U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Future Lighting Systems: The Path to Optimized Energy Performance

Lightfair
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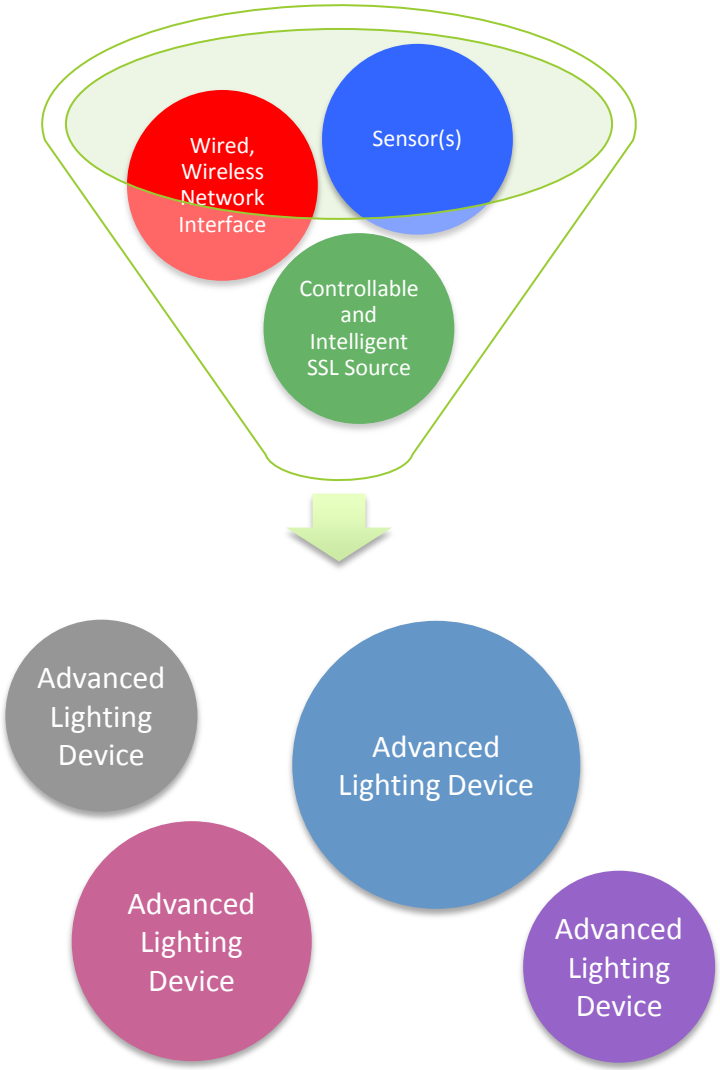
SSL technology is re-defining the role of lighting devices

- SSL is the most energy efficient, flexible, controllable lighting technology in history
  - Spectral power distribution, light output (e.g. luminous flux, intensity, distribution), color characteristics (e.g. CCT, CRI, Duv)
  - System architecture, partitioning, and power conversion
- SSL is blurring the traditional lines between lighting system devices (e.g. lamps and ballasts/drivers, luminaires and lighting controls)
- SSL is poised to catalyze the deployment of intelligent, networked lighting devices that collect and exchange data
  - Embedded intelligence (e.g. for managing power conversion) can be leveraged or enhanced for other purposes (e.g. output control, network interface management)
  - Microelectronic platform facilitates the cost-effective integration of additional functionality (e.g. network interfaces, sensors)

Lighting devices will look dramatically different in the future



- Many integration possibilities
  - Single-function (e.g. sensor-only) devices
  - Multi-function devices (e.g. controllable and intelligent SSL source + sensor(s) + network interface)
- Not clear that any particular device integration or system architecture will dominate
  - Many will be likely be able to succeed in the market
  - Solutions for retrofits and new install

How can the energy performance of future lighting systems be optimized?

