The emergence of Connected Lighting

ENERGY STAR Products Partners Meeting

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What is a Connected Lamp or Luminaire?

- No industry standard
- DOE SSL Program: controllable and intelligent SSL source (capable of using, or consuming data), one or more network interfaces, one or more sensors (i.e. data producers)
- ENERGY STAR Connected Luminaire (V2.0 Final): A luminaire or retrofit which includes elements or instructions (hardware and software or firmware) required to enable communication in response to consumer-authorized energy or performance related commands and complies with all requirements for connected in the specification. These elements may be resident inside or outside of the base luminaire or retrofit.
- ENERGY STAR Connected Lamp (V2.0 Draft 3): An ENERGY STAR eligible connected lamp includes elements (hardware and software or firmware) or instructions required to enable communication in response to consumer-authorized energy or performance related commands and complies with all requirements for connected lamps in the specification. These elements may reside inside or outside of the base lamp.

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What is driving the emergence of Connected Lighting?

- Significant technology trends driving performance improvements and cost reductions
  - Computing
  - Mobile
  - Intelligence (i.e. microcontrollers), network interfaces, and sensors
- Solid-State Lighting
- Emergence of cloud storage, computing
- Focus on systems and data

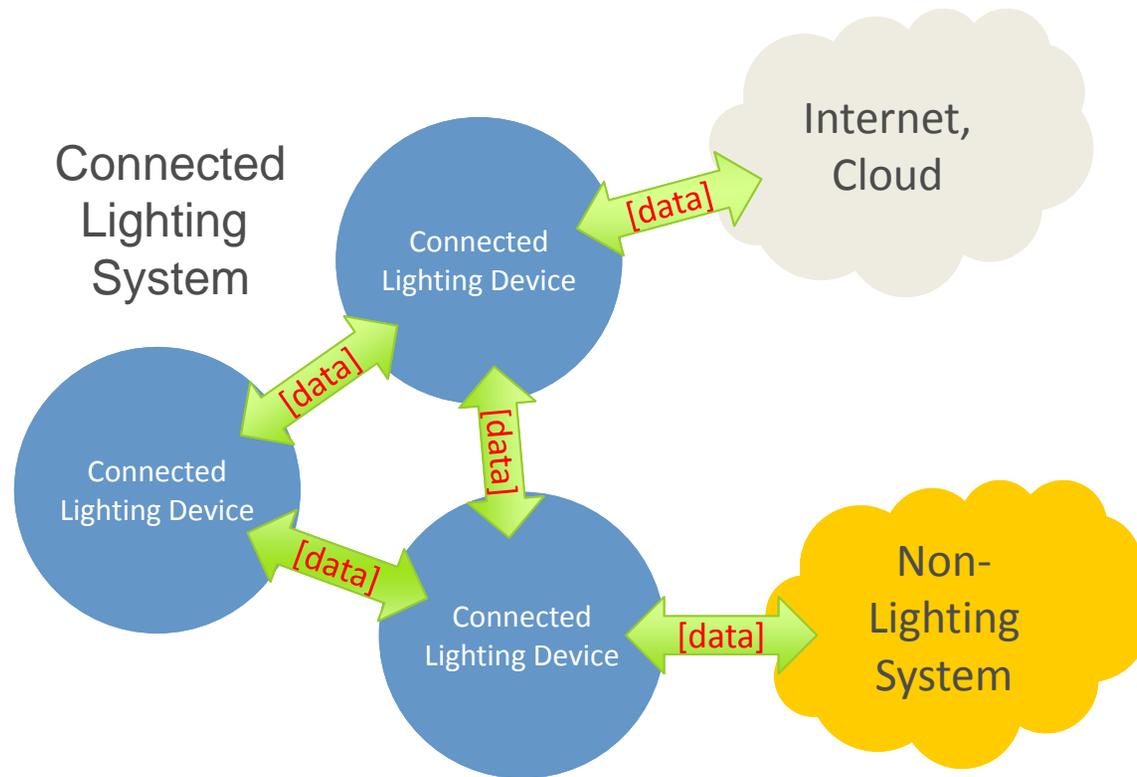U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy
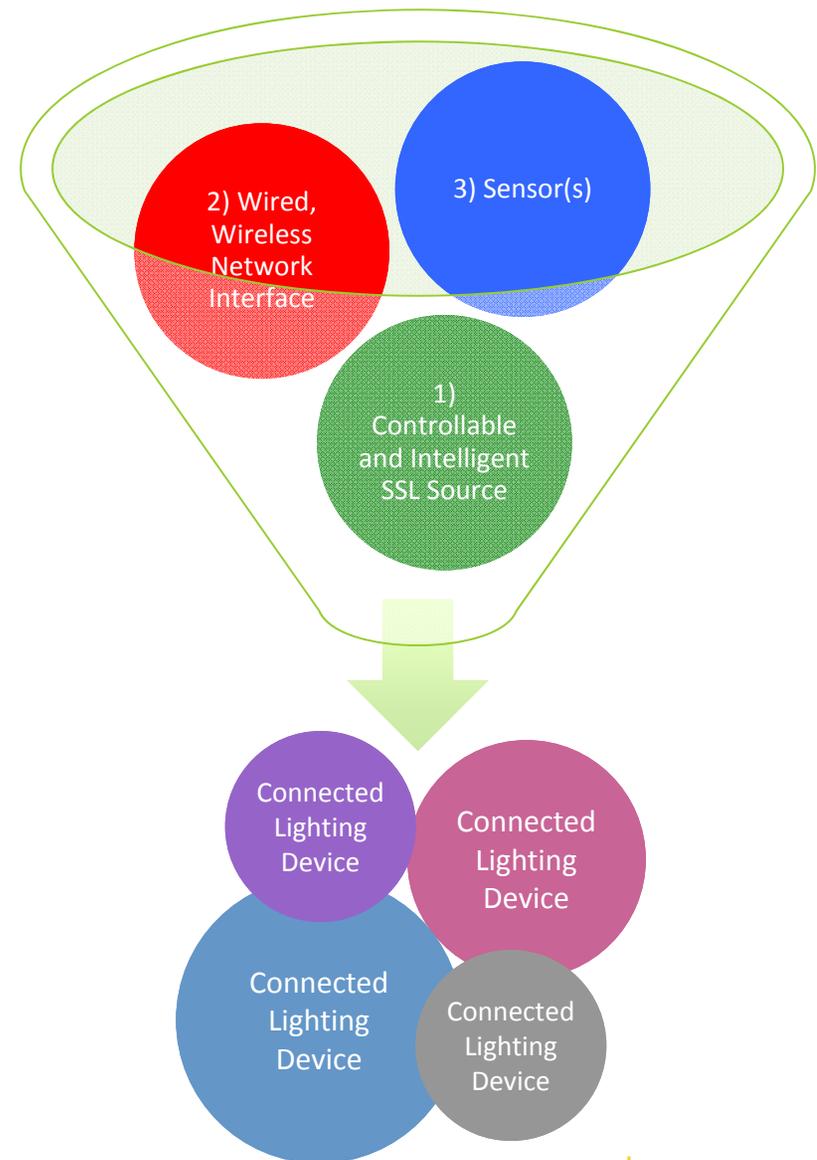
What can Connected Lighting products do today?

- Dimming
- Dim-to-warm
- White or color tuning (single ENERGY STAR product category)
- Notification
- Sensing
- Indoor positioning
- Energy reporting

Where might Connected Lighting go in the (near?) future?

Connected Lighting System

Connected Lighting Device

Connected Lighting Device

Connected Lighting Device

Internet, Cloud

Non-Lighting System

[data]

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How might connected Lighting Systems change lighting?

