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Energy Harvesting Technologies for Buildings

Cory Vanderpool

Business Development Director, North America

The Work of EnOcean Alliance

- Non profit trade association of over 200 member companies dedicated to the advancement of self-powered, interoperable wireless solutions for sustainable buildings.
- Standardization & Interoperability
- Promotion & Education
- Proven in over 200,000 building projects
- Over 750 interoperable products

Energy Efficiency in Government Buildings

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- Growing emphasis on energy conservation in federal government
- Built environment has significant opportunities to reduce energy consumption
- EISA 2007 calls for energy efficiency in lighting and appliances in federal facilities
    - 30% by 2015
- Facility managers are the focal point for energy savings at government institutions
- The Federal Government consumes 1.6% of the Nation's total energy budget or $14.5 billion in annual energy costs

State of the Federal Workplace

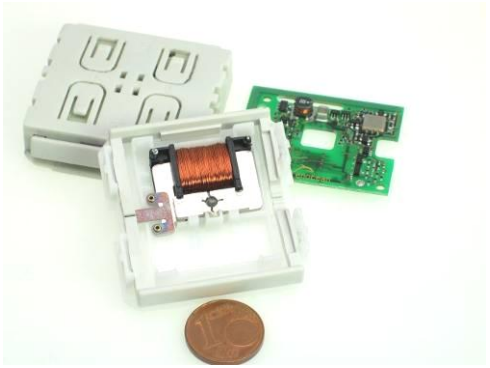
- GSA surveyed over 6,000 federal workers and measured environmental conditions at 624 workstations in 43 workplaces in 22 separate buildings
- Findings include:

1. Adjust workplace temperature for the summer months
2. Replace HVAC filters on schedule and with high performance filters
3. Consolidate and reduce the number of printers and copiers
4. Replace CRT monitors with LCD monitors
5. Upgrade ambient and task lighting in the workplace
6. Improve access to daylight in the workplace
7. Upgrade windows for better energy performance

Energy Harvesting Technologies

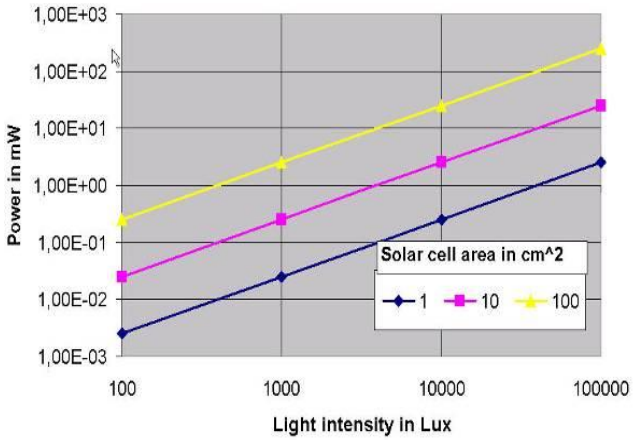
Sensors & Switches are powered by tiny changes in the environment:

- **Mechanical** pressing a light switch / turning a window handle
- **Solar** room or sunlight – stores energy for multiple days & nights
- **Thermo** temperature differences of >4 degC



Mechanical Energy Harvesting Product Examples

Light Energy Harvesting



- Indoor light: 50 -1000 lux
- Outdoor light: 1000 -100,000 lux
- Devices function and charge from 50 lux
- Fully charged devices survive 3 -7 days in darkness