- Enabling intelligent lighting systems with data can result in reduced energy consumption and improved lighting performance
- The data collected (via sensors) by advanced lighting devices and exchanged (via network interfaces and interoperability protocols) with other lighting and non-lighting devices can facilitate reduced energy consumption and improved performance of those devices, as well as a growing number of non-lighting and non-energy related benefits
  - Lighting is pervasive (in all buildings and spaces), well-distributed, and AC powered
  - Leverage SSL transition driven by energy and maintenance savings

Growing focus on interconnecting systems in buildings

- Lighting and other building systems look more like IT systems
- Intelligence increasingly distributed or cloud-based, not tied to one centralized management system
- Data exchange facilitated by interoperability, but likely not one set of protocols
  - Multiple physical/data links
  - Multiple network, transport mechanisms
  - Application specific functional profiles
- Data exchange facilitated by gateways, drivers, schemas, APIs
- Devices and systems connect to communication networks, exchange data, perform local analysis, and make intelligent decisions

What have we learned from past lighting control approaches?

- Lighting control is a function that requires the integration of devices; while a controlled lighting system can far out-perform a static system, performance depends on much more than device capabilities
- Lighting control strategies have been overly focused on devices that are tightly coupled to installed luminaires, with not enough consideration given to system issues and intangibles such as owner organizational maturity
- Lighting control energy savings have been widely varying and unpredictable, and limited by the number of installations, failure to adopt performance monitoring and continuous optimization, and lack of interaction with non-lighting systems
- Complex configuration requirements, high total cost of deployment, poor user satisfaction, and difficult to predict performance have been and remain significant barriers to adoption (estimated as < 1%) and energy savings

Device/system interaction can affect performance

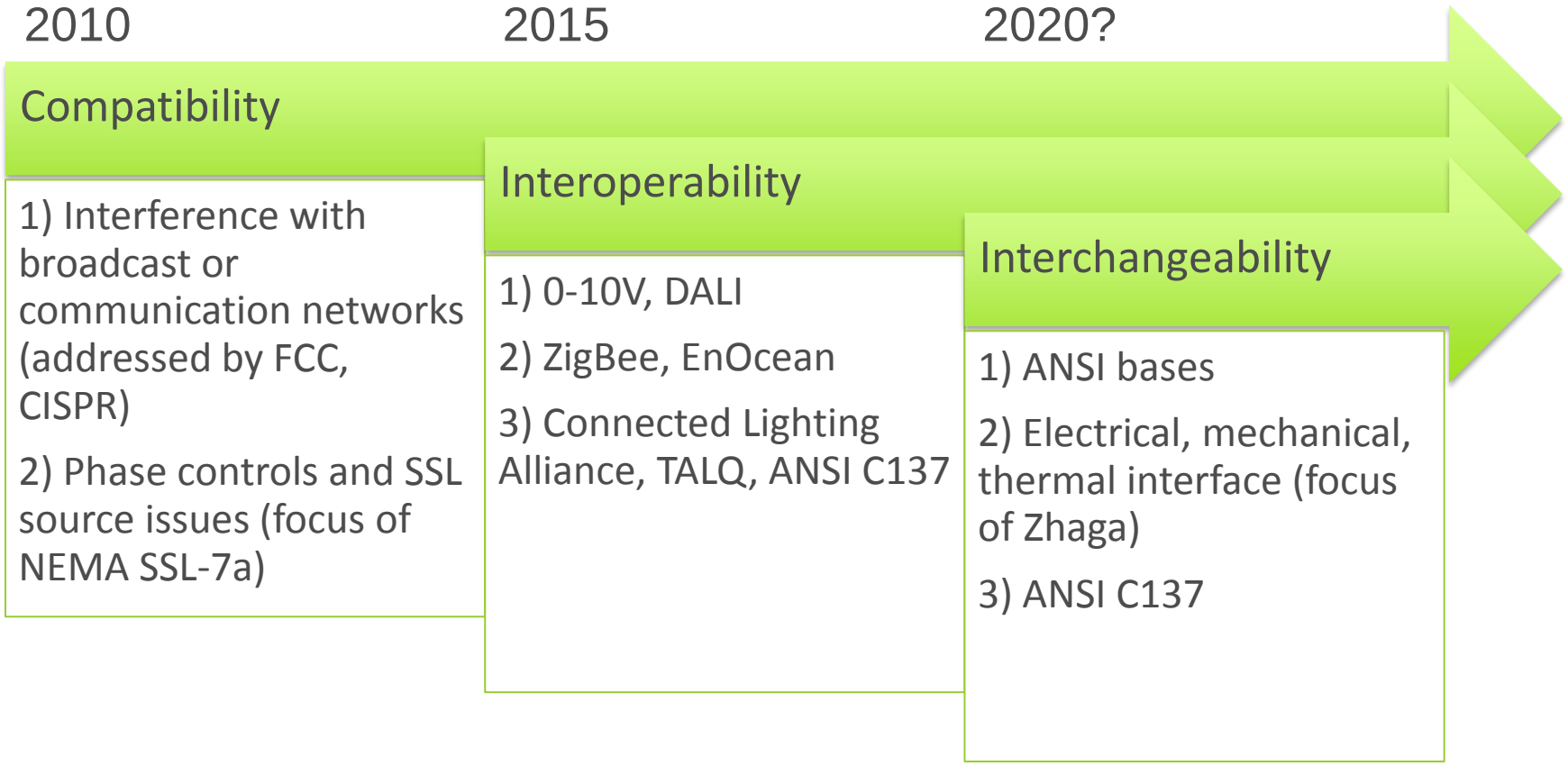
- Compatibility: The capability of two or more devices, applications, networks, or systems to coexist in the same physical environment – that is, operate without corrupting, interfering with, or hindering the operation of the other entity.
- Interoperability: The capability of two or more devices, applications, networks, or systems to reliably and securely exchange and readily use data with a commonly shared meaning.
- Interchangeability: The capability 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.