Opportunity

Enabling intelligent lighting devices with (the right type and amount of) data can result in reduced energy consumption and improved lighting performance
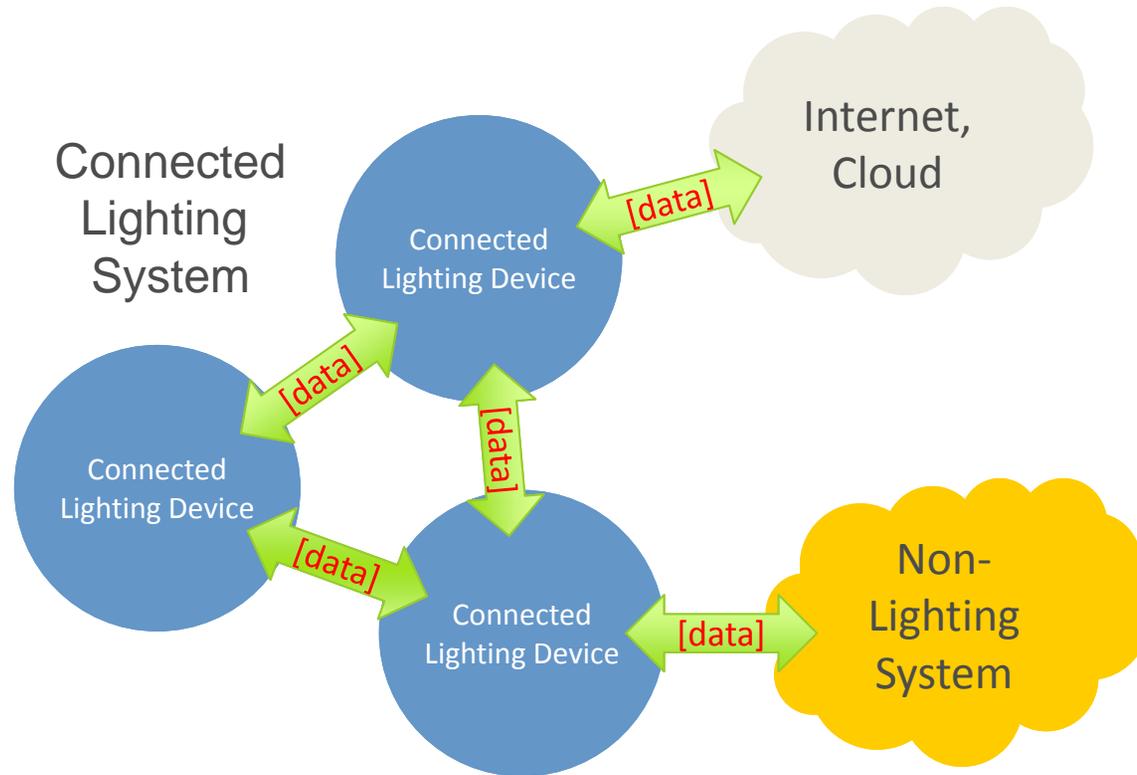
The collected data may enable other revenue streams that compete with lighting and energy performance. **Threat**