Light Energy Harvesting Product Examples

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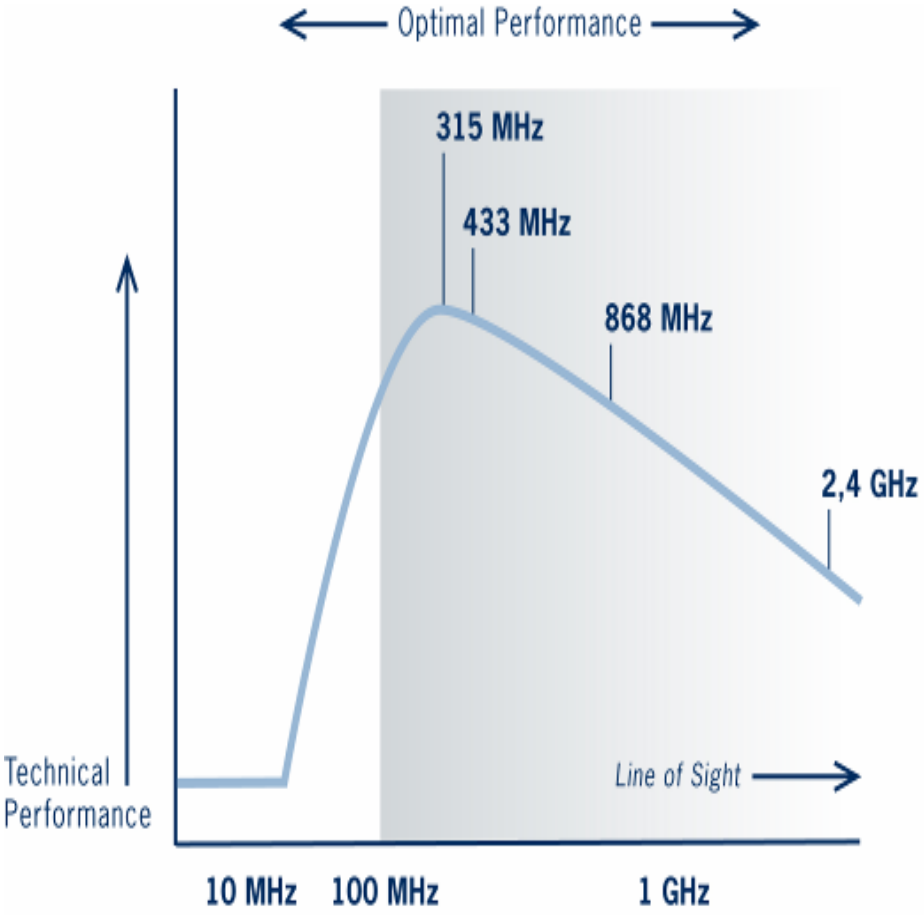
Thermal Energy Harvesting Research Example

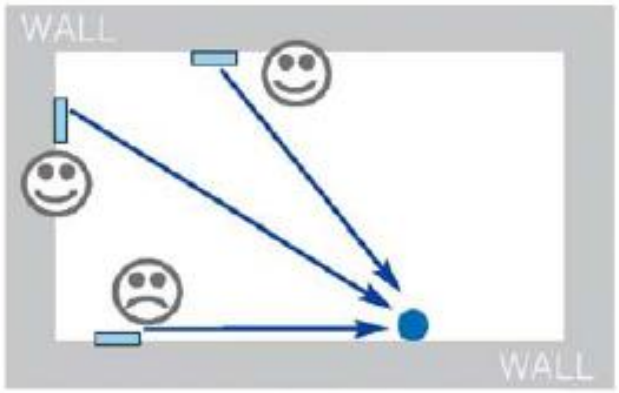
Technology Principles: Wireless Transmission

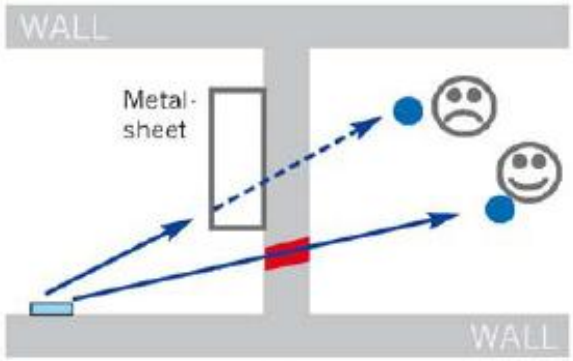


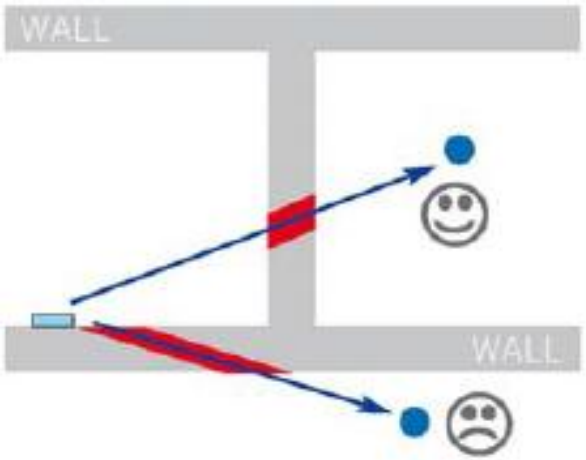
Wireless Control & Monitoring in a Building - considerations:

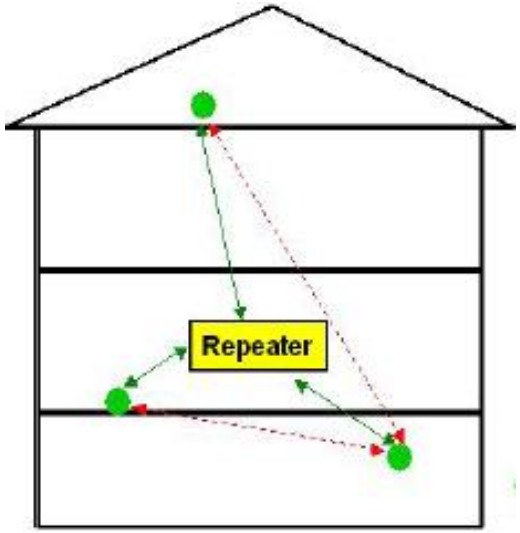
- **Frequency**
  - use license free-band.
- **Range**
  - lower frequency, longer range.
  - ensure receiver within safe range.
  - take attenuators/angles into account
- **Attenuators**
  - metal & concrete block most signals
  - other materials reduce signal range

Technology Principles: Wireless Transmission



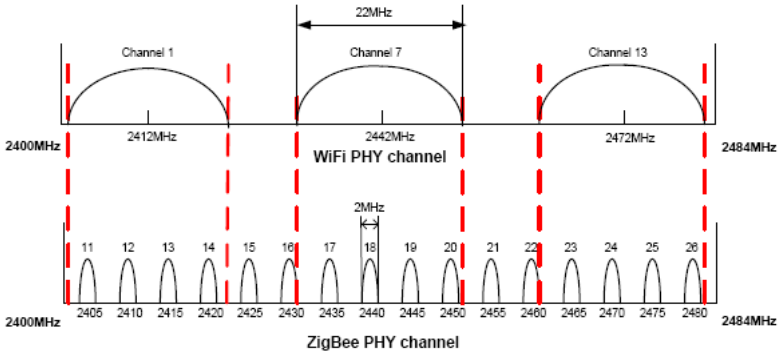






Technology principles: Wireless Transmission

Wireless Control & Monitoring in a Building - considerations:



- **Interference**
  - avoid 2,4GHz inside buildings
  - WLAN, Bluetooth, Microwave Ovens,…
- **Health**
  - use low power, low duty-cycle wireless
  - short signals, low amount of data
- **Power Requirements**
  - cables, batteries, energy harvesting?
  - avoid batteries in buildings where possible (maintenance / failure)

The Benefits of Wireless Controls

- Labor savings of up to 75% over hardwired
- Installs in ¼ the time of hardwired
- Eliminates need for dedicated control wiring, switch legs, traveler wires and other materials
- 50% installed cost savings over hardwired
- Ideal retrofit solution
  - No damage to walls or ceilings
  - Little to no disruption to operations

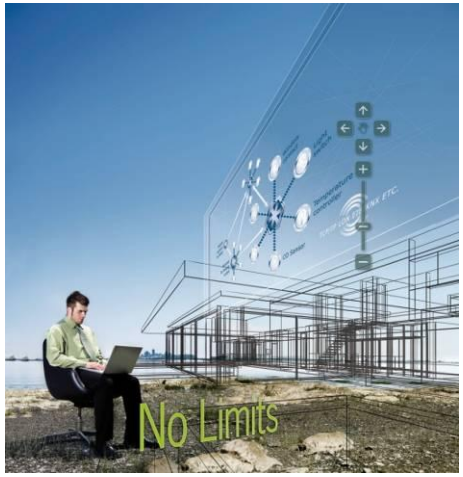
When Does Wireless Make Sense?