Greater interoperability can have a significant market impact

- Facilitates the incorporation of best-of-breed devices, deployment of an energy-saving platform (i.e. multi-phase, not limited to initial install choices)
- Reduces incremental cost of system enhancement (e.g. software vs. hardware)
- Facilitates crowd-sourced development (software, use cases)
- Reduces user risk (e.g. device, manufacturer obsolescence), increase user satisfaction and adoption
- Facilitates greater data exchange
  - Use data from, share data with non-lighting systems
  - Improved performance of lighting and non-lighting systems
  - Non-energy benefits
  - Communicate measured performance (hours-of-use, energy)
  - Engage in transactive energy markets

Now is the time to focus on interoperability

Early SSL compatibility issues identified and being addressed
Many industry interoperability efforts underway
Still too far from SSL technology maturity to focus on interchangeability



Growing demand for application layer interoperability (functional profiles)

Having all these different standards efforts practically ensures one thing: There's no way all of these devices will actually be able to all talk to each other until all this gets settled …. Ina Fried, July 2014

Growing industry focus on application layer interoperability (functional profiles)

"*The ZigBee Alliance is addressing the critical need for application level standardization*," said Mareca Hatler, Director of Research with ON World.

"*The ZigBee Alliance has always believed that true interoperability comes from standardization at all levels of the network, especially the application level which most closely touches the user*," said Tobin J. M. Richardson, President and CEO of the ZigBee Alliance. "*Lessons learned by Alliance members when taking products to market around the world have allowed us to unify our application standards into a single standard….*"

