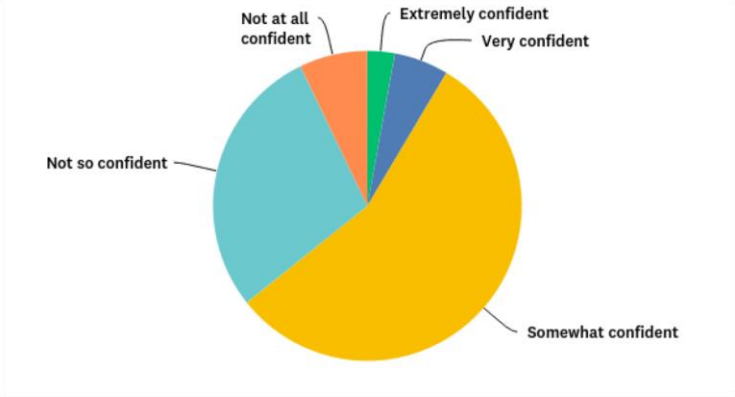
Q12: To what extent, if any, would you support a connected public lighting system which could be monitored and controlled remotely?

Answered: 72 Skipped: 0

ANSWER CHOICES	RESPONSES	
Very likely	16.67%	12
Likely	50.00%	36
Neither likely nor unlikely	27.78%	20
Unlikely	0.00%	0
Very unlikely	5.56%	4
TOTAL		72

Q13: How confident are you in the ability of local government to carry out a Public Smart Lighting project?

Answered: 70 Skipped: 2



Q13: How confident are you in the ability of local government to carry out a Public Smart Lighting project?

Answered: 70 Skipped: 2

ANSWER CHOICES	RESPONSES	
Extremely confident	2.86%	2
Very confident	5.71%	4
Somewhat confident	55.71%	39
Not so confident	28.57%	20
Not at all confident	7.14%	5
TOTAL		70

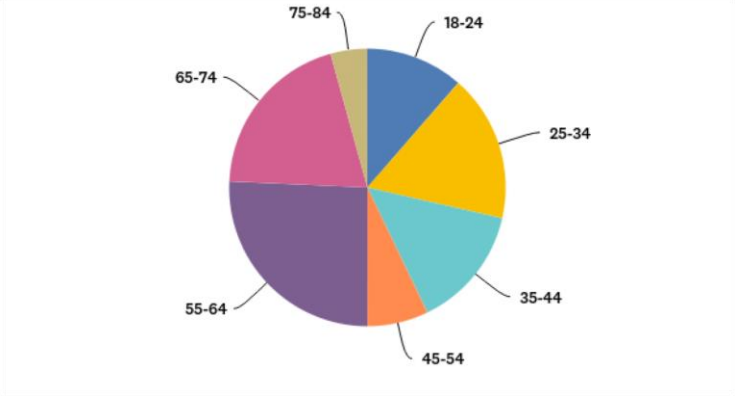
Demographic Questions

Question 14 – In what city do you live?

As the survey was sent out through social media, this question was asked to determine how many respondents were from the City of Monterey and if the idea of smart lighting was of interest in surrounding communities as well. There were 70 respondents to this question with 42.86% living in Monterey. The other respondents were from surrounding communities which could partner with the City of Monterey in any smart lighting solution.

Q15: What is your age?

Answered: 70 Skipped: 2



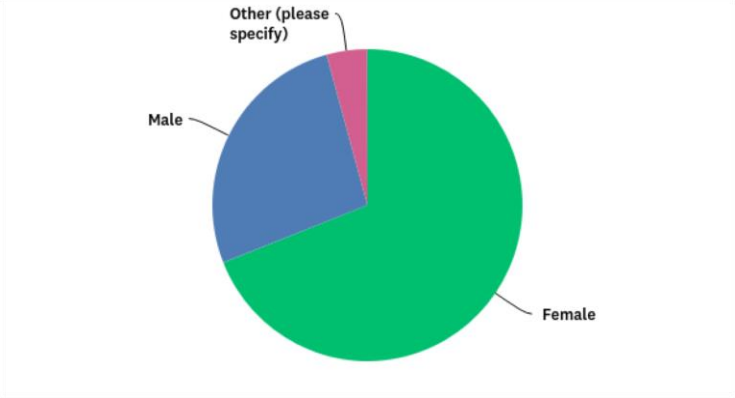
Q15: What is your age?