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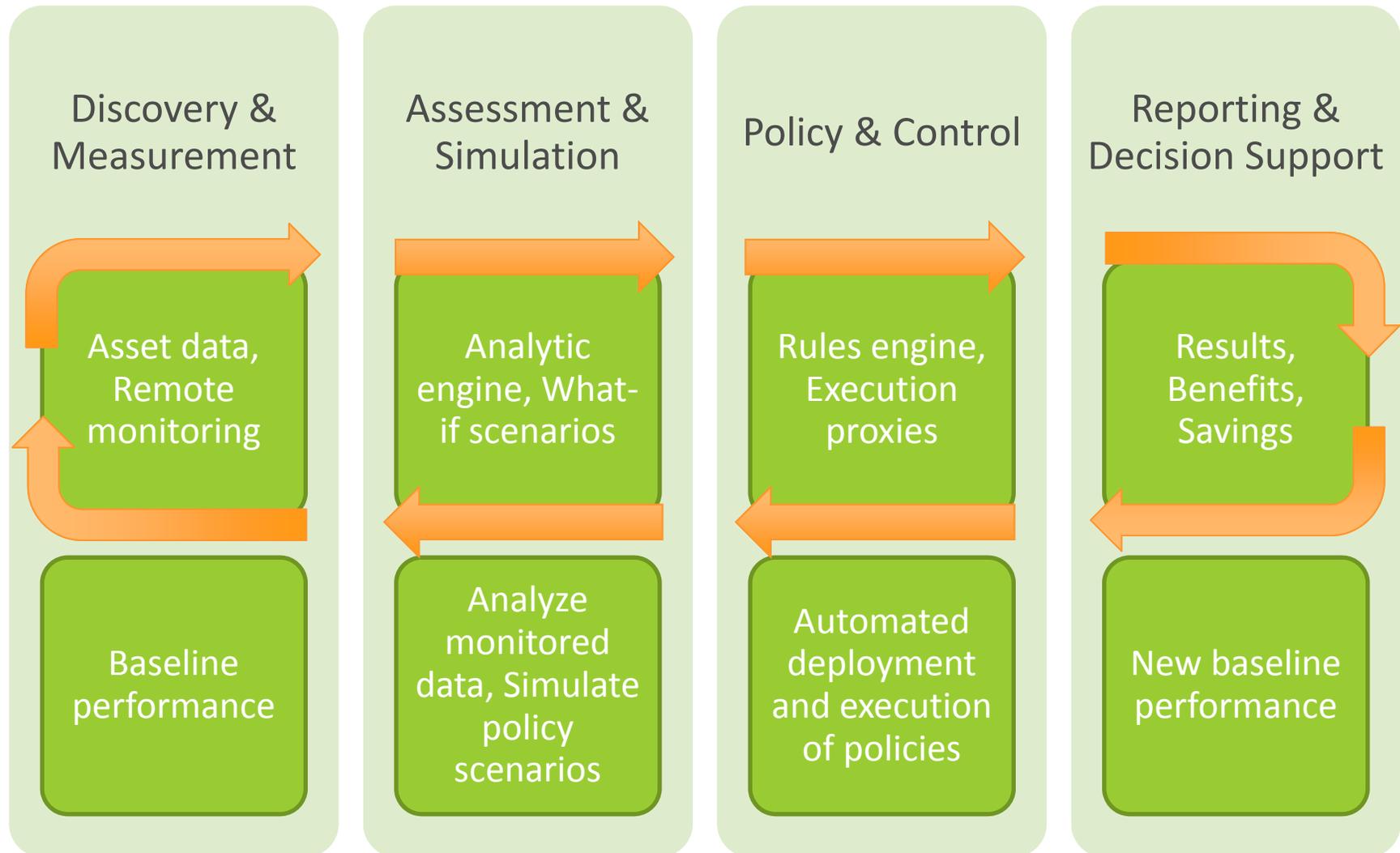# What can we do to enable Connected Lighting?

| Technology Development	Technology Deployment
• Energy reporting, key new features • Interoperability • System configuration • Standards and specifications	• Real-world performance • User engagement and education • High performance product identification
Collaborations	Outcomes
• Industry Consortia • Energy Efficiency Programs • Lighting system designers, integrators	• Increased adoption, viable business models • Data-driven energy management • Transactive energy markets

Energy reporting: why?

- Enable new market opportunities
  - Energy billing for devices currently on flat-rate tariffs
  - Pay-for-performance energy efficiency incentives
  - Lower cost, more accurate energy savings validation for service-based business models
  - Self-characterization of available (i.e. marketable) "building energy services"
  - Verified delivery of utility incented energy transactions e.g. peak and other demand response

- Reduce energy consumption
  - Data-driven energy management
  - Transactive energy markets

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Data driven performance management

Discovery & Measurement	Assessment & Simulation	Policy & Control	Reporting & Decision Support
Asset data, Remote monitoring	Analytic engine, What-if scenarios	Rules engine, Execution proxies	Results, Benefits, Savings
Baseline performance	Analyze monitored data, Simulate policy scenarios	Automated deployment and execution of policies	New baseline performance

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Energy reporting: how?

- Identification of major energy data use cases

- Consideration of implementation cost vs. performance trade-offs

- One or more sets of accuracy, precision requirements that meet use case needs

- Standard accuracy classes, test & measurement methods, pass/fail criteria
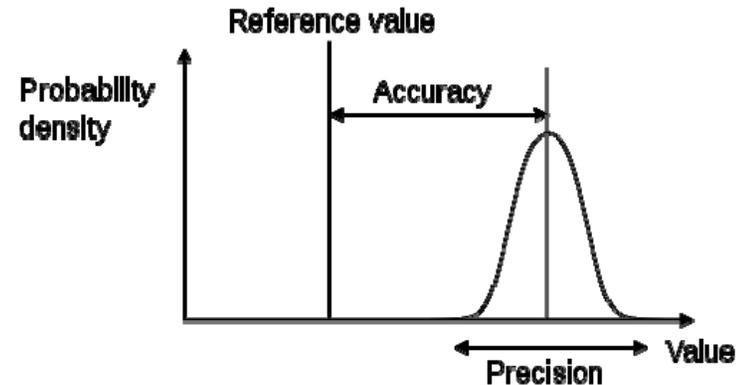
Interoperability: why?