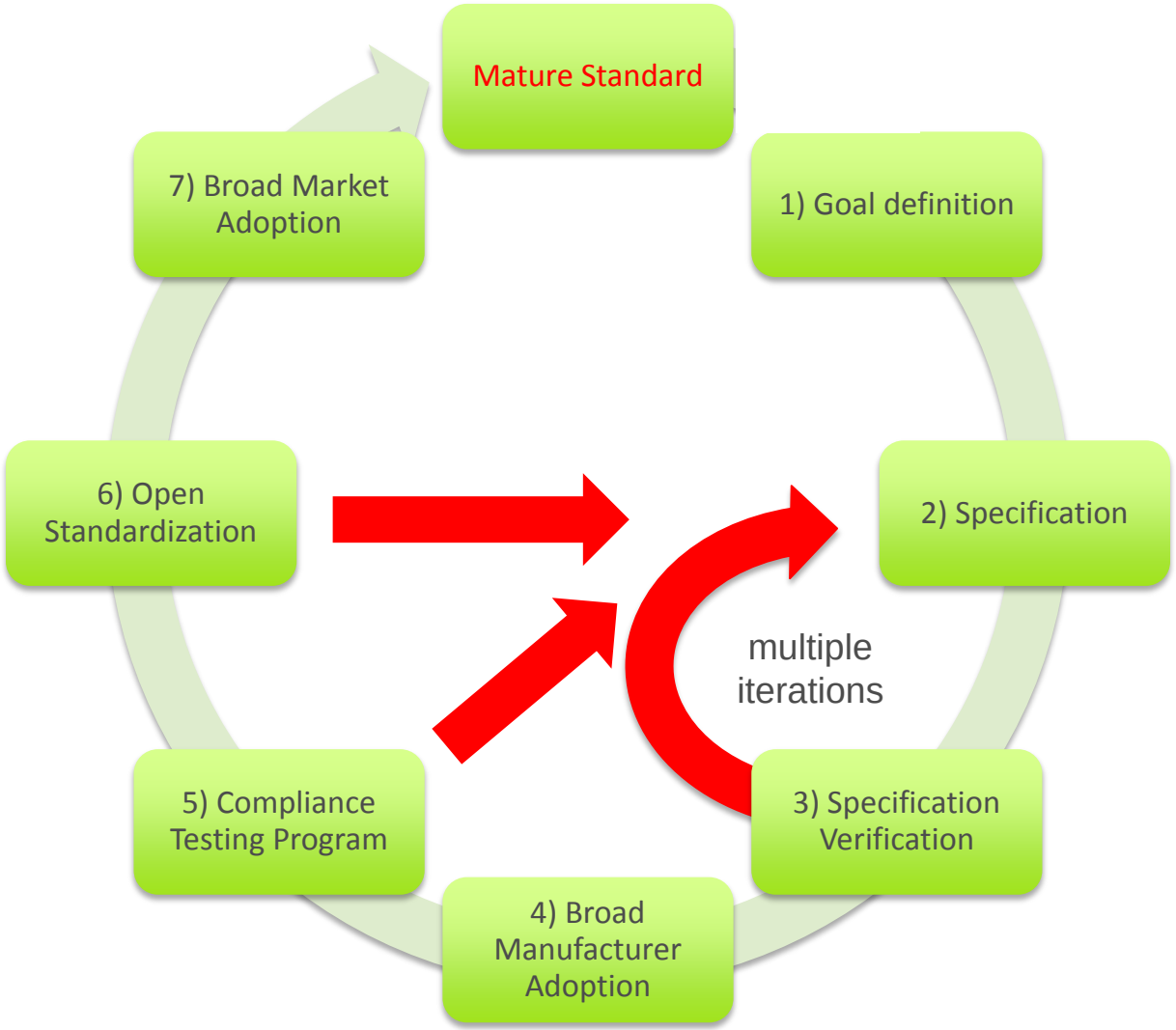
"*The IoT needs a set of open APIs and protocols that work with a variety of physical-layer networks*," says Tanuj Mohan. In this way, he feels, IoT networks should act more like IT nets.

"*Anyone who tries to build a physical layer and drive a software stack based on it all the way up to the application layer is a fool*," he says

"Today Zigbee is the most cost effective, but tomorrow WiFi will figure it out. Networks talk SNMP or CORBA -- every few years there's a new management protocol. In some sense, that's what will happen in IoT, it will keep moving, and people will need open APIs."

http://zigbee.org/zigbee-3-0-creates-single-open-global-wireless-standard-for-devices
http://www.eetimes.com/document.asp?doc_id=1325114&_mc=MP_IW_EDT_STUB