- Building Automation System planned (Energy Saving, Central Control, Energy-use Monitoring etc.)
- Flexible Placement on glass, furniture, partition walls etc
- Multi-functional buildings / Open plan offices
- During renovation when multiple new cables / wall opening would be necessary (costs, time, mess etc)
- Time critical projects
- Certified Green / Sustainable building requirement

Calculation of Raw Materials Savings

- 100 Millions of switches & sensors are installed every year
- Every 10 million wireless switches & sensors with wireless technology save at installation:
  - 50,000 miles of cable
  - 3,000 tons copper - 11,500 tons of CO2
  - 7,100 tons PVC - 19,000 tons of CO2
  - Thousands of man years of installation time

Government Support from EnOcean Member Companies



- Leviton Manufacturing
  - Daylighting, dimmers, occ sensors
  - Metering
  - Multiple Contract Vehicles
    - GSA Schedule 70, IMOD, 8(a) Stars
- Magnum Energy Solutions
  - First GSA Net Zero building in CO
  - Working with Ft. Knox

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Office Tower Buildings & Coorporate HQs

Exhibition Centers

Hospitals

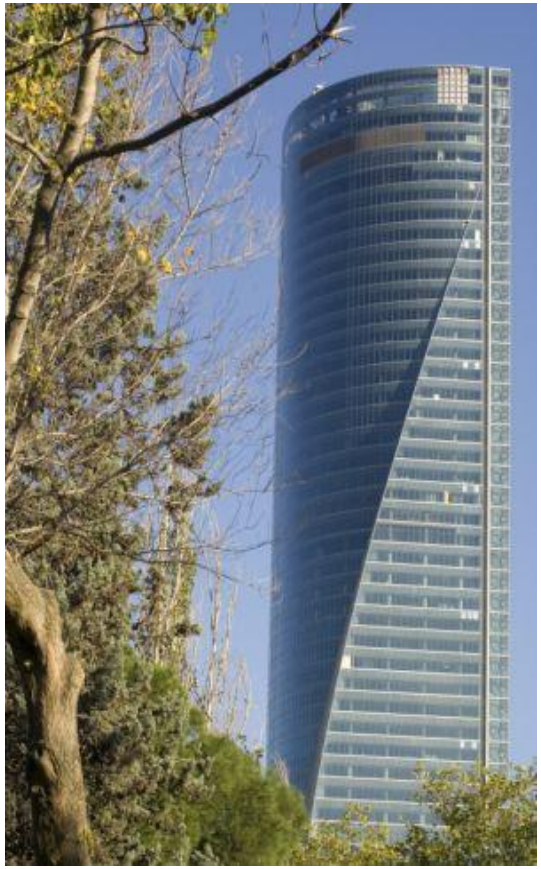
Schools, Colleges & Nurseries

Hard to wire location

Industrial Plants

Residential

Case Study: Torre Espacio - Madrid

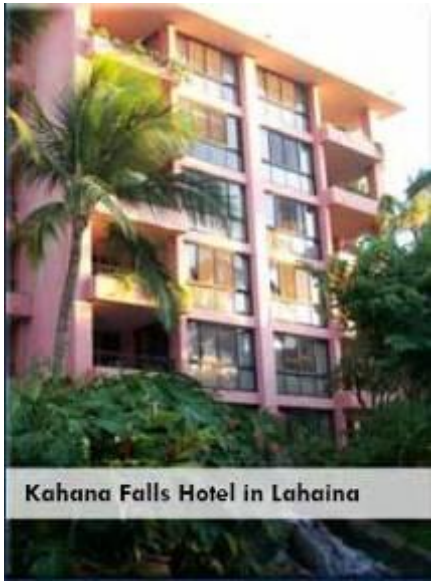


- **4200 Wireless & Battery-less Light Switches**
- **Occupancy Sensors**
- **Daylight Sensors**
- **Savings**
  - 30% to 40% Lighting Energy Costs through:
    - automatic dimming (sunlight)
    - Automatic switch off (non-occupancy)
  - 20 miles Cable, saving:
    - 1,2 Tons Copper / 4,5 Tons CO2
    - 2,8 Tons PVC / 7,5 Tons CO2
    - Man years installation
  - 42.000 Batteries (over 25 years)
  - Thereafter: 80% cost of retrofitting

Case Studies

St. Josephs School, Lacoll, Quebec (2008)

- Individual Room Temperature Control
- - 30% HVAC Energy Costs



Olympic Village, Whistler (2009)

- Flexibility

Kahana Falls Hotel, Hawaii (2009)

- In-Room Energy Control
- - 20% HVAC Energy Costs
- ROI 8 Months

Case Studies - Green Building Certifications

Leggat MacCall Properties, Boston, MA (2009)

- Flexible & Fast Office Installation for Tenants
- LEED Certified

Promutuel Insurance Company, Quebec (2009)