Answered: 70 Skipped: 2

ANSWER CHOICES	RESPONSES	
Under 18	0.00%	0
18-24	11.43%	8
25-34	17.14%	12
35-44	14.29%	10
45-54	7.14%	5
55-64	25.71%	18
65-74	20.00%	14
75-84	4.29%	3
85-99	0.00%	0
99+	0.00%	0
TOTAL		70

Q16: How do you identify?

Answered: 71 Skipped: 1



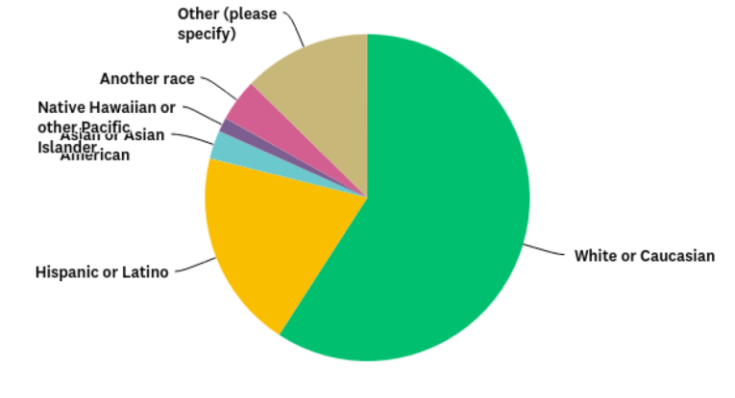
Q16: How do you identify?

Answered: 71 Skipped: 1

ANSWER CHOICES	RESPONSES	
Female	69.01%	49
Male	26.76%	19
Non-binary	0.00%	0
Transgender Male	0.00%	0
Transgender Female	0.00%	0
Gender Variant / Non-Conforming	0.00%	0
Other (please specify)	4.23%	3
TOTAL		71

Q17: What is your race or ethnic category?

Answered: 71 Skipped: 1



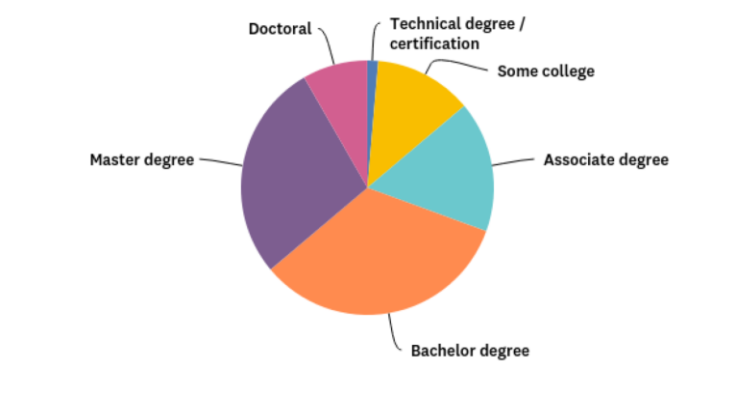
Q17: What is your race or ethnic category?

Answered: 71 Skipped: 1

ANSWER CHOICES	RESPONSES	
White or Caucasian	59.15%	42
Black or African American	0.00%	0
Hispanic or Latino	19.72%	14
Asian or Asian American	2.82%	2
American Indian or Alaska Native	0.00%	0
Native Hawaiian or other Pacific Islander	1.41%	1
Another race	4.23%	3
Other (please specify)	12.68%	9
TOTAL		71

Q18: What is your level of education

Answered: 72 Skipped: 0



Q18: What is your level of education

Answered: 72 Skipped: 0

ANSWER CHOICES	RESPONSES	
High school / GED	0.00%	0
Technical degree / certification	1.39%	1
Some college	12.50%	9
Associate degree	16.67%	12
Bachelor degree	33.33%	24
Master degree	27.78%	20
Doctoral	8.33%	6
TOTAL		72

Question 19 – Please share and ideas, thoughts and / or feedback on this topic

There were 25 responses on the final question. The main take away was that respondents were interested in more information on the specifics of what a smart lighting project would look like and a need to reevaluate lighting ordinances for the cities.

Significant Findings / Conclusion from Survey Data

According to the survey results 93.05% of the community respondents stated having a positive relationship with technology. The respondents reported at a rate of 100% they feel local governments should be using technology to understand and solve problems facing the communities. According to the results of the survey, there is a gap between what the community expects of the government use of technology and their perception of how effective

local governments actually are with their use of technology. The survey showed that 80% of respondents feel that local governments are average or below at effectively using technology to help understand and solve issues facing the community.