Interoperability standards development takes time



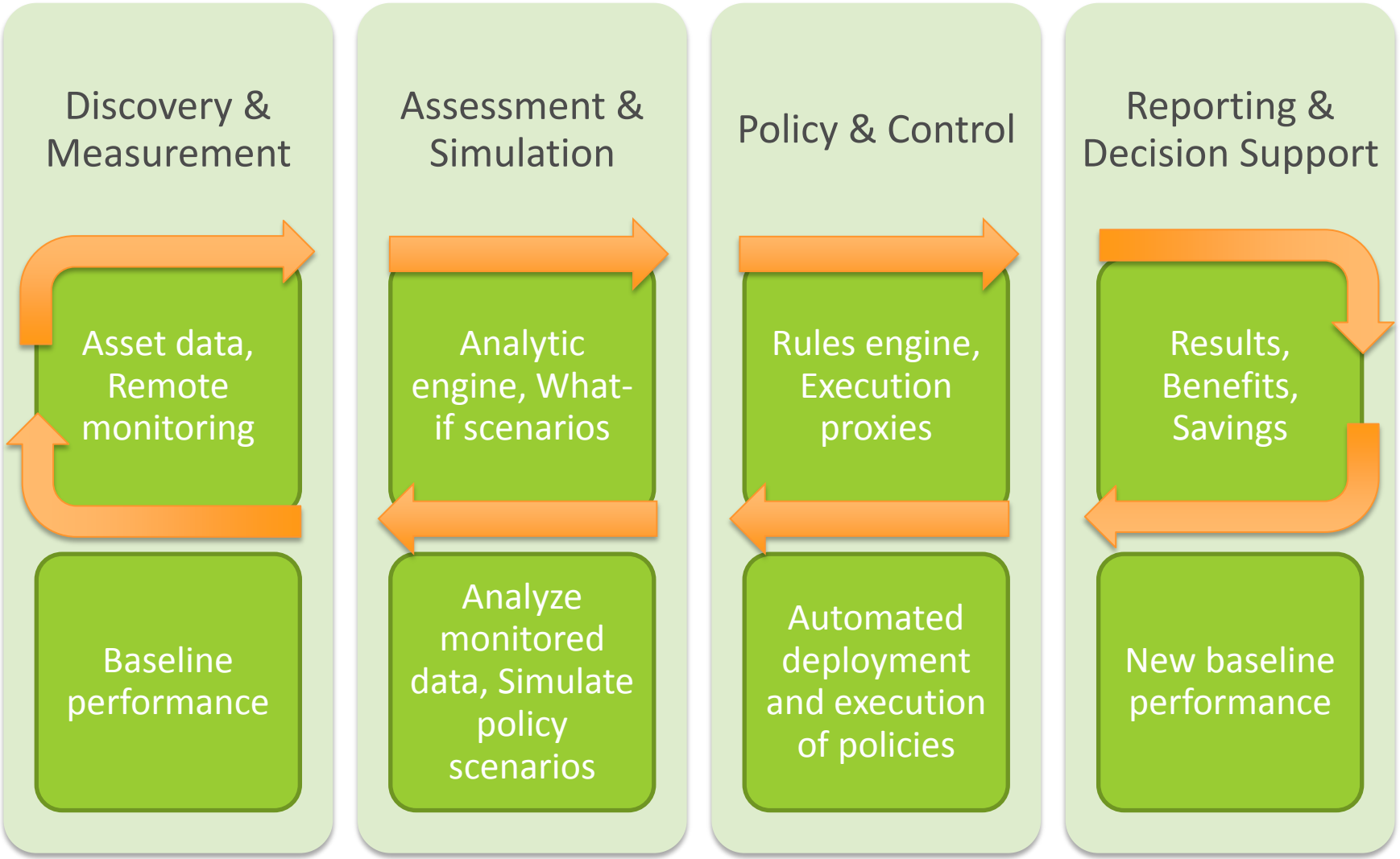
Energy measurement can have a significant market impact

- Emerging system feature in market-available products
- All measurements are actually estimates with an associated uncertainty (i.e. accuracy, precision)
- Existing standards not application appropriate
- Varying manufacturer performance claims, self-certification procedures
- Potential use for utility energy billing replacing outdoor tariffs
- Determination of baseline levels, evaluation of energy savings due to varying lighting control strategies
- Facilitate data-driven (as opposed to predictive model-driven) energy efficiency programs
- Improve cost-effectiveness of service-based business models that are already emerging
- Facilitate data-driven energy management, transactive energy market development