- 800 Energy Harvesting Sensors & Switches
- LEED Gold Certified

1000 Continental, King of Prussia, PA (2007)

- LEED Gold Certified

Office of the Future

Glumac "Office of the Future"
Irvine, CA

- **New Construction – LEED Platinum**
- **Occupancy based Lighting & HVAC Controls for energy savings (> 75% better than Title 24)**
- **Flexible for varying office space usage**
- **EnOcean Wireless - BACnet Solution**

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LEED 2009 For New Construction And Major Renovations - examples

Indoor Environmental Quality			***Up to 4 Points***
IEQ Credit 1	Outdoor Air Delivery Monitoring	1	Monitor outdoor air flow rates and CO_2 levels within the occupied spaces.
IEQ Credit 6.1	Controllability of Systems - Lighting	1	Enable occupants with flexible and convenient control over their lighting levels in both individual and common spaces.
IEQ Credit 6.2	Controllability of Systems - Thermal Comfort	1	Enable occupants with flexible and convenient control over their environment and comfort in both individual and common spaces. Provide feedback on to building systems on comfort parameters and related factors, such as detection of open windows.
IEQ Credit 7.2	Thermal Comfort - Verification	1	Temperature and humidity sensors can be located and relocated as needed to collect data necessary to verify thermal comfort.
IEQ Credit 10 (Schools)	Mold Prevention	1	Monitor humidity, condensation, growth of spores.
Innovation in Design			***Up to 5 Points***
ID Credit 1	Innovation in Design	1-5	In projects with a substantial number of sensors, a case can be made for reduction in waste over time yielded by the absence of batteries. Plus, other innovative and novel applications may apply.

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LEED 2009 For New Construction And Major Renovations - examples

Energy & Atmosphere			***Up to 24 Points***
EA Prereq 1	Fundamental Commissioning of Building Energy Systems		Wireless connectivity and flexibility to relocate wireless devices facilitates commissioning of building systems with simplified installation, calibration, and verification.
EA Credit 1	Optimize Energy Performance	1-19	Apply technology to improve energy efficiency. Use wireless energy metering to verify energy use.
EA Credit 3	Enhanced Commissioning	2	Wireless connectivity and flexibility to relocate wireless devices facilitates commissioning of building systems with simplified installation, calibration, and verification.
EA Credit 5	Measurement and Verification	3	Wireless connectivity and flexibility combined with reduced installation cost enable comprehensive measurement and verification.

EnOcean & LEED

LEED for Existing Buildings: Operations and Maintenance - examples

Credit	Title	Points	EnOcean Technology Impact
Sustainable Sites			***Up to 1 Point***
SS Credit 8	Light Pollution Reduction	1	Enable measurement of outdoor light levels at the perimeter of the property.
Water Efficiency			***Up to 4 Points***
WE Credit 1	Water Performance Measurement	1-2	Monitor and measure water use for various purposes.
WE Credit 4	Cooling Tower Management	1-2	Monitor water conductivity and/or meter non-potable make-up water.
Energy & Atmosphere			***Up to 26 Points***
EA Prereq 1	Energy Efficiency Best Management Practices		Enable validation of operating plan parameters that cover heating, cooling, ventilation, and lighting.
EA Prereq 2	Minimum Energy Efficiency Performance		Use wireless energy metering to enable collection of energy use data.
EA Credit 1	Optimize Energy Performance	1-18	Apply technology to improve energy efficiency. Use wireless energy metering to verify energy use.
EA Credit 2.1	Existing Building Commissioning—Investigation and Analysis	2	Apply wireless sensors to cost effectively perform testing associated with existing building commissioning.
EA Credit 2.3	Existing Building Commissioning – Ongoing Commissioning	2	Apply wireless sensors to facilitate system testing, performance verification, and ongoing measurement.
EA Credit 3.1	Performance Measurement – Building Automation System	1	Apply wireless sensors to performance measurement integrated with BAS.

Commercial Buildings Tax Deduction 179D

- Tax deduction for commercial buildings (EPACT)
- $1.80 per square foot for new or existing commercial buildings saving at least 50% heating and cooling over current ASHRAE Standards.
- Partial deductions ($0.60) are allowed for separate building systems
  - Interior lighting system (20%)
  - Heating, cooling, ventilation and hot water (20%)
  - Building envelope (10%)
- Provision is for property placed in service Dec 31, 2005 and prior to January 1, 2014

Tax Exempt Organizations

- “Pass through” the value of the tax deduction on public projects
- Assign credit to the building designer, or company responsible for the retrofit
- Designer is considered an architect, engineer, contractor, environmental consultant or energy services provider.