The survey showed that 85.72% of respondents were interested in smart lighting initiatives, with 62.85% reporting they would support a smart lighting initiative if brought forward and 35.71% of respondents remaining undecided. According to the survey there is a lack of knowledge about smart lighting with 67.6% of respondents reporting having little to no knowledge on the topic. This lack of knowledge may be the reason for the respondents who were undecided.

Light pollution is an area of importance to the community according to the survey with 86.11% of respondents reporting somewhat important or higher. A lighting system which is connected and remotely controlled is supported by 67.76% of respondents. According to the survey, to assist with light pollution reduction 69.44% of respondents reported shutting lights off when no pedestrians of vehicles are present would be helpful.

The respondents were asked about various technologies to supply power to a smart lighting system. Respondents replied with 26.76% feeling solar alone was the best option and 57.75% feeling an option which has both solar and wind power would be best. The option of having a system which is supported by both solar and wind is in agreement with the results of studies by IIT on smart lighting systems.

According to the survey, 81.94% of respondents support a smart lighting system which could be integrated with other systems such as weather, traffic and pedestrian monitoring

services. The survey shows a lack of confidence in the ability of local government to carry out such a project with on 8.57% of respondents reporting a high level of confidence.

According to the survey the community supports a smart lighting system which can be integrated, controlled remotely and powered through means other than the current connection to the power grid, providing reduced light pollution and cost to the city. The lack of knowledge about smart lighting and the lack of faith in the ability of the government to use technology to effectively carry out such a project are areas which stand out from the results.

Chapter 5: Conclusion and Recommendations

Conclusion

The data in the literature review, as well as in the research, support the hypothesis that the implementation of a smart lighting solution would improve the City of Monterey's ability to provide cost savings, reductions in emissions, decreased light pollution, disaster tolerance and interoperable compatibility with emerging smart technologies. The data gathered suggested there is evidence to support a smart lighting solution implementation in the City of Monterey.

A smart lighting solution for the City of Monterey should focus on the following areas which are supported through the survey results and by other smart lighting implementations globally.

- Identify key areas where light is most critical and begin implementation there.
- Collect and Analyze additional community feedback as smart lighting solutions are deployed.
- Monitor the effect of light on the natural habitat measuring any change as smart lighting solutions are implemented.
- Reevaluate lighting codes to meet modern environmental standards.
- Develop a roadmap to address identified areas of concern from the community.

Addressing the focus areas mentioned above, will allow the City of Monterey to focus efforts on incorporating the following recommendations.

Recommendation 1 – Select potential test sites for a smart lighting pilot by February 2019

The City of Monterey should work to select several potential smart lighting pilot sites. These various sites should be evaluated on possible impact to the community and seek feedback from the community as to that perceived impact.

Recommendation 2 – Open a 90-day public comment window in March 2019

Smart lighting can be a foundation to build upon for the City of Monterey. A smart lighting solution provides the capability to control the lighting remotely to more effectively service the community, reduce impact on the environment, and create cost savings for the city. There is interest from the community members as supported by the survey but there is also a lack of knowledge and skepticism about the ability to effectively carry out such a task.

The local government must reach out to the community with simple to understand information that clearly defines the goals and benefits of such a system to create buy-in. The city should host an informational session to gather feedback and ensure they are representing all voices.

Recommendation 3 – Prepare project proposal by June 2019

The City of Monterey should have project proposals ready by June 2019 for submission to various smart city grant opportunities given annually. A primary target for grant funding locally should be Monterey Bay Community Power, but a larger focus on potential regional and national grant funding should also be targeted.

Recommendation 4 - Create collaboration with surrounding communities and institutions

The research and past implementations show that collaboration is essential to success with smart solution implementation. The City of Monterey must look to define potential partners in the region which could support and collaborate on smart lighting implementations in the region. Other successful cities have created innovation collaboration teams which are comprised of cross-functional teams from industry, academia, policy makers, and community members. Having input from each of the various sectors allows for a more cohesive plan which can be scaled and developed in conjunction with other key stakeholders, reducing the burden on each.

Recommendation 5 – Review 2019 California Energy Commission policy updates

The City of Monterey must stay current with updated energy policy guidance at the state, national and international level. As new standards are set, local governments must look to align policies and determine how to best align through regional innovation collaboration solutions.

Recommendation 6 - Start small, create momentum, be flexible, design for the future

Undertaking innovation and infrastructure projects can be a challenge. As recommended by others who have begun on the smart solution journey, start small. Create a pilot or small test region of smart lighting where the community can go and evaluate and provide feedback on the system. A small pilot allows to quickly show the value and to make adjustments based on community feedback and performance in local conditions. Flexibility to adjust the plan as

needed is a key element of a connected and remotely controlled lighting system allowing changes to the lighting solution as needed.