- Facilitates competition
- Facilitates collaboration
- Reduces risk
- Enables choice
- Enables integration
- Reduces cost
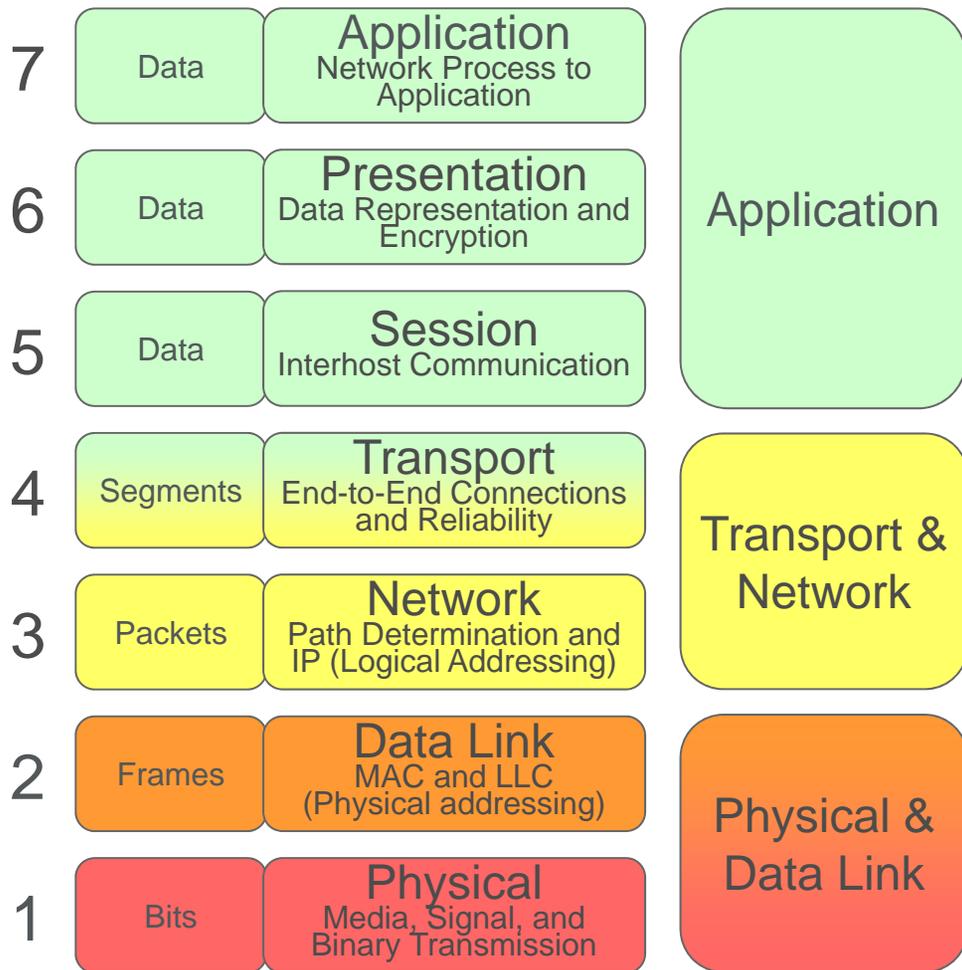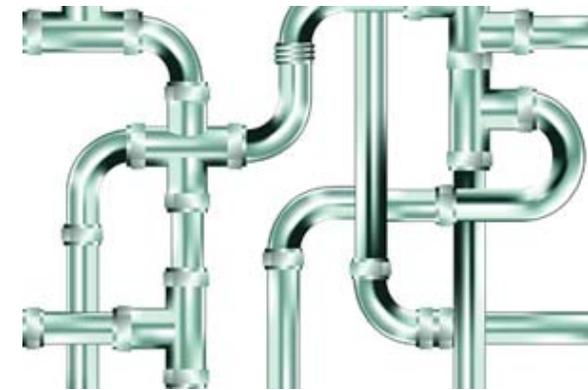- Facilitates greater data exchange

Interoperability: what?