The EnOcean Standard

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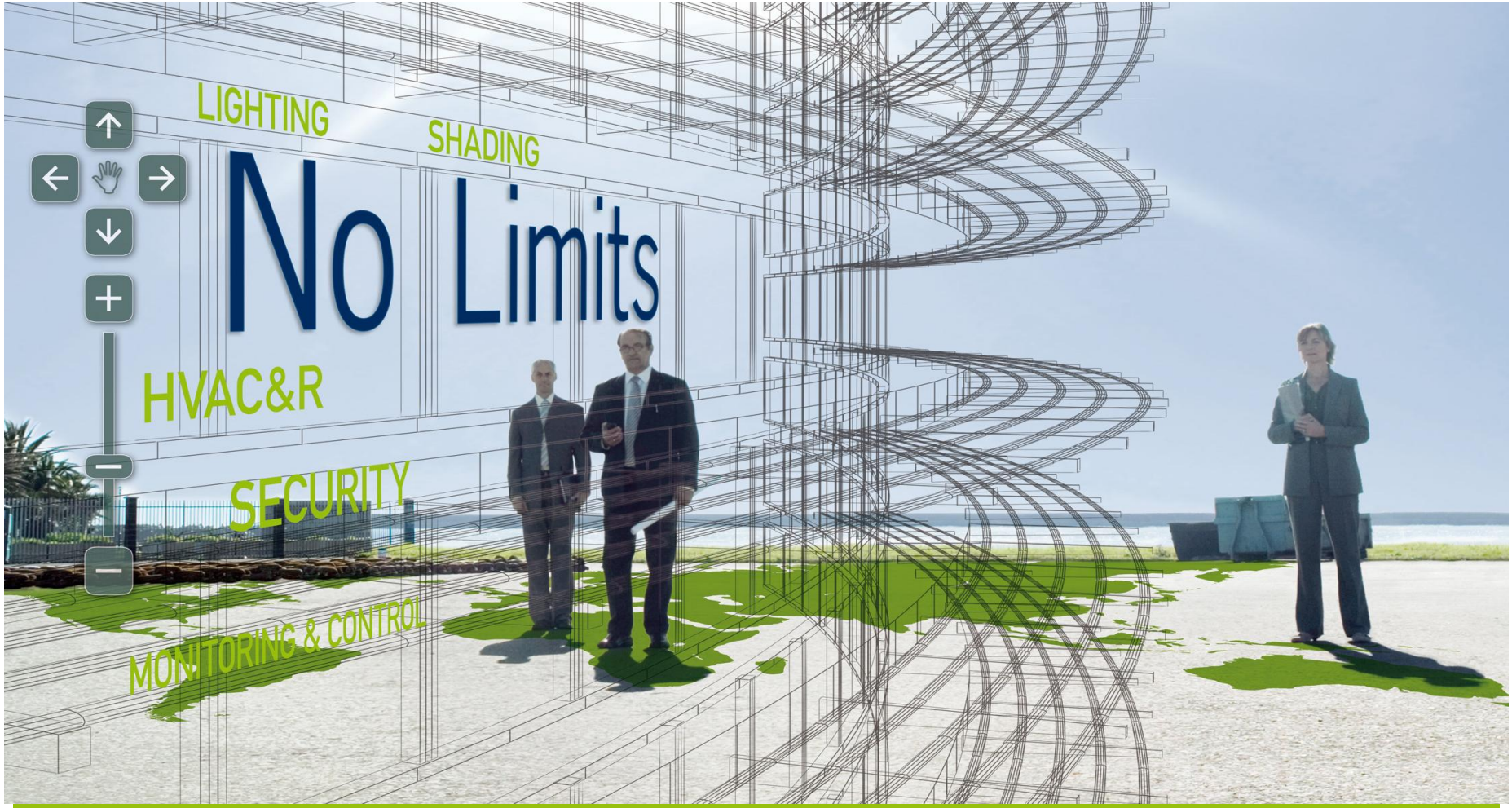
- 200 Companies supporting
- 750 Interoperable products
- 200,000 buildings deployed
- Award Winning Green Technology
- IEC Standardization
- The Only Wireless Standard developed for and proven with Energy Harvesting



Thank you for your attention.

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