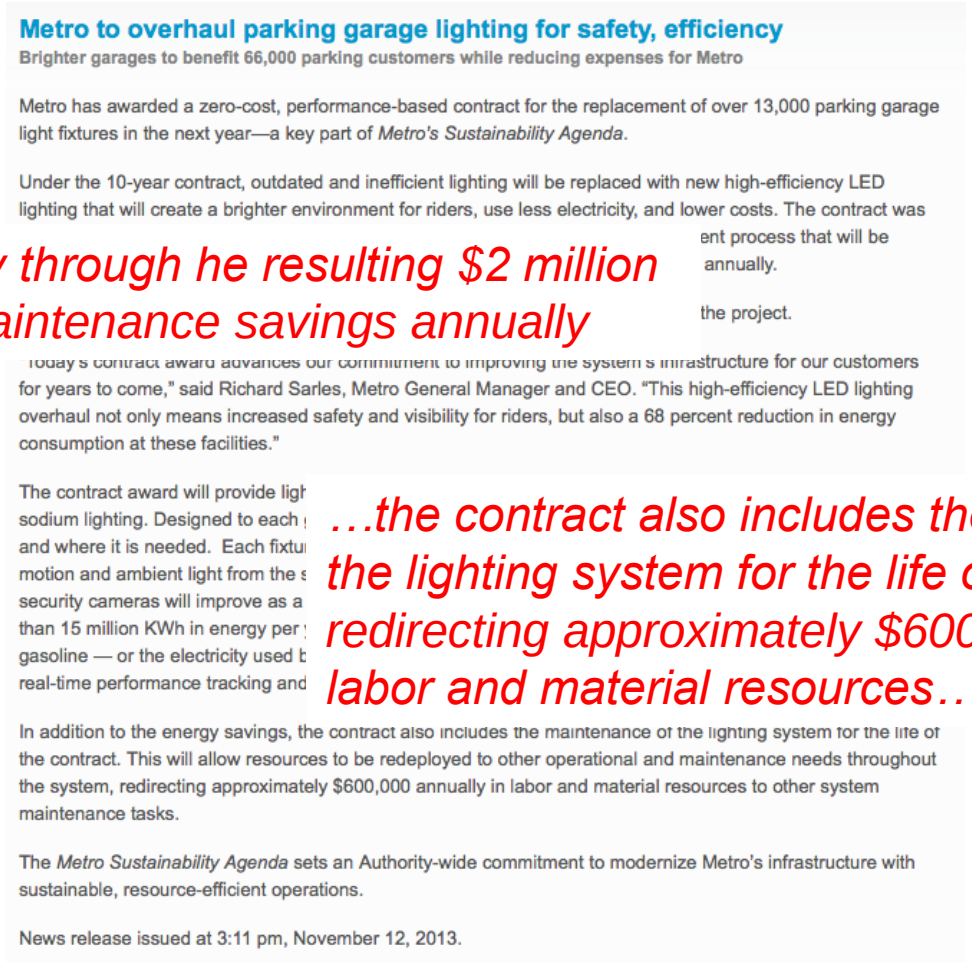
Energy measurement and interoperability enable data-driven energy management

- Lower cost, more accurate energy savings validation (e.g. automated M&V)
- New ways of providing incentives (e.g. pay-for-performance)
- Effectively reduced technology complexity (e.g. new service-based business models, financing mechanisms)
- Complimentary user incentives (e.g. new features, services, non-energy benefits)
- Support (self) characterization of available “building services” that can deliver value to end users, energy markets, the grid, and society
- Closed-loop control or verification of compliance with utility (peak and other) demand response incentives
- Support engagement in transactive energy markets

Data driven energy management



Service-based business models can overcome financing, complexity hurdles



Metro to overhaul parking garage lighting for safety, efficiency

Brighter garages to benefit 66,000 parking customers while reducing expenses for Metro

Metro has awarded a zero-cost, performance-based contract for the replacement of over 13,000 parking garage light fixtures in the next year—a key part of *Metro's Sustainability Agenda*.

Under the 10-year contract, outdated and inefficient lighting will be replaced with new high-efficiency LED lighting that will create a brighter environment for riders, use less electricity, and lower costs. The contract was

ent process that will be

annually.

the project.

Today's contract award advances our commitment to improving the system's infrastructure for our customers for years to come," said Richard Sarles, Metro General Manager and CEO. "This high-efficiency LED lighting overhaul not only means increased safety and visibility for riders, but also a 68 percent reduction in energy consumption at these facilities."