- Compatibility: The ability of two or more devices, applications, networks, or systems to coexist in the same physical environment – that is, operate without corrupting, interfering with, or hindering the operation of the other entity.

- Interoperability: The ability of two or more devices, applications, networks, or systems to work together, and (more specifically) to reliably and securely exchange and readily use data with a common shared meaning.

- Interchangeability: The ability of two or more devices, applications, networks, or systems to be physically exchanged for each other and provide a defined level of identical operation without additional configuration.

Interoperability: what?

OSI Model

7	Data	**Application** Network Process to Application	
6	Data	**Presentation** Data Representation and Encryption	**Application**
5	Data	**Session** Interhost Communication	
4	Segments	**Transport** End-to-End Connections and Reliability	
3	Packets	**Network** Path Determination and IP (Logical Addressing)	**Transport & Network**
2	Frames	**Data Link** MAC and LLC (Physical addressing)	
1	Bits	**Physical** Media, Signal, and Binary Transmission	**Physical & Data Link**

20_kWh 21_kHh
1ab 43c ac5 789
[0010][1001][0101][0101]
0010100101010101

http://en.wikipedia.org/wiki/OSI_model

Interoperability: why now?

2010

Compatibility

1) Interference with broadcast or communication networks (e.g. FCC, CISPR)

2) Phase control and SSL source issues (e.g. NEMA SSL-7a)

2015

Interoperability

1) 0-10V, DALI

2) ZigBee, EnOcean

3) Connected Lighting Alliance, TALQ, ANSI C137, AllJoyn, many others…

2020?

Interchangeability

1) ANSI bases

2) Electrical, mechanical, thermal interfaces (e.g. Zhaga)

3) ANSI C137?

Interoperability: How?

- Leverage, lean on industry consortia and standard development organizations (SDO's)

- Let technology providers and the market pick winners

- Characterize and promote maturity (e.g. compliance testing programs, databases)

- Identify priorities

- Focus: Useable data

- Application layer i.e. information models

- Start with API's

- Power and energy data

- Key non-energy or non-lighting data opportunities?
  - Lighting quality
  - Human factors
  - Non-energy benefits
  - Non-lighting systems

11.1 Source Start Time: All Luminaires (Exempt: Outdoor Luminaires)

Source Type	ENERGY STAR Requirements	Methods of Measurement and/or Reference Documents	Supplemental Testing Guidance
Fluorescent	Light source shall remain continuously illuminated within 750 milliseconds of application of electrical power.	Method of Measurement: ENERGY STAR Start Time Test Method	Laboratory test results shall be produced using the specific models of lamp and ballast or LED package, LED module or LED array and LED driver that will be used in production.
Solid State			
Connected Luminaires All sources	Light source shall remain continuously illuminated within 1 second of application of electrical power.	Reference Documents: ANSI C82.11 Consolidated-2002 Section-5.2	Sample Size: 1 sample of each lamp-ballast model combination, or LED package/LED module/LED array and LED driver model combination shall be tested.

Passing Test: Sample shall pass. |

11.5 Standby Power Consumption: All Luminaires

Source Type	ENERGY STAR Requirements	Methods of Measurement and/or Reference Documents	Supplemental Testing Guidance
All Source Types	Luminaires shall not draw power in the off state.

Exceptions:
• Luminaires with integral motion sensors, occupancy sensors or photosensors, or connected functionality may draw up to 0.5 watts in standby mode.
• Luminaires with energy saving features i.e. integral motion sensors, occupancy sensors or photosensors and connected functionality may draw up to 1 watt in standby mode.
• Power supplies connected to multiple luminaires may draw up to 1.5 watts in standby mode.
• External power supplies (EPS) employed to power luminaires shall meet the level V or higher performance requirements under the International Efficiency Marking Protocol and include the level V or higher marking on the EPS. | Method of Measurement: IEC 62301 ED.2.0 B-2011 Household Electrical Appliances - Measurement of Standby Power