Think and design for the future. If you solve the problem for today what will you do tomorrow? Solutions for the City of Monterey must be forward thinking, looking to the future needs of the community and how to best serve and address those. Other cities and communities which are on the forefront of the smart lighting movement can be models on which Monterey can build and adjust to the needs of their coastal community. A well-executed smart lighting solution will allow the City of Monterey to scale capabilities and services into the future, providing added benefit to the community, reducing impact on the environment through reduced light pollution and emissions. A smart lighting solution for the City of Monterey is a key to future development and sustainment of the community.

Possible Barriers to implementation

The City of Monterey faces policy challenges when it comes to technical concerns such as RF signal strength in neighborhoods and its potential negative effects. These issues are currently being further explored and data must be provided on any potential smart lighting solution installation. Information must be explained in easy to understand terminology which residents can understand to be able to provide informed feedback.

Leaders must ensure they are able to reach influential community members at the public who have strong community support and understanding. These members of the community are key to helping leaders bridge the gap in ensuring any solution implemented will effectively meet the needs of the citizens.

Areas for Further Research

Globally energy trends are a high priority for research being conducted. The City of Monterey must continually look to understand where the current research trends are heading and how they may affect the community.

Li-fi is an emerging technology which transmits data over light waves. This technology could eventually help to reduce data transmission loads over the RF spectrum as the technology develops over the coming years.

The City of Monterey should follow emerging battery storage capabilities and look to partner with local universities and businesses developing such technologies which could benefit any smart lighting solution implementation.

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Appendix A

Community Survey Questions

Question 1- What is your relationship with technology?

Question 2 – To what extent, if any, do you feel the local government effectively uses technology to understand and solve problems?

Question 3 - To what extent, if any, do you feel local government should use technology to understand and solve problems?

Question 4 – In what areas would you like to see the local government focus in term of innovation, technology and community improvement (Optional)?

Question 5 – What is your level of interest in smart lighting initiatives?

Question 6 – What is your level of knowledge in public smart lighting initiatives?

Question 7 – How likely would you be to support a smart lighting initiative?

Question 8 – If a smart lighting initiative were brought for discussion, which do you feel would be the best option for providing power to that system?

Question 9 – Is light pollution (light which encroaches upon the darkness of the night) an issue which city government should address?

Question 10 – How valuable is it, if at all, that public outdoor lighting be shut off when there are no people or traffic in the area?

Question 11 – To what extent, if any, would you support a public lighting system which could be integrated with other capabilities (i.e. weather monitoring, traffic/pedestrian monitoring)?

Question 12 – To what extent, if any, would you support a connected public lighting system which could be monitored and controlled remotely?

Question 13 – How confident are you in the ability of local government to carry out a public smart lighting project?

Demographic Questions

Question 14 – In what city do you live?

Question 15 – What is your age?

Question 16 – How do you identify?

Question 17 – What is your race or ethnic category?

Question 18 – What is your level of education?

Question 19 – Please share and ideas, thoughts and / or feedback on this topic

Appendix B

Key Informant Interviews

1. Information Resources Division, City of Monterey

    Semi-structured around smart lighting

Question 1 - Does the organization play any role in support of the street lighting system?

Question 2 - What roadblocks, if any, could impede an integrated street lighting system?

Question 3 - Is there a roadmap for an upgrade of the lighting grid?

2. Fleet and Street Division

    Semi-structured around future roadmap

Question 1 - What role does this organization play in the upkeep of the street lighting system?

Question 2 - What is the current budget for street lighting?

Question 3 - Is there a roadmap for upgrades to the lighting grid?

3. Administration Division

    Semi-structured around city innovation

Question 1- Does this organization play a role in planning for the street lighting system?

Question 2 - Would this organization have any technical problems with supporting a smart lighting system?

4. Fanny Soulard

    Semi-structured around input from design into community planning?

Question 1 - What are your thoughts on the sustainability of outdoor lighting?

Question 2 – What outdoor lighting methods are on the horizon?

Question 3 – How does light pollution play into urban lighting plans?

5. Terry Yates

Semi-structured around input from design into community planning?

Question 1 – What role has smart lighting played in your town?

Question 2 – What are the main goals for smart lighting in the town?

Question 3 – Could you see smart lighting as a foundation on which you could build out additional services and capabilities?

6. Mehdi Ganji

Question 1 – How should smart lighting projects be used by cities?

Question 2 – What has been the most effective off-grid smart lighting system?

Question 3 – What challenges do you see to implementing a smart lighting system?