The contract award will provide ligh
sodium lighting. Designed to each
and where it is needed. Each fixtu
motion and ambient light from the s
security cameras will improve as a
than 15 million KWh in energy per
gasoline — or the electricity used b
real-time performance tracking and

In addition to the energy savings, the contract also includes the maintenance of the lighting system for the life of the contract. This will allow resources to be redeployed to other operational and maintenance needs throughout the system, redirecting approximately $600,000 annually in labor and material resources to other system maintenance tasks.

The *Metro Sustainability Agenda* sets an Authority-wide commitment to modernize Metro's infrastructure with sustainable, resource-efficient operations.

News release issued at 3:11 pm, November 12, 2013.

…funded entirely through he resulting $2 million in energy and maintenance savings annually

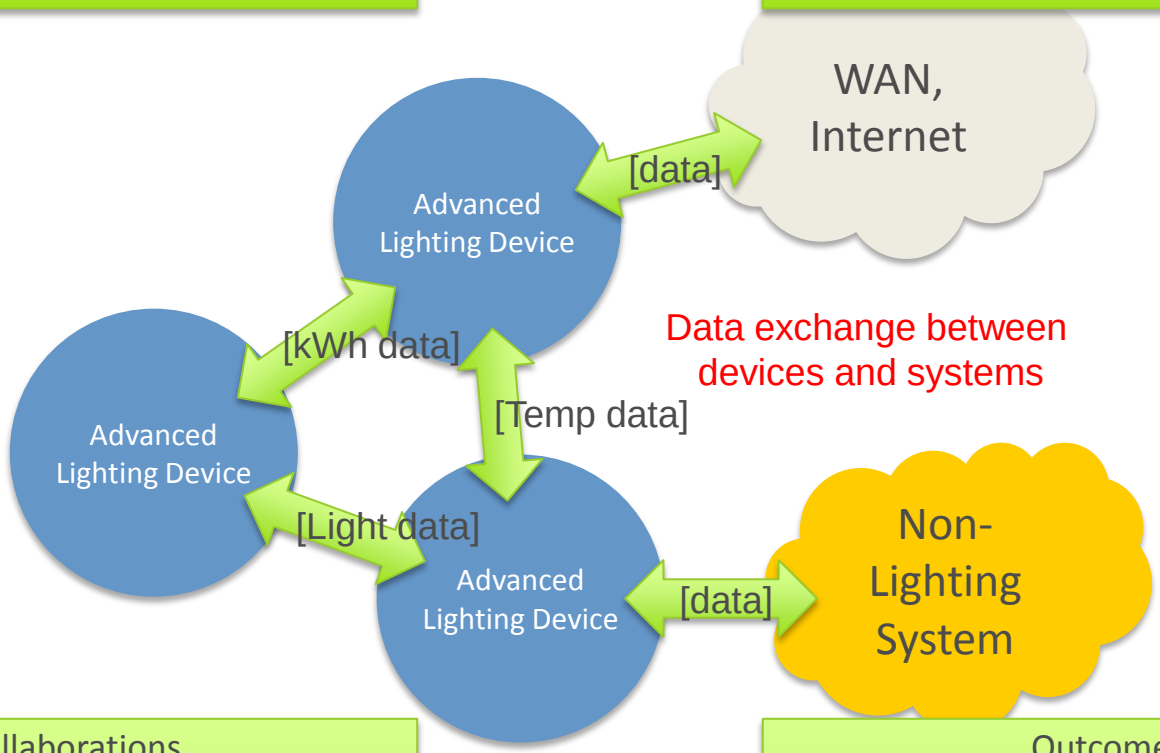
…the contract also includes the maintenance of the lighting system for the life of the contract … redirecting approximately $600,000 annually in labor and material resources…

http://www.wmata.com/about_metro/news/PressReleaseDetail.cfm?ReleaseID=5613
http://greatergreaterwashington.org/post/21636/wmata-gets-turned-on-to-public-private-partnerships/

DOE future lighting system vision and focus

Technology Development Challenges
- Interoperability, system configuration
- Energy measurement, new features
- Standards and specifications

Technology Deployment Challenges
- Real-world performance
- User engagement and education
- High performance product identification



Data exchange between devices and systems

Collaborations
- Industry Consortia
- Energy Efficiency Programs
- Lighting system designers, integrators

Outcomes
- ⇧ Adoption, viable business models
- Data-driven energy management
- Transactive energy markets

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Questions?

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