Reference document: International Efficiency Marking Protocol http://www.regulations.gov/#!documentDetail;D=EERE-2008-BT-STD-0005-0218 | Laboratory test results shall detail standby power consumption to the tenth of a watt. |

15.2 Products with Connected Functionality – Optional

Source Type	ENERGY STAR Requirements	Methods of Measurement and/or Reference Documents	Supplemental Testing Guidance
All source types	Product must continue to comply with the applicable product safety standards – the addition of the functionality shall not override existing safety protections and functions. Must comply with section 11.5 Standby Power	Method of Measurement: None	Connected products without color tuning capabilities shall be tested at full power for all applicable requirements. Connected products with color tuning capabilities shall be tested under the conditions specified under Section 5.1. Compliance with connected functionality requirements shall be demonstrated through examination of product and/or product documentation.

15.2.1 Connected Product Criteria:

To be recognized as connected, a "connected luminaire" (or retrofit) shall include the base luminaire or retrofit kit plus elements (hardware and software or firmware) or instructions required to enable communication in response to consumer-authorized energy or performance related commands (e.g. instructions for downloading a mobile application, Bluetooth syncing guidance) and shall meet the requirements in sections 15.2.2-15.2.6. These elements may be resident inside or outside of the base luminaire. Connected luminaires typically communicate with controls via a radio frequency system, although some versions use other methods (such as DMX or DALI). The specific design and implementation of the connected luminaire is at the partner's discretion provided it is interoperable with other devices and enables economical, consumer-authorized third party access to the functions provided for in sections 15.2.3,15.2.4, and 15.2.5.

15.2.2 Open-access

To enable interconnection with the product; an interface specification, Application Programming Interface (API) or similar documentation shall be made available to interested parties that enables section 15.2.3, 15.2.4 and 15.2.5 connected functionality, and includes accuracy, units and measurement intervals for Energy Consumption Reporting.

15.2.3 Energy Consumption Reporting

The product shall be capable of interconnecting with consumer authorized entities to communicate data representative of its interval energy consumption. It is recommended that data be reported in watt-hours for intervals of 15 minutes, however, representative data may also be reported in alternate units and intervals as specified in the partner's interface specification or API.

15.2.4 Operational Status Reporting

At a minimum, the product shall be capable of providing the on/off status to energy management systems and other consumer authorized devices, services or applications via a communication link.

15.2.5 Remote Management

The product shall be capable of receiving and responding to energy management system or other consumer authorized remote requests, via devices, services or applications, similar to hard-wired consumer controllable functions.

15.2.6 Information to Consumers

If additional devices, services, and/or infrastructure are required to activate the product's connected capabilities, prominent labels, or other forms of consumer notifications shall be displayed at the point of purchase and in the product literature. (e.g. "This product has Z-wave control capability and requires interconnection with a Z-wave controller to enable local lighting control.")

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ENERGY STAR Lamp (V2.0 Draft 3) Specifications

11.4. Start Time: All Lamps

Lamp Type	ENERGY STAR Requirements	Methods of Measurement and/or Reference Documents	Supplemental Testing Guidance
Non-Connected Lamps	Reported value of time for lamp to remain continuously illuminated shall be within 750 milliseconds of application of electrical power.	**Measurement:** ENERGY STAR Start Time Test	**Sample Size:** 3 units per model. The reported value shall be the average of measured unit values tested, rounded to the nearest millisecond.
Connected Lamps	Reported value of time for lamp to remain continuously illuminated shall be within 1 second of application of electrical power.	**Measurement:** ENERGY STAR Start Time Test	**Sample Size:** 3 units per model. The reported value shall be the average of measured unit values tested, rounded to the nearest millisecond.

11.7. Standby Power Consumption: All Lamps

Source Type	ENERGY STAR Requirements	Methods of Measurement and/or Reference Documents	Supplemental Testing Guidance
All Source Types	Lamps without integral controls shall not draw power in the off state. Exception: Lamps with integral controls (e.g., motion sensors, photosensors, wireless control, standby mode, or connected functionality) shall consume no more than 0.5 watt in standby mode.	IEC 62301 Edition 2.0 2011-01 Household electrical appliances - Measurement of standby power U.S. Department of Energy Conservation Test Procedures for Compact Fluorescent Lamps (once final) U.S. Department of Energy Conservation Test Procedure for Integrated Light-Emitting Diode Lamps (once final)	Laboratory test results shall detail off-state power consumption to the tenth of a watt. This applies to lamps that may have wireless controllability but may not meet all connected criteria as identified in the specification definition for connected lamp and Section 12.7 Connected Product Criteria.

12.6. Products with Connected Functionality – Optional

Source Type	ENERGY STAR Requirements	Methods of Measurement and/or Reference Documents	Supplemental Testing Guidance
All source types	Product must continue to comply with the applicable product safety standards – the addition of the functionality shall not override existing safety protections and functions. Product shall not consume more than 0.5 watts when in standby mode.	Measurement: None	Test Requirements: Connected products without color tuning capabilities shall be tested at full power for all applicable requirements. Connected products with color tuning capabilities shall be tested under the conditions specified under Section 5.1. Compliance with connected functionality requirements, in Sections 12.7-12.12, shall be demonstrated through examination of product and/or product documentation.

12.7. Connected Product Criteria:

To be recognized as connected, a "connected lamp" shall include elements (hardware and software or firmware) or instructions required to enable communication in response to consumer-authorized energy or performance related commands (e.g., instructions for downloading a mobile application, Bluetooth syncing guidance) and shall meet the requirements in Sections 12.8-12.12. These elements may reside inside or outside of the base lamp.

The specific design and implementation of the connected lamp is at the manufacturer's discretion provided it is interoperable with other devices via open communications protocol and enables economical, consumer-authorized third party access to the functionalities provided for in sections 12.9, 12.10and 12.11.

12.8. Open-standards & Open-access

1. Communication that enables connected functionality; (sections 12.9 – 12.12) must use, for all communication layers, protocols that are open and interoperable.

2. The product shall enable connectivity by one of following means:
   a. Open-standards communications from the lamp, or
   b. Open-standards communications from an external controller, included with the product or available separately.
   c. Where no suitable open standards communications method exists (e.g., an IP interface), an open and documented communication method must be used. In these cases, a manufacturer-specific method shall be published for use with the product.

To enable interconnection with the product; an interface specification, Application Programming Interface (API) or similar documentation shall be made available to interested parties that enables sections 12.9, 12.10 and 12.11 connected functionality, and includes accuracy, units and measurement interval for Energy Consumption Reporting.

12.9. Energy Consumption Reporting

The product shall be capable of interconnecting with consumer authorized entities to communicate data representative of its interval energy consumption. It is recommended that data be reported in watt-hours for intervals of 15 minutes; however, representative data may also be reported in alternate units and intervals as specified in the product manufacturer's interface specification or API. If the lamp does not provide power consumption directly in watts, the manufacturer shall make available a method for estimating power consumption, in watts, from the representative data that is provided by the lamp.

12.10. Operational Status Reporting

At a minimum, the product shall be capable of providing the following information to energy management systems and other consumer authorized devices, services or applications via a communication link: operational status; e.g., on/off.

12.11. Remote Management

The product shall be capable of receiving and responding to energy management system or other consumer authorized remote requests, via devices, services or applications, similar to hard-wired consumer controllable functions.

12.12. Information to Consumers

If additional devices, services, and/or infrastructure are required to activate the product's connected capabilities, prominent labels, or other forms of consumer notifications shall be displayed at the point of purchase and in the product literature. (e.g., "This product has Z-wave control capability and requires interconnection with a Z-wave controller to enable local lighting control.")

Note box 17: In Draft 3, EPA has added language to clarify 1) the means by which a product enables connectivity (§12.8), and 2) that reporting of estimated power consumption (watts) is allowed (§12.9).

EPA's intent in §12.11 Remote Management is for the product to provide the ability to receive and respond to signals from at least one device, service or application.

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Future Connected Lighting Specification Considerations

- User interface requirements (e.g. industry standard white or color picker)

- Compliance with specific Data/Information Model for energy data/information

- Reporting of other data/information (e.g. occupancy, ambient lighting, environmental conditions)

- Compliance with specific Data/Information Model for other data/information

- Certified compliance with industry standard or industry consortia interoperability specification

Questions?

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